IFAC Newsletter
Issue 3/02, June 2002

Contents:

IFAC Administrative Meetings in Barcelona, Spain
in conjunction with the IFAC World Congress

As every three years, the IFAC World Congress is also the time, when the IFAC General Assembly meets to discuss the development of the Federation and to elect a new group of officials to conduct business of IFAC in the coming three-year period.

This time, the XVth World Congress in Barcelona will be the setting for the administrative meetings of IFAC to take place. Technical Committees, Coordinating Committees, Executive Committees, the Technical Board and Executive Board as well as the Council will hold their meetings in the composition of the preceding triennium, and, following the Elections at the General Assembly, the Incoming Boards and Council will discuss the future development of the Federation on the basis of past experience and future orientation.

A lot of exciting developments have taken place and will occur. For this purpose, the Technical Board of IFAC is continuously monitoring if the activities of IFAC are up-to-date, which can lead to the termination of Technical Committees and sometimes to the formation of new ones. Thus, in the past triennium, the TC on Mechatronics was formed and several subjects will be taken up by TCs about to be founded. All this has led to a reorganization of the IFAC Technical Board whose outlines were already decided at the last meeting of the Council in 2001. Exciting developments have also taken place in the area of electronic communication. Most of the work of IFAC is now done electronically, which considerably shortens lead times as well as response times. Also the IFAC homepage was redesigned and will be further developed, with interactive features, access to the IFAC Newsletter and many links, among others, to Elsevier, the IFAC publisher.

A lot of thought is also given to the structure of IFAC, and all guidelines as well as the Constitution and By-Laws are regularly scrutinized to see if they meet contemporary requirements. Thus, for instance, the Procedure for the Organization of Technical Meetings has been updated. The IFAC Constitution proves to be a very important tool in the operation of IFAC and it is very rare that amendments are needed. One such amendment was made in the past triennium, which will, in the future, allow to shorten the lead time between Congress site selection and the Congress. Altogether it may be said that IFAC is in good shape and takes great care that its operation and finances are in order. One of the greatest assets of IFAC is that all IFAC officials do their work on a voluntary and entirely unpaid basis. This helps keeping the administrative overhead very low, with the only expenses incurred for a well-functioning Secretariat and its staff, something which is also supported by the authorities in Austria, the location of the Secretariat.

We shall keep you informed on all developments and report on the administrative meetings as well as on the IFAC World Congress – the highlight event in each triennium – in future issues of the IFAC Newsletter.

But we do hope that many of our readers will be present in Barcelona, to attend the IFAC World Congress there. If you are there, do not miss the opportunity to meet members of the IFAC administration. The members of the IFAC Secretariat will have their own office at the Congress site and will be happy to tell you more about IFAC.

Meet at the
XVth
IFAC World Congress
in Barcelona, Spain
July 21 - July 26, 2002

Fuzzy Logic Controllers: Light and Shadow

Compiled by the Valencia organisers of the IFAC Workshop on Advanced Fuzzy/Logic Control in 2001, some ideas and conclusions of the experts attending the IFAC Workshop are summarised.

People in favour of fuzzy logic postulate that the use of linguistic rules and approximate reasoning is the simplest and easiest way to solve concrete control problems, and there is no need for sophisticated models and control design tools. They even say that it is sometimes the only way to initially approach the control of a complex, uncertain, and not well defined process. Those against this methodology define fuzzy solutions as simple interpolation, without guarantee of achieving the desired controlled system performance. But the main conclusion is that fuzzy logic approaches should be considered as one of many options, complementary many times, to solve a given control problem.

Fuzzy logic approach

The difference between logic-based controllers and mere interpolation rests on their linguistic interpretation and their parallelism to the ”reasoning” processes. However, there is a lack of results in the control area based on the “formal’’ side of the fuzzy models: the fuzzy control community has not exploited the fact that fuzzy theory offers a new way of dealing with uncertainty. The way it is commonly used raises the question why uncertainty is not managed by using probabilistic techniques instead. Full use of this uncertainty representation needs to address the propagation of uncertainty on membership functions, possibility distributions and the like.

