INFORMATION PROCESSING 68

VOLUME 1

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PREFACE

This book and its companion volume contain the Proceedings of IFIP Congress 1968, consisting of 33 Invited Papers, 213 Submitted Papers, 15 Panel Position Papers, and discussion on these papers, together with opening and closing speeches. The fact that these Proceedings are well over twice as long as those of any previous IFIP Congress speaks eloquently of the world-wide interest in, and the rapidly growing use of computers.

The papers have been divided into four main groups: Mathematics, Software, Hardware, and Applications, the last group being nearly twice the size of any of the others. Within each group, the invited papers come first and the submitted papers are further grouped into sections corresponding to sessions of the Congress. Most of the invited papers are followed by invited commentaries by experts working in the same field, and most papers, whether invited or submitted, are followed by a summary of the discussion on them.

The amount and quality of discussion varied considerably from one paper to another. In some cases there was none at all, and in many others it was, for various reasons, extremely difficult to record. Where speakers responded to our invitation and supplied their own version of their contributions, the discussion has been reproduced fairly fully, but we must apologize in advance to any others whose remarks may have been incorrectly or inadequately reported.

On the whole, the papers were presented in excellent English, but some required considerable editing and we cannot be sure that we have always understood the authors correctly. Wherever possible, the revised version has been checked with the author, but almost certainly some mistakes remain. No attempt has been made to change American spelling to English, or vice versa.

It has been a pleasure to work with North-Holland Publishing Company, who have published these Proceedings with their usual efficiency. I am greatly indebted to my colleagues on the Proceedings Committee, particularly Mr. J. F. Nicholson for his valuable assistance before the Congress, Mr. J. C. Macpherson for his help on the editorial board during the Congress, and above all, Miss Cicely Popplewell, the Editor of the 1962 Congress Proceedings, whose experience, ability and willingness to work have been a tremendous help. I am extremely grateful to Mrs. M. A. Jones for relieving us so efficiently of a great deal of administrative and clerical work, and to Miss Vera Rich, who has so ably compiled the Subject Index - a mammoth task in itself. Finally, I should like to thank the Reporting Secretaries who organised the discussion, and Mr. R. E. Day, who had the even more difficult task of recruiting and organising them.

A. J. H. Morrell,
Chairman, Proceedings Committee

INTRODUCTION

IFIP Congress 68 is the fourth in a row of global congresses on Information Processing, held at intervals of three years. The first, organized in 1959 in Paris under the auspices of UNESCO, demonstrated the great need for a forum where computer scientists from all over the world can meet regularly. The following year, IFIP came into existence. It undertook, as one of its foremost aims, to continue and develop the pattern established by the Paris conference. The success of IFIP Congress 62 in Munich and IFIP Congress 65 in New York has given us assurance and encouragement to continue on this path.

A few remarks on the structure and the goals of IFIP are in order, for the benefit of those readers who are unfamiliar with our Federation. IFIP is a multi-national federation of professional-technical societies, or groups of societies, concerned with information processing. Its membership currently comprises 28 of those countries most active in the information sciences. Its aims, as set out by its founders, are and continue to be:

a) To sponsor international conferences and symposia on information processing, including mathematical, engineering and business aspects.

b) To establish international committees to undertake special tasks falling within the spheres of action of its national member societies.

c) To advance the interests of member societies through international co-operation in the field of information processing.

In achieving these aims, IFIP fulfils the need for better world-wide communication and increased understanding among scientists of all nations of the role which information processing can play in accelerating technical and scientific progress. Emphasis is clearly on the term "international". In the General Assembly, the rule "one country – one vote" is established, thereby giving each national group, whether large or small, equal rights. Officers are elected by the General Assembly from among its members.

Since 1965, when the last congress took place, the three technical committees of IFIP have continued their activities; they are: T. C. 1 – Terminology; T. C. 2 – Programming Languages, and T. C. 3 – Education. Besides, two important new steps were taken in the past two years. The first is the creation of Special Interest Groups. Such Groups have as their members national special interest groups, with the restriction that there shall be only one such Group in each country. Special Interest Groups have a greater degree of independence and autonomy in the formulation and implementation of their activities than Technical Committees. They propose their own programme which is submitted to the IFIP General Assembly for approval. The first IFIP Group in this category is the IFIP Administrative Data Processing Group. Its purpose is to promote and co-ordinate research, education and exchange of experience in the field of information processing as applied to organisational, economic and administrative problems in public and business administration. This constitutes a welcome opportunity for IFIP to extend its activities into the area of the administrative (as against the predominantly scientific) sphere. The need for such a broadening has been felt in several of our member countries. The second step is the formation of a technical committee on Medical Data Processing. This group is now in the process of establishing a programme which will be chosen from among these areas: the compiling of information from already accomplished or existing medical data processing experiments; the investigation of the most appropriate methods in approaching the solution of a few of the main problems in medical data processing: medical records, hospital information systems, utilisation of mathematical models in medicine; extension of medical, paramedical and administrative staffs' training in the field of data processing.

