

Digital Computer Applications to Process Control



International Federation of
Automatic Control

International Federation for
Information Processing

Editors:

H.R. van Nauta Lemke
H.B. Verbruggen

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edited by

H. R. VAN NAUTA LEMKI
H. B. VERBRUGGEN



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Digital Computer Applications to Process Control

EDITORIAL

In the short history of digital computers, almost a tradition is set in the IFAC/IFIP conferences, organized every three years on

'Digital Computer Applications to Process Control'.

However, a tradition in itself forms no fertile base for a healthy growth. The field of these conferences is still expanding and it is producing continually richer yields.

After the successful conferences in Stockholm (1964), Menton (1967), Helsinki (1971) and Zürich (1974) the fifth conference at The Hague shows again a continuing progress in hardware, software and applications.

The contributions to this Conference that are given in these Proceedings are:

<u>code</u>	<u>type</u>	<u>number of contributions</u>
S	Survey papers	7
C	Case studies	11
A	Applications	42
M	Methods	36
R	Round Table	1

<u>code</u>	<u>category</u>	<u>number of contributions</u>
A	<u>Applications</u>	
A1	Chemical and oil industry	8
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A7	Cement industry, paper and pulp processes	6
A8	Food and fermentation	4
M	<u>Methods</u>	
M1	Control algorithms	8
M2	Optimisation and adaptation	10
M3	Modelling and identification	7
M4	Systems and software developments	4
M5	Hardware and interfacing	4
M6	Performance and reliability	3

The papers are arranged according to the topics of the Conference and are distinguished into two categories: 'Applications' and 'Methods'. These two categories are used just as a convenient means for ordering the papers according to the Editor's point of view. Not too much emphasis should be attached to this ordering.

The large number and the high quality of the majority of the submitted abstracts required some special measures for controlling the available number of sessions and the available printed volume. The Committees involved considered that probably the engineering/scientific community would be served best, if a wide variety of interesting papers were published. The limits imposed by the size of the papers can be circumvented by personal contacts at and contacts by mail after the Conference.

It is a pleasant duty to express gratitude:

- to the members of the International Program/Paper Selection Committee for their contribution in the selection of the papers;
- to the members of the Local Organizing Committee for their time, ideas and effort put into the many tasks connected with organization of a conference;
- to the Congress Office of the Royal Institution of Engineers in the Netherlands (KIVI), especially Mr. J.M. van der Kamp, for his fine assistance in technical matters;
- to my secretary, Mrs. I.Ch. Gielen-de Jong, for her help in general secretarial work,
- to Mrs. Stephanie Smit, of North-Holland Publishing Company, for her efforts in preparing the manuscript for printing.

H.R. van Nauta Lemke

H.B. Verbruggen

These Proceedings of the 5th IFAC/IFIP International Conference on Digital Computer Applications to Process Control were reproduced by means of the photo-offset process, using the manuscripts supplied by the authors of the different papers. This manner of production allowed Preprints to be published before the opening of the Conference. The manuscripts of the papers had been typed with different typewriters/types. The lay-out, the figures as well as tables of some papers did not agree completely with the standard requirements; consequently, the reproduction does not display complete uniformity. To ensure rapid publication this discrepancy could not be changed; the English could not be thoroughly checked either. Therefore, the readers are asked to kindly excuse the deficiencies of this publication due to the above mentioned reasons.

The Editors

OPENING ADDRESS

Prof. A.A.Th.M. van Trier
Chairman, Advisory Council for Science Policy, The Netherlands

It is a great honour and a pleasure to address you, this distinguished audience at the opening of this International Conference on Digital Computer Applications to Process Control, the fifth conference of its kind - organized at roughly three year intervals as a joint venture - one is tempted to say : a joint adventure - of IFAC and IFIP.

The variety of subjects and topics covered by nearly 100 contributions, the number and qualifications of the 400 participants and the relevance of your theme to many branches of science and technology all indicate the importance of this meeting. Speaking - in a way - as a representative of the Dutch scientific and technological community I can only stress the fact that it is of great interest to this country that this conference takes place here, since the characteristics of your field of study - computer application to process control - satisfy to a high degree the policy guidelines formulated by our government in various memoranda on industrial policy and science policy.

