13th IFAC Symposium on System Identification

SYSID 2003

Rotterdam, August 27-29, 2003

Final Program and Book of Abstracts

Welcome

The Organizing Committee of SYSID-2003 has the pleasure of welcoming you to Rotterdam, the Netherlands, to participate in the 13th IFAC Symposium on System Identification (SYSID 2003).

The SYSID symposium is organized every three years and is among the most successful symposia organized by IFAC. This will be the first SYSID symposium in the 3rd millennium and the second SYSID symposium to take place in The Netherlands, following the The Hague symposium in 1973.

Being the only worldwide symposium that is fully directed towards system identification, it is the ideal opportunity for researchers and industrial engineers from very many disciplines to present and discuss the developments, the results and the future challenges in all aspects of modelling dynamical systems on the basis of experimental data.

The symposium covers all major aspects of system identification, experimental modelling, signal processing and adaptive control from theoretical and methodological developments to practical applications in a wide range of application areas. For the 13th IFAC Symposium, the International Program Committee has taken steps to position SYSID 2003 as a meeting place where scientists and engineers from several research communities can meet to discuss issues related to these areas.

Out of a total of 422 papers that were submitted to SYSID 2003, the IPC has selected 333 papers and these have been incorporated in the final program and the preprints that appeared on CD-ROM. The selection was based on two referee reports per paper. The final program is composed of 3 plenary papers, 6 semi-plenary papers, 232 papers in oral sessions, 82 posters and 10 software demonstrations. The large number of submissions has forced us to construct a program with 7 parallel sessions. This large number of parallel sessions might lead to severe problems when making the necessary choices on which particular session to attend. On the other hand, it should give ample opportunity for everyone attending the symposium to satisfy their own personal interests.

The CD-ROM with the symposium preprints is provided to each registered participant as part of the registration material. The official Symposium Proceedings will be distributed by the IFAC publisher, Elsevier Science, Ltd., after the symposium.

The symposium venue is in Rotterdam, the second largest city in the Netherlands. It can easily be reached from Amsterdam Airport (Schiphol) by means of a 40 minute train connection. Conference Center "De Doelen" in Rotterdam is one of the most modern conference locations in the Netherlands. It is situated in the heart of the city of Rotterdam, at walking distance from the main railway station, and adjacent to the downtown shopping and restaurant area of Rotterdam. It should give people an excellent opportunity to enjoy both an interesting symposium program and the relaxing atmosphere of Dutch city life in summer.

We hope that you will enjoy your stay in Rotterdam.

The organizing committee

Paul Van den Hof

Bo Wahlberg

Siep Weiland

General information

History of SYSID symposia

SYSID-2003 is the 13th edition of this IFAC symposium. The previous SYSID symposia were held as follows: Prague ("Symposium on Identification in Automatic Control Systems," 1967), Prague ("Symposium on System Identification and Parameter Estimation," 1970), Den Haag (1973), Tbilisi (1976), Darmstadt (1979), Arlington, VA (1982), York, U.K. (1985), Beijing (1988), Budapest (1991), Copenhagen (1994), Kitakyushu (1997), Santa Barbara (2000).

Venue

The symposium will be held in congress center "De Doelen" which is located in the center of the city of Rotterdam, 5 minutes walking distance from Rotterdam Central Station. The conference center was completely renewed and extended in the year 2000 and is among the most modern conference locations in the Netherlands. All lecture rooms are situated on the third and fourth floor. There are clear directions to the conference rooms in the foyer. During the breaks, coffee and tea will be served in the foyer which is located next to the main lecture hall. Announcements and personal messages will be posted in the foyer, near the conference secretariat. The address of the conference center is:

Congress Center "De Doelen"
Kruisstraat 2
3012 CT Rotterdam
The Netherlands
tel: +31.10.2171735
fax: +31.10.4332237
URL: http://www.doelen.nl/index3.html.

Registration and conference secretariat

The SYSID registration desk and conference secretariat are located in the main foyer on the third floor. The opening hours are as follows:

Tuesday	17.00 – 20.00
Wednesday	07.30 – 18.00
Thursday	08.00 – 18.00
Friday	08.00 – 17.00

Late registrations can still be made at the conference registration desk. The fee is Euro 460.– for regular registrations and Euro 200.– for students.

The registration fee includes admission to all sessions, the registration package incorporating a copy of the Final Program and the Book of Abstracts a CD-ROM with the preprints of all conference papers, admission to the welcome reception, the reception at the city hall, coffee, tea, during all breaks and admission to the farewell reception.

Students are defined as full time students, enrolled for degrees of diplomas with a university or a similar institution. Student status must be certified in writing by the student's institution or advisor.

Registration for this conference implies that the participant agrees that the organizers do not assume any liability whatsoever. Participants are requested to make their own arrangements in respect of medical, travel and personal insurance.

IFAC council and IFAC secretariat

The annual IFAC council and various IFAC technical and executive board meetings have been scheduled in conjunction with SYSID-2003. The IFAC secretariat is located in the "Hospitality Room" (between the first and the third floor). All board meetings will take place in the Van der Vorm Zaal, Plate Zaal and Mees Zaal, all located on the fourth floor. The IFAC council meeting will take place on Saturday August 30 in the Eneco Dakfoyer.

Emerging areas discussion

Control systems and automation have a rich heritage of significant accomplishments. What will become the future significant contributions? Tomorrow's applications will probably require more autonomous, higher performance, increased efficiency, and lower cost solutions. Future control methodologies and implementations must become more powerful, but what will enable these improvements?

On Tuesday, August 26, the IFAC Technical Board will hold a working session in conjunction with SYSID-2003 to address these challenges and attempt to identify the major emerging trends for our field. Participants in the session will be IFAC Technical Board members and specially invited guests from appropriate Industry sectors. The results of the working session will be presented in a Panel Presentation on **Tuesday evening, from 19.30 till 21.00** in the Van Beuningen Zaal. All SYSID participants are invited to this presentation.

Social events

Welcoming reception

A welcoming reception will be held on the **Tuesday evening**, prior to SYSID-2003 **from 18.00 till 19.00** in the foyer. All participants are cordially invited to attend the reception.

Reception at the city hall

The major of Rotterdam has invited all participants of SYSID for a reception at the City Hall on Wednesday evening. This event will start immediately after the last sessions on **Wednesday evening at 18.30** at the City Hall and will last until about 20.00. All participants are invited to attend the reception. The City Hall is within walking distance of the conference site.

Conference banquet

The conference banquet will be on **Thursday evening, August 28, at 19.00** in the "Sint Laurenskerk". This monumental church was completed in 1525, but only the walls and the tower remained after a German air raid in 1940. The church was rebuilt between 1947 and 1968. The church is within walking distance of the conference center. The address is Grotekerkplein 27, Rotterdam. The dinner will last until about 23.00 hrs. Tickets for the banquet can be purchased at the Conference Secretariat for Eur. 60.-.

Farewell reception

The symposium will close with a farewell reception in the foyer on **Friday, August 29 from 17.00-18.00 hrs.**

Speaker information

Poster presentations

Poster presentations have been scheduled on Wednesday and Thursday afternoon in the foyer around the main lecture hall. There will be sufficient space and no parallel activities have been planned during the poster sessions. Poster presentations have been grouped in sessions of 90 minutes each. The session title of a group of posters will be clearly indicated. One poster board will be allocated for each poster. The size of the poster board is 150 cm wide and 100 cm high. The size of the useable area is 145 cm wide and 98 cm high. Posters should be mounted before the indicated time-slot in the program and removed after the time-slot. Assistance and material for mounting the posters (tape and pins) will be available during the time slots of the poster sessions at the Poster Desk.

Oral presentations

A beamer and a switch-board is available in each lecture room for electronic projections from your notebook or PC. If you wish to project your slides from a notebook, we recommend that you connect your notebook to the switch-board *before the beginning of the session*. Leave your notebook connected at the switch-board in stand-by mode and use the switch-board to connect it to the beamer at the beginning of your presentation. This, to allow smooth transition between the various presentations in one session. Please do not connect cables to the beamers or switch-boards during the sessions and make sure that screen resolutions on your notebook have been set correctly *before* the session (beamer resolutions are 1024×768 pixels at 60Hz). Technical assistance is available at any time. In addition, an overhead projector will be available in each lecture room.

Software presentations

Two sessions with software demonstrations have been scheduled on Thursday (Session ThA07 and ThP07) in the Van Ryckevorsel Zaal. These sessions will consist of a brief (10 minutes) presentation of each contribution and will be followed by software demonstrations during the time of the session.

Conference website

The conference website

http://www.sysid2003.nl

will remain available after the symposium. The final program and the book of abstracts have been posted on the site and can be downloaded.

Internet cafe

An internet cafe with printing, email and internet facilities is located in the main foyer on the third floor. This facility is free for use by symposium participants and has been sponsored by the Department of Electrical Engineering of Eindhoven University of Technology.

Badges

All participants and accompanying persons are kindly requested to wear their name badge during when attending any conference meeting or social gathering. Only participants who are wearing their name badge can be admitted to the lecture halls.

Lunches

Lunches are not included in the registration fee. A modest lunch can be purchased at the lunch bar in the Expo hall (ground level). There are many lunch facilities, restaurants and cafés in the immediate vicinity of the congress center.

Smoking

Please note that Dutch law does not allow smoking in public buildings. The entire conference center is a non-smoking area.

Accessibility

Congress center “De Doelen” is next door to Rotterdam Central Station (CS) (a 5 minutes walk) and directly linked to the Westin Rotterdam hotel. It can be reached as follows:

By train: Rotterdam CS is within 15 minutes from Rotterdam airport, and 50 minutes from Schiphol airport. Arriving at Amsterdam Schiphol Airport there is a direct train (45 minutes) connecting to Rotterdam CS. Rotterdam Airport offers a fifteen minutes connection to the town center. For details on train connections, tickets and prices we advise to consult the Dutch railways site www.ns.nl.

By car, from northern area (Amsterdam, Den Haag): A13 direction Rotterdam, A20 in the direction of Dordrecht/Utrecht (Ring East), exit Rotterdam Centrum/ Schiebroek/ Hillegersberg. At end, follow direction Centrum (Schieweg/ Schiekade). Then drive towards Hofplein.

By car, from eastern area (Frankfurt, Arnhem, Utrecht): A20 in the direction of Den Haag/ Hoek van Holland, exit Rotterdam Centrum/ Schiebroek/ Hillegersberg, at end, follow direction Centrum (Schieweg/ Schiekade). Then drive towards Hofplein.

By car, from southern area (Antwerp, Brussels, Breda): A16, cross the Van Brienenoordbrug, first exit (Rotterdam Centrum). At end, on the roundabout, turn left in the direction of Centrum, along the water. Straight on, along the ‘Boompjes’. At the Intell hotel (right side), turn right. Follow Schiedamsedijk to the crossing Coolsingel-Westblaak. Turn left on this crossing to the Westblaak or drive straight on to the Coolsingel.

Parking: De Doelen has its own underground parking (Parking Schouwburgplein) accomodating up to 850 vehicles. Access to the parking is next to the Holiday Inn. Parking Plaza and Parking Weena are alternative covered parking spaces.

Local transport

Rotterdam has a dense public transport network of bus, metro and tram, operated by RET. The RET information office and customer service is located at Coolsingel 141. Their internet address is www.ret.rotterdam.nl. Dutch public transport works with a zone system. All the areas operated by public transport are divided into zones. You can use the “strippenkaart” (strip card) throughout the Netherlands for buses, trams, metros (but not trains). You need to stamp $n+1$ strips for every journey, where n is the number of zones that you cross. Bus or tram drivers can stamp the card for you, or you can use the yellow machines in tram, bus or at the metro platforms for stamping the card. The “strippenkaart” can be purchased at the railway station, post office and a number of stores. The card is more expensive when purchased with bus or tram drivers. There are also special 1, 2 or 3-day passes which allow to travel throughout the Rotterdam area without restriction. Taxis are available in the central station area near the conference center.

Banking service

Banking hours in Rotterdam are from 9.00 till 16.00, Monday till Friday. Banks are closed on Saturday and Sunday. Cash dispensers, to be used with bank cards, are available in the close vicinity of the conference center.

Cloakroom and luggage

A cloakroom including luggage storage is located in the registration area.

Electricity supply

In the Netherlands, electricity is supplied at 220 V, 50 Hz.

Congress secretariat

Registrations, payments, and financial administration are handled by Eurocongres Conference Management. For questions, you can reach a representative of Eurocongres at the registration desk. After the conference you should contact:

Eurocongres Conference Management
Jan van Goyenkade 11
1075 HP Amsterdam
The Netherlands
tel: +31-20-679.3411 fax: +31-20-673.7306
email: sysid@eurocongres.com

Accomodation/Hotel information

The following hotels have been booked fro the conference.

1. Bastion Rotterdam/Capelle a/s/ IJssel; Rhijnspoor 300, Capelle a/d IJssel.
2. Best Western Pax Hotel; Schiekade 658, Rotterdam.
3. Best Western Savoy Hotel Rotterdam Center; Hoogstraat 81, Rotterdam.
4. Hilton Rotterdam; Weena 10, Rotterdam
5. NH Atlanta Rotterdam; Coolsingel/Aert van Nesstraat 4, Rotterdam.
6. NH Capelle; Barbizonlaan 2, Capelle a/d IJssel.
7. The Westin Rotterdam; Weena 686, Rotterdam

For information and on-site bookings, please contact RAI Hotel service, P.O. Box 7777, 1070 MS Amsterdam, The Netherlands. Tel.: +31.(0)20.549.1927. Fax: +31.(0)20.549.1947. Email: hotelservice@rai.nl. URL: www.rai.nl/hotelservice.

Shopping in Rotterdam

The opening hours of most shops and stores in Rotterdam are Monday 12.00-18.00 hrs., Tuesday to Saturday from 09.00 till 18.00 hrs. Shops in the city center stay open until 21.00 hrs. on Friday night. Shops are closed on Sunday.

Tourist information

For tourist information about Rotterdam we refer to the site www.rotterdam.nl or to the SYSID website www.sysid2003.nl. For further information, please contact ANWB/VVV Rotterdam, Coolsingel 67, 3012 AC Rotterdam. Tel.: +31.(0)10.414.0000, Fax: +31.(0)10.413.3124.

Weather

The weather in August in the Netherlands is usually warm with temperatures ranging between 18 and 21 degrees Celsius. However, you are advised to bring a raincoat or an umbrella.

IFAC copyright conditions

Committees and sponsors

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- B. Wahlberg (Royal Institute of Technology, Stockholm, Sweden)
- S. Weiland (Eindhoven University of Technology, Eindhoven, The Netherlands).

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- S. Weiland (IPC secretariat, paper handling, website)
- A.C.P.M. Backx (sponsoring, industrial participation)
- M.H.G. Verhaegen (publications)
- Y. Zhu (exhibitions)
- T. Van der Weiden (local arrangements, technical and social events)

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* Appointed by IFAC Technical Committee MISP;
** Appointed by IFAC Technical Committee ACT.

Sponsors

This symposium is sponsored by

- IFAC Technical Committee on Modeling, Identification and Signal Processing.
- IFAC Technical Committee on Adaptive Control and Tuning.

SYSID-2003 is co-sponsored by

- Division of Automatic Control (MRBT) of the Royal Institution of Engineers in The Netherlands. (KIVI).
- IEEE Control System Society.
- Netherlands Organisation for Scientific Research (NWO).
- Dutch Institute of Systems and Control (DISC).
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- Control Systems Group, Department of Electrical Engineering, Eindhoven University of Technology, The Netherlands (TU/e).
- Stichting Meten en Regelen ER-THE.

Scientific program

The scientific program of SYSID-2003 consists of 3 plenary lectures, 6 semi-plenary lectures, 17 invited sessions, 2 software sessions and a total of 324 regular contributions. Regular contributions will be presented in oral and poster presentations. We refer to the speakers information in the previous chapter for the details on these categories. The complete scientific program is also available on-line on the symposium website **http://www.sysid2003.nl**

Plenary lectures

Plenary lecture 1

- **"From experiments to closed-loop control"**
  Prof. Håkan Hjalmarsson, KTH Stockholm
  Session P1, Wednesday, August 27, 08:30 - 09:30, Willem Burger Zaal

Abstract. In this paper we examine the links between identification and control. The main trends in this research area are summarized, with particular focus on design of low complexity controllers. It is argued that a guiding principle should be to model as well as possible before any model or controller simplifications are made, as this ensures the best statistical accuracy. Particular attention is given to the experiment design issue since well-designed experiments facilitates this task. Furthermore, the interaction between experimental constraints and performance specifications is discussed.

Biography. Håkan Hjalmarsson was born in 1962. He received the M.S. degree in Electrical Engineering in 1988, and the Licentiate degree and the Ph.D. degree in Automatic Control in 1990 and 1993, respectively, all at Linköping University. In 1997 he became Docent in Signal Processing at the Royal Institute of Technology, Stockholm, where he presently serves as Professor in the Department of Signals, Sensors and Systems. He has held visiting research positions at Caltech, Louvain University, the University of Newcastle (Australia), the Computer and Automation Institute of the Hungarian Academy of Science and at the Vrije Universiteit Brussel. He has been an Associate Editor for Automatica since 1996 and he has been Guest Editor for Control Engineering Practice and European Journal of Control. He has co-authored more than 90 journal and conference papers. His research interests include system identification, signal processing, control and estimation in communication networks and automated tuning of controllers.

Plenary lecture 2

- **"System identification for structural dynamics and vibroacoustics design engineering"**
  Prof. Herman Van der Auweraer, Katholieke Universiteit Leuven
  Session P2, Thursday, August 28, 08:30 - 09:30, Willem Burger Zaal

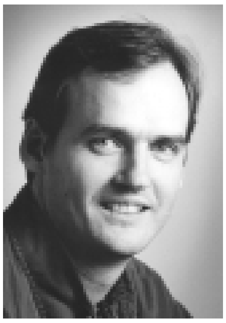
Abstract. System identification plays a crucial role in structural dynamics and vibro-acoustic system optimization. The "Modal Analysis" approach allows a visual interpretation of the Eigenmodes and the derivation of design improvements. The main modal testing procedures and parameter identification methods are reviewed and a number of typical industrial applications are discussed. The critical elements in system identification for these applications are outlined in the broader context of the changing role of testing in the product engineering process. New trends in modal analysis that specifically address these problems are reviewed and illustrated with case studies.

Biography. Herman Van der Auweraer is an Electronical Engineer (MSEE) from the Katholieke Universiteit te Leuven, (Belgium), 1980. He also holds a Ph.D. in Mechanical Engineering from the same university (1987). His specific fields of expertise include noise and vibration testing and analysis methods, applied system identification, subjective sound perception (sound quality) and virtual product optimization. Since 1986, he works for one of the earliest K.U. Leuven spin-offs, LMS International, where, at present, he is the manager of the corporate Research and Technology Development activities.

Plenary lecture 3

- **"Prediction algorithms: Complexity, concentration and convexity"**
  Prof. Peter Bartlett, University of California at Berkeley
  Session P3, Friday, August 29, 08:30 - 09:30, Willem Burger Zaal

Abstract. In this paper, we review two families of algorithms used to estimate large-scale statistical models for prediction problems, kernel methods and boosting algorithms. We focus on the computational and statistical properties of prediction algorithms of this kind. Convexity plays an important role for these algorithms, since they exploit the computational advantages of convex optimization procedures. However, in addition to its computational advantages, the use of convexity in these methods also confers some attractive statistical properties. We present some recent results that show the advantages of convexity for estimation rates, the rates at which the prediction accuracies approach their optimal values. In addition, we present results that quantify the cost of using a convex loss function in place of the real loss function of interest.



Biography. Peter Bartlett is a professor in the Division of Computer Science and Department of Statistics at the University of California at Berkeley. He is the co-author, with Martin Anthony, of the book Learning in Neural Networks: Theoretical Foundations. He has served as an associate editor of the journals Machine Learning, Mathematics of Control Signals and Systems, the Journal of Machine Learning Research, and the Journal of Artificial Intelligence Research. In 2001, he was awarded the Malcolm McIntosh Prize for Achievement in the Physical Sciences, for his work in statistical learning theory. He was a Miller Institute Visiting Research Professor in Computer Science and Statistics at U.C. Berkeley in Fall 2001, and a professor in the Research School of Information Sciences and Engineering at the Australian National University's Institute for Advanced Studies, and he has an adjunct position at the University of Queensland. His research interests include machine learning, statistical learning theory, and adaptive control.

Semi-plenary lectures

Semi-plenary lecture 1

- **"Snippets of identification theory in computer vision"**
  Prof. Stefano Soatto, University of California at Los Angeles
  Session SP1, Wednesday, August 27, 13:30 - 14:30, Willem Burger Zaal

Abstract. In this paper we illustrate the use of identification-theoretic techniques in computer vision, and hint at some open problems.

Biography. Stefano Soatto received his Ph.D. in Control and Dynamical Systems from the California Institute of Technology in 1996; he joined UCLA in 2000 after being Assistant and then Associate Professor of Electrical and Biomedical Engineering at Washington University, and Research Associate in Applied Sciences at Harvard University. Between 1995 and 1998 he was also Ricercatore in the Department of Mathematics and Computer Science at the University of Udine - Italy. He received his D.Ing. degree (highest honors) from the University of Padova - Italy in 1992. His general research interests are in Computer Vision and Nonlinear Estimation and Control Theory. In particular, he is interested in ways for computers to use sensory information (e.g. vision, sound, touch) to interact with humans and the environment. Dr. Soatto is the recipient of the David Marr Prize (with Y. Ma, J. Kosecka and S. Sastry) for work on Euclidean reconstruction and reprojection up to subgroups. He also received the Siemens Prize with the Outstanding Paper Award from the IEEE Computer Society for his work on optimal structure from motion (with R. Brockett). He received the National Science Foundation Career Award and the Okawa Foundation Grant.

Semi-plenary lecture 2

- **"Interval analysis for guaranteed nonlinear parameter estimation"**
  Prof. Eric Walter, French National Center for Scientific Research
  Session SP2, Wednesday, August 27, 13:30 - 14:30, Fortis Bank Zaal

Abstract. Interval analysis, initially developed to analyze and control numerical errors in computers, can be used to minimize possibly nonconvex cost functions or to characterize sets defined by nonlinear inequalities. No solution can be lost, a definite advantage over the usual local iterative techniques. After recalling basic concepts of interval analysis, this introductory paper describes algorithmic tools that can be used for nonlinear parameter estimation and applies them to simple illustrative examples drawn from compartmental modeling. Guaranteed numerical integrators and properties of cooperative systems make it possible to deal with differential models. Pointers to freely downloadable software are provided.

Biography. Eric Walter was awarded a Doctorat d'État in control theory in 1980. He is Directeur de Recherche at CNRS (the French national center for scientific research). His research interests revolve around parameter estimation and its application to chemical engineering, chemistry, control, image processing, medicine pharmacokinetics, and robotics. He is the author or co-author of Identifiability of State-Space Models (Springer, Berlin, 1982), Identification of Parametric Models from Experimental Data (Springer, London, 1997) and Applied Interval Analysis (Springer, London, 2002). He is now Director of the Laboratoire des Signaux et Systèmes.

Semi-plenary lecture 3

- **"Data-based methods in process control"**
  Prof. John MacGregor, McMaster University, Montreal
  Session SP3, Thursday, August 28, 13:30 - 14:30, Willem Burger Zaal

Abstract. This paper gives an overview of methods for utilizing the massive amounts of highly correlated data available in most process databases. These data matrices are almost always of less than full statistical rank, and therefore latent variable methods are shown to be well suited to obtaining useful subspace models for treating a variety of important industrial problems. The following problems are discussed and illustrated with industrial examples: (i) the analysis of historical databases and trouble-shooting process problems; (ii) process monitoring and FDI; (iii) building soft sensors or inferential models; (iv) using of multivariate information from novel sensors; (v) subspace identification; and (vi) process control in reduced dimensional subspaces. In each of these problems latent variable models provide the framework on which solutions are based.

Biography. John MacGregor received his PhD degree in Statistics, his MSc degrees in Statistics and in Chemical Engineering from the University of Wisconsin, Madison, and his Bachelor of Engineering degree from McMaster University, Hamilton, ON, Canada. After working in industry for several years as a process specialist with Monsanto Company in Texas, he joined McMaster University in 1972 as an Assistant Professor in the Department of Chemical Engineering. He is currently holds the title of "University Professor" as well as the Dofasco Chair in Process Automation and Information Technology at McMaster University. He is a co-founder of the McMaster Advanced Control Consortium that is sponsored by many international companies. Dr. MacGregor's research interests have spanned a wide range of areas, from polymer reaction engineering to process systems engineering, control theory, and statistical methods. In recent years he has concentrated on the development of multivariate statistical methods for use in process monitoring, fault detection, and control using the very large multivariate data-bases available from industrial processes. This multivariate research includes problems in both continuous and batch processes as well as image analysis methods. Dr. MacGregor is a Fellow of the Canadian Academy of Engineering and the American Statistical Association. He has received numerous prestigious awards over the years including the Shewhart Medal from the American Society for Quality, the Century of Achievement Award from the Canadian Society for Chemical Engineering, the Computing in Chemical Engineering Award from the American Institute of Chemical Engineers, and the Herman Wold Medal from the Swedish Chemical Society.

Semi-plenary lecture 4

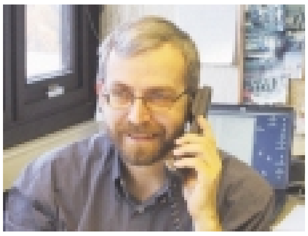
- **"Subspace algorithms"**
  Dr. Dietmar Bauer, Technical University of Vienna
  Session SP4, Thursday, August 28, 13:30 - 14:30, Fortis Bank Zaal

Abstract. In the last decades the term 'subspace algorithms' has been used to denote a class of algorithms, which are based on the property of the state of being an interface between the past and the future in a specific sense. Under this class fall a large number of different algorithms. The basic idea has been used in a number of different contexts in order to derive estimation algorithms, including bilinear models, continuous time models, Hammerstein models, time varying models etc. In this talk only the estimation of linear, time invariant, finite dimensional state space systems is considered. For this model class, subspace algorithms are an alternative to the classical prediction error methods based on criterion optimization. The main advantages of subspace algorithms in this respect are their numerical properties and their conceptual simplicity. This talk provides a detailed description of the most popular algorithms (including N4SID, MOESP and CCA) in a tutorial fashion. This description includes a discussion of numerical details as well as a short survey of asymptotic results. The main emphasis is put on a comparison of the various proposed methods. Secondly an application example tries to pinpoint a number of situations, where subspace algorithms seem to be the favorable estimation tool.

Biography. Dietmar Bauer was born in St. Pölten, Austria. He received his Diplom Ingenieur and his PhD (in 1998) from the Technical University Vienna under the supervision of Manfred Deistler. Since then he was holding post-doc positions at the University of Newcastle, Australia, and Linköping, Sweden. After the conference he will start at Yale University, Conn., USA, for another post-doc position. Beside the theoretical analysis of estimation algorithms his research interests include the application of time series methods in particular in econometrics.

Semi-plenary lecture 5

- **"Identification of linear systems with nonlinear distortions"**
  Prof. Johan Schoukens, Free University of Brussels
  Session SP5, Friday, August 29, 13:30 - 14:30, Willem Burger Zaal



Abstract. In this paper the impact of nonlinear distortions on the linear system identification framework is studied. In the first part, the nonlinear system is replaced by a linear model plus a nonlinear noise source. The properties of this representation are studied. Next, a method to detect, qualify and quantify the nonlinear distortions is presented. In the second part, the (non)-parametric identification of the best linear approximation is studied. In the last part, the linear modelling approach is extended towards nonlinear modelling. A fast approximate nonlinear modelling framework is set up that is a natural extension of the linear framework, and bridged the gap between the linear and the nonlinear identification approaches.

Biography. Johan Schoukens received the degree of Electrical Engineer, and the degree of doctor in applied sciences, from the Free University of Brussels (VUB), Brussels, Belgium in 1980 and 1985, respectively. He is presently a professor at the VUB in the Electrical Measurement Department (ELEC). His research interests are in the field of identification of linear and nonlinear systems and growing tomatoes in his greenhouse. He is co-author of the book: Rik Pintelon and Johan Schoukens (2001). System Identification. A frequency domain approach. IEEE Press and John Wiley.

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- **"Some problems in statistical inference following model selection"**
  Prof. Benedikt Pötscher, University of Vienna
  Session SP6, Friday, August 29, 13:30 - 14:30, Fortis Bank Zaal

Abstract. Statistical inference following a preliminary model selection step is common practice in most applied statistical analyses. In practice, statistical inference is frequently conducted in a classical manner thereby ignoring the model selection phase. Not surprisingly, this leads to invalid procedures. We review some recent attempts towards a coherent theory for statistical inference in the presence of model selection.

Biography. Benedikt M. Pötscher is currently with the Department of Statistics at the University of Vienna. Prof. Pötscher has held visiting positions at Yale, the University of Maryland at College Park, the University of Heidelberg, IAS Vienna, and the University of California at Santa Barbara. He is author of the books "Game Theoretical Foundations of Evolutionary Stability" (co-authored with I.M. Bomze), published by Springer Verlag in 1989 and "Dynamic Nonlinear Econometric Models: Asymptotic Theory" (co-authored with I.R. Prucha), published by Springer Verlag in 1997. He is Associate Editor for the Journal of Econometrics, Co-Editor of Econometric Theory. His research interests include model selection, time series analysis, and asymptotic theory.

Scientific program

WEDNESDAY, AUGUST 27, 2003

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Session organizer: M. Viberg

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Session organizer: D. Bauer

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Session organizer: H. Garnier

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T. Uhl Univ. of Mining and Metal., Krakow
M. Bogacz Univ. of Mining and Metal., Krakow

17:20 - 17:40
Statistical approach to flutter monitoring 713
L. Mevel IRISA/INRIA
M. Basseville IRISA/CNRS
A. Benveniste IRISA/INRIA

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Reliable system identification for large flexible structures 719
V. Babuska Veridian Systems
R.S. Erwin AFRL
S.L. Lacy AFRL
A.M. Melin

WeP07 Van Ryckevorsel Zaal
Identifiability
Chair: H.F. Chen Co-chair: M. Verhaegen

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New results on global identifiability of linear state space models 725
A. Tatyana Novosibirsk State Technical University
K. Sergey Novosibirsk State Technical University

16:20 - 16:40
Identifiability analysis of a class of systems described by convolution equations 731
L. Belkoura USTL

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Identification of fully parameterized linear and nonlinear state–space systems by projected gradient search 737
V. Verdult Delft University of Technology
N. Bergboer Maastricht University
M. Verhaegen Delft University of Technology

17:00 - 17:20
A differential geometric viewpoint on local identifiability and identification, part 1: theory 743
B. Eitzinger Tann Papier GmbH
K. Schlacher Johannes-Kepler University Linz

17:20 - 17:40
A differential geometric viewpoint on local identifiability and identification, part 2: application 749
B. Eitzinger Tann Papier GmbH
K. Schlacher Johannes-Kepler University Linz

17:40 - 18:00
Identifiability of nonlinear homogeneous polynomial systems 755
R.L.M. Peeters Universiteit Maastricht
B. Hanzon CWI, Amsterdam

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P2 Willem Burger Zaal
Plenary lecture
Chair: P. Van den Hof

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System identification for structural dynamics and vibroacoustics design engineering 761
Dr. Herman Van der Auweraer Kath. Univ. Leuven

ThA01 Willem Burger Zaal
Selected topics in identification
Chair: S. Bittanti Co-chair: B. Ninness

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A personal view on the development of system identification 773
M. Gevers Université Catholique de Louvain

10:40 - 11:00
System identification via a computational Bayesian approach 785
B. Ninness University of Newcastle

11:00 - 11:20
A new information theoretic approach to order estimation problem 791
S. Beheshti MIT
M. Dahleh MIT

11:20 - 11:40
Conditions for local convergence of maximum likelihood estimation for ARMAX models 797
G.C. Goodwin The University of Newcastle
J.C. Aguero The University of Newcastle

R.E. Skelton University of California, San Diego

11:40 - 12:00
A nonparametric approach to model selection 803
M. Bekara SUPELEC
A.K. Segouane SUPELEC
G. Fleury SUPELEC

ThA02 Fortis Bank Zaal
Reproducing kernels 2
Chair: J. Suykens Co-chair: E. Vazquez

Invited session

Session organizers: J. Suykens, E. Vazquez, E. Walter

10:00 - 10:20
An introduction to learning with reproducing kernel Hilbert spaces 809
M. Pontil University College London

10:20 - 10:40
Sparse Gaussian processes: inference,subspace identification and model selection 815
L. Csato Aston University, Birmingham
M. Opper Aston University, Birmingham

10:40 - 11:00
Sparse kernel methods 821
S.R. Gunn Univeristy of Southampton

11:00 - 11:20
A generalised LS–SVM 827
J. Valyon Budapest Univ. of Techn. and Econom.
G. Horváth Budapest Univ. of Techn. and Econom.

