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1 January – 31 December 1988
Department of Information Technology

Risø National Laboratory, DK-4000 Roskilde, Denmark
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Abstract. This progress report describes the work carried out in the Department of Information Technology.

The department comprises three sections. The Applied Laser Physics Section works in the areas of holographic optical elements, optical image processing, and the photorefractive effect. The Computer Section is primarily responsible for the central computer facilities and computer networks at Risø. The Section for Information Processing and Cognitive Science, Sicos, is concerned with cognitive science, decision support, knowledge-based systems, and process simulation.

Information given may be preliminary.

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Contents

1. Introduction to the Department of Information Technology

The Department of Information Technology has its activities within the areas of information retrieval, information storage, information processing, decision making, and process simulation. The processes may be in humans (cognitive science), electronic computers (computer science), or in opto-electronic systems (optical metrology and information processing). Architecture, technology, and modelling are incorporated in the activities.

The department participates in a number of projects, with international and industrial partners.

The department is divided into three sections: the Applied Laser Physics Section, the Computer Section, and the Section for Information Processing and Cognitive Science (Sicos). Research professor Jens Rasmussen is associated with the department.

The Applied Laser Physics Section works on information retrieval and information processing using light - especially from lasers - and associated technologies. The activities range from basic investigations to applied work in collaboration with the private industry.

A facility for making holographic optical elements (HOEs) has been established. It serves both ongoing research activities and industrial efforts in applying HOE.

The newly developed formalism for analysing propagation of light through optical systems has been expanded so that a number of perturbations can be incorporated - e.g. refractive index fluctuations.

A dynamic model of the photorefractive effect has been developed in connection with a Ph.D. project.

A method of compressing two-dimensional images has been developed in connection with the work on optical image processing.

Verification of a series of concepts for opto-electronic sensors has been performed as a part of an industrial collaboration project.

The Computer Section is responsible for the central computer facilities at Risø, currently comprising a VAX-8700, a MicroVAX II, a VAX-11/750, and a Unisys A6K. The VAX 8700 was installed in the beginning of the year and is now being heavily utilised. The A6K was delivered by the end of the year and will be installed in the beginning of 1989.

In addition to the machines mentioned above the Computer Section is also responsible for networks, including external connections and electronic mail.

A number of courses were held on the use of the machines and on application of special software. Courses and consultations on the use of personal computers (PCs) are now also an integral part of the activities.

The section has provided major contributions to the establishment of numerical models of chemical reaction systems and atmospheric diffusion.

Sicos works in the areas of cognitive science, knowledge-based systems, and process simulation. Major emphasis is placed on the area of "decision support systems". The section is involved in both basic and applied research. A considerable amount of effort has been devoted to the preparation of several Esprit projects. Two of the projects have now been approved with Risø as the prime contractor. One is on "Modelling Human Actions in Work Contexts" to be sponsored under the Esprit Basic Research Action. The other project is about "Information Technology Support for Emergency Management" which is a continuation of a Nordic project where the section was the project coordinator.

Collaboration with industry has been performed within several projects on various aspects of the use of knowledge-based systems for diagnosis and control, and also on process simulation. A PC version of a process simulation package has been prepared for commercial use.

A project on "Information Retrieval and Decision Making with an Icon-based User Interface" applied to library systems has received a considerable amount of interest. A related project about investigating mental models of how information is categorised is close to completion.

In order to investigate human problem solving strategies, a model of forest fire has been estab-

lished. The model was made in the object-oriented language "Smalltalk".

Initiatives have been taken to enhance activities in the area of neural networks/parallel distributed processing. A Ph.D. project in this area is about automatic recognition of handwritten numerals.

2. The Applied Laser Physics Section

2.1. Introduction

The work carried out in the Applied Laser Physics Section has been centred around three major activities in the year 1988. The primary project has been an industry-related programme in which certain types of optical sensors have been investigated and considered for practical implementation. The second major task, which has been pursued, is the establishment of a facility for design and manufacture of holographic optical elements to be employed in the project mentioned above. Elements based on the holographic technique moreover play an important role in the third activity, optical signal processing, which is the basis for an Esprit project to commence in 1989. The participation in this project has been established in 1988.

The scientific basis for the work carried out in the Applied Laser Physics Section is highly diversified. The work with coherent optics is complemented with chemical insight related to the work with holographic recording. The development of optical sensors calls for profound knowledge of electronic processing, whereas optical processing demands deep understanding of mathematical analysis and computer architecture. To be able to cope with future scientific areas, knowledge in areas related not only to optics, but also to electronic processing and chemistry has to be updated during the day-to-day work with the present projects.

2.2. Optical Sensors

Verification of a series of non-contact optical sensors for service in an industrial environment has been performed and tests have been accomplished. The development of sensors is done in cooperation with two Danish industrial firms and is accordingly subject to a non-disclosure agreement.

Sensors based on holographic optical elements and diode lasers have the possibility of being produced to form a robust sensor at a competitive price. In the light of these new technologies several sensor concepts have been scrutinised to investigate new ways of implementation. The freedom in designing optical systems based on laser diodes and holographic optical elements has furthermore resulted in new measurement principles which could hardly be installed with conventional optical elements.

The practical implementation of optical sensors has been accompanied by theoretical considerations on the optical and electronic signals not to be released before proper protection of proprietary rights has been achieved.

A previously documented matrix method for analysis of complex optical systems has been further expanded to take into consideration tilt, decentre, and despace in optical systems, ref. 11. The method brings about a simple, and yet accurate method of analysing coherent optical systems where the optical axes of the optical elements (lenses, prisms, etc.) have been translated or tilted with respect to each other. Besides, a perturbation in the distance between the centres of the elements can be treated.

The matrix formulation of Gaussian optics has furthermore been employed in the description of wave propagation through optical turbulence. Closed form expressions are here derived for various statistical functions that arise through arbitrary optical systems that can be characterised by a complex ABCD matrix in distributed random inhomogeneities along the optical path. Specifically within the second order Rytov approximation, explicit general expressions are presented for the mutual coherence function, the log-amplitude and phase correlation function, and the mean square irradiance that is obtained in propagation through an arbitrary paraxial ABCD optical system containing Gaussian-shaped limiting apertures.

2.3. Holographic Optical Elements (HOEs)

A new design centre for holographic optical elements was inaugurated in February 1988. The aim of the centre is to support Danish industry in its efforts to use HOEs in optical sensors and to support the ongoing work on optical sensors in the Applied Laser Physics Section.

The laboratory of the centre has been set up in the basement of the building in order to minimise interference from vibrations in the building and temperature variations. A dehumidifier has been installed during 1988 to maintain a relative humidity around 45 % necessary for work on dichromated gelatin.

To facilitate the work on HOEs and holographic recording materials, a comprehensive amount of equipment has been installed in the laboratory. The equipment includes a number of items such as:

2 high power argon ion lasers with etalons,
1 40 mW HeNe laser,
2 vibration insulated tables,
1 laminar flow box class 100,
1 fume hood,
various optical components and optomechanical devices,
computer-assisted laser beam diagnostics equipment.

A number of HOEs have been created for use in optical sensors based on coherent as well as incoherent light. Most of the work, however, has been carried out in connection with the sensor project and is proprietary.

Retrofit optical elements such as polarising beamsplitters, Amici prisms, and interference filters have been produced as HOEs. Particularly the interference filters have proved to be of great theoretical interest as they provide us with a vast amount of information concerning the behaviour of the holographic recording material.

The work on the holographic recording material, dichromated gelatin (DCG), is carried on in order to gain improved knowledge about the parameters which determine its sensitometric properties.

A new scheme for coating the DCG on glass substrates has been developed, effectively cutting down the chromium consumption in the casting process by 98 %. This is achieved by casting the gelatin film from a solution containing both gelatin, ammonium dichromate and prehardener, rather than doing it in three separate steps.

The incapsulation techniques to protect the DCG from humidity have been further refined and are now close to the state-of-art.

An instrument for laser beam diagnostics has been acquired through the Technological Development Programme run by the National Agency of Industry and Trade. Measurements using this instrument have demonstrated that beams originating from the HOEs have a nearly Gaussian beam profile.

Experiments on the aberrations in HOEs introduced by the difference in recording and replay wavelength have shown that proper choice of recording geometry can minimise this effect. This finding is of interest as most of the lasers used in the optical sensors are near infrared diode lasers and thus differ considerably from the recording wavelength of 488 nm. (See figure p. 8)

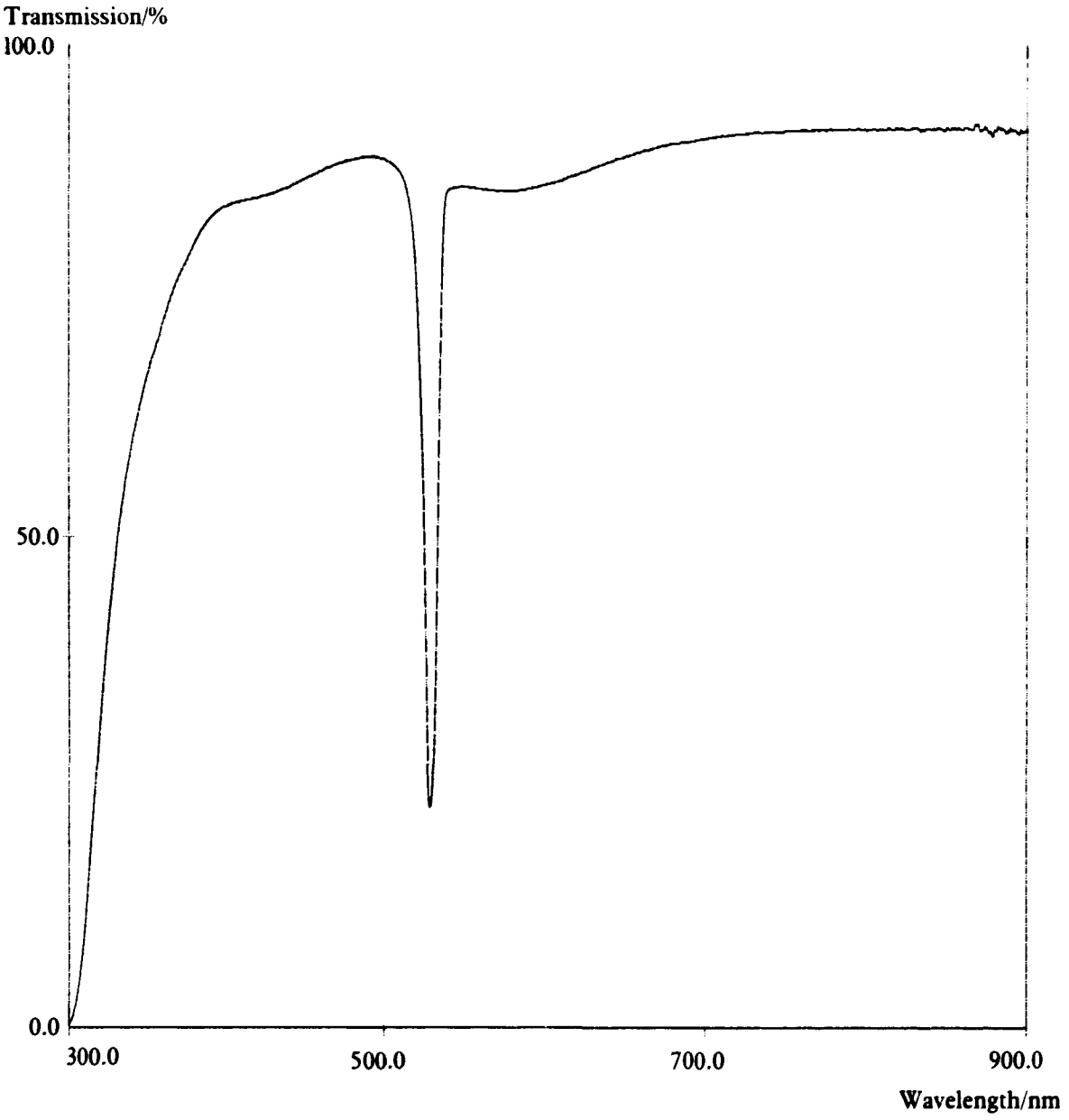
2.4. Optical Signal Processing and Research in Non-Linear Optical Materials