Before elaborating on this statement somewhat further let me try and make some observations on the subject of your conference. Following the chain of events organized under the auspices of IFAC and IFIP in the past decades, one is impressed by the width and depth of your activities, as they are reflected in your program of conferences and seminars. There seems to be a rapidly increasing fine structure, separating new fields of application or new technological disciplines. Taking IFAC as an example one can observe that since the constitutive meeting in Paris in 1957 and following the first IFAC Congress in Moscow in 1960 a considerable spectrum of subjects has been covered at numerous conferences with a greatly increased frequency. In this spectrum of activities the joint IFAC-IFIP conference is one of the older - and evidently well established - events.

Comparing the areas of application covered this time with the Zurich conference three years ago, one cannot but notice the fact that some new areas of application are introduced in your program. This no doubt reflects the fact that the development has not reached the same level in the various areas of application. Among the older, more mature fields should be mentioned the computer application in chemical industry, metallurgical industry, cement industry and power systems. The subjects were covered both in the Zurich conference and the present one. New are sessions on food and fermentation,

traffic and transportation and economic and environmental systems.

Looking - as an outsider - at these very divergent fields of applications, one wonders when a new off-spring will be born.

The program of your conference illustrates again the crucial importance of computers to the present and future developments in many areas of science and technology. From this program - it seems to me - several trends can be derived.

First of all it is clear that ever more complicated and extensive systems can be dealt with in a way that is both technically possible and economically feasible. This evidently extends the possibility of optimizing processes according to various criteria. Another extension can be found in new applications of simulation models to study properties and arrive at conclusions in systems that cannot be dealt with by mathematical models.

Furthermore the field continues to give rise to the development of new mathematical methods. In this respect one should mention in particular certain branches of numerical and discrete mathematics.

The increasing complexity of the systems to be controlled requires moreover the development of distributed, multi-level and hierarchical control systems, in order to keep the systems manageable. Here the smooth and sophisticated cooperation between various computers is of vital importance.

If you will allow me a personal remark, Mr. Chairman, I share your concern in this respect that it might prove easier to make computers cooperate harmoniously than to realize constructive cooperation between human individuals and organizations.

Another trend certainly is the continuous development and improvement in components, materials and technology, which results in ever faster, smaller and energy-efficient computing.

Realising the key-function of control theory and practice in many industrial areas, it may be of some interest to you to hear something about recent developments in industrial policy and in science policy in this country.

About a year ago the Minister of Economic Affairs published a policy memorandum formulating the government policy with respect to the economic

structure. In particular this memorandum dealt with ways and means to reach the dual goal of maintaining continuity and at the same time realising a selective growth. Continuity of economic activity has become very important since the situation on the labour market has shown dramatic changes. Contrary to the situation in the sixties, when the demand for labour at all levels could hardly be satisfied, the situation today is characterized by loss of employment in many areas i.e. by an over supply of labour. Selectivity has become of key-importance in view of the necessity of a long term development of a pattern of industrial and economic activities that satisfies the aspirations of the people and that satisfies the restrictions and limitations set by environmental conditions, physical planning considerations, effective use of raw materials and energy, and changing international relations, in particular the new position of the industrialized world vis à vis the developing countries. The Dutch government policy is aimed at giving direction to the future structure of industry by influencing the pattern of investments in such a way that existing activities are supported to the extent that they are sound and that new activities are stimulated by direct or indirect means.

In addition to the new approach to industrial policy which I have first touched upon very briefly, there has been a parallel development in the area of science policy. A deliberate attempt has been made by the previous cabinet to launch a coherent, national approach to science and technology. This approach aims at a science and technology policy realising four main objectives.

- to gear the national R & D effort to social priorities;
- to promote high professional quality; here of course there is a direct link to the educational system;
- to promote efficiency both in the university and in non-university R & D;
- to promote democratization, both internally, i.e. in the decision making procedures in the research institutions, and externally, i.e. in the relation of the research institutions to society at large.

To realise these four objectives a number of instruments have been developed.