The international character of IFIP's role extends to its congresses as well. To assure that the programme is truly international in its composition, and in the same time to enable local arrangements and preparations to proceed efficiently, responsibilities are divided between two committees. One committee, composed of people from the host nation, is responsible for all the arrangements of the congress. The other committee, composed of people from many of the nations represented in IFIP, is responsible for the development of the programme of the congress. Both of these committees report to the president of IFIP and, through him, to the General Assembly.

The international membership of the Programme Committee and the review of its plans by the multi-national General Assembly of IFIP provide assurance that the congress will be truly international in its coverage.

Preparations for an international Congress of this size are demanding. We are indebted to those whose time and endless efforts have made the meeting possible. Mr. B.B. Swann (U.K.), Chairman of the Congress Committee, and the many people working with him deserve our sincere thanks for their tireless energy. The Programme Committee, chaired by Monsieur F. Genuys (France), with members from seven different countries, has spent countless days of work and study and has succeeded in co-ordinating a programme which is both broad in coverage and international in character. To these men we owe our recognition.

Computers have undergone great changes since the day when IFIP came into being, and a computer manufactured in 1959 can now be called thoroughly obsolete. There is no other industrial product in which technological progress is quite as fast as with computers, and information exchange on an international basis is essential for those who wish to keep up with the rapidly developing state of the art. The proceedings of the IFIP congresses therefore are of great value since they give an authoritative picture of the progress of the past years.

A. P. Speiser
President of IFIP

February 16, 1968

ACKNOWLEDGEMENTS

The help we received in preparing for IFIP Congress 68 reflected the interest in computers in many quarters. Her Majesty the Queen graciously consented to be the Patron, and Earl Mountbatten of Burma, who took over the Presidency of the British Computer Society about the time the planning work commenced, gave his enthusiastic help to make the event a success, including delivering the opening address.

As soon as it was decided that Edinburgh would be the most suitable venue, the Secretary of State for Scotland and the Lord Provost of Edinburgh and their staffs were most generous in helping to make the necessary plans and in giving hospitality to the Congress.

We are also very much indebted to the following organisations for recruiting members of the organising committees and giving experience and authority to their deliberations:

Ministry of Technology
Board of Trade
University of Edinburgh
Heriot-Watt University
Institute of Physics and The Physical Society
Institution of Civil Engineers
Institution of Mechanical Engineers
Institution of Electrical Engineers
Institution of Electronic and Radio Engineers
Institution of Structural Engineers
Institute of Chartered Accountants in England and Wales
Institute of Chartered Accountants of Scotland
Institute of Cost and Works Accountants
Operational Research Society
Institute of Statisticians
British Computer Society

We also owe our thanks to the General Post Office, the British Electrical and Allied Manufacturers Association, The Business Equipment Trade Association (B.E.T.A.) and the Electronic Engineering Association who helped by providing the very experienced committee to plan and direct the Exhibition.

The work, however, has to be done by individuals and we owe our particular thanks to the conscientiousness and energy of the large number of men and women who formed the working committees. Their names are listed on pp. 1650/1. In particular, we wish to thank Mr. Coaten who, with the able assistance of Mr. D'Urban of B.E.T.A., created a very successful exhibition, and Messrs. McSwan, Day and McTernan, who, with the other committee members, gave many months to planning the work and also bore particularly heavy burdens during the Congress itself. Also we want to thank the producers of these Proceedings; theirs has been an enormous job.

We owe much to the British Computer Society, particularly to Mr. Mackarness, the Secretary, and to Miss Finch, who worked on the project for three years, assisted nearer the time by Mrs. Jones and Miss Smith. In Edinburgh we were much indebted to Mr. Bogie, Mrs. Holroyd and Miss West, and the staff, many of them from the Universities, who helped them.