Scientific Basis

The interest in optical processing comes from the ability of the optical systems to process two-dimensional information with, popularly speaking, the speed of light. The physical basis for this is the ability of a lens to perform a two-dimensional Fourier transform with coherent light (laser light). In analogy to electronic processing of temporal signals, filtering, spectral analysis, and correlations can be done optically on spatial signals.

Non-linear optics and optical processing are connected in the sense that the processing of optical information can be performed in non-linear optical media.

The media used for the processing may be various, but at Risø we concentrate on the photorefractive crystal of bismuth silicon oxide ($Bi_{12}SiO_{20}$) and barium titanate ($BaTiO_3$). The photorefractive effect has been a widely accepted term for describing light intensity dependent changes in the refractive index observed in electro-optic materials. When a spatially modulated intensity pattern impinges on a photorefractive crystal, electrons are photoexcited from a filled donor site at high intensity levels to the conduc-



Transmission curve of HOE interference filter with peak reflection at 535 nm and a spectral width of 10 nm (FWHM).

tion band. Due to drift and diffusion, the ejected photoelectrons migrate into dark regions in the crystal where they recombine with empty traps. This charge separation results in a spatially modulated electric field which modulates the material refractive index via the linear electro-optic effect. The photorefractives are fast, have large electro-optic coefficients, and can store a vast amount of optical information.

Activities

As a continuation of a terminated Esprit I project, an Esprit II project has been planned. The new project named "NAOPIA" (New Architectures for Optical Processing in Industrial Applications) has been accepted by the Commission of the European Communities initially, but the final contract has not yet been signed. The partners in the project are Thomson-CSF (France,

prime contractor), GEC (UK), Krupp (Germany), University of Erlangen (Germany), and Risø. The partners are all involved in optics, and the cooperation with the partners is in itself expected to be highly beneficial to Risø.

The Risø work is planned to be a continuation of the Esprit I work and a development of an industrial prototype of the optical robot vision system. The prototype development is planned to be carried out in close cooperation with Krupp.

Research has been undertaken on the architecture of optical vision systems for recognition of objects. Especially data reduction methods for compressing two-dimensional images into a one-dimensional representation have been studied.

Models for volume holograms and non-linear optical devices working as volume holograms have been studied.

The work performed at Risø on photorefractive materials has been carried out as a Ph.D. study and has been concentrated on the field of enhanced four-wave mixing, and on outlining a proper set of equations describing the frequency analysis of the band transport equations, describing resonant phenomena.

3. The Computer Section

3.1. Introduction

The main responsibility of the Computer Section is to maintain the central computer services at Risø and to facilitate their use and availability to all edp users at Risø.

According to the present edp strategy the central computer services are covered by computer systems from two vendors, which are Digital Equipment Corporation and Unisys.

At present, the Computer Section has three VAX systems from Digital. The most powerful of these is a VAX-8700 which was installed in early 1988, as mentioned in detail below. Furthermore, a MicroVAX II and a VAX-11/750 are available although most of the workload has been moved to the VAX-8700. The MicroVAX II is now dedicated to serve Risø Library for their online search and registration system and to function as a gateway in some computer nets. The VAX-11/750 is only used for software experiments which might jeopardise the normal operation if performed on a service computer.

Through 1988 the Unisys B7800 mainframe, which was installed in 1982, has ensured continuity in the edp service offered at Risø. A replacement of this computer by a Unisys A6K was planned and the new computer arrived at Risø in late December. Together with the build-up of VAX power this implements the aim of the edp strategy to have flexibility through several medium systems, rather than one large system.

In addition to these systems, the Computer Section takes care of the central operation of the Domain net with Apollo work stations, a net which covers some departments at Risø.

Access to the computers and to external services through diverse networks is an important part of modern edp use, and this is also the concern of the Computer Section.

An important responsibility of the Section is to help Risø scientists in their use of the computers. This may be by acting as troubleshooters or consultants on all kinds of problems arising in connection with programming and using the computers, and sometimes by giving programming assistance to other sections or departments of Risø.

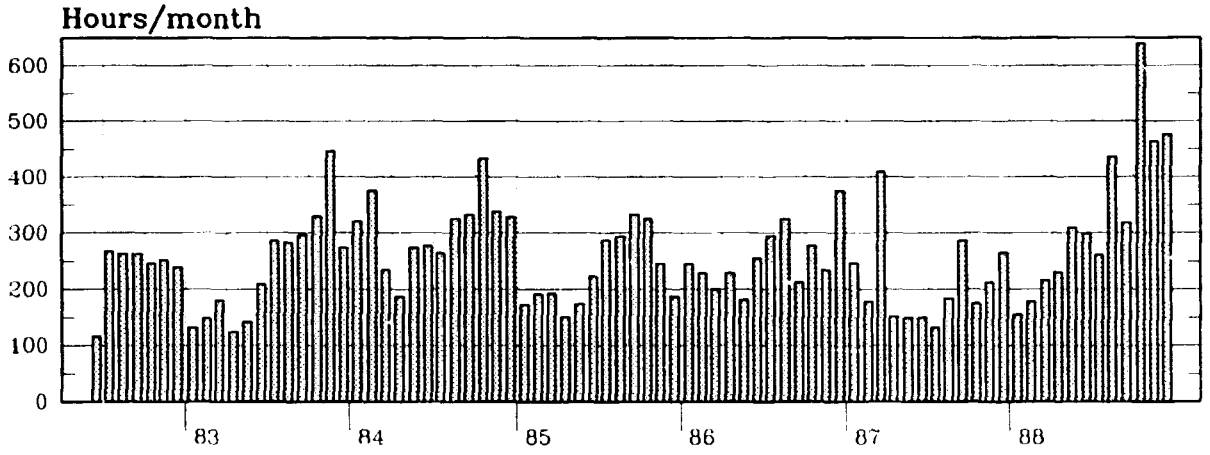
Furthermore, the Computer Section gives a series of courses on areas of more general interest. During 1988, 40 courses and seminars were held ranging from introduction to use of the computers via courses on computer languages and data structures to more specialised areas.

A new area of interest is the increasing need for assistance in the use of PCs. In the second half of 1988 the Computer Section therefore gave a series of courses of the use of PCs.

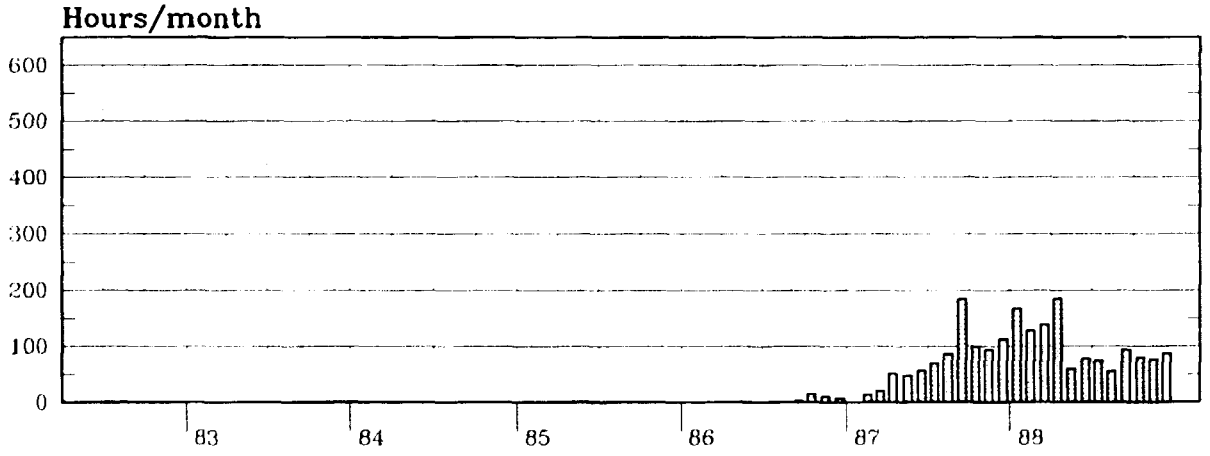
Four issues of the newsletter RMS-nyt (Regnemaskinens Meddelelser til Samtlige brugere) announcing new features and facilities have been sent out in 1988.

A detailed description of production and activities in 1988 will be reported separately, but diagrams of the processor time and the online time, i.e. the sum of the duration of the users' sessions with terminals connected to the computer, are shown on the next pages. As the B7800 has now been closed down for good, the diagrams have been chosen to cover its full period of service.