We need to redefine stability concepts with respect to membership functions and to rethink many concepts, but there are significant technical barriers in the sense that the computation with multi-dimensional membership functions is intractable except for naïve settings if the propagation of uncertainty is done using the extension principle.

In fact, does a fuzzy controller really use fuzzy logic? An agreement seemed to be the conclusion of this interesting question. When speaking about fuzzy controllers, the technique provides just an interpolation method to obtain the control inference surface. But regarding a decision or supervision system, fuzzy logic provides a powerful tool to extract the best from semantics.

The difference between specific fuzzy-neural and nonlinear control applications is unclear. However, the fuzzy rule-based modelling is a way to describe a non-linear controller that might be better suited for in-plant modifications.

The fuzzy logic approach can be used not only to describe the plant and controller models but also to set the specifications.

Fuzzy logic is often deemed as just a convenient interface with non-control skilled people. Although emphasis is made on showing off specific advantages, the opposite question about which are the specific disadvantages of using fuzzy logic was not answered.

Use of models in fuzzy control design

If the fuzzy models are, however, interpreted in the previously mentioned wider sense (i.e., representation of uncertain, simplified models) then controllers can be designed at this level of abstraction (near qualitative). The more quantitative and precise the information is, the more the classical nonlinear models should be applied.

A common opinion was that fuzzy control is appropriate when there is no model about the plant but operator knowledge instead. If a plant model is used, more realistic models should be considered (not only first and second order), because realistic industrial applications involve saturation of actuators and dead time delays, as well as higher order dynamics. High order models might be better handled by black-box neural approaches as most fuzzy models suffer a combinatorial explosion on the number of membership functions, hence losing their interpretability.

The “identification for control’’ paradigm that has recently been developed in the “classical’’ community needs to be transferred into the intelligent control research: Model type and level of detail in the model depends on the complexity of underlying dynamics but also on the control goal, i.e. from a simple need of stabilisation to an accurate tracking.

In that context, identification is a very important issue and some effort should be devoted to that, particularly on-line adaptation. Intelligent modelling with neural networks has a high number of parameters that may require long series of data. The issues of excitation, frequency distribution of the modelling error and the like are often overlooked in intelligent modelling discussions, where the black-box is assumed to be able to learn nearly anything. These ideas need to be addressed to be able to extend the real applications of adaptation algorithms.

In many cases a fuzzy model is the easiest way to start with the controller design. Fuzzy models encapsulate the highest level of abstraction, and the final tuning or further modelling goes down to actual physical actions and variables. However, in the literature, many applications are developed to well known (low uncertainty) controlled systems. Does this make sense?

The local-model or multiple-model paradigm is used many times in the fuzzy-neural approach as rules are a natural description of the validity zones of those models. One of the reasons of the extensive use of Takagi-Sugeno models in the design of fuzzy logic controllers is their suitability to combine fuzzy- with classical control design tools
.
The Takagi-Sugeno approximators are a bridge between classical models and fuzzy ones.

Analysis and design tools

Other than the interpretability and easy use by the end user, the relevance of stability and robustness, as well as adaptation of the designed fuzzy controlled systems should be emphasised. Varied stability issues arise in fuzzy systems, and a huge variety of behaviours can be found even in very simple fuzzy systems, as the real systems they try to model.

Many presentations (not only in the scope of fuzzy-neural control) overlook the robustness issue so that implementation in practice is hindered.

As previously mentioned, a wider interpretation of the representation of fuzzy systems with respect to uncertainty would pose a need to redefine stability concepts in the linguistic framework.

It was pointed out that stability methods described in the sessions, and lateron discussed, are mostly classical (and conservative) for the special cases of controllers generated via fuzzy control methodologies. The stability should be analysed with functions (we have membership functions) not with points (Lyapunov). Those settings could be approximate, for example, establishing different notions of stability where the state is a fixed-shape membership function. Other related approaches (such as differential inclusions) should be considered.

It could be of significant interest to examine the relation between fuzzy and switched systems research results, particularly in stability and optimal control. Of course, its relationship to older gain-scheduling techniques is also clear.