11:20 - 11:40
Adaptive kernel methods 833
A. Kuh University of Hawaii

11:40 - 12:00
Subspace regression in reproducing kernel Hilbert space 839
L. Hoegaerts Katholieke Universiteit Leuven
J.A.K. Suykens Katholieke Universiteit Leuven
J. Vandewalle Katholieke Universiteit Leuven
B. De Moor

ThA03 Van Beuningen Zaal
Identification of nonlinear block models
Chair: V. Cerone Co-chair: E.W. Bai

Invited session

Session organizers: V. Cerone, E.W. Bai

10:00 - 10:20
Frequency domain identification of Wiener models 845
E.W. Bai University of Iowa

10:20 - 10:40
Non-parametric identification of non-linearity in Hammerstein systems 851
W. Greblicki Wroclaw University of Technology
P. Sliwinski Wroclaw University of Technology

10:40 - 11:00
Generation of enhanced initial estimates for Wiener systems and Hammerstein systems 857
P. Crama Vrije Universiteit Brussel
J. Schoukens Vrije Universiteit Brussel
R. Pintelon Vrije Universiteit Brussel

11:00 - 11:20
User choices and model validation in system identification using nonlinear Wiener models 863
T. Wigren Uppsala University

11:20 - 11:40
Approximation of feasible parameter set in worst case identification of block-oriented nonlinear models . . 869
L. Giarré Università di Palermo
G. Zappa Università di Firenze

11:40 - 12:00
Parameters set evaluation of Wiener models from data with bounded output errors 875
V. Cerone Politecnico di Torino
M. Milanese Politecnico di Torino
D. Regruto Politecnico di Torino

ThA04 Schadee Zaal
New results in subspace identification
Chair: G. Picci Co-chair: T. Katayama

Invited session

Session organizers: A. Chiuso, T. Katayama, G. Picci

10:00 - 10:20
Constructing the state of random processes with feedback 881
A. Chiuso University of Padova
G. Picci University of Padova

10:20 - 10:40
Closed-loop subspace identification with innovation es-

timation 887
S.J. Qin University of Texas at Austin
L. Ljung Linköping University

10:40 - 11:00
A frequency domain subspace algorithm for mixed causal, anti-causal LTI systems 893
R. Fraanje Delft University of Technology
M. Verhaegen Delft University of Technology
V. Verdult Delft University of Technology
R. Pintelon

11:00 - 11:20
A stochastic realization in a Hilbert space based on "LQ decomposition" with application to subspace identification 899
H. Tanaka Kyoto University
T. Katayama Kyoto University

11:20 - 11:40
Subspace-based identification methods using Schur complement approach 905
Y. Takei Kanazawa Inst. of Tech.
H. Nanto Kanazawa Inst. of Tech.
S. Kanae Kyushu University
Z.-J. Yang, K. Wada

11:40 - 12:00
Recursive subspace identification for continuous-/discrete-time stochastic systems 911
A. Ohsumi Kyoto Institute of Technology
Y. Matsuüra Kyoto Institute of Technology
K. Kameyama Kyoto Institute of Technology

ThA05 Hudig Zaal
Identification for process control: input design
Chair: D.E. Rivera Co-chair: J.H. Lee

Invited session

Session organizers: D.E. Rivera, J.H. Lee

10:00 - 10:20
Plant-friendly system identification: a challenge for the process industries 917
D.E. Rivera Arizona State University
H. Lee Arizona State University
M.W. Braun Texas Instruments
H. Mittelmann

10:20 - 10:40
Multi-objective input signal design for plant friendly identification 923
S. Narasimhan Clarkson University
R. Srinivasan Clarkson University
R. Rengaswamy Clarkson University

10:40 - 11:00
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D.K. Rollins Iowa State University
N. Bhandari Iowa State University

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J.H. Lee Georgia Institute of Technology

11:20 - 11:40
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T. Li Lehigh University
C. Georgakis Polytechnic University, Brooklyn

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Constrained minimum crest factor multisine signals for plant-friendly identification of highly interactive systems 947
H. Lee Arizona State University
D.E. Rivera Arizona State University
H.D. Mittelmann Arizona State University

ThA06 Ruys Zaal
Identification of mechanical systems
Chair: A.G. de Jager Co-chair: D.S. Bernstein

10:00 - 10:20
Online identification of a robot using batch adaptive control 953
B. Bukkems Technische Universiteit Eindhoven
D. Kostic Technische Universiteit Eindhoven
B. de Jager Technische Universiteit Eindhoven
M. Steinbuch

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Dynamic identification of a compactor using splines data processing 959
C.-E. Lemaire LCPC, Bouguenais
P.-O. Vandanjon LCPC, Bouguenais
M. Gautier IRCCyN, Nantes

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A.G. Poulimenos University of Patras

S.D. Fassois University of Patras

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D.S. Bernstein University of Michigan
A. Sanyal University of Michigan
M. Chellappa University of Michigan
J.L. Valk, J. Ahmed, J. Shen

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P. Renaud LaRAMA
N. Andreff LaRAMA
G. Gogu LaRAMA
P. Martinet

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A geometric approach to motion tracking in manifolds . . . 983
J.G. Silva ISEL, Lisboa
J.S. Marques IST/ISR, Lisboa
J.M. Lemos INESC-ID/IST, Lisboa

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Chair: R. Schumann Co-chair: -

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L. Ljung Linköping University

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A.G. Alexandrov Inst. of Control Sciences, Moscow
Y.F. Orlov Moscow State University
L.S. Mikhailova Moscow State Inst. of Steel and All.

10:00 - 12:00
Process identification, controller tuning and control circuit simulation using MS Excel . . . 1001
H.M. Schaedel University of Applied Sciences, Köln

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Developments for the Matlab CONTSID toolbox 1007
H. Garnier Université Henri Poincaré, Nancy
M. Gilson Université Henri Poincaré, Nancy
E. Huselstein Université Henri Poincaré, Nancy

10:00 - 12:00
DetectNARMAX: a graphical user interface for structure detection of NARMAX models using bootstrap method . . . 1013
E. Shafai ETH, Zürich
M. Bianchi ETH, Zürich
H.P. Geering ETH, Zürich

SP-3 Willem Burger Zaal
Semi-plenary lecture
Chair: L. Ljung

13:30 - 14:30
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Prof. John MacGregor McMaster Univ. Montreal

SP-4 Fortis Bank Zaal
Semi-plenary lecture
Chair: T. McKelvey

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Subspace algorithms . . . 1030
Dr. Dietmar Bauer Technical University of Vienna

ThM01 **Poster session**
Filtering and estimation

14:30-16:00
Optimal filtering for linear systems with multiple delays in observations . . . 1042
M. Basin Auton. Univ. of Nuevo Leon
R. Martinez-Zuniga Auton. Univ. of Coahuila

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The information analysis in joint problem of continuous-discrete filtering and generalized extrapolation . . 1048
N.S. Dyomin Tomsk State University
I.E. Safronova Tomsk State University
S.V. Rozhkova Tomsk Polytechnic University

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Guaranteed ellipsoidal state estimation for uncertain MIMO models . . . 1054
B.T. Polyak Russian Academy of Sciences
S.A. Nazin Russian Academy of Sciences
C. Durieu ENS Cachan
E. Walter

14:30 - 16:00
Regularized robust estimators for time varying uncertain discrete-time systems . . . 1060
A. Subramanian Adaptive Systems Lab

A.H. Sayed Adaptive Systems Lab

14:30 - 16:00
Minimax L_2-E_2 FIR filters for deterministic continuous-time state space signal models 1066
S.H. Han Seoul National University
W.H. Kwon Seoul National University

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P. Suchomski Gdansk University of Technology

ThM02 Poster session
Diagnosis, detection and tracking

14:30 - 16:00
Statistical analysis of subspace-based method for direction estimation without eigendecomposition 1078
J. Xin Fujitsu Laboratories Ltd.
A. Sano Keio University

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Fault detection of nonlinear systems based on multi-form quasi-ARMAX modeling and its application to the ship benchmark 1084
K. Kumamaru Kyushu Institute of Technology
K. Inoue Kyushu Institute of Technology
Y. Hosoyamada Kyushu Institute of Technology
T. Söderström

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A comparison of two methods for stochastic fault detection: the parity space approach and principal components analysis 1090
A. Hagenblad Linköping University
F. Gustafsson Linköping University
I. Klein Linköping University

14:30 - 16:00
Identification of object's movement models in a radar tracking filter 1096
M. Sankowski Telecom. Research Inst., Gdansk
Z. Kowalczuk Gdansk University of Technology

14:30 - 16:00
Estimation and tracking of quasi-periodically varying processes 1102
M.J. Niedzwiecki Technical University of Gdansk
P. Kaczmarek Technical University of Gdansk

ThM03 Poster session
Identification of nonlinear systems 2

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A pruning method for the identification of polynomial NARMAX models 1108
L. Piroddi Politecnico di Milano
W. Spinelli Politecnico di Milano

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Identification of fuzzy dynamical model with local state-space neural networks 1114
X. Huang North China Electric Power University
J. Liu North China Electric Power University

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Generalized orthonormal basis selection for expanding quadratic Volterra filters 1119
A.Y. Kibangou I3S/CNRS/UNSA
G. Favier I3S/CNRS/UNSA
M. Hassani FSSM/UMAC Marrakesh

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A localised forgetting method for on-line adaptation of Gaussion RBFN models 1125
D.L. Yu Liverpool John Moores University
J.B. Gomm Liverpool John Moores University
D.W. Yu Liverpool John Moores University
D. Williams

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Subspace identification of switching model 1131
K.M. Pekpe CRAN, Nancy
K.K. Gasso PSI CNRS
G. Mourot CRAN, Nancy
J. Ragot

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Application-oriented neural modelling 1137
K. Li Queen's University Belfast
G. Irwin Queen's University Belfast

ThM04 Poster session
Identification methods

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Closed-form frequency estimation using second-order notch filters 1143
S.M. Savaresi Politecnico di Milano
S. Bittanti Politecnico di Milano
H.C. So City University of Hong Kong

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L_1 prediction error system identification: a modified AIC rule 1149
J.C. Carmonia LSIS CNRS UMR, Marseille
M. Ouladsine LSIS CNRS UMR, Marseille

M. El Adel LSIS CNRS UMR, Marseille

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On parameter estimation of ARMAX model via BCLS method 1154
L.-J. Jia Kyushu University
S. Kanae Kyushu University
Z.-J. Yang Kyushu University
K. Wada

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Estimation in the presence of interferences 1160
J.J. Fuchs Université de Rennes

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Autoregressive spectral analysis with randomly missing data 1165
P.M.T. Broersen Delft University of Technology
S. de Waele Delft University of Technology
R. Bos Delft University of Technology

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Estimating unknown probabilty density functions for random parameters of stochastic ARMAX systems 1171
H. Wang UMIST
Y. Wang UMIST

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Controller tuning and identification

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Iterative controller tuning by minimization of a generalized decorrelation criterion 1177
L. Miskovic EPFL, Lausanne
A. Karimi EPFL, Lausanne
D. Bonvin EPFL, Lausanne

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Subspace identification based PID control tuning 1183
A. Sanchez University of Strathclyde
R. Katebi University of Strathclyde
M. Johnson University of Strathclyde

14:30 - 16:00
Evolutionary tuning of pid parameters 1189
T. Yamamoto Hiroshima University

14:30 - 16:00
Adaptive, cautious, predictive control with Gaussian process priors 1195
R. Murray-Smith University of Glasgow
D. Sbarbaro Universidad de Concepcion
C. Rasmussen Max Planck Institute

A. Girard

14:30 - 16:00
Controller design for systems suffering nonlinear distortions 1201
M. Solomou University of Glamorgan
D. Rees University of Glamorgan
N. Chiras Praxis Critical Systems Ltd

14:30 - 16:00
How the output saturation of a regulator influences the reachable performance and robustness measures . . 1207
L. Keviczky Hungarian Academy of Sciences
Cs. Banyasz Hungarian Academy of Sciences

ThM06 Poster session
Applications of identification

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Random loading identification of a plastic glass cantilever beam 1212
D. Li Dalina University of Technology
X. Guo Dalina University of Technology
H. Li Dalina University of Technology

14:30 - 16:00
On sequential identification of a diffusion type process with memory 1217
U. Küchler Humboldt University
V. Vasil'iev Tomsk State University

14:30 - 16:00
Incremental identification of transport coefficients in distributed systems 1222
A. Bardow RWTH Aachen
W. Marquardt RWTH Aachen

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On the structure of static balanced flow systems . . 1228
E. Weyer The University of Melbourne
A. Gleiss University of Vienna
M. Deistler Technical University of Vienna
K. Gruber, T. Matyus

14:30 - 16:00
Endogeneity and identification in transportation systems: econometric relationships to partial observability 1234
J. Naveen University of Washington
V. Shankar University of Washington
S. Chayanan University of Washington

14:30 - 16:00
Tool for equal opportunity evaluation in dynamical organizations 1240

P. Albertos Universidad Polytécnica de Valencia
J. Benítez Universidad Polytécnica de Valencia
J.L. Díez Universidad Polytécnica de Valencia
J.A. Lacort

ThM07 **Poster session**
Bioengineering systems

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Linearization in the parameters via differential algebra techniques 1246
M.P. Saccomani University of Padova

14:30 - 16:00
A penalty function approach to HIV/AIDS model parameter estimation 1252
R. Filter University of Pretoria
X. Xia University of Pretoria

14:30 - 16:00
Sensitivity analysis and parameter identification of wastewater treatment system based on activated sludge models 1258
J. Sato Keio University
H. Ohmori Keio University

14:30 - 16:00
A methodology for nonlinear system identification using Volterra series - application to an anaerobic digestor . . 1264
G. Bibes LAII, Poitiers
P. Coirault LAII, Poitiers
R. Ouvrard LAII, Poitiers
J.P. Steyer

14:30 - 16:00
Some relations of sensitivity functions in bio-reactor models 1270
J.A. Romero Pérez Technical Univ. of Valencia
J.L. Navarro Herrero Technical Univ. of Valencia

14:30 - 16:00
An experimental object-oriented modelling of an hydraulic valley 1275
T. Bastogne CRAN, Nancy
A. Libaux EDF

ThP01 Willem Burger Zaal
Particle filters
Chair: F. Gustafsson Co-chair: F. Le Gland

Invited session

Session organizer: F. Gustafsson

16:00 - 16:20
Particle filters for system identification with application to chaos prediction 1281
F. Gustafsson Linköping University
P. Hriljac Emgry-Riddle Aeronautical University

16:20 - 16:40
Particle filters for system identification of state-space models linear in either parameters or states 1287
F. Gustafsson Linköping University
T. Schön Linköping University

16:40 - 17:00
Fault detection, isolation and diagnosis with particle filters for nonlinear stochastic systems 1293
V. Kadirkamanathan The University of Sheffield
P. Li Loughborough University

17:00 - 17:20
Monte Carlo mixture Kalman filter and its application to space-time inversion 1299
T. Higuchi Institute of Statistical Mathematics
J. Fukuda University of Tokyo

17:20 - 17:40
A particle filter implementation of the recursive MLE for partially observed diffusions 1305
F. Le Gland IRISA / INRIA
A. Guyader Universite de Rennes
N. Oudjane EDF

17:40 - 18:00
Online sampling for parameter estimation in general state-space models 1311
C. Andrieu University of Bristol
A. Doucet University of Cambridge
V.B. Tadic University of Melbourne

ThP02 Fortis Bank Zaal
Wiener Hammerstein models
Chair: T. Söderström Co-chair: M. Campi

16:00 - 16:20
Nonlinear structure identification with application to Wiener-Hammerstein systems 1317
D.J. Leith NUI Maynooth
W.E. Leithead University of Strathclyde / NUI
R. Murray-Smith University of Glasgow / NUI

16:20 - 16:40
Identification of a Wiener system with some general discontinuous nonlinearities 1321
F. Guo Forschungszentrum Karlsruhe GmbH

G. Bretthauer Forschungszentrum Karlsruhe GmbH

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Parameter identification based on Hammerstein models - a subspace approach 1327
A. Naitali LAP, Caen
F. Giri LAP, Caen
F.Z. Chaoui LAP, Caen
M. Haloua, Y. Rochdi

17:00 - 17:20
Nonlinear model identification using working point variables 1333
Y. Zhu Eindhoven University of Technology

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Identification of Wiener-Hammerstein models with cubic nonlinearity using LIFRED 1339
A.H. Tan Multimedia University, Malaysia
K.R. Godfrey University of Warwick

17:40 - 18:00
Performance investigation of SLICOT Wiener systems identification toolbox 1345
V. Sima Nat. Inst. for Res. and Dev. in Inform.

ThP03 Van Beuningen Zaal
Identification using basis functions
Chair: B. Ninness Co-chair: B. Wahlberg

16:00 - 16:20
Rational bases generated by Blaschke-product systems 1351
F. Schipp Eötvös Loránd University, Budapest
J. Bokor Hungarian Academy of Sciences

16:20 - 16:40
More on sparse representations in arbitrary bases. 1357
J.J. Fuchs Universite de Rennes 1

16:40 - 17:00
On spectral estimation using models with pre-specified zeros 1363
Bo Wahlberg KTH, Stockholm

17:00 - 17:20
Identification of rational spectral densities using orthonormal basis functions 1369
A. Blomqvist KTH Stockholm
G. Fanizza KTH Stockholm

17:20 - 17:40
Orthonormal basis functions for modeling continuous-time fractional systems 1375
M. Aoun LAP - Université Bordeaux I
R. Malti Université Paris 12
F. Levron Université Bordeaux I
A. Oustaloup

17:40 - 18:00
Adaptive Laguerre time scaling factor in predictive control 1381
M. El Adel LSIS CNRS, Marseille
M. Ouladsine LSIS CNRS, Marseille
J.C. Carmona LSIS CNRS, Marseille

ThP04 Schadee Zaal
Subspace identification and applications
Chair: G. Picci Co-chair: T. McKelvey

Invited session

Session organizers: A. Chiuso, T. Katayama, G. Picci

16:00 - 16:20
Identification of MIMO state space models for helicopter dynamics 1387
M. Lovera Politecnico di Milano

16:20 - 16:40
Estimation of damped and undamped sinusoids with application to analysis of electromagnetic FDTD simulation data 1393
T. McKelvey Chalmers University of Technology
T. Rylander Univ. of Illinois, Urbana-Champaign
M. Viberg Chalmers University of Technology

16:40 - 17:00
Application of a recursive subspace identification algorithm to change detection 1399
H. Oku Osaka Institute of Technology

17:00 - 17:20
Subspace-based modal identification and monitoring of large structures, a Scilab toolbox 1405
L. Mevel IRISA/INRIA
M. Goursat INRIA
M. Basseville IRISA/CNRS
A. Benveniste

17:20 - 17:40
Identifying positive real models in subspace identification by using regularization 1411
I. Goethals KULeuven
T. Van Gestel KULeuven
J. Suykens KULeuven
P. Van Dooren, B. De Moor

17:40 - 18:00

Modeling human gaits with subtleties 1417
A. Bissacco UCLA
P. Saisan UCLA
S. Soatto UCLA

ThP05 Hudig Zaal
Identification in large scale systems
Chair: P. Astrid Co-chair: S. Weiland

Invited session

Session organizers: P. Astrid, S. Weiland, R. Bos

16:00 - 16:20
Model reduction of nonlinear dynamical systems utilizing proper orthogonal decomposition 1423
K. Kunisch Karl-Franzens-Universität Graz
S.Volkwein Karl-Franzens-Universität Graz

16:20 - 16:40
Reduction of large-scale groundwater flow models via the Galerkin projection 1425
P.T.M. Vermeulen Delft University of Technology
A.W. Heemink Delft University of Technology
C.B.M. te Stroet Netherlands Inst. of Appl. Geoscience

16:40 - 17:00
Model reduction for large-scale linear applications 1431
K.E. Willcox MIT
A. Megretski MIT

17:00 - 17:20
Reduced order modeling of an industrial glass feeder model 1437
P. Astrid Eindhoven University of Technology
S.Weiland Eindhoven University of Technology
A.Twerda TNO Institute of Applied Physics

ThP06 Ruys Zaal
Industrial applications of identification
Chair: G. Goodwin Co-chair: E. Walter

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Identification of the topology of a power system network 1442
Y. Hassaine Reseaux Transport Electricite (RTE)
E. Walter CNRS-Supelec-Université de Paris-Sud .
M. Dancre Electricité de France
B. Delourme, P. Panciatici

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LPV identification of a diesel engine torque model 1448
X. Wei Johannes Kepler Universität Linz
L. Del Re Johannes Kepler Universität Linz

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Identification and control of a pv–supplied separately excited dc motor using universal learning networks 1454
A. Hussein Kyushu University
K. Hirasawa Waseda University
J. Hu Waseda University

17:00 - 17:20
Validation of stability for an induction machine drive using experiments 1460
B. Wahlberg KTH, Stockholm

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Automatic steering control system design utilizing a visual feedback approach 1466
S. Adachi Utsunomiya University
T. Fujihira Utsunomiya University
Y. Fujiwara Honda R & D Co., Ltd

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Application of RBF-type ARX modeling and control to gas turbine combined cycle SCR system 1472
Y.Toyoda Niihama National College of Technology
H. Peng Institute of Statist. Mathem., Tokyo
T. Ozaki Institute of Statist. Mathem., Tokyo
K. Nakano, H. Shioya

ThP07 Van Ryckevorsel Zaal
Software session 2
Chair: R. Schumann Co-chair: -

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Automatic time series identification - spectral analysis with MATLAB toolbox ARMASA 1478
P.M.T. Broersen Delft University of Technology

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MULTI-EDIP - an interactive software package . . 1484
J. Kasprzyk Silesian University of Technology

16:00 - 18:00
KALMTOOL for use with MATLAB 1490
P.M. Nørgaard Widex ApS
O. Ravn Technical University of Denmark
N.K. Poulsen Technical University of Denmark

16:00 - 18:00
The ADAPTx software for automated and real-time multivariable system identification 1496
W.E. Larimore Adaptics, Inc

16:00 - 18:00
Frequency domain system identification toolbox for MAT-

LAB: automatic processing - from data to model 1502
I. Kollár Budapest Univ. of Techn. and Econom.
R. Pintelon Vrije Universiteit Brussel
Y. Rolain Vrije Universiteit Brussel
J. Schoukens, G. Simon

FRIDAY, AUGUST 29, 2003

P3 Willem Burger Zaal
Plenary lecture
Chair: B. Wahlberg

08:30 - 09:30
Prediction algorithms: Complexity, concentration and convexity . . . 1507
Prof. Peter L. Bartlett Univ. of California at Berkeley

FrA01 Willem Burger Zaal
Identification and physical modeling
Chair: L. Ljung Co-chair: A. Isaksson

Invited session

Session organizer: L. Ljung

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T. Bohlin KTH, Stockholm
A.J. Isaksson ABB Corporate Research

10:20 - 10:40
Initialization of physical parameter estimates . . . 1524
P.A. Parrilo ETH-Zürich
L. Ljung Linköping University

10:40 - 11:00
Parameter estimation in linear differential-algebraic equations . . . 1530
M. Gerdin Linköping University
T. Glad Linköping University
L. Ljung Linköping University

11:00 - 11:20
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J. Holst Lund Institute of Technology
E. Lindstrom Lund Institute of Technology
H. Madsen Technical University of Denmark
H.A. Nielsen

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A.J. Isaksson ABB Corporate Research
R. Lindkvist ABB Corporate Research
X. Zhang ABB Corporate Research
M. Nordin, M. Tallfors

11:40 - 12:00
Identification and model predictive control of a pH neutralization process based on linear and Wiener models . . . 1548
J.C. Gomez The University of Western Ontario
A. Jutan The University of Western Ontario

FrA02 Fortis Bank Zaal
Identification of nonlinear systems
Chair: R. Pintelon Co-chair: J. Roll

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J. Roll Linköping University
A. Nazin Institute of Control Sciences, Moscow
L. Ljung Linköping University

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Optimality in SM identification of nonlinear systems . . . 1560
M. Milanese Politecnico di Torino
C. Novara Politecnico di Torino

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S.L. Kukreja Linköping University

11:00 - 11:20
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F. Previdi Universita' di Bergamo
M. Lovera Politecnico di Milano

11:20 - 11:40
Modeling and identification of rate-independent hysteresis using a semilinear Duhem model . . . 1578
J. Oh University of Michigan
D.S. Bernstein University of Michigan

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Least squares harmonic signal analysis using periodic orbits of ODEs . . . 1584
T. Wigren Uppsala University
E. Abd-Elrady Uppsala University

T. Söderström Uppsala University

FrA03 Van Beuningen Zaal
Education and training
Chair: D.E. Rivera Co-chair: R.P. Guidorzi

Invited session

Session organizers: D.E. Rivera, R.P. Guidorzi

10:00 - 10:20
Educational aspects of identification software user interfaces 1590
L. Ljung Linköping University

10:20 - 10:40
An identification course on the web: rationale, realization and students' evaluation 1595
R.P. Guidorzi University of Bologna
I. Pagani University of Bologna
R. Diversi University of Bologna

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Control related topics in identification - closed loop experiments and identification for control 1601
R.R. Bitmead University of California, San Diego
R.A. de Callafon University of California, San Diego

11:00 - 11:20
Teaching semiphysical modeling to chemical engineering students using a brine-water mixing tank experiment 1607
D.E. Rivera Arizona State University

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R.A. de Callafon University of California, San Diego

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FrA04 Schadee Zaal
Recursive and subspace identification
Chair: J.J. Fuchs Co-chair: W. Scherrer

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M. Lovera Politecnico di Milano

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M. Jansson Royal Inst of Technology, Stockholm

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S.J. Qin University of Texas
L. Ljung Linköping University

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G. Mercère Ecole d'Ingénieur du Pas-de-Calais
S. Lecoeuche Ecole des Mines de Douai
C. Vasseur Univ. des Sciences et Techn. de Lille

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Canonical correlation partial least squares 1643
U. Kruger Queen's University Belfast
S. . Qin The University of Texas at Austin

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Frequency-domain system identification techniques for experimental and operational modal analysis 1649
P. Guillaume Vrije Universiteit Brussel
P. Verboven Vrije Universiteit Brussel
B. Cauberghe Vrije Universiteit Brussel
S. Vanlanduit

FrA05 Hudig Zaal
Process control: theory
Chair: M. Grimble Co-chair: L. Huisman

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D. Bonné Technical University of Denmark
S.B. Jørgensen Technical University of Denmark

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PID parameter cycling to tune industrial controllers:a new model-free approach 1661
J. Crowe University of Strathclyde
M. A. Johnson University of Strathclyde
M. J. Grimble University of Strathclyde

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M Brendel RWTH Aachen
W Marquardt RWTH Aachen

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Iterative Identification for Robust Bioreactor Control Design 1673

K. Bøjstrup CAPEC
N.K.Poulsen Technical University of Denmark
Henrik Niemann Technical University of Denmark
S.B. Jørgensen

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Modified subspace-ID based design of a long-term correlation model for inferential control 1679
Y. Pan Georgia Institute of Technology
J.H. Lee Georgia Institute of Technology

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L. Huisman Eindhoven University of Technology
S. Weiland Eindhoven University of Technology

FrA06 Ruys Zaal
Application of system identification
Chair: H. Kimura Co-chair: J. Bokor

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K. Mahata Uppsala University
T. Söderström Uppsala University
L. Hillström Alfa Lavel Tumba AB

10:20 - 10:40
Identification of underlying intensity processes of interference patterns 1696
L. Nadai Hungarian Academy of Sciences
J. Bokor Hungarian Academy of Sciences
A. Edelmayer Hungarian Academy of Sciences

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R. Malti I2S
M. Aoun LAP – UMR 5131 CNRS
J.-L. Battaglia LEPT – UMR CNRS
A. Oustaloup, K. Madani

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B. Bhikkaji Uppsala University
T. Söderström Uppsala University
K. Mahata Uppsala University

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S. Datcu Université Paris XII
L. Ibos Université Paris XII
Y. Candau Université Paris XII
S. Matteï, N. Ramdani

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Filtering of stochastic volatility model 1719
S.I. Aihara Tokyo University of Science, Suwa
A. Bagchi University of Twente

FrA07 Van Ryckevorsel Zaal
Optimal filtering
Chair: A. Lindquist Co-chair: Q. Zhang

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T. Raissi University Paris XII Val de Marne
N. Ramdani University Paris XII Val de Marne
Y. Candau University Paris XII Val de Marne

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M. Simandl University of West Bohemia
J. Kralovec University of West Bohemia

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Q. Zhang INRIA
A. Xu Shandaong University
G. Besancon ENSIEG

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A. Guyader Universite de Haute Bretagne
Q. Zhang INRIA

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I. Markovsky K.U. Leuven
B. De Moor K.U. Leuven

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The p-norm generalization of the LMS algorithm for adaptive filtering 1755
J. Kivinen Australian National University
M.K. Warmuth University of California, Santa Cruz
B. Hassibi California Institute of Technology

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Semi-plenary lecture
Chair: M. Gevers

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Prof. Johan Schoukens Free University of Brussels

SP-6 Fortis Bank Zaal
Semi-plenary lecture
Chair: M. Deistler

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Some problems in statistical inference following model selection 1773
Prof. Benedikt Pötscher University of Vienna

FrP01 Willem Burger Zaal
User choices in subspace identification
Chair: D. Bauer Co-chair: B. De Moor

Invited session

Session organizer: D. Bauer

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D. Bauer TU Wien

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A. Chiuso University of Padova
G. Picci University of Padova

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A finite sample comparison of automatic model selection methods 1790
D. Bauer TU Wien
S. de Waele Delft University of Technology

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B.L.R. De Moor K.U.Leuven

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L. Ljung Linköping University

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W.E. Larimore Adaptics, Inc

FrP02 Fortis Bank Zaal
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Chair: M. Milanese Co-chair: E. Walter

15:00 - 15:20
Mathematical results concerning kernel techniques 1814
R. Schaback Universität Göttingen

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Multi-output support vector regression 1820
E. Vazquez LSS-CNRS-Supélec-Univ. Paris Sud
E. Walter LSS-CNRS-Supélec-Univ. Paris Sud

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A. Bemporad Universita' di Siena
A. Garulli Universita' di Siena
S. Paoletti Universita' di Siena
A. Vicino

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Piecewise-linear output-error models 1832
F. Rosenqvist Chalmers University of Technology
A. Karlström Chalmers University of Technology

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Q. Gan University of Essex
E. Rosales University of Essex

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R.J.G.B. Campello Univ. de Nice - Sophia Antipolis
G. Favier Université de Nice - Sophia Antipolis
W.C. Amaral Universidade Estadual de Campinas

FrP03 Van Beuningen Zaal
Identification and model validation
Chair: R. Bitmead Co-chair: X. Bombois

15:00 - 15:20
Parameter variance of estimated transfer functions in the presence of undermodeling 1850

R. Hildebrand Université Catholique de Louvain
M. Gevers Université Catholique de Louvain

15:20 - 15:40
Reliable parameter estimation in presence of uncertain variables that are not estimated 1856
I. Braems LSS - CNRS - Supelec - Univ. Paris-Sud
L. Jaulin LISA - Univ. d'Angers
M. Kieffer LSS - CNRS - Supelec - Univ. Paris-Sud
N. Ramdani, E. Walter

15:40 - 16:00
Validation test based parameter uncertainty versus analysis-based confidence bounds 1862
S.G. Douma Delft University of Technology
X.J.A. Bombois Delft University of Technology
P.M.J. Van den Hof Delft University of Technology

16:00 - 16:20
Empirical estimation of parameter distributions in system identification 1868
W.J. Dunstan University of California, San Diego
R.R. Bitmead University of California, San Diego

16:20 - 16:40
Uncertainty of transfer function modeling using prior estimated noise models 1874
R. Pintelon Vrije Universiteit Brussel
J. Schoukens Vrije Universiteit Brussel
Y. Rolain Vrije Universiteit Brussel

16:40 - 17:00
The size of the membership-set in a probabilistic framework 1880
H. Akcay Anadolu University

FrP04 Schadee Zaal
Model approximation
Chair: J. Bokor Co-chair: A. Vicino

15:00 - 15:20
Connections between L_2-model reduction and balanced truncation 1886
W. Scherrer Technische Universität Wien
F. Tjärnström Linköping University

15:20 - 15:40
Recursive exact H_∞ identification from impulse response measurements 1892
O. Kaneko Osaka University
P. Rapisarda Maastricht University

15:40 - 16:00
Properties of optimal solutions in ℓ_1 identification problem 1898
M. Namvar Canadian Space Agency
A. Besancon-Voda LAG-ENSIEG, Grenoble

16:00 - 16:20
Optimal approximation and model quality estimation for nonlinear systems 1904
P.M. Mäkilä Tampere University of Technology

16:20 - 16:40
Linear models of nonlinear FIR systems with Gaussian inputs 1910
M. Enqvist Linköping University
L. Ljung Linköping University

16:40 - 17:00
An algebraic method for system reduction of stationary Gaussian systems 1916
D. Jibetean CWI, Amsterdam
J.H. van Schuppen CWI, Amsterdam

FrP05 Hudig Zaal
Parameter estimation and convergence
Chair: K. Kumamaru Co-chair: M. Jansson

15:00 - 15:20
Separable least squares data driven local coordinates . . 1922
T. Ribarits TU Vienna
M. Deistler TU Vienna
B. Hanzon TU Vienna

15:20 - 15:40
Optimal Yule Walker method for pole estimation of ARMA signals 1928
M. Jansson KTH Stockholm
P. Stoica Uppsala University

15:40 - 16:00
Initializing parameter estimation algorithms under scarce measurements 1933
P. Albertos Universidad Polytécnica de Valencia
R. Sanchis Universitat Jaume I
I. Peñarrocha Universidad Polytécnica de Valencia

16:00 - 16:20
Robust parameter estimation for uncertain gross-error models 1939
K. Uosaki Osaka University
K. Saito NTT
T. Hatanaka Osaka University

16:20 - 16:40
Limit covariance of estimation error for quasi-stationary functions 1945

A.E. Barabanov St.-Petersburg State University

FrP06 Ruys Zaal
Identification of hydrologic systems
Chair: J. Lee Co-chair: K.J. Keesman

15:00 - 15:20
Structural identification of multivariate neural networks for rainfall runoff modeling 1951
G. Corani Politecnico di Milano
G. Guariso Politecnico di Milano
S. Castelli Politecnico di Milano

15:20 - 15:40
Parameter and state regularization for prediction of distributed hydrologic systems 1957
E.E. van Loon Wageningen University
K.J. Keesman Wageningen University

15:40 - 16:00
Time-delay estimation of a managed river reach from supervisory data 1963
M. Thomassin CRAN
T. Bastogne CRAN
A. Richard CRAN
A. Libaux

16:00 - 16:20
Geohydrological application of a nonlinear physically based time series model 1969
W.L. Berendrecht Delft University of Technology
A.W. Heemink Delft University of Technology
F.C. van Geer TNO Inst. of Appl. Geoscience
J.C. Gehrels

16:20 - 16:40
On physical and data driven modelling of irrigation channels 1975
S.K. Ooi The University of Melbourne
M.P.M. Krutzen TNO Institute of Applied Physics
E. Weyer The University of Melbourne

16:40 - 17:00
Identification and on-line estimation of the unsaturated hydraulic conductivity in presence of forced air convection based on a distributed-parameter model 1981
O. Schoefs Université Catholique de Louvain
D. Dochain Université Catholique de Louvain
M. Perrier Ecole Polytechnique de Montréal
R. Chapuis

FrP07 Van Ryckevorsel Zaal
Errors in variable identification
Chair: P. Guillaume Co-chair: M. Verhaegen

15:00 - 15:20
Confidence regions for non-parametric errors-in- variables estimates 1987
W.P. Heath University of Newcastle

15:20 - 15:40
A new criterion in EIV identification and filtering applications 1993
R. Diversi University of Bologna
R.P. Guidorzi University of Bologna
U. Soverini University of Bologna

15:40 - 16:00
Strongly consistent parameter estimate for error-in- variables models 1999
H.-F. Chen Chinese Academy of Sciences

16:00 - 16:20
Ellipsoid set refinements by simultaneous use of multiple hyperplane cuts 2005
D. Joachim Tulane University
J.R. Deller Michigan State University

16:20 - 16:40
Identification methods in a unified framework 2010
I. Vajk Budapest Univ. of Techn. and Econom.