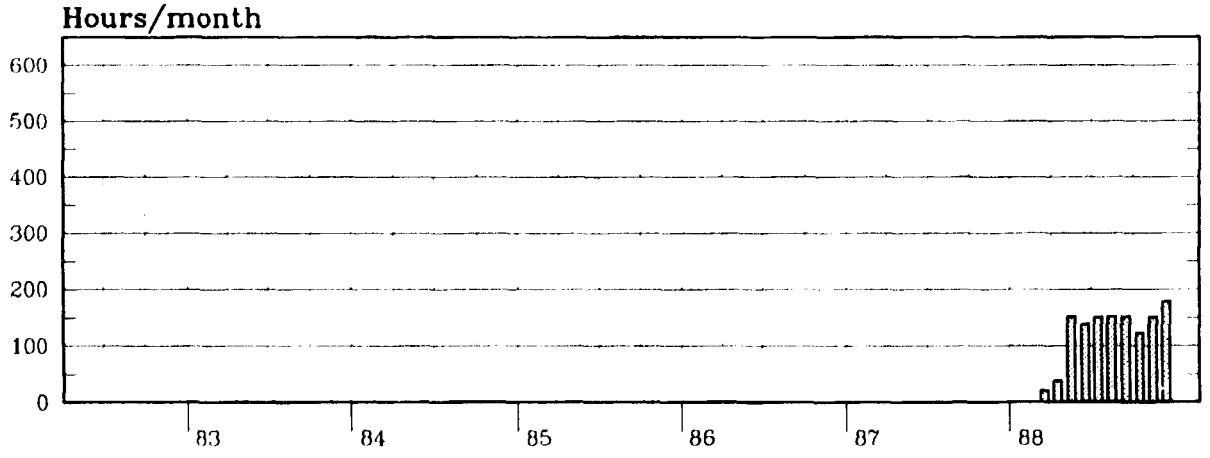
Statistics of the use of B7800
Processor time



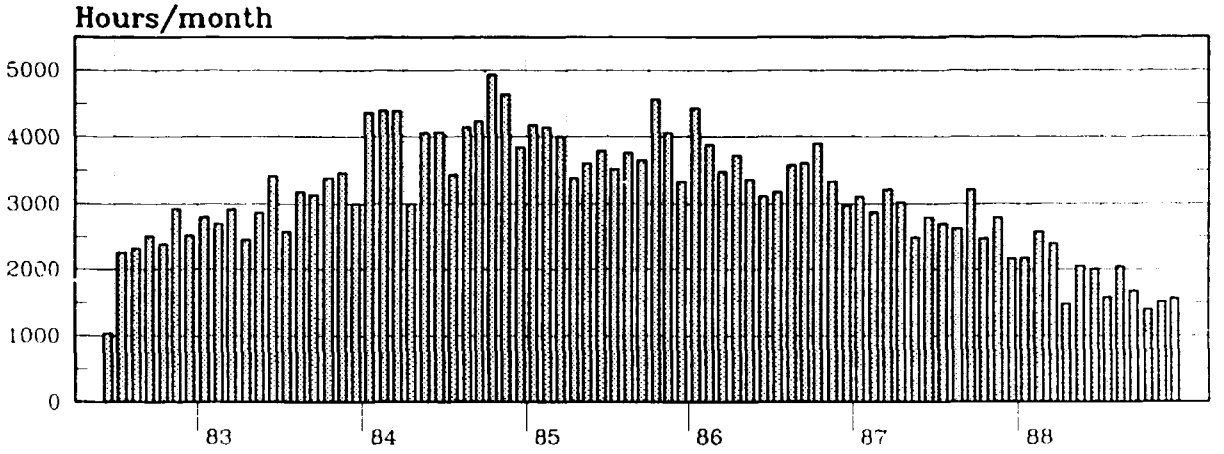
Statistics of the use of MicroVAX II
Processor time



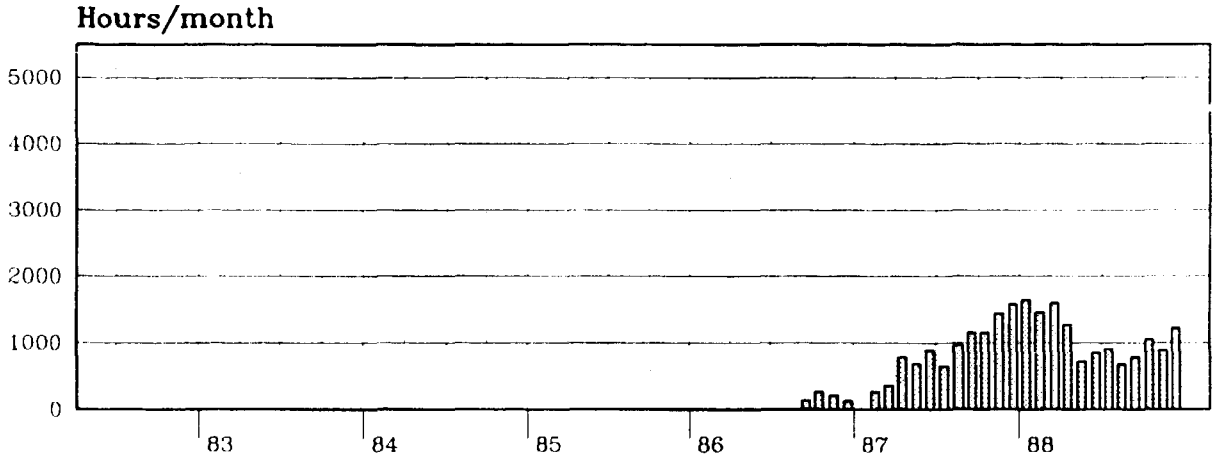
Statistics of the use of VAX-8700
Processor time



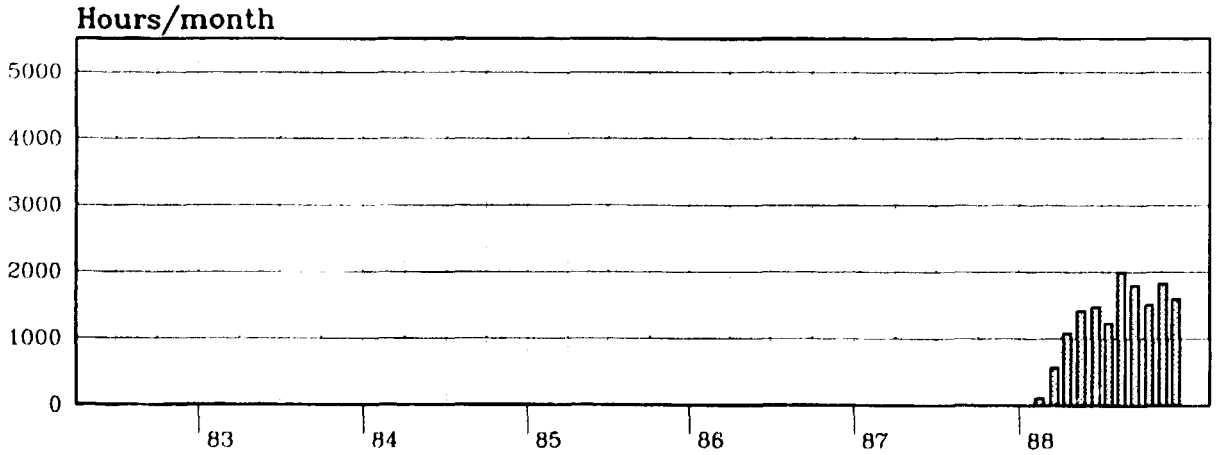
Statistics of the use of B7800
Online time



Statistics of the use of MicroVAX II
Online time



Statistics of the use of VAX-8700
Online time



3.2. Central Computing Facilities

VAX-8700

The main VAX event of the year was the arrival of the VAX-8700 by the end of February. With a processing speed of about eight times that of the MicroVAX II or the VAX-11/750 the new VAX belongs to the upper end of the DEC VAX series. In computing power it is comparable with the Unisys B7800.

The hardware configuration includes:

48 MB memory,
3 x 456 MB Winchester disk (RA81),
1 1600/6250 bpi tape station (TA79),
40 user terminal connections.

The installation is actually a VAX cluster although, so far, the cluster consists of only one member.

The configuration can be extended in two ways, either by adding to the present VAX-8700 (e.g. additional CPUs, more disk space) or by adding extra members to the cluster.

The operating system of the VAX-8700 is VMS as for the two smaller VAX computers. Compilers for Fortran and Pascal are also found on all three VAXes.

In addition, the Logitech Modula-2 compiler is available on the VAX-8700. As regards special programming facilities, the VAX-8700 came with the Language Sensitive Editor (LSE) installed, and towards the end of the year the license was purchased for the Source Code Analyzer (SCA), an analytic tool for use in the development of large programs.

The Use of the VAXes

Immediately after installation of the VAX-8700 all general Risø VAX users were transferred to the new computer. The MicroVAX II was then reserved for two main areas of work: as a dedicated computer for the data base systems of Risø Library and as a gateway for the network connections to the world outside Risø. The VAX-11/750 was taken out of general use and has since served as an experimental computer in testing various software products.

In early 1988 the MicroVAX II was heavily overloaded, running the library systems and the general user jobs at the same time. After the arrival of VAX-8700 a good part of the load was removed, but since then the demands of the Library have increased, and by the end of the year MicroVAX II is once again overloaded with the result of very long response times for interactive users.

The work load on VAX-8700 has been increasing month by month. To encourage users to run CPU-demanding batch jobs during the evening and night hours, a charge-free queue which is open only from 8 p.m. to 8 a.m. was created. Due to the tight computing budgets of the departments this queue has become very popular.

The diagrams on the opposite page show the CPU utilisation for VAX-8700 and MicroVAX II, respectively, hour by hour for the average week of November 1988. This load pattern is typical of the situation during the last six months of the year. In the case of VAX-8700 the CPU demand is highest outside normal working hours. A very sudden rise in CPU demand (at times up to 100 per cent utilisation) is seen every day at 8 p.m. when the charge-free queue is started. The CPU load of the MicroVAX II shows a different pattern which is dominated by interactive use during working hours with a tail of batch jobs in the early evenings.

With an average CPU utilisation as high as for the MicroVAX II during the day, interactive response times are often unacceptable. In fact, the average load for a mainly interactive computer should not increase much above the level seen for the VAX-8700 at daytime.