First of all there is the annual science budget, which contains all budgetary items of the various government departments that refer to R & D activities. This budget is prepared under the responsibility of the coordinating minister for science policy. It is discussed in parliament at the beginning of the parliamentary year, that is before the separate departmental budget proposals are being dealt with. The annual science budget not only contains the proposals for the next budgetary year, but it also gives an indication of the possible allocations in the

four-year period following the budget year. The aim is that eventually this budget will develop into a national medium-term science plan, in which the connection between the R & D objectives and the allocation of government funds will be clarified.

In order to influence the future directions of R & D efforts and to promote quality, efficiency and coordination, the concept of National Programs has been introduced. These Programs are launched in areas where a recognised need exists for an intensification and for a stronger policy-orientation of R & D. So far National Programs have been started in energy research, environmental research, labour-market research and demographic research.

Another instrument of science policy is the review committee to review the state of affairs in certain areas and to suggest improvements. Examples of review committees are those for building research, social science research and (national, regional) policy, educational research (which has proliferated strongly in recent years in this country).

In addition to the instruments dealing with the subject-matter of R & D several initiatives have been taken in recent years to bring about certain changes in the organisational pattern of R & D. It would lead too far today to indicate some of the most important developments.

Evidently the art of designing and applying digital computers for process control is of great importance to the economy of a country like the Netherlands.

First of all it can be noted that it is a clean technology with little adverse environmental effects; it does not put heavy demands on raw materials and the energy consumption per unit is low; the added value is high and requires skilled professionals. Moreover the products can contribute essentially to the more effective and efficient use of energy and raw materials in a variety of industrial processes.

Secondly it is noteworthy that while prices of raw materials and energy in recent years have risen to high - sometimes critical - levels, the prices of information and information processing have decreased sharply. One might wonder, however if there will be limits to the amounts of information that we might usefully generate, process and apply. Looking at the program of this week's conference, one gets the impression that the emphasis is more on refining theoretical methods and describing new fields of application rather than on new conceptual breakthroughs, again indicating the maturity of this technology.

This is not to suggest - of course - that progress seems to be coming to an end. As is also

clear from your program there are still many fields being infiltrated by digital computer control resulting in better analysis of the processes involved, improved process control, improved management information and improved reliability and safety.

A central issue will remain the overall effect on the future of economic and industrial activity, more particular the effect on the labour market caused by the ever extending introduction of digital computer control. On the one hand new possibilities for the application of this type of control will result in the feasibility of new industrial processes and products, including the creation of new employment. On the

other hand jobs will disappear or change in many sectors of industry. We seem to know too little about the net result of these counteracting processes. Another problem will be how to keep people motivated for the new types of jobs associated with digital computer controlled processes.

Mr. Chairman, in conclusion of the opening remarks may I express the hope or rather the conviction that staying in this country will be a pleasant experience for our foreign guests, and that this conference will be a great success, both from the scientific point of view and from the point of view of the personal contacts.

WELCOME ON BEHALF OF THE INTERNATIONAL FEDERATION OF AUTOMATIC CONTROL

U. LUOTO

It is my very great pleasure and honour to address you on behalf of the International sponsoring organizations, IFAC and IFIP.

On behalf of these organizations and also on behalf of those of us from abroad, I should like to express our great appreciation to KIVI, the Royal Institution of Engineers in the Netherlands, the national organizer of this conference for their kind invitation to this so interesting city of 's-Gravenhage.

Also, I wish to express our very best thanks to Prof. Trier, the Chairman of the Advisory Council for Science Policy, for his opening address.

The International Federation of Automatic Control and the International Federation for Information Processing sponsor jointly these international conferences in order to aid managers, engineers and scientists in the application of digital computers to the control of various production processes in the most effective and profitable manner.

I have followed this series of conferences with a very great interest since 1964 as the first conference was held in Stockholm. I happened to be on the International Program Committee of the Stockholm Conference and it was my first real task within IFAC activities. The second conference was held in 1967 in Menton, France, with an associated conference in 1968 in Toronto. Then this conference returned to the North. The third conference being held in Helsinki, my home town, in 1971. The fourth conference was then held in Zürich in 1974 with a great success. - And now we have come northwards again to this City, The Hague.

I remember very well my first visit to this city almost twenty years ago. It was a meeting of the Working Group on Automation of the European Federation of Chemical Engineering. The agenda of this meeting had many items on process control but that time we did not discuss the computers at all. - At that time IFAC was very young indeed.