Abstracts

WEDNESDAY, AUGUST 27, 2003

P1 Willem Burger Zaal
Plenary lecture
Chair: B. Wahlberg

08:30 - 09:30
From experiments to closed-loop control
In this paper we examine the links between identification and control. The main trends in this research area are summarized, with particular focus on design of low complexity controllers. It is argued that a guiding principle should be to model as well as possible before any model or controller simplifications are made, as this ensures the best statistical accuracy. Particular attention is given to the experiment design issue since well-designed experiments facilitates this task. Furthermore, the interaction between experimental constraints and performance specifications is discussed.

WeA01 Willem Burger Zaal
Identification for control
Chair: R. De Callafon Co-chair: S.M. Veres

10:00 - 10:20
Exploratory modelling for controller optimization
Internal model control (IMC) is shown to have self-excitation for identification for control. Although IMC can be designed for tolerance against modelling errors for higher frequencies, tuned models can bring enhanced and more reliable performance. It is shown in this paper that the internal model control has synergistic interaction with system identification of the plant odel. A new scheme called exploratory modelling for controller optimisation (EMCO) is introduced to obtain simple robust controllers.

10:20 - 10:40
Connecting PE identification and robust control theory: the multiple-input single-output case. Part I: Uncertainty region validation
This paper and its companion paper extend previous results to connect Prediction Error Identification and robust control theory in the SISO (single-input single output) case to the MISO (multiple-input single-output) case.

10:40 - 11:00
Connecting PE identification and robust control theory: the multiple-input single-output case. Part II: Controller validation
This paper and its companion paper extend previous results to connect Prediction Error Identification and robust control theory in the SISO (single-input single output) case to the MISO (multiple-input single-output) case.

11:00 - 11:20
Relation between uncertainty structures in identification for robust control
Various techniques of system identification exist providing for a nominal model and uncertainty bound. An important question is what the implications are for the particular choice of the structure in which the uncertainty is described when dealing with robust stability/ performance analysis of a given controller and when dealing with robust synthesis. An amplitude-bounded (circular) uncertainty set can equivalently be described in terms of an additive, Youla parameter and ν-gap uncertainty. Closed-loop performance functions based on these sets are again bounded by circles in the frequency domain, allowing for exact worst-case performance calculation and for the evaluation of the consequences of uncertainty for robust design.

11:20 - 11:40
Strong robustness measures for sets of linear SISO systems
The notion of strong robustness of sets of systems is introduced and motivated in a scenario of adaptive control. The framework is exhibited for a class of linear and time-invariant SISO systems in discrete time with fixed order n for a specified control objective. It is established that if a set of systems satisfies some robustness measures involving the classical structured complex radius, then the set is strongly robust. Then, for a more specified class of control objectives, strongly robust polyhedral sets of systems are characterized by means of linear matrix inequalities (LMI's).

11:40 - 12:00
Using a sufficient condition to analyze the interplay between identification and control
In this contribution we use a standard condition for robust stability and performance to discuss the interplay between identification and control. This leads to a criterion which can be used in the control design to analyze the connections between closed loop bandwidth, model complexity, noise characteristics and input design. Based on this criterion experiment design of H_∞-type is derived.

WeA02 Fortis Bank Zaal
Nonlinear identification
Chair: J. Suykens Co-chair: J. Schoukens

10:00 - 10:20
Structure selection with ANOVA: local linear models
The structure identification problem when estimating local linear models can be eased by using Analysis of Variance (ANOVA) as a prior step in the estimation procedure. The information gained from using ANOVA on the input/output data is what regressors that should be used to partition the input space and what regressors are needed only for the linear models in each part. Also the complexity of the partitioning can be restricted due to the extra information.

10:20 - 10:40
On identification of Hammerstein systems using excitation with a finite number of levels
Identification of nonlinear systems of Hammerstein type is considered in a scenario where the input signal is constrained to attain only a finite number of amplitude levels. This leads to the possibility to obtain asymptotically unbiased point-wise estimates of the non-linear function without the need for a priori assumptions about the shape of the function. A three step identification procedure is presented which provides estimates of the non-linearity and the linear subsystem.

10:40 - 11:00
Fast approximate identification of nonlinear systems
A method is presented to extend the classical linear system identification methods towards nonlinear modelling. A well chosen nonlinear model structure is proposed that is identified in a 2-step procedure. First, a best linear approximation is identified using the classical linear identification methods. Next, the nonlinear extensions are identified with a linear least squares method. The proposed model not only includes Wiener and Hammerstein systems, it is also suitable to model nonlinear feedback systems. The method is illustrated on experimental data.

11:00 - 11:20
Gaussian processes framework for validation of linear and nonlinear models
A statistical nonlinear model validation method is suggested based on the Gaussian processes framework. Instead of testing for correlation between the residuals and certain test variables, as in traditional statistical tests, a parameterized model of the correlation is proposed and the significance for this model is tested. The test makes it possible to validate against nonlinear models without making detailed assumptions on the structure of the nonlinearities.

11:20 - 11:40
Functional analytic framework for model selection
Model selection is one of the most important tasks in the identification of black-box systems. In this paper, we give a novel model selection method from the viewpoint of functional analysis. We formulate the system identification problem as a function approximation problem in a reproducing kernel Hilbert space (RKHS), where the approximation error is measured by the RKHS norm. Within this framework, we derive an estimator of the approximation error called the subspace information criterion (SIC) and show its properties.

11:40 - 12:00
Robust complexity criteria for nonlinear regression in NARX models
Many different methods have been proposed to construct a smooth regression function, including local polynomial estimators, kernel estimators, smoothing splines and LS-SVM estimators. Each of these estimators use hyperparameters. In this paper a robust version for general cost functions based on the Akaike information criterion is proposed.

WeA03 Van Beuningen Zaal
Identification of MIMO communication channels
Chair: M. Viberg Co-chair: A.J. van der Veen

10:00 - 10:20
Analysis of MIMO channel measurements
In this paper, we introduce a new method to estimate the Rice factor in MIMO (Multiple Input - Multiple Output) systems with a line of sight path (LOS) and omnidirectional scattering. This method is based on eigenvalue decompositions of the spatial correlation matrices at the transmitter and the receiver. To improve the performance, the correlation between subsequent temporal snapshots is used to get a more reliable estimate of the subspaces. The performance of the new technique is illustrated with MIMO channel sounder measurements obtained from a measurement campaign in Ilmenau.

10:20 - 10:40
Performance evaluation of MIMO channel prediction algorithms using measurements
Knowledge of future channel conditions can increase the performance of many types of wireless systems. This is especially true for radio channels with multiple transmit and receive antennas, i.e. MIMO systems. This

paper investigates the performance of several prediction schemes for MIMO channels using both simulations and measurements. It is found that in scenarios with few scattering clusters corresponding to outdoor scenarios, a significant performance gain is possible. Using a MIMO AR predictor, the prediction horizon almost doubles compared to the corresponding SISO AR predictor. However, for indoor scenarios, prediction algorithms that exploit the special structure of the MIMO radio channel are needed.

10:40 - 11:00
High-resolution channel parameter estimation for communication systems equipped with antenna arrays
This contribution describes an extension of the recently proposed ISI-SAGE (initialization-and-search-improved space-alternating generalized expectation maximization) algorithm to include polarization estimation. The proposed scheme allows for joint estimation of the relative delay, the direction (i.e. azimuth and co-elevation) of departure, the direction of incidence, the Doppler frequency and the polarization matrix of propagation paths between the transmitter and receiver sites in mobile radio environments. Experimental investigations in a non-line-of-sight pico-/micro-cellular environment show that the polarization characteristics of individual propagation paths can be related directly to the types of interaction that the waves experience along their paths, such as reflection, diffraction, scattering. This detailed insight into the propagation mechanisms is of paramount importance for the design of accurate propagation models, i.e. stochastic models for optimization and performance simulation of communication systems equipped with multiple transmit and receive antennae as well as deterministic models for field prediction.

11:00 - 11:20
Analysis of spectral-based localization of spatially distributed sources
Antennas that are able to adaptively direct the transmitted (and received) energy are of great interest in future wireless communication systems. The focussing implies reduced transmit power and interference, and also a potential for increased capacity. Due to e.g. local scattering around the transmitter, the source as seen from the receiver appears spatially distributed. A characterization of the spatial channel, in particular mean direction of arrival and spatial spread, is of great interest for system optimization and performance prediction. Despite not exploiting the model, the variance of the proposed non-parametric estimators is found to be close to the Cramer-Rao lower bound for Gaussian spreads.

11:20 - 11:40
Ray tracing interpretation of multiple-input multiple output wireless systems
A wireless system with multiple antennas at both transmitter and receiver has a channel capacity which grows linearly (rather than logarithmically) with the number of antennas (assuming fixed bandwidth and total radiated power and many scatterers). In this paper, we show that such high capacities can be achieved on line-of-sight (LOS) paths (no scatterers) by explicitly spreading out the antennas well beyond a wavelength. Roughly speaking, the wide spacing, replicates the effect of scatterers which create images and thus serves to spread out the apparent source of the signals over a wider angular range.

11:40 - 12:00
Computationally efficient blind MMSE receivers for long code WCMDA using time-varying systems theory
UMTS systems will employ long-code wideband CDMA modulation schemes. Receivers for this system are for computational reasons usually based on simple matched-filter techniques, and hence suffer from multiaccess interference. Decorrelating RAKE and MMSE receivers do not have this problem but, until now, were considered as too complex, due to the inversion of a large code matrix. As is shown in this paper, the code matrix can be interpreted as a time-varying system. Efficient implementations are then possible by carrying out the inversion using time-varying state space theory, yielding a complexity comparable to that of the conventional RAKE receiver.

WeA04 Schadee Zaal
Estimation in physical and medical systems
Chair: P. Albertos Co-chair: R.L. Kosut

10:00 - 10:20
Maximum likelihood identification of quantum systems for control design
The construction of quantum devices and computers will not be possible without a combination of control and error correcting codes. And it is likely that the control will have to be found using data from the actual system rather than solely from a theoretical model. Thus we are led to developing strategies for identification and adaptive control of quantum systems.

10:20 - 10:40
Maximum likelihood estimation of signal amplitude and noise variance
Data received from an acquisition system may be complex valued. If the signal amplitude is to be estimated from these (inevitably noise corrupted) data, one has two options. Either the signal amplitude is estimated directly from the complex data, or, the complex data is

first transformed into a magnitude data set after which the signal amplitude is estimated. Similarly, the noise variance can be estimated from both data sets. The question is addressed whether it is better to use complex data or magnitude data for the estimation of these parameters using the maximum likelihood method. As a performance criterion, the mean-squared error is used.

10:40 - 11:00
Reliable nonlinear identification in medical applications
Nonlinear system identification for patient dynamic models in medical applications requires comprehensive and rigorous evaluation of reliability and safety, and must be performed with limited data points, constrained input design, stringent time constraints, and non-repeatable patient dynamics. In this paper, we offer some ideas in evaluating and improving reliability, complexity, and efficiency of identification algorithms and methods in face of these challenges. A benchmark example is used to study real-time identification of patient models for anesthesia decisions in operating rooms.

11:00 - 11:20
Pattern recognition of EEG signals during right and left motor imagery
Electroencephalograph (EEG) recordings during right and left motor imagery can be used to move a cursor to a target on a computer screen. Such an EEG-based brain-computer interface (BCI) can provide a new communication channel to replace an impaired motor function. It can be used by e.g., handicap users with amyotrophic lateral sclerosis (ALS). In this study, statistical pattern recognition method based on AR model was introduced to discriminate the EEG signals recorded during right and left motor imagery. And learning methods (processing period, AR order, etc.) were investigated. The effectiveness of our method was confirmed through the experimental studies.

11:20 - 11:40
From dynamic metabolic modelling to unstructured model identification of complex biosystems
In this study, a class of dynamic models based on metabolic reaction pathways is analyzed, showing that systems with complex intracellular reaction networks can be represented by macroscopic reactions relating extracellular components only. Based on rigorous assumptions, the model reduction procedure is systematic and allows an equivalent 'input–output' representation of the system to be derived. The procedure is illustrated with a few examples.

11:40 - 12:00
Flow controlled non-invasive ventilation considering mask leakage and spontaneous breathing
A procedure for volume-controlled non-invasive ventilation considering leakages and spontaneous breathing is introduced. The identification implemented was tested with a nonlinear model of a single-hose home-care ventilator with sensors inside the device. Measured values of clinical tests were used to examine the influence of spontaneous breathing on the identification. The method permits leakage compensation and classification of the patient's breathing effort for the first time. Since only data of the inspiration is needed the procedure applies even to simple ventilators. Thus sophisticated monitoring, adaptation of the mechanical ventilation level and better patient compliance are possible.

WeA05	Hudig Zaal
Stochastic systems	
Chair: J.H. van Schuppen	Co-chair: S.D. Fassois

10:00 - 10:20
Confidence estimation for statistically uncertain systems
The state estimation problem for a statistically uncertain system is investigated. A system is statistically uncertain if it contains both random and nonrandom uncertain perturbations. Confidence estimates for system states are studied. The definition of the confidence set for the phase vector of the statistically uncertain system with observation is discussed. The confidence sets for the system state are constructed on the base of the confidence estimates for random perturbations. The optimal confidence estimate for the system state is obtained as a solution of a quantile optimization problem. It is shown that the linear estimate is not optimal even for linear uncertain systems with Gaussian random perturbation and may by significantly improved in the case of relatively small dispersion of random perturbations. The proposed approach is illustrated by two examples.

10:20 - 10:40
Estimation and identification of non-stationary functional series TARMA models
A complete estimation and identification method for the modeling of non-stationary signals via Functional Series Time-dependent ARMA (FS-TARMA) models is developed. Model estimation is based upon the generalization of an isomorphic matrix algebra type method to the case of "incomplete" functional subspaces. Model identification is based upon a two-phase optimization scheme that utilizes genetic algorithms and backward regression. The effectiveness of the complete method is demonstrated via a Monte Carlo study.

10:40 - 11:00
Modelling multi-variate pollutant time series with wavelet

functions
The paper deals with a new approach based on wavelet functions to model multivariate time series. Time series are formalised in terms of NARX (Non Linear Auto Regressive with eXogenous inputs) models and the vector of unknown parameters is determined by using a genetic algorithms (GAs) optimisation approach, since GAs allow finding the global minimum of a function with many variables, overcoming the limitation of typical gradient based techniques. A case study, referring to the modelling of daily averages of SO2 time series recorded in the industrial area of Syracuse (Italy) is reported. The performance of the proposed approach is compared with other traditional approaches such as ARX and Multi-layer neural networks. The results obtained show that while there are no significant differences between the neural and the wavelet approach in terms of model performance and computational effort, there is an appreciable advantage in using the proposed technique in terms of internal model complexity.

11:00 - 11:20
Estimating the Lyapunov exponents of chaotic time series based on polynomial modelling
The problem of Lyapunov exponents (LEs) estimation from chaotic data based on Jacobian approach by polynomial models is considered. The optimum embedding dimension of reconstructed attractor is interpreted as suitable order of model. Therefore, based on global polynomial modelling of system, a novel criterion for selecting the embedding dimension is presented. By considering this dimension as the model order, the best nonlinearity degree of polynomial is estimated. The selected structure is used for local estimating of Jacobians to calculate the LEs. This suitable structure of polynomial model leads to better results and avoids of sporious LEs. Simulation results show the effectiveness of proposed methodology.

11:20 - 11:40
Sampling density design for particle filters
The particle filters for state estimation of discrete time dynamic stochastic systems are treated. The stress is laid on design of sampling pdf which is significant for quality of the particle filters. A new functional sampling density design based on utilization of transition and measurement pdf's is proposed. The functional approach compares two pdf's of a reference variable which are obtained by transformation of the transition and measurement pdf's, using Kullback J-divergence. The functional approach to sampling density function synthesis can be understood as improvement of the sampling density design of the auxiliary particle filter which uses point estimate of the transition pdf only. High quality of the functional particle filter with respect to the bootstrap and the auxiliary particle filter is illustrated in a numerical example.

11:40 - 12:00
Diffusive representation of n-th order fractional Brownian motion
This paper generalizes the previously announced diffusive representation method to include a newly introduced n-th order fractional Brownian motion processes (n-fBm). The n-fBm itself is an expansion of ordinary fBm. In fBm the value of Hurst parameter H, which describes the degree of self similarity of the processes, is restricted in the range of 0.

WeA06 Ruys Zaal
Applications of system identification
Chair: K. Godfrey Co-chair: J.C. Carmona

10:00 - 10:20
Multi-channel active noise control for uncertain secondary channels
Fully adaptive feedforward control algorithm is proposed for general multi-channel active noise control (ANC) when all the noise transmission channels are uncertain. To reduce the actual canceling error, two kinds of virtual errors are introduced and are forced into zero by adjusting three adaptive FIR filter matrices in an on-line manner, which can result in the canceling at the objective points. Unlike other conventional approaches, the proposed algorithm does not need exact identification of the secondary paths, and so requires neither any dither signals nor the PE property of the source noises, which is a great advantage of the proposed adaptive approach.

10:20 - 10:40
Channel estimation and coupling wave cancellation in OFDM relay station
The paper is concerned with adaptive cancellation of coupling effect in SFN relay station of an OFDM system. Due to the band limit of the source signal, the precise estimation of coupling wave channel outside the signal bandwidth is almost infeasible and that makes the performance of coupling effect cancellation very poor, even deteriorates the system stability. A new approach to estimate the channel model and to evaluate its estimation error is proposed for stable canceller updating.

10:40 - 11:00
Application of system identification for the prediction of avalanche hazard
The paper demonstrates that avalanche hazard can be thought as of a dynamic phenomenon. System identification methods are applied to predict avalanche hazard.

A ten-year record of avalanche hazard and snow cover from Davos and the peak of Weissfluhjoch in the Swiss Alps is analyzed. Several models are estimated and validated. Dynamic models present a substantial improvement in the quality of hazard predictions compared to predictions derived from a commonly used static nearest neighbor model structure. Further possible modeling improvements are briefly discussed.

11:00 - 11:20
Models for incoming calls forecasting in a customer attention center
Telephone customers attention centers (CAC) are complex systems. In order to provide the best service to clients with minimum costs a careful scheduling of human resources (agents) is needed. Call centers often receive thousands of incoming calls. A large data base of services is in many cases available for modelling. Such data has been used in different ways to improve the quality of service. In this particular case, the schedule of attention staff a week in advance. In this paper the number of incoming calls in the hour is modelled using autoregressive models, both linear and nonlinear (neural networks). The results obtained in this application shows the importance of selecting input variables and model order for forecasting. In this particular case it has been shown that overestimation of model order has a negative effect on model forecasting performance.

11:20 - 11:40
Identification of the dynamics of the Google's ranking algorithm
Among the search engines, Google is one of the most powerful. It uses an accurate ranking algorithm to order web pages in search results. In this paper, it is shown that a simple linear model can approximately model the dynamics governing the behaviour of Google. Least Squares method is used for the system identification procedure. Identification results are provided to show the effectiveness of the identified system.

11:40 - 12:00
Modeling the relationships between the users DB and the web-log file of a large virtual community
In this paper the analysis and modeling of a large dataset related to a very popular Italian virtual community is presented. The community is constituted by more than half-million registered users, characterized by a unique nickname. Each user has its own “profile”, which is filled during the registration procedure, on a voluntary basis. Two data-sets are used: the database of the users (nickname and profile), and the database of their web navigation sessions. The latter has been obtained from the log-file of the servers hosting the community website. This work is constituted by three main parts: 1) analysis and clustering of the users DB; 2) analysis and clustering of the navigation sessions; 3) correlation of users clusters and navigation sessions clusters. This analysis provides a complete and full-rounded picture of the virtual community users.

WeA07	Van Ryckevorsel Zaal
Financial econometrics	
Chair: D. Bauer	Co-chair: B. Hanzon

10:00 - 10:20
A short introduction to time-varying volatility.
This is a tutorial introduction to the invited session entitled Links between financial econometrics and system identification. We present two classes of models with time-varying volatility, namely stochastic volatility models and the class of ARCH and GARCH models and make a comparison. Some remarks about the relation to option pricing are made.

10:20 - 10:40
Forecasting emerging equity market volatility using nonlinear GARCH models
In this paper we examine the usefulness of nonlinear Generalized Autoregressive Conditionally Heteroskedastic (GARCH) models for forecasting daily volatility in a number of Asian and Latin American emerging equity markets. Two of the most popular nonlinear GARCH specifications, the GJR model and the Exponential GARCH model, are found to outperform a linear GARCH model in terms of one-day ahead out-of-sample volatility forecasts. This conclusion holds both when volatility forecasts are evaluated directly by means of traditional criteria that rely upon a proxy for unobserved volatility or indirectly by means of indirect probability forecasts.

10:40 - 11:00
Stochastic properties of multivariate time series equations with emphasis on ARCH
Markov chain theory is applied to the nonlinear modelling of conditional variance with focus on the in financial econometrics widely applied class of multivariate autoregressive conditional heteroscedastic (ARCH) processes. The multivariate socalled BEKK-ARCH of Engle and Kroner (1995) as well as other multivariate ARCH processes in the literature are discussed. The results show that an essential regularity condition for the existence of moments is that the largest modulus of the eigenvalues or equivalently, that the spectral radius of a certain matrix parametrizing the conditional heteroscedasticity in the ARCH process is smaller than one. Due to the fact that multivariate systems are considered it is demonstrated that an important step in the

derivations is based on changing the measure of matrix size from norm to spectral radius.

11:00 - 11:20
A rational probability density approach to stochastic volatility estimation
In financial time series the Black-Scholes model is often used. It assumes constant volatility. In practice this assumption is violated. This has led to the investigation of models in which the volatility is described by some stochastic process. In general it is difficult to solve the volatility estimation problem for such models. Here a class of models is presented for which the estimation problem can be solved exactly. In our models all disturbances have a rational probability density function on the real line.

11:20 - 11:40
Predicting financial volatility: high-frequency time-series forecasts vis-a-vis implied volatility
Recent evidence suggests option implied volatilities provide better forecasts of financial volatility than time-series models based on historical daily returns. In this study both the measurement and the forecasting of financial volatility is improved using high-frequency data and long memory modelling, the latest proposed method to model volatility. This is the first study to extract results of three separate asset classes, equity, foreign exchange and commodities. The results for the S&P 500, YEN/USD and Light, Sweet Crude Oil provide a robust indication that volatility forecasts based on historical intraday returns do provide good volatility forecasts that can compete with, and even outperform implied volatility.

SP-1 Willem Burger Zaal
Semi-plenary lecture
Chair: G. Picci

13:30 - 14:30
Snippets of identification theory in computer vision
In this paper we illustrate the use of identification-theoretic techniques in computer vision, and hint at some open problems.

SP-2 Fortis Bank Zaal
Semi-plenary lecture
Chair: M. Basseville

13:30 - 14:30
Interval analysis for guaranteed nonlinear parameter estimation
Interval analysis, initially developed to analyze and control numerical errors in computers, can be used to minimize possibly nonconvex cost functions or to characterize sets defined by nonlinear inequalities. No solution can be lost, a definite advantage over the usual local iterative techniques. After recalling basic concepts of interval analysis, this introductory paper describes algorithmic tools that can be used for nonlinear parameter estimation and applies them to simple illustrative examples drawn from compartmental modeling. Guaranteed numerical integrators and properties of cooperative systems make it possible to deal with differential models. Pointers to freely downloadable software are provided.

WeM01 **Poster session**
Identification in automotive systems

14:30-16:00
Online detection of tyre pressure deflation in passenger cars
Monitoring of tyre a pressure in passenger vehicle is a major aspect of improved active vehicle safety. In this contribution, a new velocity compensated method for monitoring tyre pressure using vertical body acceleration signals is presented. Limitations of using the shift of wheel hop frequency are presented. To avoid the influence of nature of road excitation, a virtual transfer function has been derived between front and rear body acceleration signals based on certain predefined event of the vehicle. The delay in transfer function is compensated. The sensitivity analysis presents the effects of the variation of mass of the vehicle and the spring stiffness has no effect on the frequency response but the damping coefficient has an influence. A simple threshold is found from experiment data for classification of relative tyre deflation.

14:30 - 16:00
A subspace-based identification approach for the analysis of road vehicles yaw dynamics around steering-pad conditions
The topic of this paper is the identification of the yaw dynamics of a road vehicle, around a steering-pad condition. Unfortunately, a linearized model cannot be easily computed from the simulator since the working condition is not an equilibrium for the vehicle. Hence a black-box identification approach has been used. The generator of Input/Output data is a detailed simulator of the vehicle (high-order, non-linear). The I/O data-set is constituted by impulse responses from the steering angle (Input) to the slip-side angle of the vehicle (Output). Subspace-Based System Identification methods have been used. This work is a sub-task of a larger

project regarding the analysis of the improvements on the maximum lateral acceleration achievable on a modern road vehicle by means of active yaw control and active suspensions.

14:30 - 16:00
Identification and fault detection of an active vehicle suspension
After a short introduction into the topic of active vehicle suspension systems, a mathematical model of the considered active vehicle suspension, which is presented in a test rig, is derived. It is shown how the unknown parameters can be obtained experimentally by parameter estimation. The results of parameter estimation are used for model based fault detection and identification, in order to obtain reliable knowledge of the system's state. All results are shown for measurements from an active suspension on a test rig.

14:30 - 16:00
Non-adaptive neural automotive virtual sideslip sensor
A virtual sideslip sensor has been developed for automotive applications, to improve active chassis control systems devoted to increase vehicle safety and performance. High costs and scarce reliability of conventional sideslip sensors do not allow their employment on passenger vehicles, while approximated estimation methods are effective only when the vehicle lateral dynamics is confined in the linear field. The proposed virtual sensor consists in a cluster-structure neural system, trained and tested over a very wide range of maneuvers, performed on different road surface conditions.

14:30 - 16:00
Parametric identification of the car dynamics
The aim of this paper is to give a general and unifying presentation of the dynamic modelling and identification issues of a car. The modelling is based on the modified Denavit-Hartenberg geometric description of a multi-body system, which is commonly used in robotics. The kinematics and dynamic models are automatically calculated using the software package SYMORO+. The inverse dynamic model is used to identify the dynamic parameters of the car. They are estimated using a weighted least square method. Practical results are given for a 406 Peugeot car.

14:30 - 16:00
Simulating energy consumption of auxiliary units in heavy vehicles
Models that can be used to analyse the fuel saving potential of electrically driven auxiliaries in heavy vehicles are presented. With the purpose of evaluating the influence on fuel consumption from various concepts and control principals, a model library is developed in the modelling language Modelica. The library contains a mixture of models developed from physical principles and models fitted to collected data. Modelling of the cooling system is described in some detail. Simulation results are compared with measurement data from tests in a wind tunnel.

WeM02 **Poster session**
Sensor identification and monitoring

14:30 - 16:00
Porosity determination by using sensor identification
Abstract: In response to a need for a more accurate porosity measuring method for small solid samples (approximately 1 g in mass) the porosity measurement sensor using a sensitive capacitive-dependent crystal was developed. This paper presents the new sensor and the probe sensitivity, frequency dependence on the volume. In addition, the new idea of excitation of the entire sensor with stochastic test signals is described, and the porosity measuring method is provided. The latter includes the influence of test signals on the weighting function uncertainty. The experimental results of the porosity determination in volcanic rock samples are presented. The uncertainty of the porosity measurement is less than 0.1

14:30 - 16:00
Prior characterization of the performance of software sensors
Sensor performance is usually evaluated *a posteriori* after numerous essays, in a probabilistic framework were unknown quantities are modeled by random variables. This paper addresses the problem of evaluating *a priori* the limits of the performance that can be achieved with a software sensor in a given range of operation. This is done in a context of bounded-error estimation, worst-case design and MinMax optimization. An algorithm based on interval analysis is used to obtain guaranteed results, and the procedure advocated is illustrated on a simple example of saturating vapour pressure thermometers.

14:30 - 16:00
Model based source localisation by distributed sensors for point sources and diffusion
The inverse problem of locating a point source of an emission based on measurements from spatially distributed sensors is studied for isotrope diffusion. Equivalent localisation problems concern heat sources or pollution sources. A new two-step approach with the steps: estimation of a scalable sensor-source-distance for each sensor and estimation of the source position using these distances is presented. In contrast to conventional one-step approaches for solving the nonlinear least squares

output error problem by iterative algorithms, the new approach is not sensitive to local minima.

14:30 - 16:00
Continuous-time model identification by using adaptive observer
This paper proposes a continuous-time model identification from sampled I/O data by using an adaptive observer. The boundedness of the parameter estimate and the exponential convergence of the parameter estimate error to 0 under the PE assumption are guaranteed. In order to identify the plant from a finite number of the I/O data, an adaptive observer of a backward system is also proposed.

14:30 - 16:00
Optimal filtering of nonlinear systems based on pseudo gaussian densities
We consider the problem of estimating the state of a discrete-time dynamic system comprising a linear system equation and a nonlinear measurement equation based on measurements corrupted by non-Gaussian noise. The problem is solved by recursively calculating the complete posterior density of the state given the measurements. For representing the resulting non-Gaussian posterior, a new exponential type density, the so called pseudo Gaussian density, is introduced. By converting the original nonlinear system to an equivalent linear representation in a higher-dimensional space, the parameters of the pseudo Gaussian posterior are obtained by means of a linear estimator operating in the higher–dimensional space. The resulting filtering algorithms are easy to implement and always guarantee valid posterior densities.

14:30 - 16:00
A total least squares approach to sensor characterisation
The use of robust, low-bandwidth sensors makes exhaust gas temperature variations difficult to measure in internal combustion engines. One common solution involves measuring gas temperature using two thermocouples with different time-constants and estimating the time-constants from the resulting signals. This assumes that the ratio of the thermocouple time-constants is invariant and known a priori. In addition they are generally subject to singularities and sensitive to noise. This paper presents a novel total least squares (TLS) difference equation based characterisation method. It makes no such assumption and is potentially superior to existing methods in terms of time-constant estimation accuracy and noise tolerance.