Each author still tries to present his own design methodology as the best one. The compilation of a small number of design rules for fuzzy controllers in a definite handbook on fuzzy control design seems to be far away. In this context, the differences between fuzzy and nonlinear control applications are not clear. There is still a lot of work to be done in the field (fortunately).

As previously mentioned regarding modelling, the use of linguistic concepts (following the initial spirit of fuzzy logic, i.e., computing with words) still needs to reach the controller design tools.

Suitable fuzzy logic applications

The fuzzy approach is interesting for ”know-how” systematisation. On the other hand, when dealing with ”direct” fuzzy control versus fuzzy ”decision systems” in industry, the former interpolates -it is an inference map-, while the latter one reasons. Rules cannot be introduced easily in the first case, only completed after some initial controller is given by the operator and he/she ”sees” how it works. The fine-tuning of that regulator in-plant could be better done if explained in terms of rules than if explained in terms of matrices and/or complex formula.

However, the best use of FL as a reasoning tool is in automated diagnosis and supervision of complex industrial plant.

There is a need to find new areas of application where more degree of abstraction is required, and problems which are not considered in conventional control. In these cases, the main issue is the ”repeatability” and the usefulness of practical implementations to deduct general rules.

There was a session dedicated to applications in robotics. The papers presented showed few specific open problems. Fuzzy rules could help fine-tuning when solving issues arising from friction sticking in small movements of microrobots.

From the theory point of view, the control community may look down at fuzzy controllers as at poor old PIDs, but in applications 90% industry control is PID, just as fuzzy may become very useful/common in industry in the next years because it is a convenient and understandable way for the users to implement nonlinear control strategies.

Pedro Albertos

Journal of Process Control
Issue 4, June 2002

A. Rehm, F. Allgower
Nonlinear dynamics and control of process systems with recycle
A. Kumar, P. Daoutidis
Performance limitations in decentralized control
H. Cui, E.W. Jacobsen
Min-max constrained quasi-infinite horizon model predictive control using linear programming
D. Megas, J. Serrano, C. de Prada
From irreversible thermodynamics to a robust control theory for distributed process systems
A.A. Alonso, B.E. Ydstie, J.R. Banga
A decade of progress in iterative process control design: from theory to practice
M. Gevers
Design of a nonlinear distributed parameter observer for a pressure swing adsorption plant
M. Bitzer, M. Zeitz
Designing robust optimal dynamic experiments
S.P. Asprey, S. Macchietto
On the regularization of dynamic data reconciliation problems
T. Binder, L. Blank, W. Dahmen, W. Marquard
Improved monitoring of batch processes by incorporating external information
H.J. Ramaker, E.N.M. van Sprang, S.P. Gurden,
J.A. Westerhuis, A.K.Smilde
Real-time optimization and nonlinear model predictive control of processes governed by differential-algebraic equations
M. Diehl, H.G. Bock, J.P. Schloder, R. Findeisen, Z. Nagy, F. Allgower
From Plant Data to Process Control: Ideas for Process Identification and PID Design - By Liuping Wang and William R. Cluett. Published by Taylor & Francis
D. Seborg

Issue 6, September 2002

Nonlinear feedback control of multivariable non-minimum-phase processes
J.M. Kanter, M. Soroush, W.D. Seider
Experimental application of nonlinear model predictive control: temperature control of an industrial semi-batch pilot-plant reactor
F. Xaumier, M.-V. Le Lann, M. Cabassud, G. Casamatta
Temperature control in catalytic cracking reactors via a robust PID controller
R. Aguilar, A. Poznyak, R. Martnez-Guerra, R. Maya-Yescas
Minimum variance control and performance assessment of time-variant processes
B. Huang
Cell population models for bifurcation analysis and nonlinear control of continuous yeast bioreactors
Y. Zhang, A.M. Zamamiri, M.A. Henson, M.A. Hjortso
Statistical process monitoring using improved PCA with optimized sensor locations
W. Wang, S. Song, W. Wang
An economic measure for comparing dynamic robustness
R. Di Mascio