In addition to the names listed the following assisted the committees during part of the time: Mr. Archbold (whose death shortly before the Congress gave much sorrow to all who worked with him), Professors Jaeger and Stuart, and Messrs. Bennett, Davis, Hopper, Howell, Jackson, Johnson, Makower, McInninie, Rees and Jervis Smith.

In so large and complex an operation with over 4,000 persons involved, there are many conflicting priorities and unforeseeable difficulties. While dealing with the primary jobs of organising the presentation of the papers, the exhibition and all the ancillary activities, including entertainments, the committees tried to anticipate difficulties and to prepare against them. The result was a memorable week and we hope it gave pleasure to the visitors from the many countries represented. We thank all who were concerned very sincerely for the effort they put in and the results they achieved.

B. B. Swann
Chairman, IFIP Congress Committee

COMPUTERS AND MUSIC

As part of IFIP Congress 68 a Computer-Composed Music Competition was held. The results of this competition were

1st prize:	ST/4 - 1,080262 for string quartet by Iannis Xenakis.
2nd prize:	ZASP, an electronic piece, by Peter Zinovieff and Alan Sutcliffe.
Special Mention:	Quartet in C major, by Lambert Meertens.

These pieces were played in a concert on 8 August as part of the Congress.

On 7 August there was an extra session of the Congress devoted to computers and music, in conjunction with the competition. The chairman was Professor Stanley Gill. The following are summaries of the short papers presented at the session.

COMPOSING BY COMPUTER

ALAN SUTCLIFFE
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1. MUSICAL INFORMATION

The association between number and music dates back at least to the time of Pythagoras [1]. One aspect of this is the interest in automatic composing systems based on numerical methods. Samuel Pepys and Mozart are among those with systems attributed to them [2]. The more recent systems using computers [3-5] are thus part of a long tradition which does not exist in the other arts.

An important reason for the existence of such composing systems is the nature of musical information. This, as it is expressed in a musical score, is largely digital. This applies to the information about pitch and timing, and some of the information about loudness and tone quality. Performed music is not, of course, digital, and musical performers are among the most complex of digital to analogue converters.

Musical information is also formal, and some of the transformations carried out by composers are easily effected in numerical terms: simple transpositions of a melody in pitch, timing, loudness or instrumentation, and variations of individual notes, for example.

2. COMPOSING ZASP

The composing program for the piece of electronic music ZASP was written mainly in FORTRAN and run on an ICL 1900 computer. Realisation was carried out in the computer-controlled studio of Peter Zinovieff.

The composing method was based on the filtering of random values to produce patterns of distinctly differing characteristics. The aim was to balance control and randomness, for music lies somewhere between order and disorder. The pitch, timing, loudness and basic waveform of each note were specified, each controlled in a different way for musical reasons: smoother and less frequent changes in loudness than in pitch, for example. There was an element of recursion in the process, since the values of the controls were themselves set using the same method of generating patterns of values, using more explicitly programmed controls. The same method was also used to determine the overall form of the work, and of each movement. The method is described in more detail elsewhere [6].

3. INTERACTIVE COMPOSING

The whole process was carried out under program control, once starting values had been given for the random number generator. In current applications of computers to musical composition, it seems right to develop a more interactive approach.

It is now feasible to provide the composer of electronic music at least with a system that will produce material under his control, allow him to make overall or detailed alterations, and then store the material for later assembly with other parts into a composition.

ACKNOWLEDGEMENT

My thanks are due to ICL for the provision of computer time at weekends for this project.

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A COMPUTERISED ELECTRONIC MUSIC STUDIO

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Computers may be used in several ways for the realisation and composition of music. First they may be used to compose or copy so that the output is in some form of score that may be interpreted as music. Secondly they may be used to generate waveforms that may be fed directly or via tape to loudspeakers. In this category come both the usual experiment of some Bach fuguetta played on the monitor speaker where only durations and pitch are defined and also the highly complex Music 4, 5 and 6 programs where more and more minute analysis and reproduction of musical sounds is becoming possible.

Between these two comes the control of sound producing equipment directly by the computer, where the computer is used for process control and also to determine what the control shall be. In other words the computer takes over all of the work in an electronic music studio, from starting up tape machines to deciding what is actually to be recorded. One example of this is at Putney, London, where ZASP was realised. The idea here is first to define some musical parameter, then to have some specialised electronic peripheral to control it and the computer overlording the whole process. In this way a small and inexpensive computer is quite adequate as the data transfer rate is very low. A PDP8/S with an 8K store and 32K disc is very satisfactory.