B7800 Service

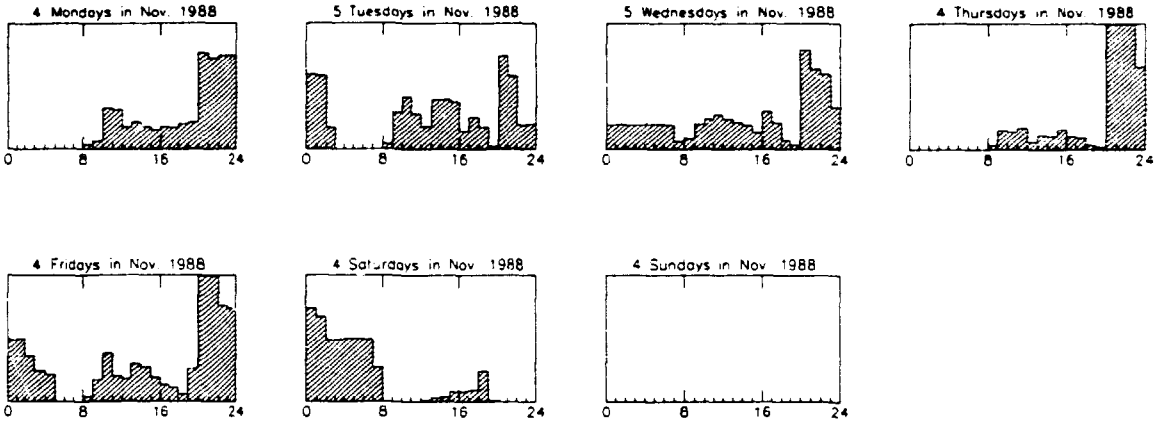
The Unisys B7800 computer has been in stable operation throughout the year. Today, the B7800 is considered old technology which is expensive in maintenance, electrical power, and cooling. Therefore, it has been the aim to replace the B7800 with a modern, compatible computer. At the same time the bigger part of its work load should be moved to a VAX computer so that the actual replacement could be economically acceptable.

After the arrival of the VAX-8700 it has been possible to relieve the B7800 of a number of Fortran and Pascal programs, and in the autumn of 1988 it was deemed feasible to replace the B7800 with a Unisys A6K at the end of the year without insurmountable capacity problems for the users who are dependent on the Burroughs/Unisys architecture.

CPU time

VAX 8700 use for the period from 1 Nov 1988 to 30 Nov 1988

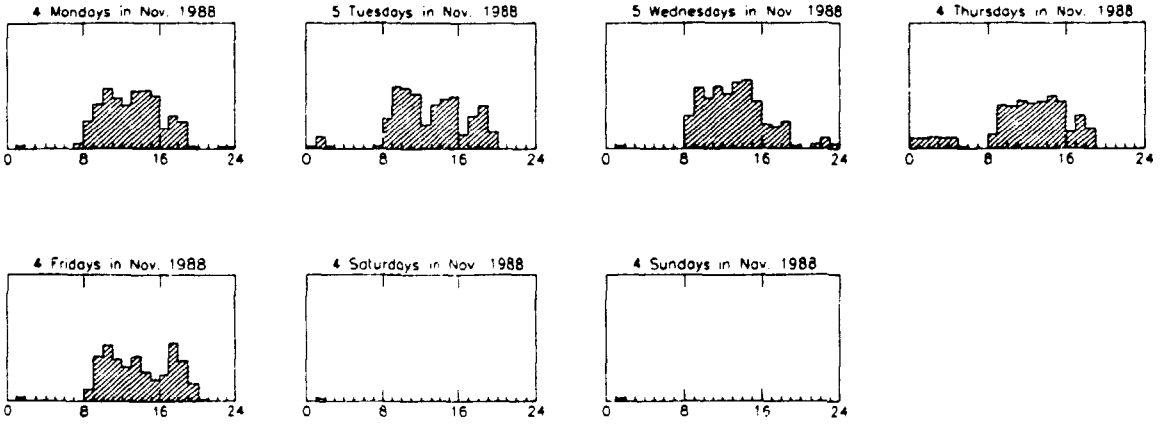
Scale: 100% use



CPU time

MicroVAX II use for the period from 1 Nov 1988 to 30 Nov 1988

Scale: 100% use



The A6K arrived at Risø in late December. The central processor is fully compatible with the B7800 so all programs can be moved without problems apart from an approximately four times larger computing time. Pascal and Cobol will not be available at the A6K. Most peripheral units will be transferred from B7800 to A6K. However, the control of data communication is different in the A6K, and this has in fact caused a difficult transition period for some users with non-trivial demands.

Miscellaneous

For some years, there has been a Domain net with Apollo work stations at Risø in departments with particular needs, e.g. mechanical and electronic CAD (Computer Aided Design).

In 1988 an Apollo work station was installed in the Computer Section, a work station which now handles operations such as backup copying of files for the Apollo users.

At the same time this work station acts as a gateway between the Domain net and the Risø computer net (see below).

3.3. Networks and Data Communication

The Computer Section is responsible for the network and data communication activities at Risø. These include a terminal network, a computer network, an electronic mail system, and a number of software packages used for communication between several computers.

Risø Terminal Net

Risø terminal net was described in detail in the progress reports of the Computer Installation for 1983-84 and 1986. It is still growing but at a much slower rate than previously. Today it has about 530 terminal interfaces in Risø's departments and is not expected to become much larger.

During this report period there have been four major achievements:

Installation of shelf no. 7 giving room for 128 extra terminal interfaces.

Installation of 48 ports for the VAX-8700 computer through a multiplexed 1.5 Mbit connection.

Upgrading of system firmware to the newest release, one of the advantages of which being the possibility of two simultaneous sessions on one terminal interface.

Replacement of old 300 and 1200 bit/sec autodial modems by new multispeed (300 - 1200 - 2400 bit/sec) autodial modems which can also be used as dial-in modems thereby rendering the old dial-in modems obsolete.

Risø Computer Net

During the report period parts of the decided Risø wide Ethernet have been installed. The Risø computer net was described in the department's progress report 1987, pages 29-31 (ref. 34). It is to consist of a backbone made up of three logically separated parts to which departmental networks may be attached. The two parts of the backbone including the fibre optic bridge have been installed as well as four of the departmental networks with the remainder of the network being scheduled for 1989.

Two departmental PC networks are in use at the moment, namely a 3COM network in the Electronics Department and a Novell network in the Administration Department. The Physics Department is using a Xerox document production system to produce high-quality printed letters.

The Apollo computers on the Domain net and the VAX computers have been linked together via the TCP/IP protocols. An Apollo DN3000 and the MicroVax II act as gateways between the two systems, the DN3000 being on the Domain net as well as on the Ethernet.

A PC version of TCP/IP has been acquired and installed on certain PCs, thereby giving these PCs access to the VAX and Apollo computers via the Ethernet.

Digital's Personal Computer Systems Architecture, PCSA, which provides an integration of PCs into the VAX world, has been installed on the VAX-8700 and on a couple of PCs. The trial runs have been successful and PCSA is expected to gain wide acceptance at Risø.

Electronic Mail

The EAN electronic mail system was installed on the VAX-8700 early in the year and the VAX-8700 now acts as the main mail machine, the

MicroVax II being reduced to a mail gateway machine linking Risø to the outer world.

55 scientists at Risø have been registered as mail users and approximately 40 of them regularly use the mail system as a means of communication with colleagues all over the world.

The Danish National Ethernet DENet

The Danish university computing centre UNI-C has been responsible for the construction of a nationwide Ethernet DENet linking most of the Danish academic institutions by 64,000 bit/sec (64 Kbit) connections. DENet is connected to the Nordic Nordunet Ethernet, which again is connected to the American NSFnet all over 64 Kbit lines. DENet and Nordunet support TCP/IP and DECnet whereas the connection to NSFnet only supports TCP/IP. This means that computers connected to DENet can reach around 1,000 DECnet nodes in the Nordic area and more than 3,000 hosts via TCP/IP mainly in the USA. At the moment Risø is only connected to DENet via a 9,600 bit/sec DECnet link over X.25 to UNI-C in Århus. This is a rather slow connection which only gives access to other DECnet nodes. Therefore it is hoped that it will be possible to establish a 64 Kbit connection to DENet via UNI-C in Lyngby which will support DECnet and TCP/IP.

3.4. Software Development

General Software

Automatic File Transfer from B7800 to VAX-8700
Because of the introduction of VAX computers in the Computer Section it was found expedient to help the users to transfer their files, both data files and program files, from Unisys B7800 to VAX-8700. A program called Burtovax developed by the Computer Section makes an automatic transfer of files from B7800 to VAX-8700. The program makes use of our routine Transfer which transfers a single file between B7800 and VAX-8700 when called by a user with file names as parameters. The files (which must be written in ASCII) are transferred by Burtovax with the hierarchical structure of the files preserved. The program exists both in an interactive and in a batch form.

Modula-2
Modula-2 compiler version 3.5 from the software house Logitec in Switzeriand was originally installed on the MicroVAX II, but was transferred to the new VAX-8700 in 1988 as a part of the redistribution of the work load. This compiler has been replaced by later versions and the actual version is now 4.1-0.

A member of the staff has been appointed as a beta tester by Logitech for testing the Modula-2 compilers from the software house. This means that the Computer Section can obtain prereleases of the Modula-2 compilers. The same member of the staff has become an expert member of the committee on programming languages and operating systems, S142u22, of the Danish Standard Organization.

Uniras
The Uniras raster graphics system has been installed on VAX-8700. On MicroVAX II the basic Uniras routines were available, but in connection with the transfer to VAX-8700 the full system was purchased. The Uniras system now includes interactive packages as well as Fortran subroutines for user applications. Drivers are available for a wide range of terminals and hardcopy devices.

Linear Programming
There have been some efforts to improve our computer code Linprog which solves large-scale linear programming problems (LP). The efficiency was enhanced, as well as its capability to handle still larger problems. For test and comparison a number of sample cases were run with Linprog and with commercially available LP codes, including IBM's MPSX at UNI-C.

Application Models and Software

Simulation of Chemical Reaction Systems
The improved version of Chemsimul in Pascal has been finished and is now working on VAX-8700. It has been tested independently at the University of Linköping, Sweden, during 1988, and there are no known errors in the program. The documentation is in progress and is expected to be finished and ready for distribution to potential users in 1989.