WeM03 **Poster session**
Identification of nonlinear systems 1

14:30 - 16:00
Estimation and validation of semi-parametric dynamic nonlinear models
An approach for measurement based modelling of nonlinear devices is proposed that extends the mixture of parametric models and nonparametric verification, that is common for LTI systems, to a class of nonlinear systems. The applicability of the method is illustrated on the baseband modelling of an radio-frequency amplifier over a wide power and frequency range.

14:30 - 16:00
Nonlinear system modeling using the RBF neural network-based regressive model
This paper presents an off-line identification-based modelling method for a class of smooth SISO nonlinear systems for the purposes of process control, output prediction or dynamics reconstruction. A pseudo-linear ARX (RBF-ARX) model with system operating-point dependent Gaussian RBF network-type coefficients is built to characterize the system. The RBF-ARX model is off-line identified, and the structured nonlinear parameter optimization method (Peng, et al. 2002) is applied to estimate its parameters. Output stability of the estimated RBF-ARX model is investigated in dynamics reconstruction problem. Comparisons of the RBF-ARX model and the on-line estimated linear time-varying ARX model are illustrated in case study.

14:30 - 16:00
Modeling and linearization of nonlinear dynamic systems
In this paper a powerful method is presented for the modeling and the linearization of even highly dynamic nonlinear systems. The method approximates Volterra-series expansion, and factors out part of the system dynamics into linear structures that can be identified with minimal effort. The latter technique is proposed to be applied where nonlinear feedback may occur in the system. The method is illustrated on experimental measured data.

14:30 - 16:00
Linear parameter estimation and predictive constrained control of Wiener/Hammerstein systems
A new, analytical, orthonormal basis functions (OBF)-based design methodology for adaptive predictive constrained control of open-loop stable, possibly nonminimum phase, time-varying Wiener and Hammerstein systems is presented. A linear adaptive least-squares parameter estimation algorithm is applied both to a nonlinear static part and a linear dynamic, OBF-modeled factor of the Wiener/ Hammerstein system. A notion of inverse systems is crucial for linear estimation of both Wiener

and Hammerstein systems, with inverses of the nonlinear or linear parts respectively involved. The adaptive estimator is coupled with a simple but robust, predictive control strategy called Extended Horizon Model Algorithmic Control, with input/output constraints handled in a trivial way. Simulation examples demonstrate computational and numerical effectiveness of the new adaptive nonlinear constrained control approach.

14:30 - 16:00
Identification of Wiener systems using reduced complexity Volterra models
In this paper we study the identification problem of single-input, single-output Wiener systems with polynomial nonlinearities. Wiener systems can be represented by a cascade of a dynamic linear subsystem followed by a static nonlinearity. Our approach is to use a reduced complexity Volterra model structure called fixed pole expansion technique (FPET) to estimate the products of the coefficients of the nonlinearity and the linear subsystems coefficients. We then present a method using the singular value decomposition to extract the coefficients of the nonlinearity and of the dynamic linear subsystem.

14:30 - 16:00
Structure selection for polynomial NARX models based on simulation error minimization
This paper investigates the problem of model structure selection for polynomial NARX models. In particular it discusses how classical identification approaches based on prediction error minimization may lead to an incorrect evaluation of the importance of the regressors within the model, with the consequent inclusion of spurious terms in the model. The paper suggests an alternative approach, in which the model structure is selected based on the minimization of the simulation error. The approach is shown to be particularly effective when the identification data are not adequately exciting or oversampled or when the model family is under-parameterized.

WeM04 Poster session
Mechanical and aerospace applications

14:30 - 16:00
Nonlinear identification of a two link robotic system using dynamic neural networks
The aim of this work is the identification of a two link robotic system using dynamic neural networks. The identified system was a mechanical leg formed by two revolute links. The theoretical model of the system corresponds to a two-link kinematic chain. However, a number of nonlinearities which are present in the real system are difficult to include in the theoretical model. An empirical model of the system was obtained instead using a dynamic neural network. New training and validation techniques that assure a good performance of the empirical model have been applied. They consist of including the initial state of the hidden neurons in the decision vector associated with the optimisation problem that is solved for training the network. Once a network has been suitably trained, the initial states of the hidden neurons are also optimised based on the validation data.

14:30 - 16:00
Neural network system identification for a low pressure non-linear dynamical subsystem onboard the Alicia II climbing robot
In this work, a 'black box' non-linear dynamic model for the low pressure subsystem onboard the base module Alicia II robot has been computed by using Artificial Neural Network methodology. The obtained model can be useful to implement and tune a control algorithm for the pressure inside the cup of the robot, also by using Neural Network, to prevent it to fall down.

14:30 - 16:00
Measurement of Young's modulus via modal analysis experiments: a system identification approach
The stress-strain relationship of linear visco-elastic materials is characterized by a complex-valued, frequency dependent elastic modulus $E(j\omega)$ (Young's modulus). Using system identification techniques it is shown in this paper how $E(j\omega)$ can be measured accurately in a broad frequency band from forced flexural (transverse) and longitudinal vibration experiments on a beam under free-free boundary conditions. The advantages of the proposed method are (i) it takes into account the disturbing noise and the nonlinear distortions, (ii) $E(j\omega)$ is delivered with an uncertainty bound, (iii) the low sensitivity to non-idealities of the experimental set up, and (iv) the ability to measure lowly damped materials. The approach is illustrated on plexiglass and copper.

14:30 - 16:00
On multicriteria parametrical identification of the cargo parafoil model with the help of PSI method
This paper addresses the problem of multicriteria parametrical identification of the autonomously controlled cargo parafoil model. Based on the structural identification as an initial step toward creation of an adequate model of the parafoil a six-degree-of-freedom model including several dozens of optimization parameters has been developed. The present paper proposes the correct statement of the multicriteria parametrical identification problem including the necessity to investigate the feasible set of variable parameters. The paper advocates the use of the Parameter Space Investigation (PSI)

method and Multicriteria Optimization / Vector Identification (MOVI) software package to solve the problem.

14:30 - 16:00
A novel algorithm for fully autonomous star identification
In this paper a novel approach to the problem of star identification for spacecraft attitude determination based on data provided by a star camera is proposed. The algorithm is based on pattern matching ideas and provides improved certainty with respect to similar methods available in the literature. The achievable performance is demonstrated via simulation results.

14:30 - 16:00
Fast model updates and simulation for efficient flight control software design
The development, verification, and validation of flight control software for aircraft is characterized by high demands on accuracy, reliability and efficiency. Processes cover all stages from first simulations to final flight test. The respective environment is described here on the basis of the experimental aircraft X-31A. Besides the applied hard- and software, special emphasis is given to simulation models and their updates, being marked by two new approaches: the use of nearly identical simulation software during the whole development and verification process and update of integrated simulation models due to special flight tests by means of global model system identification.

WeM05 **Poster session**
Closed-loop identification

14:30 - 16:00
Continuous-time identification of first-order plus dead-time models from step response in closed loop
Methods for identification in closed-loop are very attractive to industrial applications. The closed-loop identification doesn't cause stops in system operation, unlike open-loop identification. In this paper continuous-time identification from discrete-time measurements and closed loop identification are combined to estimate FOPDT models. The excitation is restricted to come from a closed loop step experiment. A simple algorithm is proposed to capture dead-times which are not multiple of the sampling period. Three closed loop estimation structures are compared using the proposed algorithm. Simulation examples are used to illustrate the techniques.

14:30 - 16:00
Identification of simple continuous-time models from relay feedback
In this paper it is presented a procedure for the estimation of a first order plus dead-time (FOPDT) model using a relay test and a relay test with an integrator. Exact expressions for the limit cycle in each case are obtained. The time constant and dead-time are computed by solving two equations from Poincaré map analysis of time-delay systems. The process gain is then estimated using three different approaches. Simulation examples illustrates the procedure in the presence of unmodelled dynamics and noise.

14:30 - 16:00
Continuous-time model identification of systems operating in closed-loop
Schemes for system identification based on closed-loop experiments have attracted considerable interest in the last two decades. Most of the existing methods have been developed for discrete-time models. In this paper, various instrumental variable-based methods for identifying continuous-time models of systems operating in closed-loop are proposed and their performances are compared on the basis of numerical simulations.

14:30 - 16:00
Multivariable closed-loop system identification of plants under model predictive control
This paper discusses a simulation where a multivariable plant under Model-based Predictive Control was identified from closed-loop data. A motivation for closed-loop system identification in this context is given and an identification methodology is proposed. To evaluate the consistency of the methodology, the plant was identified for different controller settings and different added disturbances. Different methods to ensure identifiability were also investigated.

14:30 - 16:00
Dead time measurement of closed loop system by wavelet
This paper shows that the wavelet based dead time measurement method, which has been already studied for open loop systems, is also applicable to closed loop systems. The method uses a wavelet transform of a cross correlation function between an input and an output. To achieve our objective, the cross correlation function is derived for the closed loop case and its wavelet transform is analyzed under a certain condition.

14:30 - 16:00
Closed loop identification method using a subspace approach
This paper presents a free model reduction closed loop subspace identification method for multivariable systems operating in a well posed closed loop environment. This allows to determine the impulse response

of the system from the identification of the control system sensitivity functions. The rational behind the proposed method is two-fold. Firstly, the general purpose design features of the subspace system identification approach and its inherent numerical robustness. Secondly, the model reduction performed in the available subspace identification is removed by a proper order selection procedure. A bias analysis is carried out to emphasize the robustness features.

WeM06 **Poster session**

Industrial application of identification

14:30 - 16:00

Model identication of a multivable industrial furnace

This paper presents the modeling and identification of a real industrial furnace (900 kW, 38 m) used to cure large laminated composite pieces. The system exhibits a multivariable configuration with seven inputs (heat resistors and fans) and seven outputs (temperature sensors). A very complex MIMO dynamic model is carried out by solving the heat transfer equations obtained from analogous electrical circuits that represent the multi-zone heat exchange. A set of experiments have to be designed in the mentioned industrial furnace in order to generate a useful real data collection which reliably allows to identify the parameters of the multivariable model.

14:30 - 16:00

Extended fuzzy GK clustering with application to identification of an automatic voltage regulation loop dynamics

A new strategy for nonlinear identification which combines an extended fuzzy Gustason-Kessel (GK) clustering technique using competitive agglomeration with locally weighted least-squares is proposed. This is applied to nonlinear identification of the highly noninear loop dynamics of an automatic voltage regulation (AVR) loop across a wide operating range. A Takagi-Sugeno fuzzy model is automatically constructed from plant input-output response data set. The validity of the resultant TS fuzzy model representation is confirmed on a validated simulation of a 3kVA laboratory micromachine.

14:30 - 16:00

On simplified modelling approaches to SMB processes

The Simulated Moving Bed (SMB) technology is important in various fields, from sugar to enantiomer separation, and operating conditions must be carefully selected and regulated, based on an appropriate process model. Basically, two modelling approaches exist, i.e. True Moving Bed (TMB) and SMB models. Both approaches show advantages and drawbacks. In this work, an attempt is made to develop time-varying-velocity TMB models, which retain the simplicity of the original TMB model and its modest computational load, while capturing the essential features of the cyclic steady state reproduced by the SMB model. Alternative modelling approaches are compared and their use is discussed.

14:30 - 16:00

Optimal filtering for bi-linear systems and its application to terpolymerization process state identification

The paper presents the optimal nonlinear filter for bi-linear state and linear observation equations confused with white Gaussian disturbances. The general scheme for obtaining the optimal filter in case of polynomial state and linear observation equations is announced. The obtained bi-linear filter is applied to solution of the state identification problem for the bi-linear terpolymerization process and compared to the optimal linear filter available for the linearized model and to the mixed filter designed as a combination of those filters.

14:30 - 16:00

Neural prediction of cylinder air mass for AFR control in SI engine

As parsimonious and flexible universal approximator, the one hidden layer perceptron can be used for non linear prediction. An application is described in the framework of Air-Fuel Ratio (AFR) control in spark-ignition engines, a critical point to satisfy pollutant emission legislation. AFR control depends essentially on the prediction of the air mass to be admitted in cylinder. The building of an air mass predictive neural network is described and its performances are evaluated. Compared to classical solutions based on static mappings, the neural predictor allows for reduction of AFR excursions on rapid torque transients

14:30 - 16:00

Contribution to identification of thermo-mechanic interaction at vibrating rubber-like materials

Effect of interaction between the vibration of a damped mechanical system and thermal processes is investigated. This interaction in general non-linear is important for systems containing springs made from elastomers with higher inner damping and marked dependence of mechanical properties on temperature. Response curves, often used at identification of dynamic systems, depend on a lot of mechanical and thermal parameters. In the paper, two relationships are studied: influence of decrease of stiffness with temperature and change of heat transfer on the form of response curves. Elaborated method of thermo-mechanic solution will be used for identification of dynamic systems with dissipation layers.

WeM07 **Poster session**
Process control systems

14:30 - 16:00
Identification of a high efficiency boiler by support vector machines without bias term
This paper considers the application of support vector machines for the identification of the nonlinear dynamic behavior of a high efficiency boiler. A new algorithm for the computation of support vector machines without bias term is proposed. Whereas the advantages of this concept are known in classification, it has been hardly made use of for regression. Besides a detailed description of the boiler and the algorithm, results form simulations and experiments are given. The main intention is to provide a simulation tool for the development engineer.

14:30 - 16:00
A simple method for the parameter estimation of tito models
A frequency-domain estimator for two-input, two-output (TITO) processes is presented. The estimator is based on the simple least squares method (SLSM) and on a combination of open-loop and closed-loop tests. The estimator accurately estimates the processes gain directionality, and its implementation is relatively simple. The high calculation burden of a previously obtained TITO estimator is reduced to that of several single-input single-output (SISO) ones. The estimator is worked in detail for a TITO model, and a note is given for its extension to a higher number of input-output models. A TITO recycle model is used to demonstrate the application of the method.

14:30 - 16:00
Implementing GA-based predictive controller for online control of a process mini-plant
This paper is concerned with a development of an alternative intelligent control strategy, which is an integration between Predictive Control, Neuro-Fuzzy and Genetic Algorithm (GA) techniques, and its real-time implementation for controlling a process mini-plant. Generalized Predictive Control (GPC), was integrated with neuro-fuzzy approach for plant identification/ modelling. In this strategy, GA was employed, firstly, as an optimization method for parameter learning in neuro-fuzzy based plant modelling, secondly, in determining the optimal control signal by minimizing the cost function. The implementation demonstrates the applicability and performance of the proposed control strategy to handle nonlinear and changing plants characteristics in real-time environment

14:30 - 16:00
Long-range optimal model and multi-step-ahead prediction identification for predictive control
Long-range optimal prediction algorithms use the predicted output for several steps ahead. The prediction based on traditionally estimated model parameters does not result in an optimal prediction if the measurements are noisy or/and model structure differs from real process structure. In this paper two different identification schemes are presented and compared: long-range predictive single-model identification and simultaneous multi-step-ahead prediction identification. It is shown that the first method is easier to realize but the second one leads to more accurate results. Both methods are derived for a first-order model in details. Simulation runs and a level control example illustrate the algorithms presented.

14:30 - 16:00
Predictive control of flow quantity and sloshing suppression during back-tilting of a ladle for batch-type casting pouring processes
The purpose of this paper presents a method to predict the molten metal quantity in automatic pouring processes of casting, and also to give a method to suppress the sloshing(liquid vibration) during back-tilting. A supervisory control system is given to switch without overflow of the fluid in a sprue cup from a level controller to a back-tilting controller with sloshing-suppression. A Hybrid-Shape Approach with a notch-filter under consideration of the time and the frequency characteristics is applied to suppress the sloshing. The effectiveness of the proposed method is demonstrated through experiments.

WeP01 Willem Burger Zaal
Closed loop and performance issues
Chair: H. Hjalmarsson Co-chair: R.A. Callafon

16:00 - 16:20
Optimal prefiltering in iterative feedback tuning
Iterative Feedback Tuning (IFT) is a widely used procedure for controller tuning. It is a sequence of iteratively performed special experiments on the plant interlaced with periods of data collection under normal operating conditions. In this paper we derive the asymptotic convergence rate of IFT for disturbance rejection, which is one of the main fields of application. Further we present a method to improve the convergence of IFT by prefiltering the input data for the special experiment. At each iteration step the optimal prefilter is computed from data collected under normal operating conditions of the plant.

16:20 - 16:40
Identification of performance limitations in control us-

ing general SISO models
Previously it has been shown for FIR and ARX models that the variance of identified non-minimum phase zeros depends very little on the model order. In this paper that result is extended to more general SISO model structures. An asymptotic, in the model order and the number of data, expression for the variance of non-minimum phase zeros is derived. The relevance of this expression for finite model orders and number of data is examined.

16:40 - 17:00
Control loop performance monitoring by CUSUM algorithms for local linear hypotheses
Monitoring the performance of a closed-loop by detecting whether the mean and the standard deviation of the control error (or the control signal) belong to a fixed triangular region in the (mean, standard deviation)-plane is shown to be a sensible approach. This triangular region is approximated by a set of circles and for each of them, a CUSUM algorithm for local linear hypotheses is performed. A systematic way to determine algorithm parameters is described.

17:00 - 17:20
Model approximation of plant and noise dynamics on the basis of closed-loop data
We consider the problem of estimating low order and control relevant models of plant dynamics and additive noise dynamics on the basis of closed-loop experiments. Estimating low order models for both the plant and noise dynamics is important in control design applications that focus on disturbance rejection. Several methods for low order plant model and noise model identification are discussed and compared in terms of the bias distribution of the approximate estimation. A new extended two-stage estimation method is proposed in this paper to improve the approximate estimation of both plant and noise model dynamics. The method is evaluated on the basis of simulated closed-loop data from a hard disk drive experiment and shows improvements with respect to low order approximation of plant and noise models.

17:20 - 17:40
IV methods for closed-loop system identification
In this paper, several instrumental variable (IV) and instrumental variable-related methods for closed-loop system identification are considered and set in an extended IV framework. Extended IV methods require the appropriate choice of particular design variables, as the number and type of instrumental signals, data prefiltering and the choice of an appropriate norm of the extended IV-criterion. The optimal IV estimator achieves minimum variance, but requires the exact knowledge of the noise model. For the closed-loop situation several IV methods, such as tailor-made IV, IV4 and BELS are put in an extended IV framework and characterized by different choices of design variables. Their variance properties are considered and illustrated with a simulation example.

17:40 - 18:00
Coprime factor perturbation models for closed-loop model validation techniques
The problem of checking the consistency of experimental closed-loop frequency-domain data with uncertainty models that are structured using coprime factorizations is addressed in this paper. The uncertainty models use the knowledge of a stabilizing feedback controller to structure and formulate the uncertainty on a nominal model. Subsequently, the controller dependent coprime factor uncertainty model can be used to formulate model (in)validation tests on the basis of closed-loop data. Closed-loop model validation results are developed for the cases of noise-free and noise perturbed closed-loop data. The model validation tests involve the computation of a structured singular value over a finite frequency grid. It is also shown that the computation of the structured singular value simplifies considerably when the feedback controller used for the closed-loop experiments is the same as the controller used in the controller dependent coprime factor uncertainty model.

WeP02 Fortis Bank Zaal
Reproducing kernels 1
Chair: E. Vazquez Co-chair: J. Suykens

16:00 - 16:20
An introduction to reproducing kernel Hilbert spaces and why they are so useful
We review some of the basic facts about reproducing kernel Hilbert spaces (RKHS), and the solution of optimization problems in RKHS. These facts provide some clues to how useful RKHS-based methods can be in curve fitting, function estimation, model description, model fitting and ill-posed inverse problems. A number of references are made to mostly older works of the author, colleagues and former students - not an attempt at a balanced review of the literature. The growth of the further development and application of RKHS-based methods is demonstrated in the other papers in the invited sessions WeP02 and ThA02 of this 13th IFAC Symposium on System Identification (SYSID-2003), and elsewhere in SISID-2003. A recent advanced Google search for “reproducing kernel” turned up over 4400 entries.

16:20 - 16:40
An introduction to smoothing spline ANOVA models in RKHS with examples in geographical data, medicine,

atmospheric sciences and machine learning
This paper is a brief introduction to smoothing spline ANOVA (SS-ANOVA) models in reproducing kernel Hilbert spaces (RKHS) and some of their applications. These models decompose a function of several variables as sums of functions of one variable plus sums of functions of two variables and so forth, analogous to the ordinary analysis of variance decomposition familiar to students in elementary Statistics classes. This is done in such a way that the individual terms are projections onto orthogonal subspaces in RKHS, and the relevant reproducing kernels may be found in many examples. Given the appropriate RKHS, various kinds of estimation and model fitting problems in several variables given observational data can be solved.

16:40 - 17:00
Robust design with nonparametric models: prediction of second-order characteristics of process variability by kriging
We use kriging (Krige, 1951) to predict the mean and variance of a response $y(x)$ when the input factors x are subject to random variability. Uncertainty on these predictions is obtained by considering fluctuations along one trajectory y of the process due to fluctuations of x, and then averaging over the possible trajectories, conditionally on input-output data. Possible applications include robust design engineering, where the data that are obtained from prototypes in laboratory experiments, or from simulation codes, are used to construct models for the responses of interest to the designer, but mass-production involves variability of input factors around the specifications the designer will indicate.

17:00 - 17:20
Geostatistical models and kriging
Geostatistics is an application of the theory of random functions to spatially distributed data. Geostatistical methods like kriging were initially proposed in mining and petroleum exploration and found their way back to mainstream statistics more than a decade ago. The geostatistical methodology can be subdivided into linear and multivariate geostatistics, non-stationary geostatistics, non-linear geostatistics, geostatistical simulation.

17:20 - 17:40
Hilbert space embeddings in dynamical systems
In this paper we study Hilbert space embeddings of dynamical systems and embeddings generated via dynamical systems. This is achieved by following the behavioural framework invented by Willems, namely by comparing trajectories of states. As important special cases we recover the diffusion kernels of Kondor and Lafferty, generalised versions of directed graph kernels of Gaertner, novel kernels on matrices and new similarity measures on Markov Models.

17:40 - 18:00
Bayesian input selection for nonlinear regression with LS-SVMs
Input selection for linear and nonlinear modelling is an important problem, related to the trade-off between model complexity and in sample model accuracy. For linear modelling, well-known complexity criteria like the Akaike and Bayesian Information Criteria have been developed. In this paper, we explain the Bayesian evidence framework for Least Squares Support Vector Machines (LS-SVMs) and explain its use for input selection.

WeP03	Van Beuningen Zaal
Blind estimation and equalization	
Chair: S. Dasgupta	Co-chair: P.A. Regalia

16:00 - 16:20
Turbo equalization: a new blind structure
A turbo equalizer is modified to allow its operation in a blind manner, i.e., without resorting to training sequences or to channel identification steps. It exploits a recent variant of the constant modulus algorithm, in collaboration with differential encoding, for which the decoder is linked in an iterative scheme with a conventional error correction coder. A characterization of stationary points is obtained, and conditions for proximity to a maximum likelihood decoding rule are identified.

16:20 - 16:40
A new method for channel estimation and data detection in the context of turbo equalisation
In this paper, we propose a new turbo equaliser which outputs marginal a-posteriori probabilities of each symbol. These marginal a-posteriori probabilities can be used directly by the decoder in the turbo process. We show how this equaliser is particularly interesting in the context of turbo decoding and also allows to perform blind channel estimation. We will finally show that this new method brings out significant improvements over the classical Interference Canceller (lower SNR threshold or trigger point) with an acceptable computational cost.

16:40 - 17:00
On the applicability to correlated sources of a blind channel equalization method robust to order overestimation
We consider the blind equalization problem in FIR multichannel models from the second-order statistics of the channel output, with a correlated channel input whose statistics are known to the receiver. The few algorithms

that handle colored sources require exact knowledge of the channel order, a drawback since order determination is a difficult issue. Recently, Gazzah et al. have presented a channel estimator robust to order overestimation. Although their derivation assumed white sources, we show that it can be suitably modified in order to handle colored inputs. The algorithm is still able to blindly compute an FIR pre-equalizer such that the overall response reduces to an FIR transfer function which is known a priori by the receiver, up to a complex phase rotation. Therefore a post-equalizer can be designed in a blind, straightforward manner. The method remains robust to order overmodeling in the correlated source case.

17:00 - 17:20
Blind estimation with signal scrambling
Traditional blind identification methods deal with the estimation of an unknown system which can be described by a transfer function $H(z)$. In some scenarios, the unknown system is a cascade of two systems with transfer functions $H(z)$ and $G(z)$ and both channels have to be separately estimated. This paper presents a new scrambling aided blind identification method that permits these systems to be unraveled. The identification algorithm is derived. It is shown the identification is unique up to a nonzero scalar and a delay for both channels.

17:20 - 17:40
Blind channel shorteners
Although blind, adaptive algorithms for equalization are widely studied, hitherto there has been little academic attention given to blind, adaptive algorithms for channel shortening. Channel shortening is needed to preserve subcarrier orthogonality in multicarrier modulation, and it can be used to dramatically reduce the complexity of maximum likelihood sequence estimation and multiuser detection. This paper reviews the channel shortening problem from a tutorial perspective, and shows how it is an extension of traditional equalization. It is shown that traditional methods of devising blind, adaptive equalization algorithms cannot be easily applied to the channel shortening problem. The paper concludes with a discussion of several new property restoral algorithms that enable blind, adaptive channel shortening.

17:40 - 18:00
Multiple antenna system equalization using semi-blind subspace identification methods
In this paper, we investigate the application of the subspace system identification (SSI) method (e.g. N4SID) to the MIMO frequency-selective fading channel estimation problem. The FIR constraint on the MIMO channel model is suggested to be relieved to draw benefit from possible parsimonious parametrization of the MIMO channel when subchannels become correlated. Also, the criterion for training sequence selection for SSI-based MIMO channel estimation is analyzed. Considering that the formalism of optimal input design is inappropriate for training sequence solution, we suggest still to use the conventional white and spatially uncorrelated sequences for SSI-based (non-FIR) MIMO channel estimation, even if they might be suboptimal. A modification of the SSI methods and a semi-blind approach are proposed to address the issue that only noncontiguous block-wise training sequences are available in practical mobile communication systems.

WeP04	Schadee Zaal
Continuous time identification	
Chair: H. Garnier	Co-chair: P.J. Gawthrop

16:00 - 16:40
The identification of continuous-time linear and nonlinear systems: a tutorial with environmental applications
Initially, the paper will provide a tutorial introduction to the main aspects of existing methods for identifying linear continuous-time models from discrete-time data and show how one of these methods has been applied to the identification and estimation of a model for the transportation and dispersion of a pollutant in a river. It will go on to outline a class of nonlinear, State-Dependent Parameter (SDP) models for continuous or discrete-time systems. Finally, the paper will describe how this SDP approach has been used to identify and estimate a nonlinear differential equation model of global carbon cycle dynamics and global warming.

16:40 - 17:00
Continuous-time system identification of a food extruder: experiment design and data analysis
The introduction of product quality self-regulation to food-cooking extrusion is an important aspect of process control within food manufacturing industries. In order to design an automatic control system for product quality, a mathematical model of the food extruder is required. As first-principles models are difficult to obtain in this context, a food extruder is a good candidate for applying system identification tools. This paper presents the application of continuous time system identification to such a food cooking extruder. More specifically, the reported application features an automated identification experiment apparatus designed using relay feedback control mechanisms and instrumented through existing real time supervisory system for the extruder. Experimental data from the food extruder are obtained and analysed using our identification approach.

17:00 - 17:20
Identification of continuous time models using discrete time data
Continuous-discrete stochastic state space models in the form of nonlinear partially observed Itô stochastic differential equations with measurement noise are advocated for modelling dynamic systems in continuous time using discrete time data. Such models allow unknown parameters to be estimated from experimental data in a prediction error (PE) setting, which gives less biased and more reproducable results in the presence of significant process noise than the more commonly used output error (OE) setting. To illustrate the superiority of PE estimation over OE estimation a case study is given, which demonstrates the higher sensitivity of OE estimates to process noise.

17:20 - 17:40
On possibilities for estimating continuous-time ARMA parameters
The problem of estimating the parameters in continuous-time ARMA processes from discrete-time data is considered. Three different approaches, based on the prediction error method, the instrumental variable method and an approximate maximum likelihood method, respectively, are studied. All three techniques provide reliable solutions to the estimation problem. A general discussion of the inherent difficulties of the problem is given together with an extensive numerical study.

17:40 - 18:00
On the interpretation of a continuous-time model identification method in terms of regularization
This paper presents an interpretation of a continuous-time model identification method in terms of regularization. We show that, in the case of linear filter methods, data filtering corresponds to a regularized derivative estimation. We also give the explicit form of the minimized criterion. In addition, we propose a new structure based on the use of a true regularization filter whose performances are compared with those of the GPMF method. An extension of this interpretation leads to a new formulation of continuous-time model identification as a joint output signal and model parameters estimation.

WeP05 Hudig Zaal
Input design
Chair: T. Söderström Co-chair: R. Ortega

16:00 - 16:20
A survey of readily accessible perturbation signals
There has been a rapid increase recently in the number of software packages available to generate different types of perturbation signals for the purpose of system identification. The types of signal include both computer-optimised signals, which are designed to match a specified power spectrum as closely as possible, and pseudo-random signals, which have fixed spectra. Several of these signals are now readily available, either directly from the World-Wide Web, or on disk. The objective of this paper is to review what packages are available, and from where, and to outline some of the application areas in which they might be used.

16:20 - 16:40
Multiple input design for real-time parameter estimation in the frequency domain
A method for designing multiple inputs for real-time dynamic system identification in the frequency domain was developed and demonstrated. The designed inputs are mutually orthogonal in both the time and frequency domains, with reduced peak factors to provide good information content for relatively small amplitude excursions. The inputs are designed for selected frequency ranges, and therefore do not require a priori models. The experiment design approach was applied to identify linear dynamic models for the F-15 ACTIVE aircraft, which has multiple control effectors.

16:40 - 17:00
Minimizing the worst-case ν-gap by optimal input design
Parameter identification experiments deliver an identified model together with an ellipsoidal uncertainty region in parameter space. We design an identification experiment such that the worst-case v-gap over all plants in the resulting uncertainty region between the identified plant and plants in this region is as small as possible. The experiment design is performed via input power spectrum optimization. Two cost functions are investigated, which represent different levels of trade-off between accuracy and computational complexity. We show that the input optimization problem with respect to these cost functions is amenable to standard numerical algorithms used in convex analysis.

17:00 - 17:20
Identification of resonant systems using periodic multiplicative reference signals
System identification of the forward path of a linear unity feedback system, which is almost unstable, is considered through the application of a periodic multiplicative reference signal. Motivation for this problem comes from the need to identify the linear acoustics of a combustion process on the verge of instability. The tools of cyclostationary signal analysis provide an entré to develop methods for understanding the problem and for determining requisite properties of the reference signal.

17:20 - 17:40

Aircraft parameter estimation by using the optimal input design and linear matrix inequalities

System identification based on physical laws often involves parameter estimation. Even if parameters are theoretically identifiable, they may be poorly estimable for a given experiment. Thus a significant increase in accuracy of the parameter estimation may be obtained by a suitable choice of experimental conditions. The original idea of this paper is the combination of a dynamical programming method with a gradient algorithm in the solution of the optimal design. After getting an optimal input, the parameter estimation is performed by minimizing a weighted least square criterion. Weights are either based on the known measurement noise or given by the solution of a linear matrix inequality problem.

17:40 - 18:00

The performance of multilevel perturbation signals for nonlinear system identification

A method for determining the optimal levels of multilevel perturbation signals for nonlinear system identification is described. A performance index for the optimized signals, directly related to the identification accuracy, is based on the condition number of a Vandermonde submatrix of the perturbation signal levels vector. The signal levels are optimized under the constraint that the signal has appropriate harmonic properties for system identification. The performance of all pseudo-random signals with 3, 5 or 7 levels, generated in Galois fields from GF(3) to GF(13), when used for identifying nonlinearities of order up to 6, is determined and compared.

WeP06 Ruys Zaal

Identification for flight test exploration

Chair: M. Basseville Co-chair: P. Guillaume

16:00 - 16:20

Applying system identification to assess the vibro-acoustic behaviour of airplanes

Effective aircraft interior noise reduction measures require an in-depth understanding of the operational noise and vibration fields as well as the intrinsic system characteristics. The former requires detailed mapping of the in-flight sound and vibration responses, whereas the latter requires the proper modelling of the vibro-acoustic system behaviour. The latter is discussed in this paper where the so-called global smoothing technique, a frequency-domain system identification method, is applied to acoustical transfer functions, measured in a fully-trimmed aircraft cavity.

16:20 - 16:40

Subspace identification combined with new mode selection techniques for modal analysis of an airplane

Linear system identification is an important tool in experimental modal analysis. It allows for the extraction of resonance frequencies, damping ratios and mode shapes of a vibrating structure. In general, the model order is chosen quite high so as to catch all the important characteristics of the structure, even in the presence of large amounts of measurement noise. This often results in the appearance of non-physical, or so-called spurious modes. In this paper we will present a set of heuristic techniques to remove spurious modes from a previously identified model.