Control Engineering Practice
Papers from the May 2002 Issue

Dead-time Compensation for ABR Traffic Control over ATM Networks
(F. Gomez-Stern, J.M. Fornés, F.R. Rubio)
Model-based and Wavelet Approaches to Induction Motor On-line Fault Detection
(C. Combastel, S. Lesecq, S. Petropol, S. Gentil)
Controller Design for a Real-time Air Handling Unit
(Y. Shin, Y.S. Chang, Y. Kim)
Observer-based Robust Failure Detection and Isolation in Greenhouses
(R. Linker, P.O. Gutman, I. Seginer)
A Modelling and Control Structure for Product Quality Control in Climate-controlled Processing of Agro-material
(G.J.C. Verdijck, G. van Straten)
Force Control System Design for Aerodynamic Load Simulator
(Y. Nam, S.K. Hong)

Special Section on Automated Systems Based on Human Skills and Knowledge
Preface to the Special Section on Automated Systems Based on Human Skills and Knowledge
(J. Cernetic)
Experience-based Knowledge Management: A Cooperative Information Systems Perspective
(M. Jarke)
Common Work Space for Human-machine Cooperation in Air Traffic Control
(M.P. Pacaux-Lemoine, S. Debernard)

Using Failure Detection and Diagnosis Methods to Detect Dangerous Evolutions of the Driver Behaviour
(J.C. Popieul, P. Simon, P. Losleveur)

Automatica
Papers from the July 2002 Issue

Editorial

A New Editor, and Three Editorial Areas Reviewed and Revised (see page 6, Newsletter)
(H. Kwakernaak)

Papers

Explicit Sub-optimal Linear Quadratic Regulation with State and Input Constraints
(T.A Johansen, I. Petersen, O. Slupphang)
On the Use of Constraints in Least Squares Estimation and Control
(D.G. Robertson, J.H. Lee)

Brief Papers

Overcoming the Detectability Obstacle in Certainty Equivalence Adaptive Control
(E. Panteley, R. Ortega, P. Moya)
Analysis of Fractional Delay Systems of Retarded and Neutral Type
(C. Bonnet, J.R. Partington)
Exponential Stabilization of Nonholonomic Dynamic Systems by Smooth-varying Control
(Yu-Ping Tian, S. Li)
Lower Matrix Bounds for the Continuous Algebraic Riccati and Lyapunov Matrix Equations
(H.H. Choi, T.-Y. Kuc)
Combining Switching, Over-saturation and Scaling to Optimize Control Performance in the Presence of Model Uncertainty and Input Saturation
(J.A. De Dona, G.C. Goodwin, S.O.R. Moheimani)
Canonical Forms for Stochastic Nonlinear Systems
(Z. Pan)
A Probabilistically Constrained Model Predictive Controller
(P. Li, M. Wendt, G. Wozny)
Iterative Learning Control with Initial Rectifying Action
(M. Sun, Danwei Wang)
An Improved Approach for Constrained Robust Model Predictive Control
(F. Cuzzola, J.C. Geromel, M. Morari)
Energy-based Control of a Distributed Solar Collector Field
(T.A. Johansen, C. Storaa)
Proportional Derivative and Strain (PDS) Boundary Feedback Control of a Flexible Space Structure with a Closed-loop Chain Mechanism
(Fumitoshi Matsuno, T. Ohno, Y.V. Orlov)
Dominant Pole Placement for Multi-loop Control Systems
(Yu Zhang, Qing-Guo Wang, K.J. Aström)
An Algebraic Approach Towards the Controllability of Controlled Switching Linear Hybrid Systems
(Zhenyu Yang)
Robust One-step Receding Horizon Control of Discrete-time Markovian Jump Uncertain Systems
(Byung-Gun Park, W.H. Kwon)
On the P-type and Newton-type ILC Schemes for Dynamic Systems with Non-affine-in-input Factors
(Jian-Xin Xu, Y. Tan)