It is still under consideration to make a Pascal (or Modula-2) version for PCs of Chemsimul because at small laboratories chemists have easier access to a PC than to a VAX.

Software for Positron Spectral Analysis on Micros
The implementation of the Patfit program system for use on PCs was finished in 1988 (Patfit = Positron Annihilation Techniques FITting). This project was carried out together with the Metallurgy Department. It was initiated under the auspicies of IAEA. The complete system is called Patfit-88. It comprises two fitting programs for positron lifetime analysis and one for angular correlations; moreover, there is an input-editing program for each of the fitting programs. Patfit-88 runs on PCs as well as on larger computers (e.g. VAX). It is written in portable Fortran 77. Copies of Patfit-88 have already been sold to foreign research institutes and universities. As a supplementary tool, a program Patgraph was written. It produces a graphical display of the output from the Patfit-88 programs. Patgraph runs on PCs only. A complete documentation of the software as well as the mathematical methods is being prepared and scheduled for release by early 1989.

Mathematical Models in Atmospherical Research
The cooperation with Risø's Meteorology Section continued in 1988 and was concentrated on two main issues. First, the mathematical model for puff diffusion was improved and extensions prepared for description of a smoke plume, which is considered as a train of single puffs. Different aspects of this work were presented at two conferences in 1988, see refs. 17 and 18. The other main project concerns the mathematical modelling of the statistical properties of the turbulent atmosphere by the so-called spectral velocity tensor. A paper on this topic, written together with the Meteorology Section, has now been accepted for publication.

Latex/Tex
The scientific text processing system Latex/Tex was introduced as a new application at the VAX-8700 installation. One of the merits of Latex/Tex is its capability to handle mathematical formulas. It enables authors to produce camera-ready documents of high typographical quality, using the Computer Section's laser printer as output medium. Tex has already been used on PCs for some time at Riso. However, the computer power of the VAX-8700 permits fast processing of rather large documents. Moreover, the VAX installation offers tools for production of slides, and for maintaining an automatic bibliographic reference system.

4. Section for Information Processing and Cognitive Science, SICOS

4.1. Introduction

The research area of the section is the use of information technology in organisations specifically for decision support, where emphasis will be on organisations for operation of industrial plants. Within this area the research is grouped under three headings: cognitive science, knowledge-based systems, and process simulation. In a broader context of information systems and decision support, cognitive science is seen as basic research which creates knowledge about human actors in the organisation and their interaction with the information system and where knowledge-based systems and process simulation may form elements of decision support systems. In this way research in these areas may contribute directly to the design and buildup of decision support.

In order to create links to research outside Risø and since it is important to obtain external funding, one of the major efforts has been the preparation of a number of project proposals for the European Community information technology research programme Esprit II. The section participated in four European consortia to prepare such proposals in three of which Risø was the prime proposer. Two of the proposals were successful.

The first of the successful projects is Isem, IT Support for Emergency Management. In this project a decision support system for emergency handling will be developed. The second project, Mohawc, Modelling Human Actions in Work Contexts, is funded by Esprit II Basic Research Actions.

The two projects that did not obtain funding from Esprit are now being modified in order to

be carried out on a more limited scale, since the research topics of the projects are of importance to the section. Presently, at least one of them has large probability of receiving major funding from Danish industry sources. The objective of the project is to develop an information system for support of reliability management in a power plant.

This project is an example of the industrial contacts and cooperation which are of importance to the work of the section. Thus, in addition to cooperation with industrial partners in international research programmes, one of the aims is to have a continuing contact with Danish industry, and the section has a number of projects either in cooperation with industrial companies or as commercially funded development tasks, as will be described later.

In the following a short review of the research of the section is given. Only the topics which are not reported in more detail later in the present report are mentioned.

Cognitive Science

In 1988 the research has been much influenced by the preparation of the Mohawc project.

Mohawc is a project which integrates a number of basic research activities within cognitive science. The tasks to be undertaken in the project are:

analysis of complex work domains in order to make a taxonomy for work domains,

cognitive control, mental models, and heuristics,

interaction between work domain and cognitive control,

distributed decision making, and

computer simulation to test models and hypotheses.

The project is a cooperation between Risø, Université de Liège (Belgium), JRC Ispra, Centre National de la Recherche Scientifique (France), University of Bamberg (Germany), University of Uppsala (Sweden), and University of Manchester (UK).

In the near future almost all work in this area will in some way either contribute to or use results from Mohawc. Thus, the work which was started to use computer games to study human cognitive performance will be continued within Mohawc.

The Catool project concerning knowledge elicitation has been finished. The methods developed and experience gained in Catool will be used in a Ph.D. study which will be closely related to Mohawc. Another Ph.D. study concerning visual perception was started during the year. This will also have close connections to Mohawc.

Finally, the analyses of information flow and decision making in a hospital have now reached a stage where it can be seen that previously developed concepts and models seem to be very useful for representation with the purpose of giving guidelines for introduction of information systems in a hospital.

Decision Support and Knowledge-Based Systems

In addition to the two projects on decision support systems mentioned previously, a project proposal for knowledge-based support for buildup of simulation models was prepared for Esprit II. As mentioned, it did not obtain funding but a new Danish consortium has now been formed together with two Danish companies which will try either to obtain Danish support or to prepare a new proposal for the next call of Esprit II.

Three projects concerning the use of knowledge-based systems for process control and fault diagnosis are well under way or have been finished. The Esprit I project P96, Expert System Builder, in which Risø has participated since 1984, has been concluded. The VIP project concerning a knowledge-based instruction set for electrical power distribution and a project in cooperation with the Danish company Danfoss concerning knowledge-based process control will both be finished in 1989.

A new activity on knowledge-based systems based on neural networks has been started in 1988. Although a small activity was already under way in 1987, the efforts have been increased. The work is partially carried out as a Ph.D. study.

Process Simulation

The modular modelling system for process simulation, Dysim, reached a stage in 1987 which made it possible to offer it on commercial terms, and in fact some copies were sold. Work on

numerical methods and documentation was completed. An important development has been the introduction of a simple graphic interface which allows results of simulations to be displayed on a process diagram of the simulated plant.

A Ph.D. study concerning development of a modular simulation system was formally concluded during 1988.

In addition to the developments mentioned above, major tasks have been simulation of a circulating fluid bed developed for Sydkraft AB in Sweden and preparation of modelling part of a fertiliser plant for Superfos in Denmark.

4.2. Cognitive Science

Use of Simulated Work Situations to Study Human Cognitive Performance

Experimental investigations into human cognitive performance in real life work situations are very time-consuming and involve a vast amount of effort to analyse the contents of verbal protocols. An alternative approach is to expose subjects to simulated tasks presented on a computer screen. Such an approach permits cognitive performance to be studied from automatically generated data files that contain the clue to the way people adapt to tasks of varying complexity. Experiments like these make it possible, in theory at least, to identify human problem solving strategies by algorithmic means. A major goal of the work done at Riso in this field is to develop computer tools for elucidating the higher-level human intentions that lie behind decisions made by subjects in computer-simulated work situations.

In an experimental set-up (see photo below) for trying out various kinds of statistical and graphical data integration techniques, subjects are requested to perform a simulated fire fighting task in a burning forest. The hypothetical forest displayed on the computer screen is divided into 324 rectangular cells, each representing an area of one square kilometer. When cells catch fire, the subjects must try to prevent the fire from spreading extensively over the screen. The means available for putting out single fires consists of eight mobile fire fighting units that can be directed to burning or exposed cells. However, it takes time for the units to reach their destinations and to finish their fire fighting jobs, and in the meantime the fire propagation proceeds. To perform the fire commander task successfully, the subjects must make decisions all the time as to where it is most profitable to put out fire.

Fighting a simulated forest fire in an experimental study of human cognitive performance.

The versatility of the forest fire scenario in experimental studies of dynamic human decision making was first demonstrated by Brehmer and Allard in Sweden, whose simulation model was adopted more or less unchanged. However, the simulation model developed at Risø is written in an object-oriented programming language (Smalltalk) and can run on an IBM-AT or compatible PC. The description of forest cells and fire fighting units in terms of individual objects makes it possible to quickly change the methods used to probe the fire situation and the subjects' actions. In the Risø version of the forest fire, a fire fighting unit is commanded to go to a destination by two successive mouse clicks, one on the cell where the unit is positioned, and the other on the destination cell. All mouse clicks performed by the subjects are recorded on file, so that the trial sessions can be played back and redisplayed on the screen. The playback mode has been implemented as a subclass of the Smalltalk class that simulates the fire propagation mechanism.

Directing fire fighting in a burning forest may be regarded as a prototypical dynamic control task characterised by significant feedback delays. The resulting cognitive load on the decision maker has parallels in numerous management situations. To remove this load and thus become able to perform well, the decision maker must rely on prediction, i.e. he or she must adopt a feedforward control strategy based on the temporal characteristics of the process to be controlled. Therefore, it is relevant to try to measure how fast, and prompted by which screen cues, the subjects develop a predicative cognitive model of the fire propagation mechanism.

In the playback simulations the computer continuously estimates the potential fire loss before and after each set of fire fighting destinations provided by the subject. The resulting graph demonstrates the subject's ability to predict and prevent new fires. Methodological developments for automatic categorisation of the intentions behind the subject's single decisions are in preparation, again based on the deterministic nature of the forest fire.

Catool

The project was started in June 1987 and is now in its final phase. The purpose of the project was to develop a computer-based tool, Catool, for investigation of categorical information in mental models.