It is first necessary to define the simplest parameters such as frequency, loudness, waveform and durations. These are controlled by oscillators, amplifiers and clocks. More complex parameters are glissando, acceleration and crescendo where some computation is needed to define them and complex electronic equipment to maintain them. In the end the parameters themselves are too remote from electronics and there is a gradual change from pure realisation to pure composition. About halfway come probability, dependence of one event on another, and form. Nearer composition comes tension, boredom or anything else that one may care to define as being an important aspect of the final product. The trend is from complex peripherals to sophisticated programs, and the next stage is to produce a specialised but generally accepted language and method for the production of electronic music.

THE IMITATION OF MUSICAL STYLES BY A COMPUTER

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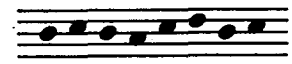
A computer can be used to compose music in an attempt to create a work that can stand its ground amongst contemporary music. But this is not the only object one can pursue in letting a computer generate music. It is possible to translate a musical theory pertaining to a particular style, provided that it is sufficiently formalised, into a program, and then to compare the computer-generated music with the original pieces in that style. By this process we can tell to what extent the musical theory is able to account for the beauty and creativity we experience in the original music, and how much is left unexplained. A great difficulty in this process, aside from the fact that it need not be a trivial problem to translate even a completely formalised theory into a program, is that most of the existing books in musicology are rather ambiguously formulated.

In the present work, for the harmonic rules use has been made of Hindemith's book "A Concentrated Course in Traditional Harmony" [1]. The harmonic rules of the first chapters have been laid down in a program in the following way: when a new four-voiced chord has to be generated, following an old tone, the program generates a great number of possible chords, each of which is checked against the harmonic rules, and for each trespass a fine is imposed, the size of which depends on the seriousness of the trespass. The resulting chord is that with the least total fine. An example of these rules is: no two voices that constitute an interval of a fifth may proceed along parallel lines to constitute another fifth.

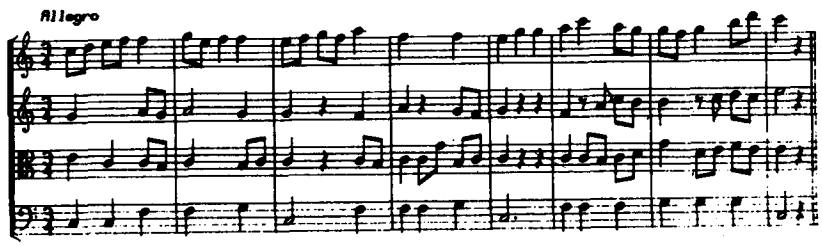
It is not possible to give a detailed account of the composition process here, but it is hoped to give one in ref. [2]. The program was written in ALGOL 60 and ran on the Electrologica X8 of the Mathematical Centre. The central procedure is the procedure "compose", which composes a passage of, for instance, eight bars (preferably a power of two). The nature of this passage is controlled by a great number of parameters. The procedure subdivides the passage into two parts, and applies itself to each part, with suitably adjusted parameters. One of these parameters is the maximum height of the melody, which is used to generate the melodic line (this may be slightly altered later on, in order to fit in with the harmonies). From aesthetical considerations the idea is derived that the highest note of one half of a musical sentence should be slightly different from that of the other half; the same applies to the half sentence divided into two, etc. The following sequence of notes complies exactly with this rule:



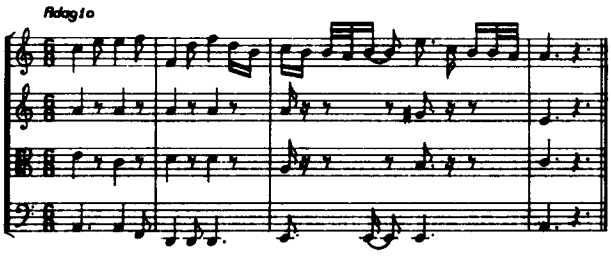
Currently, the macrostructure of the composition, which is that of a classical string quartet, is controlled deterministically, from the level of complete musical sentences on.

To conclude, two fairly different examples are taken from the actual composition.

1. First sentence of the first movement:



2. Coda of the second movement:



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