Anyhow, returning to my memories, this my first visit to this city was very memorable. To have our meeting in an old castle, how old it was I cannot remember but in every case it was standing some twelve meters below the sea level on this so historic soil.

There was the great Spanish Empire of which Holland was a part, the 80 years war in 1568-1648 than the "Golden Age" in 17th Century Amsterdam as the center of the world trade and finance, then the development of fine arts with Rembrandt, Vermeer and others - and - it is very interesting - today if you draw a circle with this city as center point and a radius up to

Manchester you are going to have more than one third of the population of Europe within this circle, possibly almost half.

One of the most amazing things here, to my mind, is the struggle against the sea, the reclamation, the dikes and all this astonishing ability to play games with water. As a result this country, with just about no natural resources, knows how to do things and how to achieve certain goals. Trade and industry are extremely important to the economy here and so much research is being done here - and - consequently - so many international enterprises have their home here. We can mention firms like AKZO, DSM, Philips, Shell and Unilever for instance and many more. So I think, this city is a perfect setting for our Conference today.

I could say so many words about this our conference - but instead - while other speakers are going to tell you that, - I'd ask for a few minutes to tell you about our Federation.

IFAC wants to be at the service of the control engineering community. It can only perform its services in an acceptable, in a good, or in an optimal way if its operations are known throughout the control-engineering world.

The purpose of IFAC is "to promote the science and technology of automatic control in its broadest sense in all systems whether, for example, engineering, physical, biological, social or economic, in both theory and application. IFAC is also concerned with the impact of automatic control on society".

It is a multinational federation, A Federation of National Member Organizations of 39 countries. Its most important activities are the organization of meetings and the dissemination of written information.

Among these meetings are: World-congresses, each 3 years; - In the intermediate years there are many specialized symposia and number of rather informal workshops.

Among the written information are the preprints and proceedings of these meetings. Also the federation can point with some pride and satisfaction to the IFAC-journal AUTOMATICA, which ranks among the best control-engineering periodicals.

In this work many people participate, through the 13 technical committees, ranging in subjects from mathematics of control to applications; from biomedical- to space applications

IFAC represents an open invitation to think, to plan and to work together. Besides the information dissemination one may think of a wide variety of tasks to be tackled:

Continuing education, studies for intergovernmental organizations, exchange of scientists engineers, social effects studies, etc.

IFAC represents an open invitation to make your professional views known

- through your National Member Organizations, - Technical Committees, - the IFAC Secretariat;
- through the Organizing Committee of this Conference.

Once in a while it is asked whether IFAC is too theoretical. No, it is trying to bridge the gap between theory and practice, between university professors and production managers.

Actually, a gap like this is necessary - or essential for continuing development.

If there is no gap, there is no development.

Planning all ahead for progress is essential for our life, growth and even survival - especially in our so much technology based world and business of today. And therefore I do hope that this Conference and each of you here may contribute to continuing successful application of digital computers for automatic control of processes.

I wish you all and this Conference the best success.

WELCOME ON BEHALF OF THE DUTCH NATIONAL MEMBER ORGANIZATION OF IFAC

Prof. J.E. Rijnsdorp
Chairman, Division for Automatic Control, Royal Institution of Engineers
The Netherlands

More than one century ago, in his novel Erewhon, Samuel Butler pondered about the similarities and differences of the biological evolution and the development of machines. He remarked:

"Some of the lowest vertebrata attained a much greater bulk than has descended to their more highly organized living representatives, and in like manner a diminution in the size of machines has often attended their development and progress."

This thought certainly has come true for the digital computer, which, thanks to a recent marriage with large scale integration, is giving rise to a real population explosion of applications.

Control engineers and computer scientists have been amongst the first ones to use the computer as a tool in their work. They have also pioneered its use as a component and, in line with Samuel Butler's predictions, they have sometimes become its slaves, a fact-of-life all too well known to their wives and children.

Finally, allow me, as a typical Dutchman, to add one moral lesson:

We, as computer scientists and control engineers, if not as human beings, should not try to solve all real-life problems in terms of computer algorithms and Boolean algebra, but accept that other approaches could sometimes be more to-the-point.

On behalf of the Dutch National Member Organization of IFAC, I wish you a pleasant and fruitful conference.

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