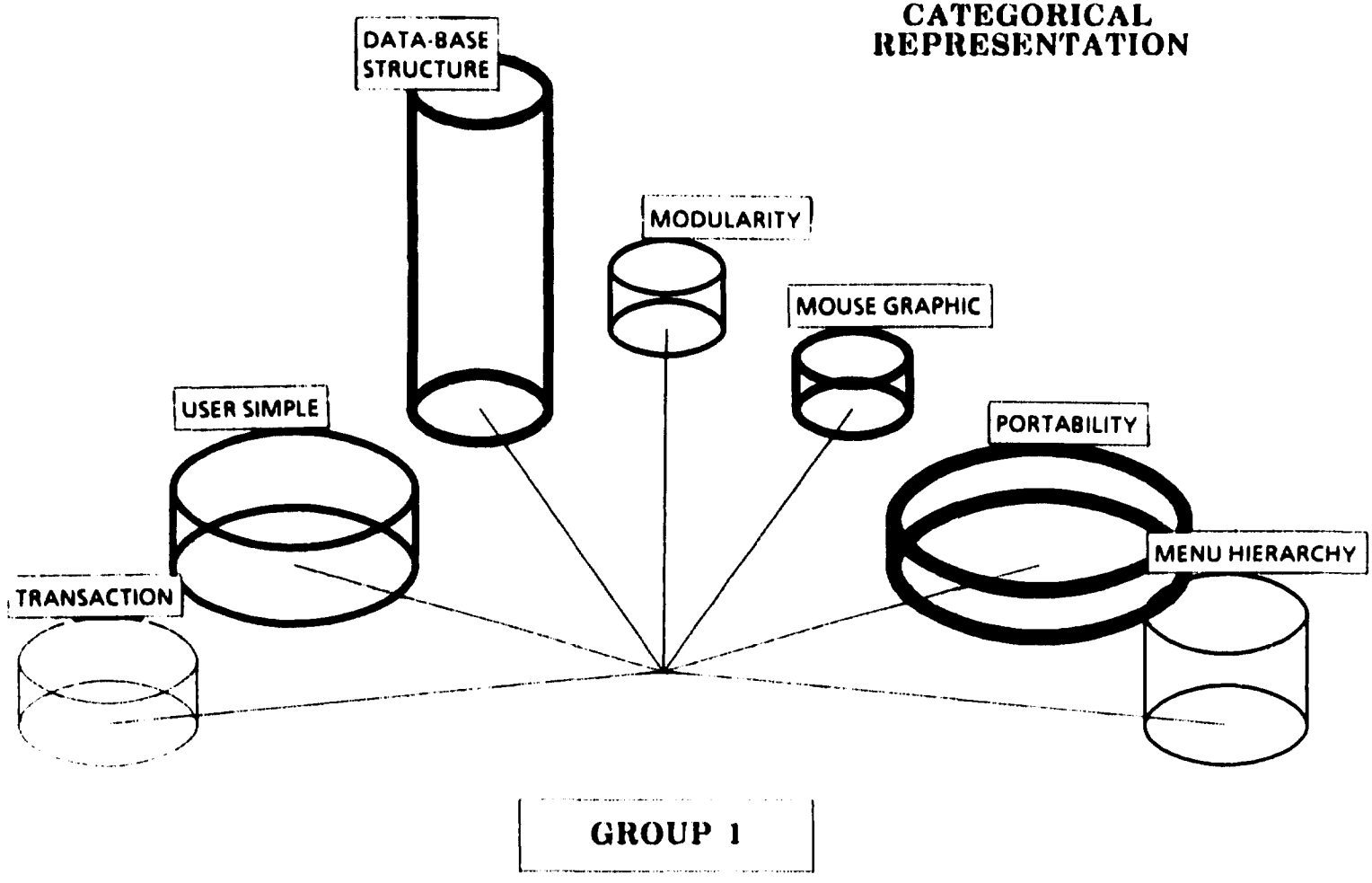
Knowing about a person's mental model is especially important when developing displays for controlling an industrial system. It is important to consider whether the construction of the displays is in agreement with the operator's mental model of the system. Moreover, knowing about a person's mental model can tell us whether the person has acquired appropriate knowledge in educational sessions.

Such a tool is not only suitable for investigation of the form of the mental model a person may have within a given domain. It would also be useful in other areas, e.g. in the study of the usefulness of metacognitive feedback - i.e. telling a person how his or her understanding of a specific subject or knowledge in a given domain is structured. Furthermore, by using Catool the person will develop classification skills, which will be for the benefit of the person's future problem solving situations.

Catool has been developed on a Xerox 1186. Catool investigates categorical aspects of mental models. A questionnaire built up of eight interrogation sessions is presented to the user. Even though the user has to answer the sessions sequentially, it is possible for him or her to modify any answer at any time. A vast amount of effort has been used to make Catool interactive by giving the user an opportunity to change already given answers. From our methodological investigations we have experienced that people very often want to change their answers as a result of the metacognitive feedback caused by the questionnaire. Small windows with a short label for each of the eight interrogation sessions can be activated with the mouse and the wanted interrogation session with already given answers is shown on the screen. When the user has finished the questionnaire, he or she is shown a graphical knowledge representation based upon the categorical information given by the user (next page).

Students from the School of Marine Engineers in Copenhagen have participated in the project by testing the methodological construction of Catool in connection with a specific technical knowledge area. Research has also been carried out to evaluate the interactive interface of Catool. Moreover, a report written in English is about to be finished.

The project is supported by the Danish Research Council for the Humanities as part of the program for technical development (FTU).



In this example the figure shows how Catool can represent the user's knowledge. In this example the knowledge domain is "Computer-assisted design of expert system interface". Keywords given by the user have been categorised into various groups. This representation shows such a group categorisation. The importance of each keyword is illustrated by the diameter of the cylinder, the height of the cylinder illustrates the amount of knowledge which the user has, and the thickness of the lines tells the clarity of the knowledge.

Man-Machine Interaction in Complex Work Domains

During 1988 the activities of this project have been to analyse complex work domains in real life work settings with the purpose of developing tools in the form of models suited for analysis of information requirements, working structures, and identification of tasks in order to implement integrated work stations and advanced information systems. The tools developed by analysing real life work situations will be used for generating proposals for guidelines for system specifications and implementation.

In 1988 the main task has been to analyse the structure of work and decision making in hospital systems. The work has been carried out in cooperation with Skanderborg Hospital. The work domain has been analysed by means of an earlier developed frame of reference by which the means-ends relationships for the whole work domain can be identified. The frame of reference has proven suitable for mapping the hospital domain.

	PATIENT		HOSPITAL		
	SOCIAL RELAT.	BIOLOGICAL	CURE	CARE	ADMINISTRATION
GOALS AND CONSTRAINTS	Working Relations and Conditions; Family Relations; Goals and Constraints of Plans and Committments;	Effects of Illness and Treatment on Persons Ability to Meet Subjective Goals and Criteria	Cure Patient, Research, Meet Public Opinion within Economic, Legal and Ethical Constraints	Patient Well being, Physical and Psychic Care, meet Public Opinion within Economic and Legal Limits	Laws and Regulations; Society, Associations and Unions; Workers Protection Rules.
PRIORITY MEASURES, FLOW OF VALUES AND MATERIAL	Personal Economy, Probability of Unemployment, Cure, etc.	Probability of Cure, Priority Measures, Speed versus Side-Effects, etc.	Categories of Diseases: Cost of Treatments, Patient Suffering, Research Relevance	Flow of Patients according to category; Treatment, and load on staff and facilities	Distribution of funds on Activities; Flow of material and personnel to diseases, departments.
GENERAL FUNCTIONS AND ACTIVITIES	Nature of Work and Employment, Family Relations, Living Conditions;	General State of Health; Category of Desease and possible Treatments;	Cure, Examinations, Diagnostics, Surgery, Medication, etc. Research, Clinincal, Experiments,	Board and Lodging, Feeding and Hygiene; Social Care, Physical Support, Transportation, etc.	Personnel and Material Administration, Accounting, Sales and Purchase;
PHYSICAL ACTIVITIES IN WORK, PHYSICAL PROCESSES OF EQUIPMENT	Physical Work Activities, Spare Time and Sports Activities; Home-Work Transportation, etc	Specific Organic Disorders and their possible treatments, Previous illness and cures,	Specific research and treatment procedures; Patient Monitoring; Functioning of tools and Equipment	Specific Processes in Monitoring, Treating, Moving, Cleaning and Feeding Patients; and in Psychic Care.	Processes in the Administrative Functions, Office and Planning Procedures;
APPEARANCE, LOCATION & CONFIGURATION OF MATERIAL OBJECTS	Patient Identification, Age, Address, Position, Education, identification of Close Family, etc	Physical State of Patient, Weight, Height, Precvious Treatment, etc.	Material Resources, Patients, Personnel, Equipment; Inventory of Medicine, Tools, etc.	Facilities and Equipment in patient quarters, kitchens, etc. Inventory of Linnen, Food, etc.	Inventory of Employees, Patients, Buildings, Equipment, etc.

The entire repertoire of functions, processes, staff, and equipment in a hospital system.

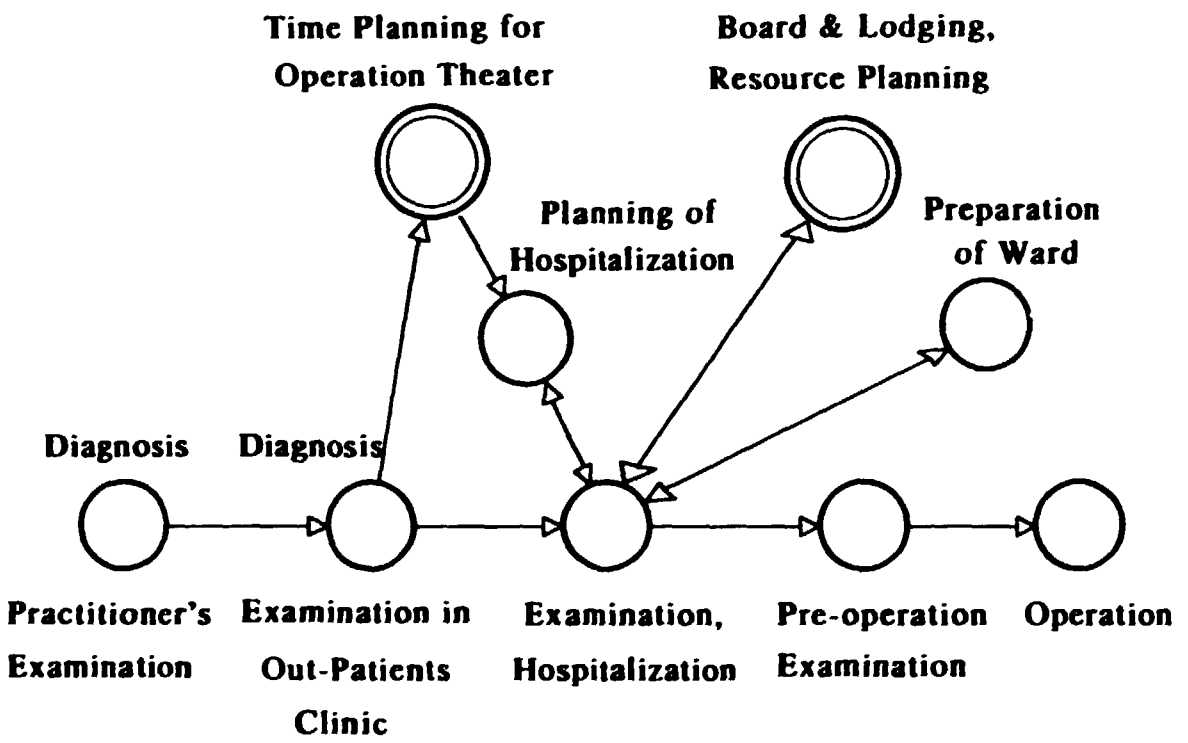
By the means of the frame of reference mentioned above, it has been possible to structure the entire complex many-to-many mapping between purposes and constraints imposed on a hospital system and the material resources available in this system, including staff. The table on the previous page illustrates an example from Skanderborg Hospital, which represents the entire repertoire of elements, i.e. functions, processes, staff, and equipment from which the relevant subsets of information can be drawn for particular situations.