16:40 - 17:00

Flight flutter analysis using frequency-domain system identification techniques

In this paper frequency-domain estimators will be presented for application in the field of flight flutter analysis. Flight flutter tests are expensive and not without risks even when approached with caution. The complete session of flight tests must be as fast as possible but this often results in low quality data. Dedicated frequency-domain estimators will be presented to estimate and track the modal parameters as a function of the flight conditions.

17:00 - 17:20

Real-time modal analysis and its application for flutter testing

This paper presents two methods for flutter testing during an aircraft flight. Proposed procedures are based on time signal windowing and recursive identification method. There are discussed the simulation results of proposed procedures for two degrees of freedom system with varying damping. The methods have been applied to identify the flutter region for trainer jet directly from flight vibration measurements. The flutter was detected on the left and right aft stabilator.

17:20 - 17:40

Statistical approach to flutter monitoring

We investigate the flutter monitoring problem, stated as a statistical hypotheses testing problem regarding a specified damping coefficient. We previously advocated for a modal monitoring algorithm based on a residual associated with subspace-based covariance-driven identification and on the statistical local approach to the design of detection algorithms. In this paper, we describe two types of flutter monitoring tests, based on such a subspace-based residual designed for a given damping coefficient. The first type of tests comes up from variations on the local approach and the GLR test adapted to several null and alternative hypotheses on the damping. The second test builds on a different approximation for the residual and on the CUSUM test.

17:40 - 18:00
Reliable system identification for large flexible structures
This paper describes considerations for identifying models of large, lightly damped, flexible space structures to be used for high-performance control system design and analysis. The specific aspects of these problems are in turn used to derive a candidate system identification process for use on such systems. Particular attention is focused on two parts of this process, namely model order selection and model tuning. Three methods of model order selection are evaluated utilizing on-orbit data from the Satellite Ultraquiet Isolation Technologies Experiment (SUITE), which also provides a sample application for illustration of the proposed process.

WeP07	Van Ryckevorsel Zaal
Identifiability	
Chair: H.F. Chen	Co-chair: M. Verhaegen

16:00 - 16:20
New results on global identifiability of linear state space models
The paper completes development of general approach to studying both local and global identifiability. Here we propose necessary and sufficient condition for testing global identifiability and offer a method for its checking. Essential advantage of the approach is that it does not involve unfeasible symbolic computations and so permits to study large dimensional model structures of practical interest. The approach is then adapted to determine true separators of parametric space which can be used to eliminate global non-identifiability.

16:20 - 16:40
Identifiability analysis of a class of systems described by convolution equations
Parameter identifiability is studied for a class of finite and infinite dimensional systems described by convolution equations. For linear differential delay equations of neutral type and with distributed delays, it is shown how the identifiability property can be formulated in terms of controllability conditions, namely approximate controllability. The notion of sufficiently rich input which enforces identifiability is also adressed, and the results are obtained assuming knowledge of the solution on a bounded time interval.

16:40 - 17:00
Identification of fully parameterized linear and nonlinear state-space systems by projected gradient search
A nonlinear optimization-based identification procedure for fully parameterized multivariable state-space models is presented. The method can be used to identify linear time-invariant, linear parameter-varying, composite local linear, bilinear, Hammerstein and Wiener systems. The nonuniqueness of the full parameterization is dealt with by a projected gradient search to solve the nonlinear optimization problem. Both white and nonwhite measurement noise at the output can be dealt with in a maximum likelihood setting. It is proposed to use subspace identification methods to initialize the nonlinear optimization problem. A computationally efficient and numerically reliable implementation of the procedure is discussed in detail.

17:00 - 17:20
A differential geometric viewpoint on local identifiability and identification, part 1: theory
The questions of local identifiability and identification of nonlinear systems are treated from a differential geometric point of view. It is shown how identifiability can be interpreted in the framework of Lie groups, which provides convenient tools for a unifying concept of identifiability. Three different notions of identifiability are interpreted in this framework. Furthermore parameter identification itself is also treated. It is shown how a parameter estimator can be formulated in a coordinate-free setting such that it can be determined to what extent the underlying geometric structure and the coordinate-specific parameterization of the system influence the properties of the estimator.

17:20 - 17:40
A differential geometric viewpoint on local identifiability and identification, part 2: application
The robustness of parameter identification for nonlinear dynamical systems is investigated by interpreting the parameter estimation problem from a differential geometric point of view. Results on robust identification are proved in a deterministic setting and an algorithm is developed to derive a robust estimator for the parameters of nonlinear dynamical systems. The proposed algorithm is tested on the offline identification of the rotor resistance of an electric machine for stochastic and deterministic disturbances. It could be shown that the robustness is significantly improved compared to conventional algorithms.

17:40 - 18:00
Identifiability of nonlinear homogeneous polynomial systems
New results are presented concerning the local state isomorphism approach to global identifiability analysis of parameterized classes of nonlinear homogeneous systems with specified initial states. For such systems, the local state isomorphism for a pair of indistinguishable

parameter vectors is homogeneous of degree one. Under certain conditions, which may only be satisfied for homogeneous polynomial systems, the local state isomorphism is linear. The key issue is whether or not the observability rank condition holds at the origin; the controllability rank condition plays a truly secondary role. A worked example demonstrates how identifiability analysis may be simplified along these lines.

THURSDAY, AUGUST 28, 2003

P2 Willem Burger Zaal
Plenary lecture
Chair: P. Van den Hof

08:30 - 09:30
System identification for structural dynamics and vibroacoustics design engineering
System identification plays a crucial role in structural dynamics and vibro-acoustic system optimization. The "Modal Analysis" approach allows a visual interpretation of the Eigenmodes and the derivation of design improvements. The main modal testing procedures and parameter identification methods are reviewed and a number of typical industrial applications are discussed. The critical elements in system identification for these applications are outlined in the broader context of the changing role of testing in the product engineering process. New trends in modal analysis that specifically address these problems are reviewed and illustrated with case studies.

ThA01 Willem Burger Zaal
Selected topics in identification
Chair: S. Bittanti Co-chair: B. Ninness

10:00 - 10:40
A personal view on the development of system identification
This paper presents the author's personal view on the development of identification theory in the control community, starting from the year 1965. We show how two landmark papers, (Ho and Kalman, 1965) and (Astrom and Bohlin, 1965), gave birth to two main streams of research that have dominated the development of system identification over the last fourty years. The Ho-Kalman paper, which gave a first solution to state-space realization theory, led to stochastic realization, and much later to subspace identification. The Astrom-Bohlin paper laid the foundations for Maximum Likelihood methods based on parametric input-output models, which later became known as the highly successful Prediction Error identification framework. The paper also shows how the thinking in the identification community moved from a search for the "true system" to the formulation of identification as an approximation problem. This led to the view of identification as a design problem, in which the ultimate use of the model plays a paramount role in the formulation of the experiment design and in the choice of the identification criterion.

10:40 - 11:00
System identification via a computational Bayesian approach
This paper takes a Bayesian approach to the problem of dynamic system estimation, and illustrates how posterior densities for system parameters, or more abstract and rather arbitrary system properties (such a frequency response, phase margin etc.) may be numerically computed. In achieving this, the key idea of constructing an ergodic Markov chain with invariant distribution equal to the desired posterior is fundamental, and it is inspired by recent developments in the mathematical statistics literature. An essential point of the work here is that via the associated posterior computation from the Markov chain, error bounds on estimates are provided that do not rely on asymptotic in data length arguments, and hence they apply with arbitrary accuracy for arbitrarily short data records.

11:00 - 11:20
A new information theoretic approach to order estimation problem
We introduce a new method of model order selection: minimum description complexity (MDC). The approach is motivated by the Kullback-Leibler information distance. The method suggests to choose the model set for which the "model set relative entropy" is minimum. The proposed method is comparable with the existing order estimation methods such as AIC and MDL. We elaborate on the advantages of MDC over the available information theoretic approaches.

11:20 - 11:40
Conditions for local convergence of maximum likelihood estimation for ARMAX models
This paper analyzes the conditions for local convergence of Maximum Likelihood estimation for ARMAX models. We do this by examining the region in which the steepest descent direction leads to a reduction in the Euclidean norm of the parameter error. Inter-alia this gives new insights into the question of existence of local maxima of the likelihood function for various commonly used model structures.

11:40 - 12:00
A nonparametric approach to model selection

We consider the problem of learning a regression function from samples based on a sequence of candidate models from which an optimal one is to be selected. In the absence of any reliable a priori information about the data generating process, we adopt a nonparametric approach to functionally characterize the data statistics. This nonparametric description is then used to derive a nonparametric reference model whose complexity is automatically determined by data-driven procedure. The nonparametric complexity can be used as a benchmark to select a suitable parametric complexity from the class of candidates. The proposed method is highly effective against overfitting and largely outperforms previous approaches in experimental study of polynomial curve fitting. The only requirement is to have access to a collection of unlabeled data.

ThA02	Fortis Bank Zaal
Reproducing kernels 2	
Chair: J. Suykens	Co-chair: E. Vazquez

10:00 - 10:20
An introduction to learning with reproducing kernel Hilbert spaces
After a brief introduction to learning theory, we review the elements of reproducing kernel Hilbert spaces and discuss learning algorithms which work thereby

10:20 - 10:40
Sparse Gaussian processes: inference,subspace identification and model selection
Gaussian Process (GP) inference is a probabilistic kernel method where the GP is treated as a latent function. The inference is carried out using the Bayesian online learning and its extension to the more general iterative approach which we call TAP/EP learning (short for TAP (Opper and Winther 2001) and “expectation-propagation” (EP) (Minka 2000)). Sparsity is introduced in this context to make the TAP/EP method applicable to large datasets. We address the prohibitive scaling of the number of parameters by defining a subset of the training data that is used as the support the GP, thus the number of required parameters is independent of the training set, similar to the case of “Support–” or “Relevance–Vectors”. An advantage of the full probabilistic treatment is that allows the computation of the marginal data likelihood or evidence, leading to hyper-parameter estimation within the GP inference. An EM algorithm to choose the hyper-parameters is proposed. The TAP/EP learning is the E-step and the M-step then updates the hyper-parameters. Due to the sparse E-step the resulting algorithm does not involve manipulation of large matrices. The presented algorithm is applicable to a wide variety of likelihood functions. We present results of applying the algorithm on classification and nonstandard regression problems for artificial and real datasets.

10:40 - 11:00
Sparse kernel methods
This work describes a transparent, non-linear modelling approach that enables the constructed predictive models to be visualised, allowing model validation and assisting in interpretation. The technique combines the representational advantage of a sparse ANOVA decomposition, with the good generalisation ability of a kernel machine. It achieves this by employing two forms of regularisation: a 1-norm based structural regulariser to enforce transparency, and a 2-norm based regulariser to control smoothness. The resulting model structure can be visualised showing the overall effects of different inputs, their interactions, and the strength of the interactions.

11:00 - 11:20
A generalised LS–SVM
The Least–Squares Support Vector Machine (LS–SVM) solution can be obtained by solving a linear equation set. This allows us to address the problems in a linear fashion. In this paper we present a generalised view of the Least–Squares Support Vector Regression (SVR), which enables us to develop new formulations and algorithms to this regression technique. The modifications are based on manipulating the linear equation set, which embodies all information about the regression in the learning process. These modifications simplify the formulations, speed up the calculations and/or provide better results.

11:20 - 11:40
Adaptive kernel methods
This paper discusses the Least Squares Support Vector Machine and implementing adaptive on-line algorithms based on recursive least squares algorithms. The algorithms are of moderate complexity and can implement nonlinear decision regions which make it suitable for many applications in communication and signal processing.

11:40 - 12:00
Subspace regression in reproducing kernel Hilbert space
We focus on three methods for finding a suitable subspace for regression in a reproducing kernel Hilbert space: kernel principal component analysis, kernel partial least squares and kernel canonical correlation analysis and we demonstrate how this fits within a more general context of subspace regression. For the kernel partial least squares case a least squares support vector machine style derivation is given with a primal-dual optimization problem formulation. The methods are illustrated and compared on a number of examples.

ThA03 Van Beuningen Zaal
Identification of nonlinear block models
Chair: V. Cerone Co-chair: E.W. Bai

10:00 - 10:20
Frequency domain identification of Wiener models
This paper discusses Wiener model identifications in frequency domain using the sampled data. By exploring the fundamental frequency and harmonics generated by the unknown nonlinearity, we propose a frequency domain approach and show its convergence for both the linear and nonlinear subsystems in the presence of noise. No a priori knowledge of the structure of the nonlinearity is required and the linear part can be non-parametric.

10:20 - 10:40
Non-parametric identification of non-linearity in Hammerstein systems
In the paper non-parametric algorithms identifying the non-linearity in Hammerstein system are presented. About the non-linearity it is only assumed that it is a piecewise Lipschitz function. It is shown that algorithms converge to the non-linearity with growing number of measurements. For Lipschitz and smoother non-linearities the algorithms attain the best possible convergence rate for non-parametric algorithms. The convergence and its rate are independent of the regularity of the input probability density function.

10:40 - 11:00
Generation of enhanced initial estimates for Wiener systems and Hammerstein systems
Wiener systems and Hammerstein systems are nonlinear models that are used in many domains for their simplicity and physical meaning. However, when these systems are identified, a cost function which is highly nonquadratic in the system parameters needs to be minimized. This paper presents a simple iterative method for generating good starting values which can be used to initialize the numerical nonlinear optimization of the cost function.

11:00 - 11:20
User choices and model validation in system identification using nonlinear Wiener models
The issue of user choices in system identification is of paramount importance. This paper therefore attempts to systematically discuss user choices for algorithms based on a specific class of nonlinear models, namely the Wiener model. In particular, the paper addresses model selection, user choices in algorithms, sampling, input signal selection as well as disturbance handling and modelling errors. Validation methods applicable to Wiener type systems are also discussed. A new method based on mean residual analysis is presented. Parts of the discussion of the paper apply also to general nonlinear system identification.

11:20 - 11:40
Approximation of feasible parameter set in worst case identification of block-oriented nonlinear models
The approximation of the Feasible Approximation of the Feasible Parameter Set for block-oriented nonlinear models in a worst case setting and unknown but bounded noise is considered. A bounding procedure is determined both for polytopic and ellipsoidic sets: it consists in the projection of the FPS of the extended parameter vector (which is a subset of $\mathbb{R}^{mn}$) onto suitable m and n-dimensional subspaces and in the solution of convex optimization problems which provide the extreme points of the Parameter Uncertainties Intervals of the model parameters. Bounds obtained are tighter then in the previous approaches.

11:40 - 12:00
Parameters set evaluation of Wiener models from data with bounded output errors
In this paper a procedure is presented for deriving parameters bounds in SISO Wiener models when the nonlinear block can be modeled by a polynomial and the output measurement errors are bounded. First, using steady-state input-output data, parameters of the nonlinear block are tightly bounded. Next in order to estimate the parameters of the linear block, the evaluation of the inner unmeasurable signal is considered. No invertibility assumption of the nonlinearity is required. Then, through a suitable design of the identification experiment, bounds on the unmeasurable inner signal are evaluated. Finally, such bounds together with the input sequence are used for bounding the parameters of the linear model.

ThA04 Schadee Zaal
New results in subspace identification
Chair: G. Picci Co-chair: T. Katayama

10:00 - 10:20
Constructing the state of random processes with feedback
Subspace identification, is based on state space construction, i.e. stochastic realization theory. However state space construction in the presence of feedback is still an open problem. In this paper we provide a geometric construction based on a oblique predictor space which yields a bona-fide (stationary) state space in the presence of feedback, if the open loop transfer functions of the system satisfy certain stability conditions.

10:20 - 10:40

Closed-loop subspace identification with innovation estimation

Most subspace identification algorithms are not applicable to closed-loop identification because they require future input to be uncorrelated with past innovation. In this paper, we propose a new subspace identification method that remove this requirement by using a parsimonious model formulation with innovation estimation. A simulation example is included to show the effectiveness of the proposed method.

10:40 - 11:00

A frequency domain subspace algorithm for mixed causal, anti-causal LTI systems

The paper extends the subspace identification method to estimate state-space models from frequency response function (FRF) samples, proposed by McKelvey (1996) for mixed causal/anti-causal systems, and shows that other frequency domain subspace algorithms can be extended similarly. The method is demonstrated by simulation experiments.

11:00 - 11:20

A stochastic realization in a Hilbert space based on "LQ decomposition" with application to subspace identification

In this paper, we develop a new stochastic realization algorithm using canonical correlation analysis, thereby deriving the forward innovation representation along the line of (Desai et al., 1985, Int. J. Control 42(4), 821-838) by means of "LQ decomposition" in a Hilbert space generated by a second-order stationary random process. As an application, we show that our abstract result is easily adapted to the case where a finite string of a time-series data is available to derive a stochastic subspace identification algorithm.

11:20 - 11:40

Subspace-based identification methods using Schur complement approach

This paper shows a new interpretation of the subspace-based identification methods by using Schur complement approach. MOESP algorithms are considered. Instead of the data matrices, we start to consider a data product moment consisted of the Hankel matrices of input-output data. It is shown that the instrumental variables (IV) extensions of data matrices in the MOESP can be expressed as modifications of the data product moment. It enables us to treat the IV-MOESP algorithms under a unified framework, and we also show that the interpretation can be applicable to the errors-in-variables (EIV) problems and the framework still can be kept.

11:40 - 12:00

Recursive subspace identification for continuous-/discrete-time stochastic systems

An efficient recursive algorithm is proposed for subspace system identification based on the direct LQ factorization and the recursion of its L-factors. This bona fide recursive algorithm is flexibly applicable to continuous/ discrete-time, time-invariant/varying stochastic systems. Efficacy of the algorithm is demonstrated by simulations.

ThA05 Hudig Zaal

Identification for process control: input design

Chair: D.E. Rivera Co-chair: J.H. Lee

10:00 - 10:20

Plant-friendly system identification: a challenge for the process industries

The term "plant-friendly" system identification has been used within the chemical process control research community in reference to the broad-based goal of accomplishing informative identification testing while meeting the demands of industrial practice. While many different identification topics (such as control-relevant identification, closed-loop identification and optimal input design) can be said to contribute to plant- friendliness in identification, the problem has some unique character of its own. This paper describes some of the issues that motivate plant-friendly identification and presents an overview of some approaches that have been proposed in this topic. The problem of identification test monitoring is presented as a novel means for accomplishing plant-friendly identification.

10:20 - 10:40

Multi-objective input signal design for plant friendly identification

The choice of perturbation inputs is critical in the identification and model building exercise. One of the major objectives of system identification is accurate estimation of the system parameters. Accurate identification requires that the input be persistently exciting so as to excite all modes of interest. The practitioner would however prefer a 'plant friendly' input signal. Typically, in identification, an input is chosen based on some criteria. We propose a unified multi-objective formulation for the input design. The input can be evaluated as a solution to a constrained multi-objective optimization problem.

10:40 - 11:00

Issues of experimental design and model structure in dynamic nonlinear model identification

Two predictive modeling methodologies for continuous-time modeling and identification based on the exact solutions to the Hammerstein and Wiener structures, called

Hammerstein and Wiener Block-oriented Exact Solution Techniques (H-BEST and W-BEST, respectively) are presented. W-BEST is compared to discrete-time models (DTM) developed using the conventional pseudo random sequence designs(PRSD) and using statistical design of experiments (SDOE). W-BEST is able to fullyexploit the SDOE and obtains models with predictive performances more accurate than the DTM. A modified discrete-time method is then presented that takes full advantage of optimal experimental data and has predictive accuracy similar to W-BEST.

11:00 - 11:20

Control-relevant design of periodic test input signals for iterative open-loop identification of multivariable FIR systems

In this paper, the problem of control-relevant test input design for iterative system identification is considered. Two approaches are presented for the L-optimal input test signal design by Cooley and Lee (2001), which minimizes the em a posteriori closed-loop error based on em a priori information given by the data already collected from previous iterations. To simplify the computation, we limit our design to a period signal of period n, which is the number of FIR coefficients. The first approach is direct time-domain search for optimal test input values, which can be formulated as a nonconvex optimization or a concave Quadratic Program. The second approach considers frequency domain solution of the L-optimal design problem to obtain the optimal discrete spectra of the test signals, which is subsequently realized as a periodic signal.

11:20 - 11:40

Constrained signal design using approximate prior models with application to the Tennessee Eastman process

Identification input design is the first and very important step towards a successful data-driven modeling task. In this paper, a previously communicated input design method, based on an approximate a-priori steady state model, is extended to the case that the known approximate model at hand is a dynamic one. Several additional issues are also discussed including the iterative signal design and identification process and the derivation of the model uncertainty. As an important case study, the methodology is applied to the challenging Tennessee Eastman problem, which is widely used in process control study. The identification results of the proposed and prior methods are compared.

11:40 - 12:00

Constrained minimum crest factor multisine signals for plant-friendly identification of highly interactive systems

Highly interactive systems are ill-conditioned and highly sensitive to model uncertainty, which imposes limitations to achievable closed-loop performance. In this paper, the goal is to develop an identification testing framework meaningful to highly interactive systems based on the application of constrained minimum crest factor multisine signals."Plant-friendliness" in the design procedure is accomplished by imposing constraints on the overall span, move size, and variability of both input and output signals. A modified "zippered" power spectral density is proposed which contains both correlated and uncorrelated harmonics to simultaneously excite low- and high-gain directions in the data. This signal design procedure is applied to a simple 2-by-2 multivariable system that exhibits challenging interaction and gain directionality issues. Validation of these signals in a closed-loop setting is accomplished by evaluating the performance of decentralized PI with steady-state decoupler controller designs based on models estimated from noisy open-loop experiments. The modified "zippered" spectrum signals present a clear advantage over standard zippered designs for short data sets under noisy conditions.

ThA06	Ruys Zaal
Identification of mechanical systems	
Chair: A.G. de Jager	Co-chair: D.S. Bernstein

10:00 - 10:20

Online identification of a robot using batch adaptive control

A technique to identify parameters of a robot dynamic model is presented in this paper. It is based on a batch adaptive control algorithm that, using a model of the robot dynamics, realizes a repetitive robot trajectory. A feedforward control input is computed after adaptation of the model parameters at the end of each trial. The algorithm can be used to recover the physical values when the robot is excited persistently. The estimation technique admits an online implementation and is quite appealing for use in practice. Its merits are experimentally demonstrated on a spatial direct-drive robotic manipulator with 3 rotational joints.

10:20 - 10:40

Dynamic identification of a compactor using splines data processing

This paper deals with the identification of a dynamic model of a compactor. This model is linear in relation to a set of dynamic parameters which can be identified using a Weighted Least Squares method. With this method, the measurement of the trajectory must be accurate enough. In order to respect this accuracy in an industrial environment, a specific data processing, based on cubic spline interpolation, as been developed to compute the trajectory of the compactor from the device mounted on standard compactors.

10:40 - 11:00
Non-stationary vibration nodeling and analysis via functional series TARMA models
The problem of modeling and analysis of the non-stationary random vibration of a time-varying "bridge-like" laboratory structure is considered via a Functional Series Time-dependent ARMA (FS - TARMA) approach. The results of the study demonstrate high modeling accuracy, as well as superiority to adaptive Recursive Maximum Likelihood - Recursive ARMA (RML - RARMA) and non-parametric Short-Time Fourier Transform (STFT) analysis. The applicability, effectiveness, and high potential of the FS - TARMA approach, which is capable of modeling fast or slow variations in the dynamics while simultaneously achieving high accuracy and resolution, are also demonstrated.

11:00 - 11:20
Globally convergent adaptive tracking of spacecraft angular velocity
Abstract: The problem of a rigid body tracking a desired angular velocity trajectory is addressed using adaptive feedback control. An adaptive controller is developed for a planar rotating body tracking a desired angular velocity command. Lyapunov analysis is used to show that tracking is achieved globally. A periodic angular velocity command is then used to identify the inertia parameter. The adaptive controller is implemented on a triaxial attitude control testbed with fan thrusters. A piecewise linear approximation of an observed input nonlinearity is inverted to obtain improved angular velocity tracking and inertia identification. To eliminate residual tracking error, an adaptive algorithm is used for improved feedback linearization. Lyapunov analysis is used to show boundedness of the angular velocity and inertia estimate errors. The approach is validated by numerical simulation.

11:20 - 11:40
On vision-based kinematic calibration of n-leg parallel mechanisms
A vision-based kinematic calibration algorithm is proposed for parallel mechanisms with end-effector connected to the base by n legs. The joint between corresponding leg ends can be a passive or actuated prismatic joint, which include constant-length legs. Information on the position and orientation of the mechanism legs is extracted from the observation of these elements with a standard camera. No workspace limitation nor installation of additional proprioceptive sensors are required. The algorithm is detailed, and an evaluation of the method is achieved for a Stewart-Gough platform, with experimental measurement accuracy evaluation and simulation of the identification process.

11:40 - 12:00
A geometric approach to motion tracking in manifolds
In many multi-dimensional tracking problems, the quantities of interest are restricted to a manifold in observation space. Learning the manifold shape is a necessary step for dimensionality reduction, which in turn allows faster and more robust tracking performance. For manifolds with arbitrary topology, learning the shape from noisy scattered data is not trivial. This paper presents a geometric approach that is valid for arbitrary manifold dimension and topology. An approximation of the tangent bundle is computed by region growing, making it possible to estimate a set of manifold charts. A tracking algorithm which takes advantage of the geometric information thus found is also presented.

ThA07	Van Ryckevorsel Zaal
Software session 1	
Chair: R. Schumann	Co-chair: -

10:00 - 12:00
Version 6 of the system identification toolbox
This paper describes the new developments in Mathwork's System Identification Toolbox to be run with Matlab. There are three main additions to the new version: (1) Frequency domain input/output data as well as frequency response data can be directly used to fit models. (2) Simple continuous-time process models of the type Static Gain, Time Constant, Dead Time can be directly estimated as a new model object class. (3) A new function, `advice`, can be applied both to data sets and to estimated models, in order to provide guidance and advice through the sometime complex identification process.

10:00 - 12:00
Adaplab-m: identification and adaptation toolbox for matlab
Description of ADAPLAB-M (MATLAB ToolBox) for identification and adaptation is given. As distinct from known MATLAB ToolBoxes, ADAPLAB-M algoritms proceeds from an assumption that an external disturbance applied to a plant and a measurement noise are unknown-but-bounded functions. An adaptive control is formed on the base of H_∞-optimization and the results of identification of the plant and a closed-loop system.

10:00 - 12:00
Process identification, controller tuning and control circuit simulation using MS Excel

The paper presents a tool for process identification, controller tuning and control circuit simulation based on spreadsheets like MS-Excel. Process identification and modelling can be carried out for the open and closed-loop control circuit. Controller tuning is done according to the criterion of cascaded damping ratios. The design is based on a direct relation between the parameters of the process and the controller. Tuning for optimal set-point control as well disturbance rejection is provided. Single-input/single output (SISO) and dual-input/dual-output (DIDO) systems can been simulated for proportional and integral plants with dead-time. The tool is designed for use in teaching as well as industrial application.

10:00 - 12:00
Developments for the Matlab CONTSID toolbox
The CONtinuous-Time System IDentification (CONTSID) toolbox is a successful implementation of the methods developed over the last twenty years for estimating continuous-time transfer function or state-space models directly from sampled data. This paper gives a short overview of the toolbox, describes the latest developments and illustrates them on a few examples. Finally, the future plans are briefly summarized.

10:00 - 12:00
DetectNARMAX: a graphical user interface for structure detection of NARMAX models using bootstrap method
This paper describes a MATLAB-based program called detectNARMAX that utilizes the bootstrap method, a numerical procedure for estimating the distribution of statistical parameters, to find the best NARMAX model structure representing the nonlinear behavior of a system using its noisy input-output data. The performance of the bootstrap-based structure detection techniques is demonstrated by using synthetic data generated by simulation as well as real data measured to determine a model structure for the thermal impact on a sensor system.

SP-3 Willem Burger Zaal
Semi-plenary lecture
Chair: L. Ljung

13:30 - 14:30
Data-based methods in process control
This paper gives an overview of methods for utilizing the massive amounts of highly correlated data available in most process databases. These data matrices are almost always of less than full statistical rank, and therefore latent variable methods are shown to be well suited to obtaining useful subspace models for treating a variety of important industrial problems. The following problems are discussed and illustrated with industrial examples: (i) the analysis of historical databases and troubleshooting process problems; (ii) process monitoring and FDI; (iii) building soft sensors or inferential models; (iv) using of multivariate information from novel sensors; (v) subspace identification; and (vi) process control in reduced dimensional subspaces. In each of these problems latent variable models provide the framework on which solutions are based.

SP-4 Fortis Bank Zaal
Semi-plenary lecture
Chair: T. McKelvey

13:30 - 14:30
Subspace algorithms
In the last decades the term 'subspace algorithms' has been used to denote a class of algorithms, which are based on the property of the state of being an interface between the past and the future in a specific sense. Under this class fall a large number of different algorithms. The basic idea has been used in a number of different contexts in order to derive estimation algorithms, including bilinear models, continuous time models, Hammerstein models, time varying models etc. In this talk only the estimation of linear, time invariant, finite dimensional state space systems is considered. For this model class, subspace algorithms are an alternative to the classical prediction error methods based on criterion optimization. The main advantages of subspace algorithms in this respect are their numerical properties and their conceptual simplicity. This talk provides a detailed description of the most popular algorithms (including N4SID, MOESP and CCA) in a tutorial fashion. This description includes a discussion of numerical details as well as a short survey of asymptotic results. The main emphasis is put on a comparison of the various proposed methods. Secondly an application example tries to pinpoint a number of situations, where subspace algorithms seem to be the favorable estimation tool.

ThM01 **Poster session**
Filtering and estimation

14:30-16:00
Optimal filtering for linear systems with multiple delays in observations
In this paper, the optimal filtering problem for a linear system over observations with multiple delays is treated proceeding from the general expression for the stochastic Ito differential of the optimal estimate and its variance. As a result, the optimal filtering equations similar to the traditional Kalman-Bucy ones are obtained in

the form dual to the Smith predictor, commonly used for robust control design in time delay systems. In the example, the obtained optimal filter over observations with multiple delays is verified for a sample system and compared with the best Kalman-Bucy filter available for delayed measurements.

14:30 - 16:00
The information analysis in joint problem of continuous-discrete filtering and generalized extrapolation
The paper has investigated an information aspect of the problem of joint filtering and generalized extrapolation of stochastic processes on the set of continuous and discrete observations with memory. The differential-recurrent relations, defining evolution of Shannon information measures, have been obtained. The structure of solution has been investigated. The example demonstrating the situation where presence of memory may both increase and decrease information efficiency of observations has been considered. The problem of optimal transmission (optimal coding and decoding) of the stochastic process Markov diffusion type on continuous-discrete channel at presence of memory in the discrete channel has been solved.

14:30 - 16:00
Guaranteed ellipsoidal state estimation for uncertain MIMO models
This paper extends to uncertain models the classical ellipsoidal outer-bounding of the set of all feasible state vectors with unknown but bounded state perturbations and measurement noise. The technique applies to linear discrete-time dynamic systems and could be extended to weakly non-linear systems. Combined quadratic constraints on model uncertainty and additive disturbances are considered in order to simplify analysis and to allow an analytical solution of the basic problems involved in parameter or state estimation. The results obtained for combined quadratic constraints are extended to other types of model uncertainty.

14:30 - 16:00
Regularized robust estimators for time varying uncertain discrete-time systems
This paper addresses the issue of robust filtering for time varying uncertain discrete time systems. The proposed robust filters are based on a regularized least-squares formulation and guarantee minimum state error variances. Simulation results indicate their superior performance over other robust filter designs.

14:30 - 16:00
Minimax L_2-E_2 FIR filters for deterministic continuous-time state space signal models
In this paper, a new minimax L_2-E_2 performance criterion is introduced, which is represented as a worst case gain between the disturbance during the recent time interval and the current estimation error. Minimax L_2-E_2 FIR filter (MLEFF) is proposed for deterministic continuous-time state space signal models. The MLEFF is designed to minimize the maximum value of the L_2-E_2 performance criterion together with linearity, unbiased property in the deterministic sense, FIR structure, and independence of the initial state information, simultaneously. The MLEFF is shown to be robust with respect to model uncertainties due to FIR structure and disturbances due to the worst case design. For efficient implementation, it is shown that the MLEFF can be expressed recursively. It is also shown to be optimal for the performance criterion for each component of the state.

14:30 - 16:00
Numerically realiable H_∞ synthesis of estimators based on J-lossless factorisations
An approach to the numerically reliable synthesis of the H-inf state estimators for discretised continuous- time processes is presented. The approach is based on dual J-lossless factorisations of chain-scattering representations of the process. It is demonstrated that for a sufficiently small sampling period the standard forward shift operator techniques may become ill-conditioned and numerical robustness of the design can be improved via employing the delta operator models. All H_∞ suboptimal estimators are obtained via considering the suitable algebraic Riccati equation. Both regular problems concerning models having no zeros on the boundary of the stability region and irregular problems of models with such zeros are examined.