Technical Communiques

On Minimal-order Stabilization of Minimum Phase Plants
(Weidong Zhang, X. Xu)
Gain Scheduled Controllers for Dynamic Systems Using Sector Nonlinearities
(E.F. Costa, V.A. Oliveira)
Variable Structure Control of Systems with Uncertain Nonlinear Friction
(H.G. Kwatny, C. Teolis, M. Mattice)
Necessary and Sufficient Condition for Convergence of Iterative Learning Algorithm
(S.N. Huang, K.K. Tan, T.H. Lee)

Book Reviews

Modeling and Control of Robot Manipulators, by L. Sciavicco and B. Siciliano

(J. Lew)
Introduction to Robotics in CIM Systems, by J.A. Rehg
(Chiharu Ishii)

Papers from the August 2002 Issue

Papers

A Probabilistic Framework for Problems with Real Structured Uncertainty in Systems and Control
(G. Calafiore, F. Dabbene)
A Discrete-event Model of Asynchronous Quantised Systems
(D. Foerstner, J. Lunze, L.M. Jung)
Asymptotically Optimal Smoothing of Averaged LMS Estimates for Regression Parameter Tracking
(A.V. Nazin, L. Ljung)
Frequency Domain Subspace Identification Using Nonparametric Noise Models
(R. Pintelon)
Auxiliary Signal Design for Rapid Multi-model Identification Using Optimization
(S.L. Campbell, K.G. Horton, R. Nickoukhah)

Brief Papers

Supervision of Integral-input-to-state Stabilizing Controllers
(J.P. Hespanha, D. Liberzon, A.S. Morse)
Virtual Reference Feedback Tuning: A Direct Method for the Design of Feedback Controllers
(M.C. Campi, A. Lecchini, S.M. Savaresi)
Off-line Robust Fault Diagnosis Using the Generalized Structured Singular Value
(D. Henry, A. Zolghadri, M. Monsion, S. Ygorra)
Synchronized Multiple Spacecraft Rotations
(J.R. Lawton, R.W. Beard)
Adaptive Neural Network Control for a Class of Uncertain Nonlinear Systems in Pure-feedback Forms
(Dan Wang, Jie Huang)
Adaptive Control of Compressor Surge Instability
(F. Blanchini, P. Giannattasio)
H2 and H-infinity Norm Computations of Linear Continuous-time Periodic Systems via the Skew Analysis of Frequency Response Operators
(J. Zhou, T. Hagiwara)
Memoried Quasi-time-fuel-optimal Feedback Control of Perturbed Double Integrator
(W.-X. Jing, C.R. McInnes)
The Infinite Time Near Optimal Decentralized Regulator Problem for Singularly Perturbed Systems: A Convex Optimization Approach
(G. Garcia, J. Daafour, J. Bernussou)
Decentralized Disturbance Attenuating Output-feedback Trackers for Large-scale Nonlinear Systems
(Z.-P. Jiang)
Infinite Horizon Backward Stochastic Differential Equation and Exponential Convergence Index Assignment of Stochastic Control Systems
(Y. Liu, S. Peng)
Series Expansions for Analytic Systems Linear in Control
(F. Bullo)

Book Reviews

Optimal Control, by R. Vinter
(B. Piccoli)
Identification of Time-varying Processes, by M. Niedzwiecki
(M. Taragna)
Partial Stability and Control, by V.I. Vorotnikov
(K. Pfeiffer)

Automatica Editorial

Huibert Kwakernaak

Almost a year ago, Sigurd Skogestad of the Norwegian University of Science and Technology at Trondheim indicated that he did not wish to have his term renewed as *Automatica* Editor for Process Control and Computer Applications, which expires on June 30, 2002. Sigurd held the post since the IFAC Congress at San Francisco in 1996, and did the job with energy and enthusiasm. We were most pleased to find Frank Allgöwer of the University of Stuttgart willing to succeed Sigurd. Frank has been an Associate Editor of *Automatica* since 1997, working with Sigurd.

A new editorial appointment is an occasion to review the editorial areas. This time we took a look at the three ”applied” areas: *Process Control and Computer Applications*, until now covered by Sigurd Skogestad, *Control System Applications*, covered by Editor Mituhiko Araki, and *Management and Decision Sciences*, which is under the wings of Editor Alain Haurie. We compared the areas and their sub-areas with the Technical Areas defined by IFAC, and also with the technical areas planned for the 15th IFAC Congress at Barcelona this year.