In order to identify characteristic task sequences, task-specific process sequences have been analysed. These process sequences have turned out to contain situation-specific information and have to be identified for each separate task sequence.

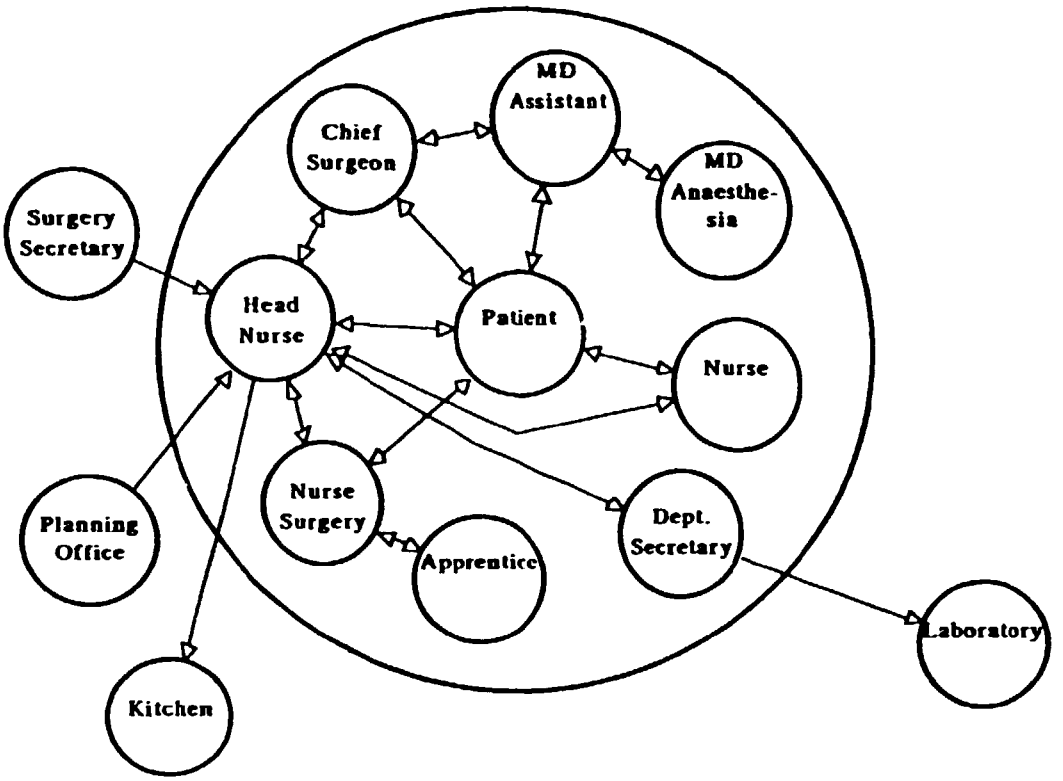
Several characteristic task sequences in relation to patient treatment in the hospital have been analysed in full, and prototypical decision situations have been identified. The analyses were based on actual performance, in particular patient treatment situations.

Patient treatment can be seen as sequences of typical actions. The analyses were aimed at identifying sets of situations defining the relevant categories of decision functions and the required knowledge base. The figure below illustrates a characteristic sequence of tasks identifying a set of prototypical decision situations. A classification of situations is necessary in order to be able to select relevant subsets of means-ends relations for the particular situations.

In a prototypical decision situation it will typically be a group of people doing a particular task that will be involved. This group will be one of the agents defining the prototypical decision situation. The figure on page 23 illustrates a group involved in a particular task, i.e. receiving a patient at the department of surgery. It is important to note that the group does not reflect the actual work organisation. The work organisation can be defined by the relational structure between the participants. The relational structure can be identified by an analysis of the communication needs in a particular task.



Characteristic task sequence in patient treatment with a set of prototypical decision situations.



The identification of a group of individual actors in a prototypical decision situation with the communication links identified.

Individual actors involved in the prototypical decision situations have been identified. The attributes of task-specific individual decision situations must be identified from field studies. Defining attributes will be the agents involved and the information content of the communication links.

The results so far have shown that this type of task analysis in complex work settings is vital in order to formulate requirements for advanced information systems and decision support systems with a larger degree of flexibility in the decision making procedures than can be acquired by more classical methods of work analyses which are aimed at formulating more rule-bound work routines.

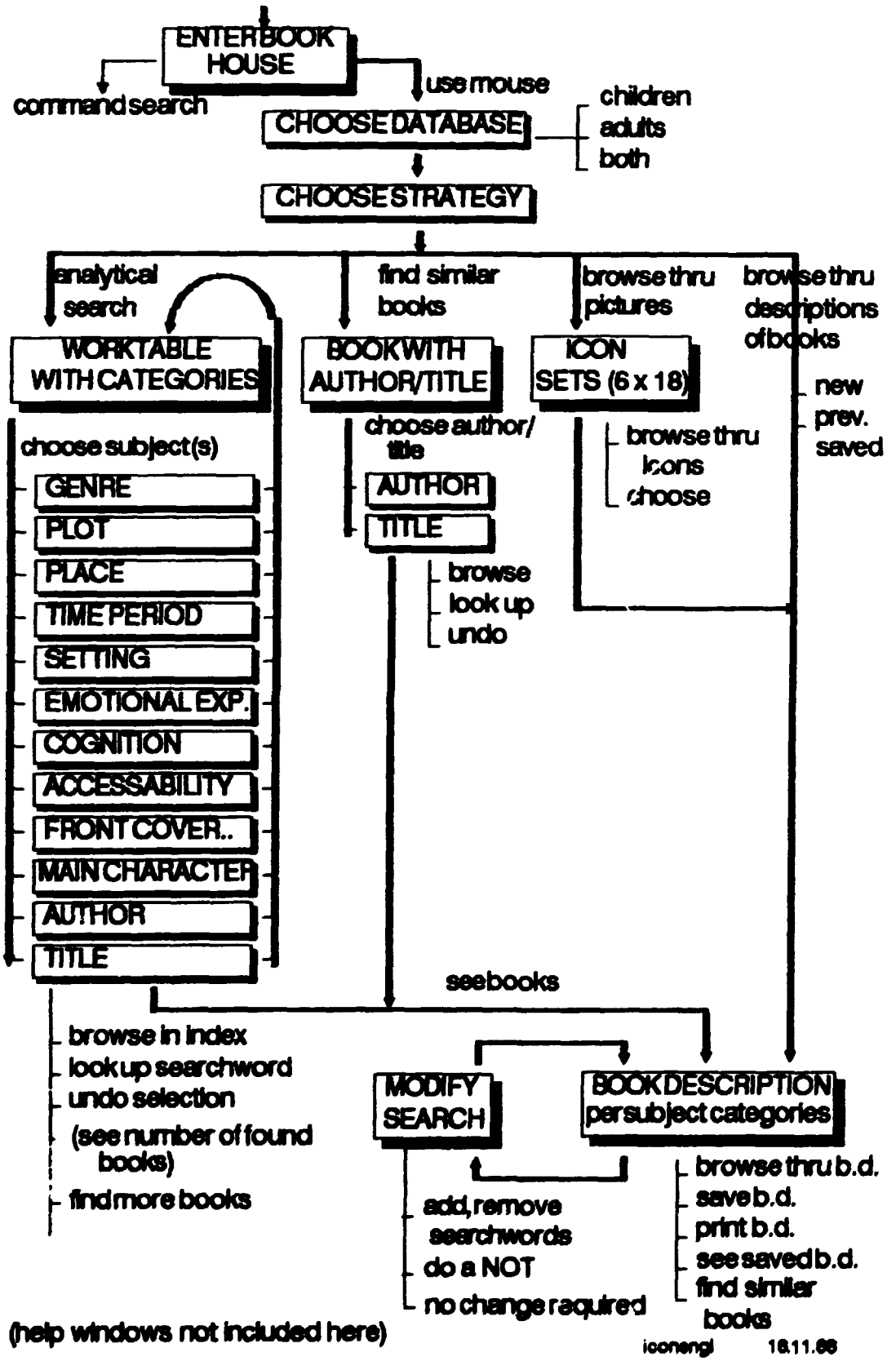
This project is supported by the Danish Technical Research Council as part of the FTU-programme.

Information Retrieval and Decision Making with an Icon-based User Interface

One of the crucial problem areas facing the designers of advanced information systems is connected with easing users' retrieval of relevant information from a wide variety of different information sources and data bases. The aim of the Book House system (and its predecessor, the Book Automat) was to investigate how an interface based on windows with icons and/or text and providing an extensive repertoire of retrieval strategies could support the users in navigating through data bases describing fiction literature.

The previous progress report (ref. 34 pp. 38-42) summarised some of the design considerations for these systems and included illustrations of the pictorial approach employed in the Book House. Further details can be found in ref. 29 . A flow diagram illustrating the various alternative strategies which are available to users of the Book House is shown on the next page. The strategies are:

> an analytical search where the user can select search terms within a classification system encompassing plot, time period, setting, genre, place, readability, main character, front cover characteristics, etc.,



Alternative strategies in the Book House

a find-a-similar-book strategy where the user inputs a known book and the Book House searches for ten "similar" books,

a browse-through-pictures strategy where the user can skim through six pages of small icons representing book contents and thereafter select one as the basis for a Book House search for matching book descriptions,

a browse-through-book-descriptions strategy where book descriptions from the data base are displayed in random order.