ThM02 **Poster session**
Diagnosis, detection and tracking

14:30 - 16:00
Statistical analysis of subspace-based method for direction estimation without eigendecomposition
The computationally simpler direction-of-arrival (DOA) estimation method with good statistical performance is attractive in many practical applications of array processing. This paper studies the statistical properties of a new computationally efficient subspace-based method without eigendecomposition (SUMWE) for estimating the directions of narrowband signals impinging on a uniform linear array (ULA), where he asymptotic mean-squared-error (MSE) expression of the estimation error is derived. The theoretical analysis is substantiated through numerical examples, and it is shown that the SUMWE can resolve closely spaced coherent signals

better with a smaller number of snapshots and at lower signal-to-noise ratio (SNR).

14:30 - 16:00
Fault detection of nonlinear systems based on multi-form quasi-ARMAX modeling and its application to the ship benchmark
This paper is concerned with an application study of model-based fault detection method to a ship propulsion system. When modeling the object system, Quasi-ARMAX model with multi-model form is used. In this model, the system non-linearity is incorporated into model parameters by using non-linear non-parametric models (NNMs). Kullback discrimination information (KDI) is introduced as fault detection index to evaluate the distortion in identified model, which is caused by a fault. The effectiveness of the method is verified through simulation studies on the ship propulsion system.

14:30 - 16:00
A comparison of two methods for stochastic fault detection: the parity space approach and principal components analysis
This paper reviews and compares two methods for fault detection and isolation in a stochastic setting, assuming additive faults on input and output signals and stochastic unmeasurable disturbances. The first method is the parity space approach, analyzed in a stochastic setting. This leads to Kalman filter like residual generators, but with a FIR filter rather than an IIR filter as for the Kalman filter. The second method is to use principal component analysis (PCA). The advantage is that no model or structural information about the dynamic system is needed, in contrast to the parity space approach. We explain how PCA works in terms of parity space relations. The methods are illustrated on a simulation model of an F-16 aircraft, where six different faults are considered. The result is that PCA has similar fault detection and isolation capabilities as the stochastic parity space approach.

14:30 - 16:00
Identification of object's movement models in a radar tracking filter
The basic problem of tracking moving objects lies in unpredictability of object manoeuvres. It is assumed that a uniform object's movement fits the model of straight-line uniform motion, while manoeuvres appear rarely. A set of manoeuvre models allows to describe how different manoeuvres influence the state estimation process performed by a Kalman filter, based on the model of uniform motion. This influence can be directly observed in a bias of its innovation process. The above methodology leads to a diagnostic algorithm, which provides for detection of the event of manoeuvre, recognition of its trajectory, and for estimation of trajectory parameters.

14:30 - 16:00
Estimation and tracking of quasi-periodically varying processes
The problem of identification/ tracking of quasi- periodically varying processes is considered. Two solutions to this problem are presented. First, the global search algorithm is derived. Then its decoupled version, with a highly parallel computational structure and improved tracking capabilities, is proposed.

ThM03 — Poster session
Identification of nonlinear systems 2

14:30 - 16:00
A pruning method for the identification of polynomial NARMAX models
A pruning mechanism is developed for the identification of polynomial NARX/NARMAX models, in order to systematically delete redundant terms inserted in the structure selection phase. The proposed approach is capable of overcoming some limitations met by classical regressor deletion criteria, especially when the data available for identification are not adequately exciting or the model family does not include all the correct regressors. The effectiveness of the algorithm is shown by comparison analysis on some simulation examples.

14:30 - 16:00
Identification of fuzzy dynamical model with local state-space neural networks
In this paper, a multiple local state space neural network and fuzzy dynamical model based algorithm is proposed for the off-line identification of nonlinear systems. The clustering optimisation algorithm is used for partition input-output data to several local regions. In each local region, one state-space neural network is employed to approach the local dynamics of the whole system. The overall nonlinear system is represented by a set of state-space neural networks, connected by fuzzy variables. There are two main advantages: one is the weights of each sub-network are physically clear; the other is that partition of input space is simpler than that with local ARMAX model, since the number of input variables is smaller. Illustrative examples demonstrate the efficacy of this method and good results are obtained.

14:30 - 16:00
Generalized orthonormal basis selection for expanding quadratic Volterra filters
Volterra models are very useful for signal and system

representation due to their general non-linear structure and their property of linearity with respect to the kernels coefficients. However, when using such models we are confronted with a complexity problem that results from the very large number of the kernels coefficients. Expanding the kernels on a generalized orthonormal basis allows to significantly reduce this parametric complexity. In the present paper, a new procedure is proposed for selecting such a generalized orthonormal basis so that a least squares criterion is minimized in the case of a homogeneous quadratic model.

14:30 - 16:00
A localised forgetting method for on-line adaptation of Gaussion RBFN models
Abstract: A localised forgetting method is proposed for on-line adaptation of Gaussion Radial Basis Function Network (RBFN) models. It is realised that the typically used forgetting factor is uniformly applied to the past data in entire operating space and is not correct for nonlinear systems where dynamics are different in different operating regions. The new method sets different regions with different forgetting factor according to the response of the local centre to the current measurement data. The method is based on the Recursive Orthogonal Least Squares (ROLS) algorithm and is simple. Application of the new method to the modelling of dissolved oxygen in a chemical reactor rig shows a smaller mean squared error (MSE) for one-step-ahead prediction than using the uniform forgetting, and indicates the effectiveness of the method.

14:30 - 16:00
Subspace identification of switching model
Subspace identification of switching model is considered in this paper. Here the switching model is supposed to be a sum of weighted linear models. The method established uses recursive subspace identification to estimate the switching function and least squares method for local model Markov parameters estimation. To perform the computation of the weighting functions a two-steps algorithm (switching times determination and model merging) is given. Finally the local model parameter estimation is based on the estimation of the Markov parameters.

14:30 - 16:00
Application-oriented neural modelling
The application-oriented neural modelling of non-linear dynamic systems, where a priori knowledge is used in the choice of activation functions for constructing a feedforward neural network, is introduced. A framework for constructing this new type of neural model using genetic algorithms is proposed, and is applied to identify a pollutant emission model for a coal-fired power generation plant. Comparison with a conventional MLP model shows that this new type of neural model produces better generalization performance.

ThM04 **Poster session**
Identification methods

14:30 - 16:00
Closed-form frequency estimation using second-order notch filters
In this paper the problem of the frequency estimation of a sinusoid embedded in white noise is considered. The approach used herein is the minimization of the sample variance of the output of constrained notch filters fed by the noisy sinusoid. In particular, this paper focuses on closed-form expressions of the frequency estimate, which can be obtained using notch filters having an all-zeros FIR structure. In this paper it is shown that the FIR notch filters obtained from standard 2nd-order IIR filters are inadequate, and an alternate 2nd-order IIR notch filter is proposed, which provides an unbiased estimate of the frequency. The FIR filter obtained from the new IIR filter provides a closed-form unbiased frequency estimate.

14:30 - 16:00
L_1 prediction error system identification: a modified AIC rule
In this paper we shall present our recent work on model estimation and model validation. An attractive expression of the AIC rule in the framework of L_1 prediction error is presented. This result based on an original formulation of the FPE criterion in the L_1 context, tends to improve either the task of model structure choice or the validation of the estimated models. Owing to the fact that the analytical properties of the LSAD criterion (least sum of absolute deviations) it was not evident at all that results comparable to the classical L_2 expressions would be found.

14:30 - 16:00
On parameter eatimation of ARMAX model via BCLS method
This paper studies the problem of parameter estimation of ARMAX model from a novel point of view. An efficient bias compensation least squares algorithm is proposed to provide consistent parameter estimate for ARMAX model. The main feature of our proposed algorithm is to introduce the auxiliary least squares linear backward predictors to construct the cross-correlations of least-squares (LS) error and backward prediction (BWP) errors. And with the help of the cross-correlations of LS error and BWP errors, estimate of the bias resulted from

LS solution can be obtained. Consequently the consistent estimate for ARMAX model can be obtained via compensating the estimated bias of LS estimate. The batch-processing approach and the recursive processing approach for the proposed method are given. Theoretical analysis that compares the proposed method with the other existing methods such as bias-eliminated least-squares (BELS) method proposed by Zheng and instrumental variables (IV) method is carried out. Simulation results are presented to illustrate the effectiveness of the proposed algorithm.

14:30 - 16:00

Estimation in the presence of interferences.

If, in a linear regression model, outliers are present on some components of the observation vector, one uses robust estimation schemes that downweight their influence. If interferences that perturb the whole observation vector are present, one generally assumes to know the interfering subspace and performs the parameter estimation on its orthogonal complement. This is a quite restrictive model and a more general interference scheme is considered. The interferences belong to a known parametrized family that spans the whole space. The number and the range space of the interferences that are indeed present is unknown and a robust estimation scheme selects the interferences that are present and downweights their influence.

14:30 - 16:00

Autoregressive spectral analysis with randomly missing data

The joint data covariance matrix determines the likelihood of an arbitrary Gaussian process. Missing data influence the structure of the covariance. However, for stationary random processes it can still be characterized by the parameters of an autoregressive (AR) model. The best AR predictor includes all previous observations if data are incomplete. The missing data likelihood will here be approximated with only those observations that fall within a finite time interval. The resulting non-linear estimation algorithm requires no user provided initial solution. In various simulations, the spectral accuracy of likelihood methods was better than the accuracy of other spectral estimates for missing data.

14:30 - 16:00

Estimating unknown probabilty density functions for random parameters of stochastic ARMAX systems

This paper presents a new method to estimate the unknown probability density functions (PDFs) of random parameters for non-Gaussian dynamic stochastic systems as represented by an ARMAX model, where the parameters and the noise term are characterized by their unknown PDFs. A simple mathematical relationship is established between the measured output PDFs and the unknown PDFs of the random parameters and noise term using the mement generating function. An identification algorithm is then established that estimates these unknown PDFs of the parameters and the noise term using the measured output PDFs and the system input.

ThM05 **Poster session**

Controller tuning and identification

14:30 - 16:00

Iterative controller tuning by minimization of a generalized decorrelation criterion

A controller tuning method based on the correlation approach is considered. A new, generalized, decorrelation criterion is proposed that allows tuning the controller parameters such that the reference signal be as little correlated as possible with both the input and output closed-loop errors. A frequency-domain analysis of the proposed criterion shows that the discrepancy between the true closed-loop system and the designed one is minimized in terms of the output and input sensitivity functions. Furthermore, it is shown that the noise has asymptotically no effect on the controller parameters. The theoretical results are illustrated via a simulation example.

14:30 - 16:00

Subspace identification based PID control tuning

This paper introduces a new method to design a PID controller using a data driven approach for identification. The tuning algorithm is developed within the subspace identification framework, which is used to identify an open loop model from closed-loop data. The PID parameters are calculated by minimising a quadratic performance index over a finite future horizon. The inclusion of a closed-loop condition to guarantee stability results in a constrained nonlinear optimisation problem. The paper includes simulation results for the case of a dissolved oxygen control loop in an activated sludge wastewater treatment plant.

14:30 - 16:00

Evolutionary tuning of pid parameters

PID control schemes have been widely used in most process control systems represented by chemical processes for a long time. However, it is still a very important problem how to determine or tune the PID parameters, because these parameters have a great influence on the stability and the performance of the control system. In this paper, a new evolutionary tuning algorithm of PID parameters is proposed. A suitable set of PID parameters is calculated based on the relationship between the generalized predictive control(GPC) and the PID control.

Then, the GPC includes some user-specified parameters. The suitable value of the user-specified parameter is sought by the genetic algorithm(GA). According to the proposed scheme, the search area of PID parameters is sharply reduced, and the computational burden is drastically shortened.

14:30 - 16:00
Adaptive, cautious, predictive control with Gaussian process priors
Nonparametric Gaussian Process models, a Bayesian statistics approach, are used to implement a nonlinear adaptive control law. Predictions, including propagation of the state uncertainty are made over a k-step horizon. The expected value of a quadratic cost function is minimised, over this prediction horizon, without ignoring the variance of the model predictions. The general method and its main features are illustrated on a simulation example

14:30 - 16:00
Controller design for systems suffering nonlinear distortions
The aim of the study presented in this paper is to provide some initial results over the potential use of best linear approximation models in the design of model-based linear controllers for systems suffering nonlinear distortions. This is illustrated on a nonlinear mechanical resonating system. Parametric best linear approximation models are estimated from frequency response function measurements using random phase multi-sines. A full nonlinear model for the system is also estimated. This provides the basis for the design of simple optimal linear controllers, and the performance obtained from the controllers based on the nonlinear model is set as the benchmark. Parametric linear models are also estimated from measurements taken using Schroeder phase multi-sine signals and controllers based on these models are designed. It is shown that in the presence of nonlinear distortions the choice of input excitation in estimating models that describe the best linear approximation to the nonlinear system is crucial. It is also shown that this choice will have an effect on the performance of the model-based controllers.

14:30 - 16:00
How the output saturation of a regulator influences the reachable performance and robustness measures
A major control design paradigm is how to find compromise between the contradictory requirements of performance and robustness. This paradigm becomes even more sophisticated if the always existing amplitude constraint at the output of the regulator should also be considered in a practical application. Because of the "nonlinear" character of the problem algebraic solutions usually do not exist. Besides the usual "trial and error" approach a possible method is to "rescale" the original problem in order to remain in the linear operating range of the regulator. In our paper another approach is presented which numerically calculates a direct relationship Robustness $= f$ (Performance;Constraints;Plant) and plots these curves to provide very useful practical regulator design tools. These curves are developed for a first order (or dominant pole) time-delay plant, where the above variables have the meaning: Robustness = Nyquist stability margin; Performance = Closed-loop bandwidth; Constraints = Actuator's amplitude limit; Plant = parameters. Then it is also presented how curves and the reachable limit robustness/performance values change for higher order plants and for inverse unstable zeros. This work was supported by the Hungarian NSF (OTKA) and the Control Engineering Research Group of the Hungarian Academy of Sciences.

ThM06 **Poster session**
Applications of identification

14:30 - 16:00
Random loading identification of a plastic glass cantilever beam
The loading power spectral density matrices of a cantilever beam made of plastic glass subjected to stationary random excitations are identified by utilizing the inverse pseudo excitation method using acceleration response measurements and structural frequency response functions. Numerical simulation is conducted for the purpose of optimal selection of sensor locations. Advantages of this method include its computational efficiency compared with other approaches and the benefit of alleviating the ill conditioning of frequency response function near some resonant frequencies. The identified loadings agree with actual ones perfectly well and this method is robust to random noise.

14:30 - 16:00
On sequential identification of a diffusion type process with memory
The sequential estimation problem of dynamic parameters in stochastic linear systems with memory is solved. The estimation procedure is based on the maximum likelihood method and yields estimators with guaranteed accuracy in the mean square sense. The proposed procedure works for that cases, when the eigenvalues of the information matrix of the observed process have certain rates of increase. The asymptotic behaviour of the duration of observations is investigated.

14:30 - 16:00
Incremental identification of transport coefficients in

distributed systems
Identification of state-dependent transport coefficients in distributed systems is considered. It is often difficult to formulate a suitable candidate model based on prior knowledge. General parameterizations are therefore employed leading to a large number of unknown parameters. This may be prohibitive due to the computational cost of parameter estimation. An incremental model identification procedure is therefore employed here. It reflects model development and splits identification into a sequence of inverse problems. Uncertainty is minimized and computational cost is reduced. The implementation uses results from inverse problems theory and is applied to the estimation of a concentration dependent diffusion coefficient.

14:30 - 16:00
On the structure of static balanced flow systems
In this paper we consider identification of static balanced flow systems. Static balanced flow systems are characterised by balancing equations and other physical laws governing the systems. These equations are used for improving estimates of flows and transfer coefficients, and we examine the structure of the equations in the case where in addition to measured flows there are also measured transfer coefficients. It turns out that in most cases the constraints imposed by the equations are linear and bilinear. An extension of the reduced balance scheme which can be used with measured transfer coefficients in some special cases is also provided.

14:30 - 16:00
Endogeneity and identification in transportation systems: econometric relationships to partial observability
This paper addresses key econometric issues related to partial observability and identification due to endogeneity in transportation systems. The purpose of this essay is to bring to the forefront the identification problem in transportation systems stemming from partial observability. Inferences from recent work in pavement condition and traffic safety models are used to build this essay. Given the highly empirical nature of transportation contexts, sources of endogeneity and forms of exogeneity and consequent impacts on identification and parameter estimation are discussed.

14:30 - 16:00
Tool for equal opportunity evaluation in dynamical organizations
In this paper, an attempt to model and evaluate the equal opportunity (EO) conditions of an organization is presented. The main goal is to develop tools to estimate this condition. For that, a measurement system based on clustering techniques is first proposed. In this way, and using numeric, logic and qualitative information, a degree of fulfillment of the gender-based EO is estimated. A rough model of the organization based on basic principles allows evaluating the EO condition of the organization and pointing out the effects of different strategies of hiring and promoting people. The tool is intended as an instrument to make decisions in public and private organizations sensitive to this issue.

ThM07 **Poster session**
Bioengineering systems

14:30 - 16:00
Linearization in the parameters via differential algebra techniques
Recently, differential algebra tools have been applied to the study the identifiability of dynamic systems described by polynomial or rational equations. These methods all exploit the characteristic set of the differential ideal generated by the polynomials defining the system. In this paper it will be shown that the procedures based on differential algebra to test identifiability provide a very useful linear reparametrization of the input-output model of the system. This linear reparametrization can be used to derive explicit one-shot least squares estimates of the parameters, thus avoiding the usual bottleneck of nonlinear parameter optimization which has to be performed by iterative local search with no guarantee of reaching global minima.

14:30 - 16:00
A penalty function approach to HIV/AIDS model parameter estimation
This paper proposes a procedure of parameter estimation for all parameters of the three dimensional HIV model. The least square based procedure uses standard optimization routines and aims to allow parameter extraction for individual patients. It is shown how additional information from outside a measurement dataset can be included in the estimation routine to increase the reliability and accuracy of parameter estimates. This procedure is also applied to a long-term dataset of the HIV/AIDS progression to find possible variations in parameters.

14:30 - 16:00
Sensitivity analysis and parameter identification of wastewater treatment system based on activated sludge models
In this paper, the application of sensitivity analysis in order to determine the key parameters of wastewater treatment systems, along with identification method based on this result has been proposed. The effectiveness of the proposed method has been verified by using real influent data provided by a pilot plant.

14:30 - 16:00
A methodology for nonlinear system identification using Volterra series - application to an anaerobic digestor
This paper introduces a Volterra series model for a continuous nonlinear system. Volterra kernels are expanded on generalized orthonormal functions around a continuous component. An application to validate this model is presented: a biological wastewater treatment process. The Volterra model presented is validated in simulation and with experimental results.

14:30 - 16:00
Some relations of sensitivity functions in bio-reactor models
Sensitivity functions are a basic tool in the parametric identification of models. They can be used to obtain the gradiente for the optimization algorithms in the parameters estimation and for calculating the Fisher information matrix during experiment design. In this work it is shown that for a class of bio-reactor models, a fixed relation between some sensitivity functions exists. This property allows the reduction of the computation load in numeric calculation of the sensitivity trajectories. Simplified equations for gradient and Fisher information matrix calculation using this property are given.

14:30 - 16:00
An experimental object-oriented modelling of an hydraulic valley
This communication presents an object-oriented modelling methodology for the development of complex systems simulators and an application to an hydroelectric system. The model structure is described by a multiport object-oriented diagram. Its implementation and simulation are based on the object-oriented modelling language Modelica and on a multiformalism simulation platform Dymola. System identification techniques are used for both estimating the behavioural models of objects and for the calibration of the multiport diagram. The originality of this contribution is the introduction of the behavioural formalism of the systems theory in the object-oriented modelling framework.

ThP01 Willem Burger Zaal
Particle filters
Chair: F. Gustafsson Co-chair: F. Le Gland

16:00 - 16:20
Particle filters for system identification with application to chaos prediction
The theory of the particle filter, or sequential Monte Carlo methods, has made substantial progress the last decade. The number of applications has increased substantially the last three years, in particular in navigation and telecommunication areas. In this contribution, we will first point out how the particle filter can be used for system identification, using a quite general problem formulation, and it is pointed out in which kind of application the particle filter can be an attractive alternative to classical system identification methods. The approach is applied to a chaotic system.

16:20 - 16:40
Particle filters for system identification of state-space models linear in either parameters or states
The potential use of the marginalized particle filter for nonlinear system identification is investigated. The particle filter itself offers a general tool for estimating unknown parameters in non-linear models of moderate complexity. We derive algorithms for systems which are non-linear in either the parameters or the states, but not both generally. In these cases, marginalization applies to the linear part, which firstly significantly widens the scope of the particle filter to more complex systems, and secondly decreases the variance in the linear parameters/states for fixed filter complexity.

16:40 - 17:00
Fault detection, isolation and diagnosis with particle filters for nonlinear stochastic systems
In this paper, we provide a particle filtering based approach to the problems of fault detection, isolation and diagnosis of general nonlinear stochastic systems. The algorithms use decision criteria based on the generalised likelihood ratios which are computed using the samples based probability distribution information of the state variables given by the particle filters.

17:00 - 17:20
Monte Carlo mixture Kalman filter and its application to space-time inversion
We develop a new time dependent inversion method for imaging transient fault slips from geodetic data. Past studies employed a linear Gaussian state space model and applied Kalman filter. In the present study, we develop/apply a new filtering scheme, Monte Carlo mixture Kalman filter (MCMKF) to the time dependent inversion. MCMKF allows variation to the temporal smoothing of slips in the following scheme; (1) we prepare a finite number of competing state space models, each of which follows a different state space model, (2) we introduce a switching structure among these competing models.

17:20 - 17:40
A particle filter implementation of the recursive MLE for partially observed diffusions
In this paper, the problem of identifying a HMM with

general state space, is considered, and a particle implementation of the recursive MLE for a parameter in the model is presented. The key assumption is that the derivative of the transition kernel w.r.t. the parameter has a probabilistic interpretation, suitable for Monte Carlo simulation. Examples are given to show that this assumption is satisfied in quite general situations. As a result, it becomes natural to jointly approximate the filter and its derivative with two (weighted) empirical probability distributions associated with the same and unique particle system.

17:40 - 18:00
Online sampling for parameter estimation in general state-space models
We consider the class of stationary nonlinear non Gaussian state space models with unknown static parameters. We propose original online stochastic gradient type algorithms to estimate these parameters. These algorithms rely on the simulation of artificial observations. Optimal state estimation is not required by our methods and the proposed algorithms are computationally efficient. Their efficiency is demonstrated through simulation.

ThP02	Fortis Bank Zaal
Wiener Hammerstein models	
Chair: T. Söderström	Co-chair: M. Campi

16:00 - 16:20
Nonlinear structure identification with application to Wiener-Hammerstein systems
While there exists a substantial literature on the identification of Hammerstein and Wiener models, the identification of Wiener-Hammerstein models has received considerably less attention yet this is a model class of very great practical importance. This paper proposes an elegant approach to estimating Wiener-Hammerstein systems from measured data.

16:20 - 16:40
Identification of a Wiener system with some general discontinuous nonlinearities
This paper presents a new recursive identification method for a Wiener system with different general discontinuous nonlinearities. It is assumed that the linear model structure and the type of the nonlinearities are known in prior. By using the key term separation principle and constructing intermediate variables, such a Wiener system can be approximately transformed into a pseudo- linear MISO system. Using the adaptive recursive pseudo- linear regressions for a linear MISO dynamic system and smoothing techniques to estimate the intermediate variables, satisfied parameter estimates can be obtained in the presence of a colored measurement noise without parameter redundancy.

16:40 - 17:00
Parameter identification based on Hammerstein models - a subspace approach
This paper focuses on parameter identification of nonlinear systems based on Hammerstein models. An identification scheme ensuring parameter estimate consistency is designed using tools from the subspace approach. Such an approach has many interesting features, e.g. prior knowledge of the system dynamics order is not necessary. The main contribution of this paper are threefolds: (i) the subspace approach, which is developped for linear systems, is adapted to (nonlinear) Hammerstein systems; (ii) a persistently exciting input signal is designed to guarantee the estimate consistency; (iii) parameter bilinearity that characterizes Hammerstein models is dealt with through a singular value decomposition.

17:00 - 17:20
Nonlinear model identification using working point variables
The identification of dynamic models with nonlinear gains is studied. The nonlinear gain is modelled as a function of so-called working-point variable (WPV). The working-point variable is introduced to represent the changes of process operation range. Parameter estimation is solved for the models. A relaxation iteration scheme is used to estimate the initial high order model and then a model reduction is used to obtain the reduced model. The convergence and consistency of the method are studied. Simulation study will be used to illustrate the estimation method.

17:20 - 17:40
Identification of Wiener-Hammerstein models with cubic nonlinearity using LIFRED
The identification of Wiener-Hammerstein models using linear interpolation in the frequency domain (LIFRED) is extended from models with quadratic nonlinearity to models with cubic nonlinearity. The modifications to the algorithm are discussed and a simulation example is presented. A further technique is proposed which enables the estimation of the gain response of the first linear subsystem from estimation lines in the output which are distorted due to contributions of several combinations of the input harmonics. This new technique is less susceptible than the first approach to the effects of noise and a possible reason for this is discussed.

17:40 - 18:00
Performance investigation of SLICOT Wiener systems identification toolbox

This paper summarizes the results obtained through a systematic and extensive investigation of the performance of the new system identification toolbox for Wiener-type multivariable discrete-time systems, incorporated in the Fortran 77 Subroutine Library in Control Theory (SLICOT). This toolbox provides drivers, computational routines, and MATLAB or Scilab interfaces, implementing several algorithmic approaches. The input-output data sets considered in this investigation include those in the DAISY collection, freely available at the site www.esat.kuleuven.ac.be/sista/daisy. The results show that SLICOT is reliable, efficient, and able to solve large identification problems.

ThP03	Van Beuningen Zaal
Identification using basis functions	
Chair: B. Ninness	Co-chair: B. Wahlberg

16:00 - 16:20
Rational bases generated by Blaschke-product systems
This paper presents an approach to generate rational orthogonal bases in $\mathcal{H}_2$ that can be used in signal modelling and identification. This approach is based on defining Blaschke product systems and the bases are generated by function compositions that act as dilation on $\mathcal{H}_2$ when compared to previous approaches where shift operators are used. The coefficients of a finite order approximating model can be computed by FFT.

16:20 - 16:40
More on sparse representations in arbitrary bases.
The purpose of this contribution is to generalize some recent results on sparse representations of signals in redundant bases. The question that is considered is the following : let A be a known (n, m) matrix with $m > n$, one observes $b = AX$ where X is known to have p nonzero components, under which conditions on A and p is it possible to recover X by solving a convex optimization problem such as linear or quadratic program? The solution is known when A is the concatenation of two unitary matrices, we extend it to arbitrary matrices.

16:40 - 17:00
On spectral estimation using models with pre-specified zeros
The fundamental theory of Lindquist and co-workers on the rational covariance extension problem provides a very elegant framework for ARMA spectral estimation. Here the choice of zeros is completely arbitrary, and can be used to tune the estimator. An alternative approach to ARMA model estimation with pre-specified zeros is to use a prediction error method based on generalizing autoregressive (AR) modeling using orthogonal rational filters. Here the motivation is to reduce the number of parameters needed to obtain useful approximate models of stochastic processes by suitable choice of zeros, without increasing the computational complexity. The objective of this contribution is to discuss similarities and differences between these two approaches to spectral estimation.

17:00 - 17:20
Identification of rational spectral densities using orthonormal basis functions
This paper gives an algorithm for identifying spectral densities using orthonormal basis functions. Mathematically, this amounts to identifying a time-invariant linear SISO system with the additional constraint that the transfer function should be positive-real. Thus, we solve the long-standing problem of how to incorporate this positivity constraint while using orthonormal basis functions. The procedure is a variant of the THREE algorithm introduced by Byrnes, Georgiou and Lindquist. The relation between and numerical properties of the proposed and the THREE algorithms are discussed. A numerical example illustrating the algorithm is given.

17:20 - 17:40
Orthonormal basis functions for modeling continuous-time fractional systems
The classical Laguerre functions are known to be divergent as soon as their differentiation order is non-integer. They are hence inappropriate for representing fractional differentiation systems. A complete orthogonal basis, having fractional differentiation orders and a single pole, is synthesized. It extends the well-known definition of Laguerre functions to fractional systems. Hence a new class of fixed denominator models is provided for system identification. Fourier coefficients are computed using a least squares method. The least squares error is plotted versus the differentiation order and the pole, in an example, and shows that an optimal differentiation order may be located away from an integer number. Hence, the use of the synthesized basis is fully justified.

17:40 - 18:00
Adaptive Laguerre time scaling factor in predictive control
This paper proposes a design method of estimation of the Laguerre time scaling factor in the predictive control context. The presented approach is based on the minimization of a cost function in the frequency domain. By discretizing the continuous Laguerre network, a simple predictive control law is presented using only the system matrices of such a network. This makes it possible to design an adaptive predictive control for unstructured

unstable systems whose a priori knowledge is not available. The simulation results show that the proposed scheme provides satisfactory performance.

ThP04 Schadee Zaal
Subspace identification and applications
Chair: G. Picci Co-chair: T. McKelvey

16:00 - 16:20
Identification of MIMO state space models for helicopter dynamics
A considerable amount of work has been dedicated in the past to the problem of identification of helicopter flight dynamics, both in the time and frequency domain, however, limited attention has been devoted so far to the application of subspace methods to the problem. The aim of this paper is to show that subspace based identification techniques can be used to determine accurate discrete-time and continuous-time linear models for helicopter dynamics. The identification techniques are applied to simulated data generated by a physical model that describes coupled rotor-fuselage dynamics for a realistic rotorcraft.

16:20 - 16:40
Estimation of damped and undamped sinusoids with application to analysis of electromagnetic FDTD simulation data
Computational electromagnetics deals with the problem of finding efficient and reliable solutions of Maxwell's equations. This is important in a variety of practical applications, such as antenna design and automatic target recognition, and time-domain computations are attractive for a large class of these problems. However, one is more often interested in the frequency characteristics of the solution. Using the Fourier transform to determine the resonance frequencies and damping factors requires long time series, implying severe computational complexity. An attractive alternative is to apply high-resolution frequency estimation, developed in the signal processing society over the past few decades. This is a challenging problem, though, as the number of interesting frequency components can be as large as several hundreds. To overcome the difficulties, we propose a frequency-domain subspace method that yields accurate frequency and damping estimates in a selected frequency band. The required electromagnetic simulation time can thereby be reduced by several orders of magnitude.

16:40 - 17:00
Application of a recursive subspace identification algorithm to change detection
This paper presents a new change detection method with the aid of subspace identification. The proposed method is based on monitoring a change in variance of a statistic generated by a recursive subspace identification algorithm. An asymptotic property of the statistic is presented. Without changes during sampling, it is shown that, under relevant assumptions, the statistic converges in probability to a stack of noise vectors left-multiplied by a Toeplitz matrix. A numerical example illustrates that the proposed method can detect changes of a system, without being disturbed by changes in the dynamics of an input signal which are not our concern.

17:00 - 17:20
Subspace-based modal identification and monitoring of large structures, a Scilab toolbox
Stochastic subspace-based structural identification and damage detection and localization methods are discussed, together with their implementation within the free INRIA software Scilab. Particular emphasis is put on the handling of high order models for large structures. Experimental results on aerospace and civil engineering examples are discussed.

17:20 - 17:40
Identifying positive real models in subspace identification by using regularization
This paper deals with the lack of positive realness of identified models that may be encountered in many stochastic subspace identification procedures. Subspace identification algorithms fail to return a valid linear model if the so-called covariance model, which is obtained from an intermediate realization step in the subspace identification algorithm, is not positive real. The main contribution of this paper is to introduce a regularization approach to impose positive realness on the covariance-model. It is shown that positive realness can be imposed by adding a regularization term to a least squares cost function appearing in the subspace identification procedure.

17:40 - 18:00
Modeling human gaits with subtleties
We present a novel approach to modeling subtleties in human motion. We represent the trajectories of a certain number of salient features on the human body as the output of a dynamical system driven by an unknown stochastic input. We present several techniques for inferring model parameters and input signal distributions corresponding to different optimality criteria, and evaluate the corresponding models for accuracy and predictive power. In particular we exploit the higher order statistical information content in motion data to arrive at input signals with independent components and show that the human motion synthesized from non-Gaussian

inputs capture best the subtle complexities of the motion data.

ThP05 Hudig Zaal
Identification in large scale systems
Chair: P. Astrid Co-chair: S. Weiland

16:00 - 16:20
Model reduction of nonlinear dynamical systems utilizing proper orthogonal decomposition
In applications the optimization of partial differential equations leads to complicated nonlinear dynamical systems. For the numerical realization model reduction can be applied to reduce the number of degrees of freedom significantly. Proper orthogonal decomposition (POD) is a method to derive reduced order methods for dynamical systems. In this talk error estimates for the POD Galerkin approximations are presented and numerical examples for open and closed loop control are discussed.