As a result, the names of the three editorial areas were slightly revised, and to each of them a list of sub-areas was appended to clarify the scope. We attempted and almost succeeded to include all the application areas listed by IFAC and the program of the World Congress. Especially the scope of the Management and Decision Sciences area, now called *Systems Engineering and Management*, was expanded to do justice to the wide interests of IFAC and its participants.

These are the new descriptions that appear in the *Automatica* front matter:

Control System Applications (Editor Mituhiko Araki)
Control applications in mechanical engineering, electrical engineering and aerospace engineering; including robotics, mechatronics, adaptronics, automotive control, transportation systems and vehicles, energy systems, marine systems, advanced manufacturing technology, low-cost automation.

Process and Computer Control (Editor Frank Allgöwer)
Control applications in chemical engineering, environmental engineering, civil engineering and biotechnology; including chemical, bio-technical and industrial process control, control in mining, mineral and metal processing, modeling and control of biomedical, environmental and agricultural systems, structural control for civil engineering applications, systems biology, computer control systems, computer-aided control system design, algorithms and architecture for real-time control, process monitoring, safety of technical processes and computer control systems.

Systems Engineering and Management (Editor Alain Haurie)
Control in systems engineering, management, economics and education; including large scale systems, business and management techniques, manufacturing modeling, management and control, enterprise integration, computation in economic, financial and engineering-economic systems, control education, social impact of control, control in developing countries, international stability, economic dynamics, decision support systems, conflict resolution.

Automatica has three editors covering applied control subjects. This is a clear signal that applications are well within the scope of *Automatica*. The misunderstandings that sometimes appear to exist about this are not justified. In an editorial that I wrote in 1996 (Automatica vol. 32, p.1) I tried to outline what *Automatica* expects of a good applications paper. Briefly, it should describe a new successful application of an existing theory or methodology. The application should to some extent be generic, that is, offer methodology that is also useful for other, related engineering problems or areas. Papers that show that a methodology is inadequate for certain application areas are also welcome. It should be superfluous to state that any paper published in *Automatica*, including applications papers, needs to be well written and timely. In 1996 I wrote: ”*Automatica* welcomes papers with the characteristics as described. Like all submissions, such papers are subject to a rigorous but fair review procedure that aims at a high level of quality of all papers appearing in *Automatica*”. This statement still stands.

The three areas that are named currently encompass about 30% of the papers published by *Automatica*. We can easily accommodate more. I cordially invite authors of good applications papers to submit them to *Automatica*. The rejection rate for papers submitted in these areas is not higher than the average rejection rate for *Automatica*, which is about 50%.

New Automatica Editor

Frank Allgöwer

Frank Allgöwer was born in Heilbronn, Germany, in 1962. He studied Engineering Cybernetics and Applied Mathematics at the University of Stuttgart, Germany, and the University of California at Los Angeles (UCLA), respectively. He received his Ph.D. degree from the Department of Chemical Engineering of the University of Stuttgart. Since 1999 he is Professor for Systems Theory in Engineering at the Department of Chemical Engineering and Engineering Cybernetics of the University of Stuttgart, and Director of the Institute for Systems Theory in Engineering. Prior to this, he held a professorship in the Electrical Engineering department at ETH Zurich, and was head of the Nonlinear Systems Group there. Prof. Allgöwer was a visiting research associate at the California Institute of Technology and the NASA Ames Research Center, and spent a year as visiting research scientist with the Central Research and Development Organization of the DuPont Company in Wilmington, DE. Prof. Allgöwer's main research interest is in the area of process control, with a focus on the development of new methods for the analysis and control of nonlinear process systems and their identification. He is Associate Editor for the Journal of Process Control and serves on the international advisory board of Chemical Engineering Science. He has been an Associate Editor for *Automatica* since 1997. He is organizer or co-organizer of several international workshops and conferences, and published over 100 scientific articles.