IFAC Report

Round Table Discussion on the Estimation and Control in Fuzzy Environments*†

Rapport IFAC. Discussion autour d'une Table, sur l'Estimation et le Contrôle dans un Environnement Flou

IFAC Bericht: Rundtischgespräch über die Schätzung und Steuerung in unscharfer Umgebung

Отчет ИФАК о дискуссии за круглым столом об оценке и управлении в размытых средах

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Summary—The main contributions to the round table discussion on 'Estimation and Control in Fuzzy Environments' which took place during the 3rd IFAC Symposium on Identification and System Parameter Estimation are summarized. Some viewpoints describing the future trends of the subject are also presented.

It was a well-attended and lengthy session which lasted for about 4 hours. Considerable information was exchanged on this newly developed discipline.

Introductory lectures were given by a panel of five speakers (Gupta—Canada, Zadeh—U.S.A., Fu—U.S.A., Tamura—Japan, Sugeno—Japan) which lasted for about 2 hours. The need for these introductory lectures was felt by the panel as well as by the audience in view of a relative unfamiliarity with the subject by many of the audience. After a brief coffee break, the session was opened for discussion and comments from the floor. A lively discussion took place and continued for another 2 hours. Even after this, the meeting proved to be too short, and Professor Zadeh was able to present some more results of his work the next day during the session on Adaptive Control.

The purpose of this brief report is to summarize the main contributions made in the course of this stimulating round table discussion, and to draw conclusions on which the future work should be directed. A partial list of the bibliography is also included.

1. Why fuzzy automata?

One of the most innovative aspects of modern control engineering is undoubtedly the prevalence of rigorous mathematical theory. The design of deterministic or stochastic optimal control policies using optimal control theory is based upon the assumption that an exact mathematical model of the process to be controlled is available to the designer either in a deterministic or stochastic sense. However, as is well known, such a model cannot be obtained for most processes. Situations of this type exist in many decision-making areas such as forecasting, economic planning, management, medical diagnostic and pattern recognition. This may, in fact, be the reason why the relation between theory and practice has recently become more tenuous and why control theory which made space mission highly successful is not directly applicable to many humanistic processes [59].

In general, mechanistic type systems are amenable to exact quantitative mathematical analysis, while humanistic type processes are too fuzzy to be amenable to such exact mathematical techniques. It is imperative, therefore, for complex fuzzily defined humanistic processes not to make use of exact models or conventional mathematical analysis as is being done today. The desirability of introducing mathematical concepts which reflect characteristics inherent to fuzzy humanistic processes has become apparent since the introduction of Fuzzy Sets in 1965 [48]. Researchers at many of the world's leading institutions are now working on the creation of the foundations of a new and exciting field, viz. Fuzzy Automata. This new field has evolved from the pioneer work of Lotfi A. Zadeh.

These newly developed concepts of fuzzy automata seem to be extremely useful for humanistic type processes and are finding applications in many fields. For example, the concepts of fuzzy sets can be used to define a complex process more realistically than that which can be provided using the deterministic or probabilistic approach. Also the fuzzy automata can be used to generate decision policies for processes which are too complex or too ill-defined to be described exactly.

2. Invited contributions

The meeting was opened with a number of brief invited contributions followed by a general discussion. The first of these was given by the chairman, Gupta, who gave a brief introduction to the fuzzy sets and the concept of the fuzzy automata, and summarized the scope of this new field as compared to the deterministic and stochastic system theory. It was pointed out that the fuzzy automata may play a very important role in humanistic type of processes where a human element is involved in decision making. Examples of such processes are economic and management processes, computer language, medical diagnostic area, pattern classification, etc.

Professor L. A. Zadeh (University of California, Berkeley) gave a very illustrative presentation on 'A Linguistic Approach to Decision-making'. His talk is briefly summarized below:

* In the linguistic approach to decision-making, some of the variables entering into the decision process are allowed...
The use of linguistic variables is motivated by the fact that in many real-world decision processes the goals, the constraints, the interrelation between variables and the underlying probabilities are not known with sufficient precision to be susceptible of characterization in numerical terms. For example, we may know that an event is very likely without being able to specify whether its probability is 0.7 or 0.8 or 0.9. In this case, the probability may be assumed to be a linguistic variable with two possible values very likely and not very likely. In effect, the concept of a linguistic variable serves to provide a basis for an approximate analysis of decision processes which are too complex or too ill-defined to be amenable to treatment by conventional algorithmically-oriented techniques.