16:20 - 16:40
Reduction of large-scale groundwater flow models via the Galerkin projection
The hydraulic head h in groundwater flow models can be described as a linear combination of a set of spatial patterns P and time-varying coefficients r. The patterns P (Empirical Orthogonal Functions) were used to create a dynamic model for dr/dt via a Galerkin Projection. As the vector dimension of r is small, we achieved for a realistic case study, a maximal time reduction of ≈ 80. Overall, the reduced model has a promising prospect as its time reduction increases whenever the complexity of the original model and the number of grid cells increases.

16:40 - 17:00
Model reduction for large-scale linear applications
Three model reduction methods are considered in the context of large scale fluid dynamic applications: the widely-used proper orthogonal decomposition, the Arnoldi method and a new Fourier method. The new method uses a Fourier expansion of the transfer function in discrete frequency to efficiently calculate reduced models with guaranteed stability and accuracy properties. Each method is described and then applied to the case of flow through a supersonic diffuser. The Fourier model reduction approach is found to be superior in all aspects; it is computationally more economical, preserves the stability of the original system, uses both input and output information to yield efficient models, and is valid over a wide range of frequencies.

17:00 - 17:20
Reduced order modeling of an industrial glass feeder model
Models of glass furnaces are described by a set of nonlinear partial differential equations which govern the mass, momentum and energy balances and a number of nonlinear functions of the independent scalars which describe the dependent variables. In this paper we consider the problem to simulate such a glass furnace and to substantially reduce the complexity of a glass feeder model while keeping its main dynamical properties. A Computational Fluid Dynamics (CFD) method is applied to simulate the dynamics of the physical and chemical processes that take place in the furnace. As a result of a fine discretization applied to the CFD, the resulting model is too large to be incorporated in control or optimization modules. We present a reduced order modelling technique by proper orthogonal decomposition applied to an industrial glass feeder model. It is shown that with less than 0.1% of the states of the original model, the temperature deviations between the original and the reduced order model is negligible.

ThP06 Ruys Zaal
Industrial applications of identification
Chair: G. Goodwin Co-chair: E. Walter

16:00 - 16:20
Identification of the topology of a power system network
This paper is devoted to the important practical problem of identifying the topology inside a suspect pocket of a power system network. Because the vector of the parameters to be estimated includes Boolean variables indicating the existence or absence of connection as well as real variables, this is a hybrid problem. It is solved here in a guaranteed way by ressorting to interval analysis and the notion of constraint propagation. The methodology is illustrated on the IEEE 14-bus network.

16:20 - 16:40
LPV identification of a diesel engine torque model
Torque estimation has an increasing importance in the field of automotive control, as most engine controllers rely on torque estimation today. In this paper a new approach based on a linear parameter varying (LPV) model is proposed. It relies on a nonlinear subspace identification method and exploits the natural dependency of many engine processes on the rotational speed, but does not use a physical model, which is very time consuming and difficult to obtain. To this end, first a LPV state space method is introduced and then experimental results are presented which show that the model exhibits high accuracy.

16:40 - 17:00
Identification and control of a pv-supplied separately ex-

cited dc motor using universal learning networks
This paper describes the use of Universal Learning Networks (ULNs) in the identification and control of a separately excited dc motor loaded with a centrifugal pump and fed from Photovoltaic (PV) generator via dc-dc buck-boost converter. The Universal Learning Network Identifier (ULNI) is trained offline using the forward propagation algorithm to emulate the dynamic behavior of the dc motor system. Then this identifier is used, instead of the motor system, for the online training of the Universal Learning Network Controller (ULNC). As a result, the motor speed can follow an arbitrarily selected reference signal. Furthermore, the overall system can operate at the Maximum Power Point (MPP) of the PV generator, which is the optimal operating point. The simulation results showed a good performance for the identifier and the controller as well.

17:00 - 17:20
Validation of stability for an induction machine drive using experiments
The objective of this contribution is to estimate and validate the closed loop properties of a non-linear induction machine drive. In particular, it is of importance to be able to verify the stability margins of the system. First, a linear approximate transfer function model of the system is identified from experimental data. The remaining model errors are mainly due to non-linear dynamics and distortion. In a second step, the gain of the nonlinear error system is estimated. Robust stability can then be analyzed by combining the small gain theorem by a stability test of the linear model. The approach taken is inspired by the work of Schoukens and co-workers, on identification of the stability of feedback systems in the presence of nonlinear distortions. The problem at hand addresses several of the challenges of system identification for control. The system is highly nonlinear and dependent of the operating conditions. The stability problem is nontrivial, and has large practical implications. The approach is evaluated on a hardware/software simulation platform.

17:20 - 17:40
Automatic steering control system design utilizing a visual feedback approach
This paper focuses on a visual feedback approach in which an automatic driving system is obtained by recognizing the road trajectory using image information. The validity of this approach is examined by conducting experiments with a radio-controlled car. First, a practical image processing algorithm that recognizes white lines on the road is proposed. Next, a model of the radio-controlled car is built by system identification experiments and an automatic steering control system is designed based upon H_∞ control theory. Finally, the effectiveness of the proposed control system is examined via traveling experiments.

17:40 - 18:00
Application of RBF-type ARX modeling and control to gas turbine combined cycle SCR system
Most electric power companies in Japan are installing the SCR system for NOx emissions. While these systems are effective, control issues often result in excess reagent NH3 usage and NH3 slip. The delay in the NOx signal from the stack causes inappropriate NH3 injection resulting in poor NOx control. This paper discusses the technical and economic evaluation about the RBF-type ARX model-based predictive control strategies of by the desktop simulation using data from the historical database in the GTCC plant computers.

ThP07	Van Ryckevorsel Zaal
Software session 2	
Chair: R. Schumann	Co-chair: -

16:00 - 18:00
Automatic time series identification - spectral analysis with MATLAB toolbox ARMASA
ARMASA provides a new automatic spectral estimator for random data. For stationary stochastic observations, time series identification gives a better accuracy in spectral estimation than what can be obtained by FFT analysis with windowed and tapered periodograms. The parameters of the time series model accurately represent the spectral density and the covariance function of the data. The increased computational speed gives the possibility to compute hundreds of models and to select only one. The three linear time series model types are: autoregressive (AR), moving average (MA) and the combined ARMA models. The ARMAsel algorithm computes models of the three types for a large number of candidate model orders. The computer first selects the best order for each of the model types separately. Then, a single type is selected from those three models by looking for the smallest prediction error. That selected model includes precisely the statistically significant details that are present in the data, and no more.

16:00 - 18:00
MULTI-EDIP - an interactive software package
An interactive intelligent software environment MULTI-EDIP for computer aided signal and system identification is presented. Motivation for the development of intelligent software for process identification is discussed. A summary of services offered by MULTI-EDIP and its main features are presented, particularly the problem of

expert advice in model structure determination is highlighted. An example of intelligent support in electro-acoustic plant identification for active noise control application is described.

16:00 - 18:00
KALMTOOL for use with MATLAB
The KALMTOOL toolbox is a set of MATLAB tools for state estimation for nonlinear systems. The toolbox contains functions for extended Kalman filtering as well as for two new filters called the DD1 filter and the DD2 filter. The toolbox specifically addresses the problem of not having observations available at all sampling instants. All functions are available as m-functions but for faster (much faster!) execution, the DD1 and DD2 filters are also available as C Mex files for MATLAB under Windows and Linux. The toolbox requires MATLAB 6. No additional toolboxes are required.

16:00 - 18:00
The ADAPTx software for automated and real-time multivariable system identification
Recent developments in the ADAPTx software for automated system identification are discussed. Unknown delays in systems occur frequently in industrial processes and other time series data. Such delays can considerably increase the state order and the number of estimated parameters. New methods and software are discussed that give fast, numerically stable and accurate determination of the multivariable delay structure that is then used for efficient subspace modeling. A second innovation is the development of a leaps and bounds type algorithm for the determination of the significant inputs that influence the outputs. The automated system identification capability has been extended for real-time use with the dSPACE data aquisition hardware. This is of considerable interest in automotive and aerospace applications. Finally, a Java graphical user interface is under development.

16:00 - 18:00
Frequency domain system identification toolbox for MATLAB: automatic processing - from data to model
The Frequency Domain System Identification Toolbox for MATLAB is an effective tool for the identification of linear dynamic system models. Since the use of advanced system identification methods deflects the attention from the modelling issues, a Graphical User Interface (GUI) was developed which allows the experimenter to visually follow and control the data processing and modelling steps. However it is desirable to obtain good models with as few decisions to be made as it is possible. Therefore, automatic processing steps have been added to the GUI. Identification can be done now in this toolbox with just a minimum of user interactions in the graphics windows, and a reasonable model is returned, ready for control or physical analysis.

FRIDAY, AUGUST 29, 2003

P3 Willem Burger Zaal
Plenary lecture
Chair: B. Wahlberg

08:30 - 09:30
Prediction algorithms: Complexity, concentration and convexity
In this paper, we review two families of algorithms used to estimate large-scale statistical models for prediction problems, kernel methods and boosting algorithms. We focus on the computational and statistical properties of prediction algorithms of this kind. Convexity plays an important role for these algorithms, since they exploit the computational advantages of convex optimization procedures. However, in addition to its computational advantages, the use of convexity in these methods also confers some attractive statistical properties. We present some recent results that show the advantages of convexity for estimation rates, the rates at which the prediction accuracies approach their optimal values. In addition, we present results that quantify the cost of using a convex loss function in place of the real loss function of interest.

FrA01 Willem Burger Zaal
Identification and physical modeling
Chair: L. Ljung Co-chair: A. Isaksson

10:00 - 10:20
Grey-box model calibrator and validator
This contribution presents a tool for designing 'grey-box' models with applications primarily to continuous industrial processes. It is the result of more than ten years development at the Automatic Control group at KTH. This has involved development of basic theory for 'grey-box' identification and a number of case studies of full-scale industrial production processes, as well as construction of the MoCaVa software tool (Model Calibrator & Validator) with user interface adapted to the task of identification under partial structure and input uncertainty. The program uses Matlab. It is available from http://www.mocava.s3.kth.se free of charge.

10:20 - 10:40
Initialization of physical parameter estimates

Grey box models of dynamical systems contain designated parameters with physical interpretation to be estimated from input-output data. This often gives distinct advantages over black-box models in terms of fewer parameters to estimate and hence better statistical accuracy. The basic theory for how this can be done is well established. The main practical obstacle may however be how the search for the estimates should be initialized. In this contribution we review the difficulties and point to a possibility to use semidefinite programming and a sum-of-squares formulation to achieve guaranteed consistent initial values for the physical parameters.

10:40 - 11:00
Parameter estimation in linear differential-algebraic equations
This paper describes how parameter estimation can be performed in linear DAE systems. Both time domain and frequency domain identification are examined. The results are exemplified on a small system. A potential application for the algorithms is to make parameter estimation in models generated by a modeling language like Modelica.

11:00 - 11:20
Model validation in non-linear continuous-discrete grey-box models
The validation part of the modeling procedure is used in the iterative process of model building and as an acceptance test of the obtained model. This paper presents a number of tools for validating non-linear continuous-discrete time stochastic state space models. For equidistantly sampled data a minor transformation of the one-step prediction errors is appropriate and the tools applied can also be used to suggest extensions of the model. Alternatively, we may regard the diffusion term as unmodelled systematic variation and in this case use the estimated diffusion as a tool to suggest possible sources of such variation. Finally, in the general case we may apply a transformation, based on numerical solution of the Fokker-Planck equation, in order to obtain standardized residuals which under the model are i.i.d. Gaussian. Standard tests can then be applied to these residuals.

11:20 - 11:40
Identification of mechanical parameters in drive train systems
This paper studies estimation of mechanical parameters in two-mass models with backlash. The suggested approach is to use a procedure based on three dedicated experiments: 1) One experiment with a sequence of setpoint steps while maintaining the controller in automatic. This enables estimation of the total inertia damping and the static friction. 2)Then an experiment tailored to guaranteeing that no gap openings are encountered, thus enabling estimation of the other mechanical parameters. Black-box estimation of a general third order transfer function is used to find initial parameters, followed by fine tuning using a physical model. 3) Finally yet another experiment that with certainty contains gap openings. Use this data set to estimate the gap size, while keeping the other model parameters fixed. This procedure has been implemented in Matlab and successfully tested on simulated data, but also on real data from a test rig as well as from both rolling mills and paper mills.

11:40 - 12:00
Identification and model predictive control of a pH neutralization process based on linear and Wiener models
In this paper, a comparison between linear model-based and Wiener model-based Identification and Predictive Control of a pH neutralization process is presented. Input-Output data from a nonlinear first principles simulation model of the pH neutralization process are used for subspace-based identification of black-box linear and Wiener-type models. The proposed nonlinear subspace method has the advantage that it delivers a Wiener model in a format which is suitable for its use in a standard linear model-based predictive control scheme. The identified models are used as the internal models in a model predictive controller which is used to control the nonlinear white-box simulation model. Simulation results show that the Wiener-based model predictive controller out-performs the one based on the linear model.

FrA02 Fortis Bank Zaal
Identification of nonlinear systems
Chair: R. Pintelon Co-chair: J. Roll

10:00 - 10:20
Local modelling of nonlinear dynamic systems using direct weight optimization
Local models and methods construct function estimates or predictions from observations in a local neighborhood of the point of interest. How large the local neighborhood should be is often determined based on asymptotic analysis. Here, a non-asymptotic approach that minimizes an upper bound on the mean square error for a linear estimate is used. It is shown that the estimator is obtained from a quadratic program, that a finite bandwidth is automatically obtained, and that the approach can be seen as a local version of fitting affine models to data. Finally, the approach is applied to two benchmark systems.

10:20 - 10:40
Optimality in SM identification of nonlinear systems
In the paper the problem of identifying discrete time

nonlinear systems from finite and noise-corrupted measurements is considered. Most methods in the literature are based on the estimation of a model within a finitely parametrized model class describing the functional form of involved nonlinearities. A key problem in these methods is the proper choice of the model class, typically realized by a search, from the simplest to more complex ones (linear, bilinear, polynomial, neural networks, etc.). In this paper an alternative approach, based on a Set Membership framework is presented, not requiring assumptions on the functional form of the regression function describing the relations between measured input and output, but assuming only some information on its regularity, given by bounds on its gradient. In this way, the problem of considering approximate functional forms is circumvented. Moreover, noise is assumed to be bounded, in contrast with statistical methods, which rely on assumptions such as stationarity, ergodicity, uncorrelation, type of distribution, etc., whose validity may be difficult to be reliably tested and is lost in presence of approximate modeling. Necessary and sufficient conditions for assumptions validation are given. An optimal interval estimate of the regression function is obtained, providing its uncertainty range for any assigned regressor values. The set estimate allows to derive an optimal identification algorithm, giving estimates with minimal guaranteed L_p error on the overall domain of the regressors. The properties of the optimal estimate are investigated and its worst-case L_p identification error is evaluated.

10:40 - 11:00
A suboptimal bootstrap method for structure detection of nonlinear output-error models
Identification of nonlinear systems involves estimating unknown parameters and structure detection, selection of a subset of candidate terms that best describe the observed output. For nonlinear systems simple output additive noise can generate multiplicative terms between the input, output and noise. The terms associated with noise need to be modeled to obtain unbiased parameter estimates, significantly increasing the number of candidate terms to be estimated and considered. In special cases, it may be possible to use an output error (OE) model structure and the instrumental variable (IV) estimator to obtain unbiased parameters without modeling the noise. This significantly reduces the dimensionality of the structure computation problem. In this paper we propose a suboptimal bootstrap structure detection algorithm. The applicability of this suboptimal bootstrap structure detection (SOBSD technique for nonlinear polynomial models was evaluated by estimating the structure of a simple NARMAX model and comparing the results to the t-test.

11:00 - 11:20
Identification of nonlinear parametrically varying models using separable least squares
The aim of this paper is to propose a novel identification algorithm based on separable least squares ideas, for a class of nonlinear, possibly parameter-varying, input/output models. These models are given in the form of a Linear Fractional Transformation (LFT) where the "forward" part is represented by a conventional linear regression and the "feedback" part is given by a nonlinear map which can take into account scheduling variables available for measurement. The nonlinear part of the model can be parameterised according to various paradigms, like, e.g., Neural Network (NN) or NARX.

11:20 - 11:40
Modeling and identification of rate-independent hysteresis using a semilinear Duhem model
In this paper we consider a semilinear Duhem model. The input-output map of the model is rate-independent, thus yielding persistent phase shift (that is, hysteresis) at arbitrarily low frequency. For the semilinear Duhem model we reparameterize the response in terms of the control input, and we provide sufficient conditions for convergence to a hysteresis map. A constrained least squares method is developed to identify the hysteresis map using the semilinear Duhem model.

11:40 - 12:00
Least squares harmonic signal analysis using periodic orbits of ODEs
The idea of the paper is to model harmonic signals by means of second order nonlinear ordinary differential equations (ODEs). This is motivated by the well known theoretical results on the existence of periodic orbits for nonlinear second order ODEs. The right hand side functions of the ODE are the estimated quantities, this being accomplished by the use of a polynomial parameterisation. A least squares estimation algorithm is then derived. The methodology reduces the number of parameters needed in cases where the signal generation can be accurately described by the suggested model, thereby enhancing estimation performance.

FrA03	Van Beuningen Zaal
Education and training	
Chair: D.E. Rivera	Co-chair: R.P. Guidorzi

10:00 - 10:20
Educational aspects of identification software user interfaces
Apparently many users of identification techniques learn the topic only via use of commercial software. This may or may not include the software manual. This means that

the software user interface –graphical or not– plays a major role in teaching identification theory and methodology to large number of users. This contribution deals with such educational / pedagogical aspects software user interfaces. In particular we focus on issues to hide certain design variables as defaults, and what can be done in case no defaults are obvious. Other questions are how to force the user to appreciate and understand the quality of an identified model, and to know what optional design choices and methods that are available, in particular if there is no Graphical User Interface (GUI).

10:20 - 10:40
An identification course on the web: rationale, realization and students' evaluation
The role of net-based tools in both traditional and remote learning is continuously increasing and will eventually define new integrated environments. This paper reports the opinions of the students that have followed a course on dynamic system identification based on hypertexts, asynchronous tutoring and platform-independent virtual laboratories.

10:40 - 11:00
Control related topics in identification - closed loop experiments and identification for control
This paper summarizes the organization of a graduate course on control related topics in identification. The course is taught at the department of Mechanical and Aerospace Engineering at the University of California, San Diego and analyzes the problems of estimation on closed-loop data and control relevant approximation of systems. As part of the course, several case studies are reviewed and include the well documented examples of a sugar cane crushing mill and the identification of the marginally stable electro-mechanical system found in a CD-ROM player.

11:00 - 11:20
Teaching semiphysical modeling to chemical engineering students using a brine-water mixing tank experiment
The Chemical Engineering program at Arizona State offers an integrated series of core courses that teach students how conservation and accounting principles can be applied to describe engineering phenomena across disciplines. A brine-water mixing tank experiment was introduced in the third course in the series (ECE 394C: Understanding Engineering Systems Via Conservation) as a capstone modeling project for the recitation portion of the course. The experiment provides students with "hands-on" experience on a real-life system incorporating process, electrical, and mechanical components, as well as real-time data acquisition and control. A major feature of the brine-water tank project is that students apply a comprehensive system identification procedure relying on semi-physical (a.k.a. "grey box") models to complement their understanding of first-principles modeling. This paper describes the brine-water tank experiment, presents the formulation of the semi-physical parameter estimation problem, and describes the comprehensive procedure that students undertake to go from process data to validated plant models.

11:20 - 11:40
Estimating parameters in a lumped parameter system with first principle modeling and dynamic experiments
Commercially available mechanical systems are available to teach and demonstrate the principles behind dynamics and control. A single system can be used for basic dynamic analysis in an undergraduate class to teaching and applying sophisticated identification techniques in a graduate class. In this paper it shown how such a commercial system is used at the undergraduate level to estimate lumped parameter coefficients using multiple step responses and first principle modeling. At the graduate level, the same commercial system is used to teach concepts of system identification for the estimation of models for a multi-degree of freedom mechanical system.

FrA04	Schadee Zaal
Recursive and subspace identification	
Chair: J.J. Fuchs	Co-chair: W. Scherrer

10:00 - 10:20
Recursive subspace identification based on projector tracking
The problem of MIMO state space recursive identification is considered and analyzed using subspace model identification (SMI) techniques. In this paper the use of projection tracking techniques for the update of the observability subspace is proposed: existing results are used for the output error case and a novel instrumental variable (IV) projection tracking approach is proposed, to accommodate for arbitrary correlation of the disturbances. Simulation results show the performance achievable with the given algorithms.

10:20 - 10:40
Subspace identification and ARX modeling
In this paper we present a new identification method that points at the close relationship between high order ARX modeling and subspace identification. A high order ARX model is utilized to obtain initial estimates of certain Markov parameters. These parameters are then used to restructure the data model used for subspace identification to facilitate the estimation of the state sequence. Based on the estimated state sequence, the sys-

tem parameters are estimated by linear regression. The method is shown to be competitive to existing subspace methods by a simulation example. The method can also be used, without modification, on closed loop data in contrast to most previously published subspace identification methods.

10:40 - 11:00
Parallel QR Implementation of Subspace Identification with Parsimonious Models
In this paper we reveal that the typical subspace identification algorithms use non-parsimonious model formulations, with extra terms in the model that appear to be non-causal. These terms are the causes for inflated variance in the estimates and partially responsible for the loss of closed-loop identifiability. We then propose a parallel parsimonious formulation of a new subspace identification algorithm and demonstrate the effectiveness of the proposed algorithm via simulation.

11:00 - 11:20
A new recursive method for subspace identification of noisy systems : EIVPM
The problem of MIMO state-space recursive identification is considered and analysed in the framework of subspace model identification using signal processing algorithms. More particularly, the adaptation of the propagator method to system identification leads to a quadratic criterion from which it is possible to estimate on-line the subspace spanned by the process observability matrix without performing any eigen-decomposition. To accommodate for arbitrary correlations of the process and measurement disturbances, an instrumental variable approach is introduced. Simulation results show the performance achievable with the given algorithms.

11:20 - 11:40
Canonical correlation partial least squares
In this paper, a novel algorithm, referred to as Canonical Correlation Partial Least Squares or CCPLS is introduced. The core algorithm is based on the deflation procedure of partial least squares and the cost function of Canonical Correlation Analysis for determining linear combinations of two sets of variables.

11:40 - 12:00
Frequency-domain system identification techniques for experimental and operational modal analysis
In this paper frequency-domain estimators will be presented for application in the field of modal analysis. In "Experimental Modal Analysis" system identification is used to model mechanical systems with a few inputs and hundreds of outputs. This requires adapted estimators designed to handle large amount of data in a reasonable amount of time. Next, attention will be paid to "Operational Modal Analysis" and it will be shown how the modal parameters can be estimated from output-only data. Finally, a combined experimental-operational identification approach will be introduced.

FrA05 Hudig Zaal
Process control: theory
Chair: M. Grimble Co-chair: L. Huisman

10:00 - 10:20
Data-driven modeling of nonlinear and time-varying processes
In this contribution, it is proposed using a novel interpretation of generalized ridge regression to identify a 1-dimensional grid of interdependent linear models from operation data. Such 1-dimensional model grids can be used to model repeated finite horizon, nonlinear and non-stationary process operations. These finite horizon process operations include chemical process operations such as start-ups, grade transitions, shutdowns, and of course batch, semi-batch and periodic processes. Explicitly, it is proposed to identify sets of interdependent linear models using modified generalized ridge regression/Tikhonov regularization that penalizes weighted discrepancies between one linear model and the models in its neighborhood. Penalizing weighted discrepancies between neighboring linear models induce both model interdependency and designed model properties.

10:20 - 10:40
PID parameter cycling to tune industrial controllers:a new model-free approach
A brief review of the background to the method of Iterative Feedback Tuning is presented. This introduces the idea of optimising a cost function to produce restricted structure controllers or to benchmark controllers for performance assessment. The new method of controller parameter cycling is introduced to achieve the same objectives as the IFT method. An advantage of the new method is the ease with which Hessian information is obtained to enhance the optimisation procedure. A multivariable example demonstrating the controller parameter cycling method is given.

10:40 - 11:00
Stepwise refinement of sparse grids in data mining applications
A stepwise refinement approach for sparse grids is proposed to recover an unknown function from a set of corrupted data. The work is based on the approach of Garcke et al. (2001), which is extended to cover non-uniform

discretizations in each dimension. Starting from an initially coarse discretization, the multivariate grid is gradually refined using sensitivity analysis. An appropriate level of refinement is identified by the L-curve criterion or split-sample validation, capable to resolve functional details while suppressing measurement noise. It is shown that the algorithm allows reliable identification of the best possible functional approximation.

11:00 - 11:20
Iterative Identification for Robust Bioreactor Control Design
This paper presents a procedure based upon the works of de Callafon (1998) and Tay et al. (1998). This procedure has the ability to handle both unstable plants and controllers. The procedure performs of an iterative minimization of the performance cost and consists of an identification step and a controller design step. The identification procedure facilitates identification of a model set describing the unknown but closed-loop stable system based on a nominal model and an allowable model perturbation. The model set is based on a dual-Youla-Kuęra parameterization and consists of a nominal model of limited complexity and a model error for which an upper bound is estimated. The controller design step facilitates a design method for an enhanced robust controller based on the DK-iteration, which is an H_∞ optimization problem, for which commercially available software exists.

11:20 - 11:40
Modified subspace-ID based design of a long-term correlation model for inferential control
In a chemical plant involving a series of processing units, it is beneficial to have a model that can accurately forecast the behavior of downstream variables based on upstream measurements. Such a model can be useful in feedforward and inferential control of the downstream variables to compensate for various upstream disturbances. However, creating such a dynamic model can be very difficult. The conventional multivariable identification approach based on minimizing single-step-ahead prediction error, can result in models leading to poor prediction and control in the described context. To alleviate this difficulty, we propose a modification to the conventional subspace identification method geared towards accurate k-step-ahead prediction, where k is a number chosen according to the estimated dead time. It is shown that the modified subspace identification method can be used in conjunction with the k-step prediction error minimization (PEM). Using an illustrative examples involving six mixing units with a recycle loop, we demonstrate the improvement that is possible from adopting the suggested modification.

11:40 - 12:00
Identification and model predictive control of an industrial glass-feeder
In this paper we discuss the use of reduced simulation models derived from first principles in the design of a model predictive controller of an industrial feeder. A linear reduced model is derived from a computational fluid dynamics model (CFD) using proper orthogonal decompositions (POD). This model is used in a model predictive controller to control the temperature as function of time and position in the feeder. It turns out that a relatively simple model captures the behaviour of the entire temperature profile quite well and that it is suitable for a well performing model predictive controller.

FrA06 Ruys Zaal
Application of system identification
Chair: H. Kimura Co-chair: J. Bokor

10:00 - 10:20
Computationally efficient estimation of wave propagation functions of viscoelastic materials
Least squares based nonparametric estimation of the wave propagation functions of a viscoelastic material is considered in this paper. Widely used nonlinear least squares based algorithms are often computationally expensive and suffer from numerical problems. In this paper we propose a class of subspace estimators which assume equidistant sensor configuration. The proposed estimator is computationally economical and numerically robust. Analytical expressions for the estimation accuracy have been derived. It is also shown that the subspace estimator achieves optimal accuracy under optimal weighting. The algorithm is employed on real experimental data.

10:20 - 10:40
Identification of underlying intensity processes of interference patterns
Time-correlated single photon counting is a technique to record low level light signals with very high time resolution. In the paper we first describe the experimental apparatus and briefly outline the statistical interpretation of the measurement series. After, we propose a stochastic model for the formulation of interference patterns based on doubly stochastic autoregressive model class. Finally, we present some results of the identification of realistic data.

10:40 - 11:00
Fractional multimodels - Application to heat transfer modeling
This paper deals with identification of non linear systems using non linear fractional differentiation multimodels.

All sub-models are described by fractional differentiation transfer functions. Performance of the newly proposed class of models is illustrated on a heat transfer process near a phase change temperature. Copyright © 2003 IFAC.

11:00 - 11:20
A recursive algorithm for estimating parameters in a one dimensional diffusion system
A one-dimensional heat diffusion system with an associated partial differential equation (PDE) model is considered. The PDE model involves unknown parameters, which need to be estimated to model the physical diffusion system. A recursive algorithm in the frequency domain is deviced for an efficient estimation of the parameters involved.

11:20 - 11:40
Regularization method in infrared image processing
Infrared images often present distortions induced by the measurement system. Thus, image processing is a vital part of infrared measurements. A distortion model based on a convolution product is presented. Image restoration is an ill-posed problem and its solution can be obtained using regularization methods. In this paper, image restoration is performed using a variation of Tikhonov regularization that makes use of the particular form of the convolution kernel matrix, which is built as a block-circulant matrix that admits a diagonal form in the two-dimensional Fourier space. The restoration procedure is used to restore a knife-edge infrared source image.

11:40 - 12:00
Filtering of stochastic volatility model
We study the filtering problem for the stochastic volatility model of Heston by using the nonlinear estimation theory. To solve the estimation problem for the stochastic volatility process, we use the random time change method. The derived basic equation for the filtering is the so-called Zakai equation and its numerically realized algorithm is proposed with the aid of the splitting-up method. Some numerical simulation studies are demonstrated to show the advantage of the proposed method.

FrA07	Van Ryckevorsel Zaal
Optimal filtering	
Chair: A. Lindquist	Co-chair: Q. Zhang

10:00 - 10:20
State estimation for nonlinear continuous systems in a bounded-error context
The aim of this paper is to study state estimation for nonlinear continuous-time systems in a bounded-error context. A causal estimator based on prediction - correction approach is proposed. The prediction part consists on a validated integration of an Initial Value Problem for an Ordinary Differential Equation. The correction part uses set inversion. The main tools used are Taylor models and interval analysis. The derived estimator is illustrated on an example.

10:20 - 10:40
Multigrid design in point-mass approach to nonlinear state estimation
Numerical solution of the Bayesian recursive relations in nonlinear state estimation by the point-mass approach is treated. The stress is laid on the new grid design for multimodal probability density functions of state. A bank of grids is used for representation of the state space to cover different modes of the density. Splitting and merging techniques are designed for managing the bank of grids. A numerical example is presented to illustrate the grid splitting technique.

10:40 - 11:00
An efficient nonlinear adaptive observer with global convergence
A nonlinear global exponential adaptive observer is proposed in this paper for joint state-parameter estimation. It is conceptually simple and numerically efficient. Its design is based on the combination of a nonlinear high gain observer and a linear adaptive observer. The considered class of systems is truly nonlinear in the sense that they cannot be linearized by coordinate change and output injection.

11:00 - 11:20
Adaptive observer for discrete time linear time varying systems
For joint state-parameter estimation in discrete time stochastic multiple-input multiple-output linear time varying systems, an efficient adaptive observer is proposed in this paper. In the noise-free case, the global exponential convergence of the adaptive observer is first established. It is then proved that, in the noise-corrupted case, the state and parameter estimation errors remain bounded if the noises are bounded, and moreover, the estimation errors converge in the mean to zero if the noises have zero means.

11:20 - 11:40
Linear dynamic filtering with noisy input and output
We establish the equivalence between the optimal least-squares state estimator for a linear time-invariant dynamic system with noise corrupted input and output, and an appropriately modified Kalman filter. The approach used is algebraic and the result shows that the noisy

input/output filtering problem is not fundamentally different from the classical Kalman filtering problem. The result is illustrated with a simulation example.

11:40 - 12:00
The p-norm generalization of the LMS algorithm for adaptive filtering
Recently much work has been done analyzing online machine learning algorithms in a worst case setting, where no probabilistic assumptions are made about the data. This is analogous to the H_∞ setting used in adaptive linear filtering. We employ methods based on Bregman divergences, commonly used in machine learning, to motivate a generalization of the the Least Mean Squared (LMS) algorithm. The loss bounds for these so-called p-norm algorithms can be significantly better if a large proportion of the input variables are irrelevant, i.e., if the weight vector we are trying to learn is sparse.

SP-5 Willem Burger Zaal
Semi-plenary lecture
Chair: M. Gevers

13:30 - 14:30
Identification of linear systems with nonlinear distortions
In this paper the impact of nonlinear distortions on the linear system identification framework is studied. In the first part, the nonlinear system is replaced by a linear model plus a nonlinear noise source. The properties of this representation are studied. Next, a method to detect, qualify and quantify the nonlinear distortions is presented. In the second part, the (non)-parametric identification of the best linear approximation is studied. In the last part, the linear modelling approach is extended towards nonlinear modelling. A fast approximate nonlinear modelling framework is set up that is a natural extension of the linear framework, and bridged the gap between the linear and the nonlinear identification approaches.

SP-6 Fortis Bank Zaal
Semi-plenary lecture
Chair: M. Deistler

13:30 - 14:30
Some problems in statistical inference following model selection
Statistical inference following a preliminary model selection step is common practice in most applied statistical analyses. In practice, statistical inference is frequently conducted in a classical manner thereby ignoring the model selection phase. Not surprisingly, this leads to invalid procedures. We review some recent attempts towards a coherent theory for statistical inference in the presence of model selection.

FrP01 Willem Burger Zaal
User choices in subspace identification
Chair: D. Bauer Co-chair: B. De Moor

15:00 - 15:20
Choosing integer parameters in subspace methods: a survey on asymptotic results
When using subspace methods, the user has to specify a number of integer parameters such as the order of the system. This paper surveys the literature on results relating to strategies for these choices and the consequences thereof. All results are asymptotic in nature and relate either to consistency questions or to the asymptotic covariance matrix of the estimated systems.

15:20 - 15:40
Asymptotic variances of subspace identification by data orthogonalization and model decoupling
Subspace estimation methods based on a block-decoupled parametrization and orthogonal decomposition of the input-output data into a "deterministic" and a "stochastic" component, have been analyzed in a series of articles by the authors of this paper. In this paper we compare the asymptotic variances of the parameter estimates of the method based on the block-decoupled parametrization with those of traditional joint-model based methods. We show that, provided a suitable choice of weights is used, they perform better than the traditional methods. The improvement is more substantial in the circumstance of nearly parallel regressors.

15:40 - 16:00
A finite sample comparison of automatic model selection methods
Three automatic model selection procedures are compared: The first one is the PEM subroutine implemented in the MATLAB toolbox system identification. The second procedure is based on the CCA subspace procedure. The third procedure finally is the ARMAsel procedure. The three procedures have been studied using a simulation experiment. The accuracy of the subspace algorithms depends heavily on the choice of the integers f and p. Simple strategies for choosing f and p can yield very inaccurate models. For one simulation example, it is shown that a more complex strategy can yield a more accurate result. The ARMAsel algorithm provided an accurate model for all processes that have been considered.

16:00 - 16:20
On the number of rows and columns in subspace identification methods
A survey is presented on the role of the number of rows and columns in subspace identification algorithms, with respect to system theoretic and geometrical issues and statistical properties of the estimates.

16:20 - 16:40
Aspects and experiences of user choices in subspace identification methods
Subspace identification methods, such as N4SID, MOESP, CVA, etc. have proven to be very successful for identification of multivariable, linear dynamic systems. These methods are associated with a number of design variables, or user choices. These include prediction horizons, weighting matrices and ways to perform the estimation. It is known that these choices may have a substantial influence on the model quality, at the same time as there is no comprehensive theory for rational decision making. In this contribution we study certain aspects of the choices, in particular their influence on both bias and variance. We also illustrate some aspects using a larger example, the Tennessee-Eastman identification challenge.

16:40 - 17:00
Inferring multivariable delay and seasonal structure for subspace modeling
ARX models are used for modeling the multivariable delay structure of a system. A fast order-recursive algorithm is used for factorization of a generalized inverse of a covariance matrix that may be highly illconditioned or singular. The Akaike information criterion and generalized likelihood ratio tests are used to decide on the most likely multivariable delay structure. Additional synthetic inputs to the system can then be defined if necessary as delayed versions of the system inputs and outputs. Subspace methods such as canonical variate analysis are used to identify a state space model. As a result, the state order and total number of estimated parameters of the identified system can be considerably decreased giving reduced parameter estimation and prediction errors.

FrP02 Fortis Bank Zaal
Identif. of static and dynamical nonlinear systems
Chair: M. Milanese Co-chair: E. Walter

15:00 - 15:20
Mathematical results concerning kernel techniques
Black–box models based on kernels K are written as mappings of the form $F_\alpha(x) = \sum_j \alpha_j K(x_j, x)$ that are intended to reproduce observational input/output data pairs (x_j, y_j) in the sense that $F(x_j) \approx y_j$. Such functions have been studied in a general mathematical context for quite some time, and this contribution reviews part of the known facts and provides links to a subset of the background literature. Special emphasis is given to questions of optimality and complexity within the context of black-box modelling.

15:20 - 15:40
Multi-output support vector regression
Support vector regression builds a model of a process that depends on a set of factors. It traditionally considers one output at a time, which means that advantage cannot be taken of the correlations that may exist between outputs. The purpose of this paper is to show how the body of knowledge accumulated by geostatisticians on Kriging and its extensions over the last 40 years can help extend support vector regression to the multi-output case and provides guidance for the choice of a suitable kernel for a given application, a recurrent, fundamental and largely open question.

15:40 - 16:00
Set membership identification of piecewise affine models
This paper addresses the problem of identification of piecewise affine (PWA) models from input-output data. Given a bound on the prediction error, the proposed PWA identification algorithm is initialized by exploiting a technique for partitioning an infeasible system of linear inequalities into a (possibly minimum) number of feasible subsystems, which provides both an initial clustering of the datapoints and a guess of the number of required submodels. A refinement procedure is then applied in order to improve both data classification and parameter estimation. The partition of the PWA map is finally estimated by considering multicategory classification techniques.

16:00 - 16:20
Piecewise-linear output-error models
Piecewise-linear systems in input/output form can have different switching schemes. In this paper two categories, instant and delayed switching, are analysed. Even though a general piecewise-linear state-space model cannot be converted into input/output form, it is shown that it is possible to find state-space models representing instant as well as delayed switching. In addition, a prediction error minimisation (PEM) method for piecewise-linear output error predictors is derived and it is concluded that the instant-switching model candidate is not necessarily the most suitable for the parameter estimation procedure.

16:20 - 16:40
CMAC with linear functional weights

Cerebellar model articulation controller (CMAC) has been widely applied to modelling and control due to its attractive features such as fast training speed and parsimonious structure. This paper modifies the CMAC model by replacing its constant weights by linear functional weights, aiming not only to improve its efficiency in modelling smooth nonlinear processes but also to increase its interpretability and applicability. Following the reformulation of the CMAC model and its learning process, experimental results are given and analysed. The approximation ability and interpretability of the modified CMAC is especially investigated.

16:40 - 17:00
Optimal expansions of discrete-time Volterra models using Laguerre functions
This paper is concerned with the optimization of Laguerre bases for the orthonormal series expansion of discrete-time Volterra models. Fu and Dumont (1993) approached this problem in the context of linear systems by minimizing an upper bound for the error resulting from the truncated Laguerre expansion of impulse response models, which are equivalent to first-order Volterra models. The present paper generalizes the work mentioned above to Volterra models of any order. The main result is the derivation of analytic strict global solutions for the optimal expansion of the Volterra kernels either using an independent Laguerre basis for each kernel or using a common basis for all the kernels.

FrP03 Van Beuningen Zaal
Identification and model validation
Chair: R. Bitmead Co-chair: X. Bombois

15:00 - 15:20
Parameter variance of estimated transfer functions in the presence of undermodeling
We study the effect of undermodeling on the parameter variance for prediction error time-domain identification with linear model structures. We consider LTI SISO systems in discrete time. We examine the asymptotic variance for large number of data and establish a sufficient condition under which it is a function of the input power spectrum only. For this case we deliver exact expressions. We show that for a stochastic input the undermodeling contributes to the parameter variance due to the correlation between the prediction errors and its gradients. Further we investigate the parameter variance under the assumptions of stochastic embedding.

15:20 - 15:40
Reliable parameter estimation in presence of uncertain variables that are not estimated
In a bounded-error context, reliable set-inversion algorithms such as Sivia provide guaranteed estimates of the set of all the parameters deemed compatible with the selected model and the collected data, assuming that all the uncertain variables of the model are those to be estimated. In this paper we propose a new approach to estimate the parameters of interest assuming that there are other parameters that will not be estimated. This leads to the idea of set projection. A new algorithm for set projection is proposed and applied to the estimation of thermal quantities via a new experimental device to be calibrated.

15:40 - 16:00
Validation test based parameter uncertainty versus analysis-based confidence bounds
Standard Instrumental Variable system identification methods provide for a particular parameter confidence region under a Gaussian distribution. Alternatively, a parameter bounding technique based on a set of constraints on a cross-correlation function directly provides for a parameter uncertainty set. This paper relates the two uncertainty regions under the standard assumption of additive noise on the measured data, both in case undermodelling is considered and in case it is not. The ellipsoidal region associated with the IV estimation technique is strongly related to the polytopic region induced by the cross-correlation constraints as both techniques are based on the same set of regressors. However, they differ due to the fact that the former incorporates a covariance between errors, while the latter is limited to the variances of the errors only. The results are also discussed in terms of the standard model validation which is identical in nature to the cross-correlation parameter bounding technique.

16:00 - 16:20
Empirical estimation of parameter distributions in system identification
The distribution of parameter estimates from a finite data record is of concern for assessing the confidence in the resulting estimate. Our interest is in the development of nonlinear dynamical models from experimental data and the problem which arises in associating a degree of confidence with the estimated parameter values. If the distribution of the estimates were known then the variance might provide a sensible measure of confidence. Accordingly we consider here procedures for using a single data record to generate a distribution of parameter estimates.

16:20 - 16:40
Uncertainty of transfer function modeling using prior estimated noise models
Assuming "small" model errors (unmodelled dynamics

and/or nonlinear distortions) and "large" signal-to-noise ratios we derive in this paper explicit expressions for the covariance matrix of a frequency domain estimator using prior estimated noise models. These analytic expressions (i) give a clear insight in the behaviour of the covariance matrix as a function of the signal-to-noise ratio, the plant model errors (unmodelled dynamics and the nonlinear distortions), and (ii) allow to predict accurately the order of magnitude of the actual uncertainty of the estimates. The link with the classical prediction error approach is also established.

16:40 - 17:00
The size of the membership-set in a probabilistic framework
In this paper, we study the size of the membership-set for system identification in a probabilistic framework. Assuming that the regressors are persistently exciting and the measurement noise is a sequence of independent, identically distributed bounded random variables, tight lower and upper non-asymptotic probability bounds on the membership-set diameter are obtained. These bounds are used in the computation of the confidence intervals for interpolatory estimators including the Chebyshev center, the analytic center, the constrained least-squares estimator (projection estimator), and the minmax estimator.

FrP04	Schadee Zaal
Model approximation	
Chair: J. Bokor	Co-chair: A. Vicino

15:00 - 15:20
Connections between L_2-model reduction and balanced truncation
In this paper we investigate the connection between model reduction by balanced truncation and by L_2 reduction. We show that locally, i.e., close to the set of lower order systems, balanced truncation and (unweighted) L_2 model reduction produce models that are almost identical. This implies that high order estimated models can be reduced by either L_2 reduction or balanced truncation, both methods giving a low order model with the same asymptotic varaiance, if the true data generating model is in the class of low order models.

15:20 - 15:40
Recursive exact H_∞ identification from impulse response measurements
We study the H_∞ partial realization problem from a behavioral point of view; we give necessary and sufficient conditions for solvability, and a characterization of all solutions. Instrumental in such analysis is the notion of time- and space-symmetrization of the data, which allows to transform the realization problem with metric- and stability constraints into an unconstrained behavioral modeling one.

15:40 - 16:00
Properties of optimal solutions in ℓ_1 identification problem
This paper presents primal-dual formulation of a convex optimization problem related to ℓ_1 interpolatory-projection algorithm. The use of duality theory permits to obtain information on the structure of optimal solutions for ℓ_1 identification problem and gives extra analytical tools for the analysis of identification error and the estimation of a lowerbound for noise amplitude. The proposed analysis applies also to the case of ℓ_1 model validation problem and characterizes properties of uncertainty block and disturbance signal. A simulation example illustrates the results.

16:00 - 16:20
Optimal approximation and model quality estimation for nonlinear systems
An optimal squared error based approximation problem for static polynomial models is solved. This problem is similar to an optimal approximation problem for linear time-invariant (LTI) models. Corresponding absolute error based approximation problems are also studied. Model quality estimation is typically based on sample variance analysis of the squared error criterion. Error squaring, however, results in increased sample variability especially for error and noise distributions with heavy tails. Error analysis based on the use of the sum of the absolute values of the errors has advantages in such situations. Two model quality estimation methods for static polynomial models are suggested based on similar techniques for LTI models.

16:20 - 16:40
Linear models of nonlinear FIR systems with Gaussian inputs
We present a result that can be viewed as a generalization of Bussgang's classical theorem about static nonlinearities with Gaussian inputs. This result is used to characterize the best linear approximation of a nonlinear finite impulse response (NFIR) system with a Gaussian input. The best linear approximation is here defined as the causal and stable LTI system that minimizes the mean-square error. Furthermore, we discuss how this characterization can be used for structure identification and for identification of generalized Hammerstein and Wiener systems.

16:40 - 17:00
An algebraic method for system reduction of stationary

Gaussian systems
System identification for a particular approach reduces to system reduction, determining for a system with a high state-space dimension a system of low state-space dimension. For Gaussian systems the problem of system reduction is considered with the divergence rate criterion. The divergence or Kullback-Leibler pseudo-distance corresponds to the expected value of the negative natural logarithm of the likelihood function. System reduction for Gaussian systems is thus a certainty equivalent way of maximum likelihood identification. An algebraic method is proposed for system reduction. The results are a theorem that this problem reduces to an infimization problem for a rational function for which programs are available and a procedure for computing the best approximant w.r.t. the divergence rate criterion. As illustration two examples of system reduction are presented.

FrP05 Hudig Zaal
Parameter estimation and convergence
Chair: K. Kumamaru Co-chair: M. Jansson

15:00 - 15:20
Separable least squares data driven local coordinates
In this paper, the parametrization of state-space systems by data driven local coordinates as introduced by (McKelvey et al., 2003) is modified. This modification leads to an alternative analogous parametrization which can be used for a suitable concentrated likelihood-type criterion function, where the concentration step can be done by a generalized least squares step. An obvious consequence is the reduced number of parameters resulting in less computational burden, but, of course, the criterion function itself is changed by the concentration step. The resulting new parametrization is called slsDDLC (for separable least squares data driven local coordinates), and its topological and geometrical properties are investigated in detail.

15:20 - 15:40
Optimal Yule Walker method for pole estimation of ARMA signals
In this paper we reconsider the analysis and implementation of weighted Yule Walker or instrumental variable methods for estimating the AR parameters of ARMA signals. We present a simplified analysis and propose a new estimate of the optimal weighting matrix leading to more accurate parameter estimates compared to previous approaches.

15:40 - 16:00
Initializing parameter estimation algorithms under scarce measurements
In this paper, the problem of initializing identification algorithms with non-regular sampling is addressed. When a recursive identification algorithm is used to estimate the parameters, the convergence of the parameters is affected by the existence of wrong attractors. The initialization of the algorithm is studied in different situations. First, the algorithm starts without past information about the model parameters. An interpolation method is used to estimate the missing data. If a change of the control action updating rate is planned, the new model parameters are initialized by estimations obtained either by interpolation (if the periods are multiple) or by approximate d modelling using the measurements taken under current operating conditions. Some examples illustrate the attractors avoidance and some conclusions are drafted.

16:00 - 16:20
Robust parameter estimation for uncertain gross-error models
Recognizing that many assumptions commonly made in science and engineering problems are at most approximations to reality and they do not always hold unfortunately, the concept of robustness has been attracted and robust procedures have been developed to cover this. One of the most important ideas on this direction is Huber's M-estimator, which minimizes the maximum degradation of performance possible for an ε-deviation from the assumption. This idea, however, is not applicable in practice since the exact value of the gross error ε is not known. In this paper, an M-estimator applicable in such situations is derived with an illustrating numerical example.

16:20 - 16:40
Limit covariance of estimation error for quasistationary functions
The linear parameter estimation problem is studied without assumption on the existence of probability measure. Instead, averaged second order statistics are assumed to converge. The limit matrix of the estimation error covariances is computed and an upper bound for the rate of the parameter estimates convergence is obtained.

FrP06 Ruys Zaal
Identification of hydrologic systems
Chair: J. Lee Co-chair: K.J. Keesman

15:00 - 15:20
Structural identification of multivariate neural networks for rainfall runoff modeling
Designing neural networks predictors by pruning instead of trial and errors significantly reduces the amount of guesswork required to select the optimal architecture.

Furthermore, the obtained model is partially connected and hence very parsimonious in the number of parameters, leading to relevant operational advantages in the hydrological forecast practice: in fact, removing from the model redundant measurement stations results in an improved forecast availability and in the reduction of the costs of the data acquisition system. We exploited pruning algorithms to design the network, providing also a better basin state representation in comparison to existing schemes. Thanks to this modelling improvement, the obtained pruned networks overperform some fully connected ones published in previous works on the same basins, while requiring a significantly smaller set of measurement stations.

15:20 - 15:40
Parameter and state regularization for prediction of distributed hydrologic systems
State and parameter regularization schemes are applied to a distributed hydrologic system for discharge prediction at different locations in the catchment. Experimental field data from a 200 ha catchment in Costa Rica have been used to evaluate the prediction method. It appears that, in general, state regularization leads to better predictions at finer resolutions than parameter regularization, and parameter regularization to better performance at coarse resolutions.

15:40 - 16:00
Time-delay estimation of a managed river reach from supervisory data
The problem addressed in this article is the estimation of the time–delay between the inflow rate and the downstream water level of a managed river reach from data collected in imposed experimental conditions. The modelling of the managed river reach shows that the feedforward control performed by the operator “hides” the reach time-delay in the transfer function of the closed–loop system. Therefore, most of the classical time-delay estimation methods are inappropriate. A time-delay estimation approach devoted to managed rivers is proposed, in which a time–day description, composed of estimated impulse responses, allows to clearly observe the evolution of the time-delays over one year. In practice, this approach is particularly interesting since it is based on production data and hence does not disturb the daily management of the process by any experimental protocol. Moreover, the use of the suggested approach does not require any synthesis parameter.

16:00 - 16:20
Geohydrological application of a nonlinear physically based time series model
This paper presents a physically based time series model that relates groundwater level fluctuations to precipitation and evapotranspiration. The model is based on the nonlinear relation between the degree of water saturation of the subsoil and the groundwater recharge. The model is written in state-space form, while the extended Kalman filter is used to estimate the state equation. An example application shows that the model performs very well and that the addition of physical knowledge is a valuable extension to standard linear transfer function-noise models.

16:20 - 16:40
On physical and data driven modelling of irrigation channels
In this paper we compare the St. Venant equations against real data in order to examine their accuracy and capability to describe the relevant dynamics of an irrigation channel. The St. Venant equations are simulated using the Preissmann scheme, and the simulated and real measured water levels are compared. In addition, a comparison with system identification models is also performed in order to examine which model is more suitable for control design and prediction purposes. The results show that the St. Venant equations can adequately capture the dynamics of the real channels. However, system identification methods are as accurate as the St. Venant equations and are preferred over the St. Venant models for control and prediction purposes since they are much simpler to use.

16:40 - 17:00
Identification and on-line estimation of the unsaturated hydraulic conductivity in presence of forced air convection based on a distributed-parameter model
The goal of this study was to calibrate a numerical model aimed at describing simultaneous air and water flow in soil and, to build a model-based estimator of the unsaturated hydraulic conductivity. The experimental approach consisted of infiltration tests in a 1.5m high column of loamy sand. The numerical model correctly described water percolation without air convection, provided parameter adjustment of the predictive model of the unsaturated hydraulic conductivity was performed. An observer-based estimator was able to estimate on-line the hydraulic conductivity in steady-state but faced oscillation problems in unsteady-state. The difficulty in implementing the software-sensor can be explained by the strong nonlinearity of the dynamical model

FrP07 Van Ryckevorsel Zaal
Errors in variable identification
Chair: P. Guillaume Co-chair: M. Verhaegen

15:00 - 15:20

Confidence regions for non-parametric errors-in- variables estimates

We construct a confidence region in the complex plane for the pointwise frequency response measurement of a plant subject to periodic excitation with noise on both the input and the output. The region is constructed via the Minkowski division of circular confidence regions for the output and input spectra. While correct, the resulting confidence region is conservative.

15:20 - 15:40

A new criterion in EIV identification and filtering applications

One of the advantages of errors-in-variables (EIV) models consists in the symmetrical description of all variables. These models, on the other hand, are characterized by more complex identification schemes that require,when applied to real data, the definition of suitable criteria. This paper introduces a new efficient and robust criterion based on covariance-matching properties and tests its performance by means of a Monte Carlo simulation concerning also the application of the identified models in EIV filtering.

15:40 - 16:00

Strongly consistent parameter estimate for error-in- variables models

The paper considers the SISO error-in-variables systems. It is assumed that the input of the system is a stable ARMA process and that the driven noise of the ARMA process and the observation noise are jointly Gaussian. Under a factorization assumption the two-dimensional observation is presented by an ARMA process whose parameters are recursively estimated by an overparameterization technique. It is proved that the estimate for parameters contained in the ARMA system including those in $A(z)$ and $B(z)$ is strongly consistent, and the convergence rate is derived as well.

16:00 - 16:20

Ellipsoid set refinements by simultaneous use of multiple hyperplane cuts

This paper derives a mathematical formulation for fitting a new, smaller volume ellipsoid to the intersection an existing ellipsoid and multiple hyperstrips . The prevailing method for solving this problem involves sequential refinement of ellipsoids as hyperstrips are considered one at a time. The simultaneous use of multiple hyperstrips results in a better fit to the underlying polytope than that achieved by sequential refinement. The problem arises in numerous control and signal processing problems - in particular the broad class of ellipsoid bounding algorithms used for identification and classification.

16:20 - 16:40

Identification methods in a unified framework

The paper derives a framework suitable to discuss the errors-in-variables (EIV) and the maximum likelihood (ML) estimation algorithms to estimate linear system parameters in a unified way. Using the capability of the unified approach a new parameter estimation algorithm is presented offering flexibility to ensure acceptable variance in the estimated parameters. The developed algorithm is based on the application of Hankel matrices of variable size and can be considered as an extended version of the EIV method.

Wednesday, August 27

08:20 – 09:30	Willem Burgerzaal Opening Plenary: *From experiments to closed-loop control*						
09:30 – 10:00	coffee break						
	Willem Burgerzaal	Fortis Bankzaal	Van Beuningenzaal	Schadeezaal	Hudigzaal	Ruyszaal	Van Ryckevorselzaal
10:00 – 12:00	WeA01 *Identification for control*	WeA02 *Nonlinear identification*	WeA03 *Identification of MIMO communication channels*	WeA04 *Estimation in physical and medical systems*	WeA05 *Stochastic systems*	WeA06 *Applications of system identification*	WeA07 *Financial econometrics*
12:00 – 13:30	lunch break						
13:30 – 14:30	Semi-plenary: Willem Burgerzaal *Snippets of identification theory in computer vision*			Semi-plenary: Fortis Bankzaal *Interval analysis for guaranteed nonlinear parameter est.*			
14:30 – 16:00	WeM01 *Identification in automotive systems*	WeM02 *Sensor identification and monitoring*	WeM03 *Identification of nonlinear systems 1*	WeM04 *Mechanical and aerospace applications*	WeM05 *Closed-loop identification*	WeM06 *Industrial application of identification*	WeM07 *Process control systems*
15:30 – 16:00	coffee break						
16:00 – 18:00	WeP01 *Closed loop and performance issues*	WeP02 *Reproducing kernels 1*	WeP03 *Blind estimation and equalization*	WeP04 *Continuous time identification*	WeP05 *Input design*	WeP06 *Identification for flight test exploration*	WeP07 *Identifiability*
18:30 – 20:00	Reception at City Hall						

Thursday, August 28

08:30 – 09:30	Plenary: Willem Burgerzaal *System identification for structural dynamics and vibroacoustics design engineering*						
09:30 – 10:00	coffee break						
	Willem Burgerzaal	Fortis Bankzaal	Van Beuningenzaal	Schadee-zaal	Hudigzaal	Ruyszaal	Van Ryckevorselzaal
10:00 – 12:00	ThA01 *Selected topics in identification*	ThA02 *Reproducing kernels 2*	ThA03 *Identification of nonlinear block models*	ThA04 *New results in subspace identification*	ThA05 *Identification for process control: input design*	ThA06 *Identification of mechanical systems*	ThA07 *Software session 1*
12:00 – 13:30	lunch break						
13:30 – 14:30	Semi-plenary: Willem Burgerzaal *Data-based methods in process control*				Semi-plenary: Fortis Bankzaal *Subspace algorithms*		
14:30 – 16:00	ThM01 *Filtering and estimation*	ThM02 *Diagnosis, detection and tracking*	ThM03 *Identification of nonlinear systems 2*	ThM04 *Identification methods*	ThM05 *Controller tuning and identification*	ThM06 *Applications of identification*	ThM07 *Bioengineering systems*
15:30 – 16:00	coffee break						
16:00 – 18:00	ThP01 *Particle filters*	ThP02 *Wiener Hammerstein models*	ThP03 *Identification using basis functions*	ThP04 *Subspace identification and applications*	ThP05 *Identification in large scale systems*	ThP06 *Industrial applications of identification*	ThP07 *Software session 2*
19:00 – 23:00	Conference banquet						

Friday, August 29

08:30 – 09:30	Plenary: Willem Burgerzaal *Prediction algorithms: Complexity, concentration and convexity*						
09:30 – 10:00	coffee break						
	Willem Burgerzaal	Fortis Bankzaal	Van Beuningenzaal	Schadee-zaal	Hudigzaal	Ruyszaal	Van Ryckevorselzaal
10:00 – 12:00	FrA01 *Identification and physical modeling*	FrA02 *Identification of nonlinear systems*	FrA03 *Education and training*	FrA04 *Recursive and subspace identification*	FrA05 *Process control: theory*	FrA06 *Application of system identification*	FrA07 *Optimal filtering*
12:00 – 13:30	lunch break						
13:30 – 14:30	Semi-plenary: Willem Burgerzaal *Identification of lin. systems with nonlin. distortions*				Semi-plenary: Fortis Bankzaal *Some problems in statistical inference*		
14:30 – 15:00	coffee break						
15:00 – 17:00	FrP01 *User choices in subspace identification*	FrP02 *Identification of static and dynamical nonlinear systems*	FrP03 *Identification and model validation*	FrP04 *Model approximation*	FrP05 *Parameter estimation and convergence*	FrP06 *Identification of hydrologic systems*	FrP07 *Errors in variable identification*

Floor plans

Floor plan of ground level

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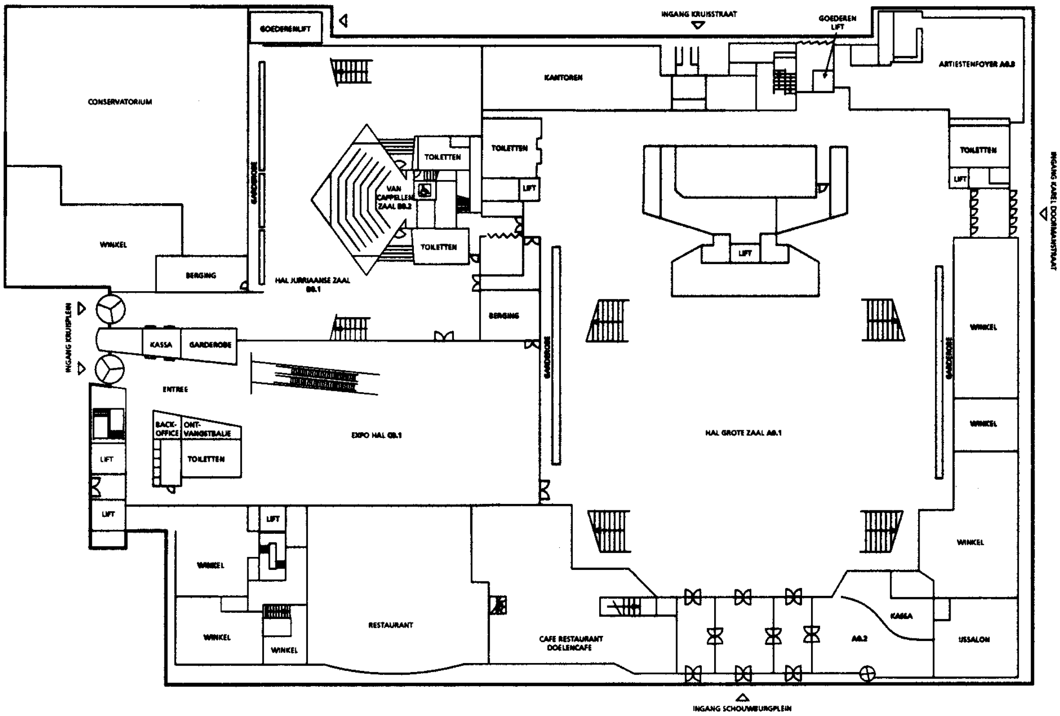
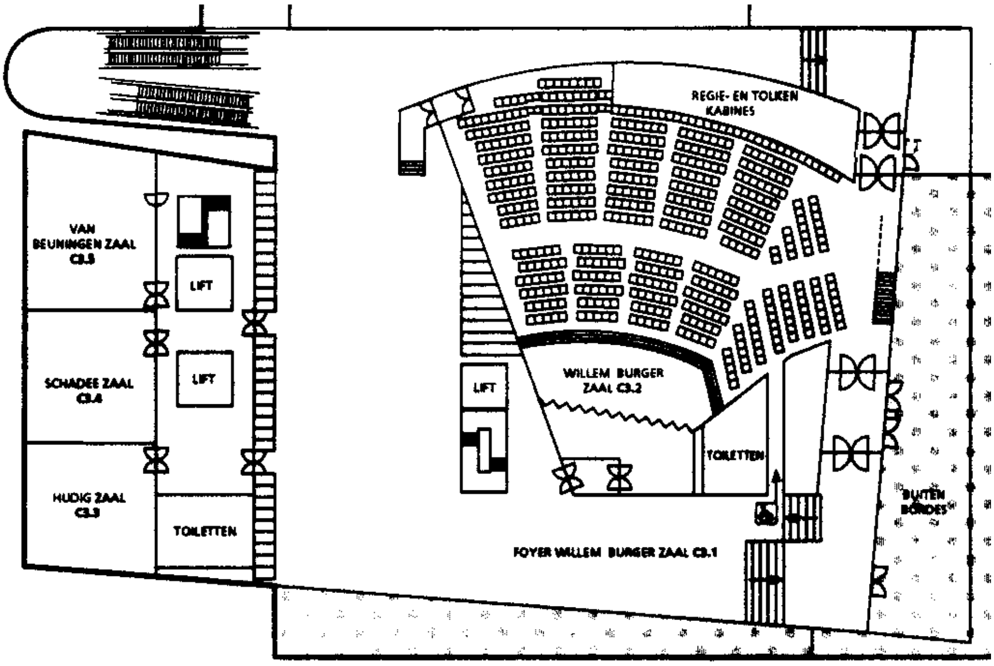


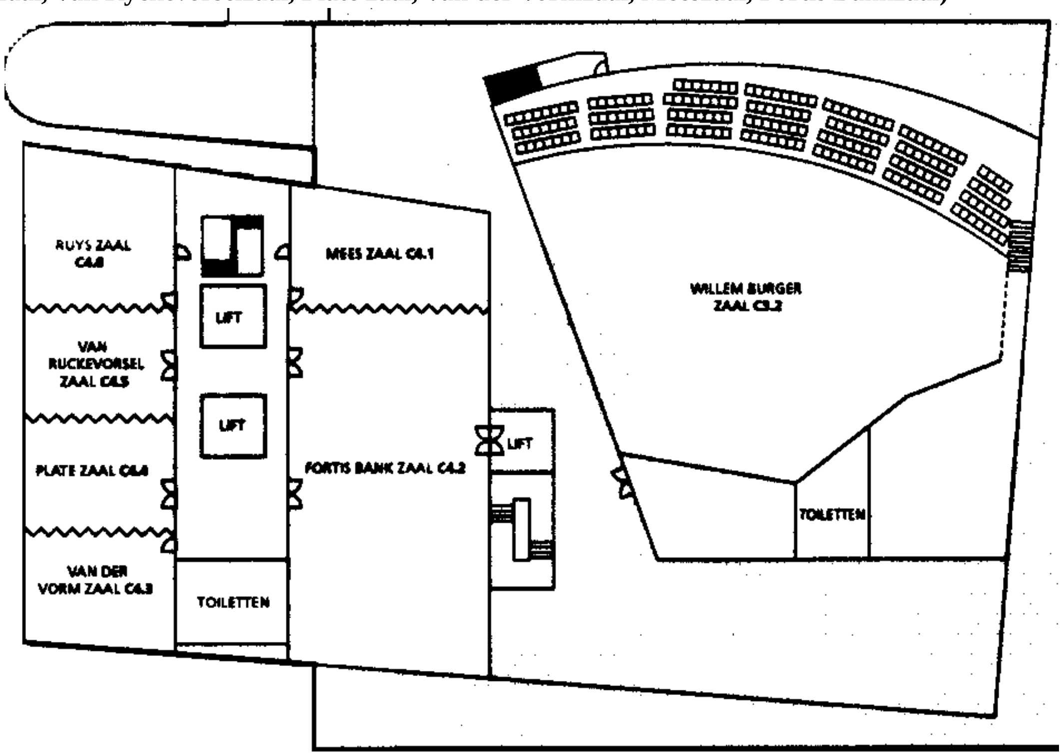
Floor plan of third floor

(Willem Burgerzaal, Van Beuningen zaal, Schadee zaal, Hudig zaal)



Floor plan of fourth floor

(Ruyszaal, Van Ryckevorselzaal, Plate zaal, Van der Vormzaal, Meeszaal, Fortis Bankzaal)



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