In his discussion, he gave a detailed account of some of the main aspects of the fuzzy approach. In particular, he showed how ill-defined goals, constraints and probabilities may be described in linguistic terms and how approximate computations with linguistic variables may be performed. He showed that, in general, the results of computations is the membership function of a fuzzy set. This membership function is approximated by a linguistic label whose meaning can be computed by a procedure described in his paper [61]. However, a general approach to this approximation problem has not yet been developed.

The control behavior has to be understood to have two roles. The one is the command signal to govern the plant, and the second is the test signal to identify the response characteristics. With increase in the order of the higher order plants (2nd and 3rd), the bang-bang mode (BB) is dominant.

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"Lately, it has become of general interest to control the complicated systems such as social, biological and economical systems. These systems have so many uncertain elements that it is difficult to make their mathematical models. Of course, it is possible to make the stochastic models by using the probability measure, if plenty of data on such systems and the environment surrounding them are available. "However, it is doubtful that the stochastic models are suitable for the mechanisms of a human decision or evaluation process including many unclear factors, because these factors mainly depend on man's subjectivity".

Dr. Sugeno proposed the concept of fuzzy measure and fuzzy integral as a means of measuring the fuzziness in such systems as described above. There were three more invited contributions which could not be discussed due to the authors' absence. These were:

(i) A. G. Isaakhanenko, "Self-organizing Theory on the Basis of Direct Complex System Modelling after the Experimental Data".

(ii) K. Asai and H. Tanaka, "On Fuzzy Mathematical Programming".

(iii) K. Tanaka, "Some Behaviors of Composite Fuzzy Automata in Random Environment".

3. General Discussion

In opening the general discussion, Professor Zadeh commented on the importance of this developing area. Then to illustrate the importance of decision making in a fuzzy environment, he gave a demonstration in which a blindfolded person was directed from a given initial position to a final destination purely with the help of fuzzy commands, or algorithms. In addition to the panel, there were many other persons who participated in the discussion although the time allocated for the session was limited, but the panel and the audience were so enthusiastic that the discussion was continued until 1.00 p.m. A partial list of the persons who showed enthusiasm in fuzzy automata and participated in the discussion is given here.

P. A. Devijver (M.B.L.E. Research Laboratory, Brussels, Belgium).

G. J. Gaalman (University of Technology, Twente, The Netherlands).

J. Štulpán (Novoborska, Praha).

M. Installe (University of Louvain, Belgium).

A. A. Van Rede (University of Technology, Eindhoven, The Netherlands).

P. A. A. Van Bostel (University of Technology, Twente, The Netherlands).


L. Pun (Laboratoire d'Electronique Appliquée, University of Bordeaux, Talence, France).

J. Gordeș (Interförföreningen Rechenzentrum, Wien).

H. Abele (Institut für Wirtschaftswissenschaften, Wien).

E. Drossel-Meijer (Gesellschaft für Kernforschung, Germany).

4. Summary

This new direction on fuzzy automata was pioneered by Zadeh in 1965, and since then a new field has evolved having many promising future developments. As stated by Professor Zadeh, the concepts of linguistic variables may serve to provide a basis for developing fuzzy algorithms in decision-making processes when processes are too-complex or too ill-defined. It was concluded that in terms of future development, the most dramatic results very likely will emerge from the implementation of fuzzy algorithms in the control of industrial processes, such as chemical processes and power systems, also in pattern classification, in designing decision processes for social sciences, in economic processes and management, and in the medical diagnostic area. It was envisaged that the fuzzy automata which underlie much of human thinking promises to have a revolutionary impact on the future of systems engineering.

5. List of the panel

(1) Dr. M. M. Gupta (Chairman), Systems and Adaptive Control Research Laboratory, University of Saskatchewan, Saskatoon, Canada.

(2) Professor L. A. Zadeh, Department of Electrical Engineering, Computer Science and Electronics, University of California, Berkeley, California 94720, U.S.A.

(3) Professor K. S. Fu, School of Electrical Engineering, Purdue University, West Lafayette, Indiana 47907, U.S.A.

(4) Dr. H. Tamura, Faculty of Engineering Science, Osaka University, Toyonaka, Osaka, Japan.

(5) Dr. M. Sugeno, Department of Control Engineering, Faculty of Engineering, Tokyo Institute of Technology, Tokyo, Japan.

(6) Dr. K. Kanai (Secretary), Systems and Adaptive Control Research Laboratory, University of Saskatchewan, Saskatoon, Sask., Canada.

Bibliography