Among other things, users are free to switch strategies, alter their search profiles, print out desirable book descriptions, and they can of course exit at any time.

The Book Automat and the Book House systems were evaluated at a public library in the town of Hjortespring over a period of six months during 1988. The experimental subjects were the normal everyday users of the library and consisted of both children from 7 to 16 years and adults from 17 to over 50. The evaluation programme was carefully planned and consisted of both an analytical and an empirical phase. The analytical portion concentrated on the functionality of the system and could build on earlier studies of user-librarian conversations/negotiations which uncovered the search strategies employed and, consequently, the information required to support these strategies. Thus, the content of the computerised displays was based on the results of these studies and could be verified analytically. The empirical validation was then necessary, e.g. to see how/whether users would accept the form of the displayed information as supportive of their efforts to retrieve relevant fiction.

More specifically, the items for evaluation included:

subject indexing - e.g. the degree to which

the dimensions in the classification scheme corresponded to users' needs,

the searchable terms were specific and exhaustive,

the indexers' representation of content was relevant and understandable,

users and indexers agreed on the correspondence between index words and book contents.

the user interface - e.g. the degree to which

users utilised one or more of the provided search strategies,

users had difficulties in understanding the system,

users considered the system pleasurable to use,

the provided "help" facilities were utilised,

the text-only system (Book Automat) was preferred to the picture/text retrieval system (Book House) or vice versa.

Evaluation techniques included online logging, an online questionnaire, traditional questionnaires, observation, and interviews. In general terms, it can be said that the two systems received an overwhelmingly positive response with regard to both indexing and user interface. The detailed results will be included in the final report on the project which will be published during 1989. This will also include the results of an attempt to generalise the results of the project in the form of guidelines for the design of iconic interfaces.

In addition, during 1988, the Book House was demonstrated in libraries, universities, and other institutions both in Denmark and abroad. It has also been presented on the Danish television. Interest in its application is high - e.g. in connection with bookstock indexing for bookshops and publishers, as an interface to fiction and non-fiction, for videotext systems, and as an interface toolkit for data bases.

For those interested in implementation details, the Book House has been built as an application of the GEM (Graphics Environment Manager) system in a DOS environment - however with much original C code for the functions not covered by GEM. As such the system uses 602 kB of the 640 kB maximum. Retrieval speed on a 386-type machine is satisfactory for the (modest) data base sizes employed.

The project was supported by the Danish Council of Technology. Other project partners were Jutland Telephone, RC Computer A/S, and The Royal Danish Academy.

4.3. Decision Support and Knowledge-Based Systems

Esprit Project P96, Expert System Builder

The project was a European Esprit project which started in 1984 and ended in the summer of 1988. The Danish partner of the project was the electronic company, Søren T. Lyngsø. Foreign partners were Cselt in Italy, Cimsa in France, and Plessey in England. Risø has collaborated with Søren T. Lyngsø as a subcontractor since the beginning of the project.

During the project a rule-based expert system builder (ESB) was created which can run at Lisp machines and which is now ready for use.

The ESB was designed with a view to use for diagnoses in technical systems, and it has a structure of a modular reasoning system which makes it suitable for such tasks. The modular structure is rooted in a data base with a knowledge domain-specific concept which contains descriptions of the basic concepts of the domain in question. This architecture makes it possible for the system to reflect on deeper knowledge. The ESB has now been transferred into Common Lisp.

In 1988 the Danish partners have concentrated on two tasks:

> industrialisation, which means product development, and
>
> the demonstrator, which was a real life on-site implementation of a diagnostic expert system on a Danish power plant in Copenhagen, the "Svanemølleværket". This system was made in order to demonstrate the feasibility of the ESB.

The work carried out at Risø in 1988 mainly concentrated on the demonstrator, in collaboration with Søren T. Lyngsø and the Technical University of Denmark. The system has been demonstrated both on a simulation model of the gas-fired power plant boiler and on site.

The ESB has a graphic model building system in which it is possible to build a model of the problem in a CAD-like user interface. Each graphic object on the screen reflects a knowledge object in the concept base and, thus, it is possible to build a diagnostic expert system by drawing the system on which it is wanted to make diagnoses. The multilevel flow model (MFM) of a gas-fired boiler in the Danish power plant shown on page 27 is made with the model builder and reflects this method.

Parallel Distributed Processing and Neural Networks

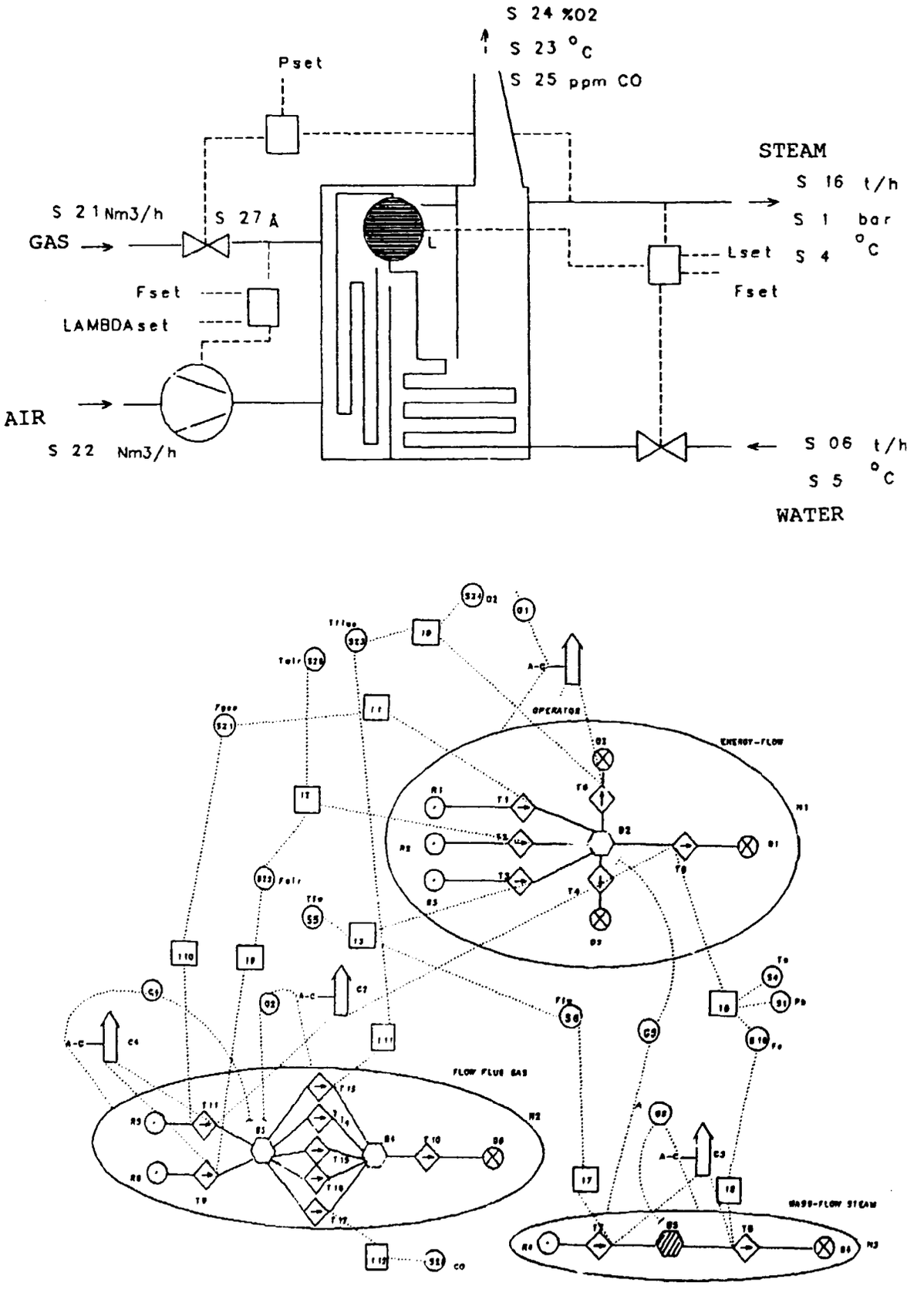
During recent years, parallel distributed processing (PDP) and neural networks have become a large and auspicious research area, particularly in the USA.

The Department of Information Technology has formed a project group to explore parallel data processing architectures, especially architectures which are based upon the biological structure of neurons.

The group has participants from the Applied Laser Physics Section as well as from Sicos to provide a broad scientific background. Its activities have mainly been in the areas of neural networks and optical processing.

Neural networks have proved to be useful in a wide range of applications. The most promising areas are probably perceptive systems (i.e. computer vision, computer speech, and computer hearing) and robot control, which are areas where traditional programming has shown little success. In contrast, neural networks have shown very good performance, and programming and training have turned out to be easy. Expert systems is another area where neural networks have evolved. Traditional expert systems require a vast amount of knowledge represented by rules, while neural networks are trained by examples. Knowledge is often very hard to elicit and transform to rules, while examples of how things behave are usually easy to provide.

In Sicos the research carried out is concerned with automatic recognition of handwritten numerals. This is part of a Ph.D. project where the main goal is to develop validation and confidence criteria for neural networks. Moreover, an expert system builder based on neural networks has been developed. This tool can be compared with the commercial expert system builder called "1st Class" which inductively builds rules, using Quinland's ID3-algorithm. The present program seems to have better capability of generalising, i.e. interpolating between the training examples, than "1st Class" has. At present, methods for improving the generalisation ability, which is a major problem in most expert systems, are investigated.



Schematic diagram and multilevel flow model of gas-fired boiler.

Training neural networks is a computational hard task when performed on traditional Von Neumann (serial) machines. To speed up computation, a vector processor card has been installed in an IBM-AT PC in Sicos. This has resulted in a computational speed of this computer that exceeds the speed of a VAX-8700 computer at Riso.

After an initial period with experimental work, some understanding of neural networks has been obtained, and the basic tools for making new applications have been developed. The tools are network training programs and an expert system builder. The tools will be tested in an industrial context in the near future.

The VIP Project

VIP is the Danish acronym for "Knowledge-based Instruction System for Process Control". The aim of the VIP project is to build a generalised expert system tool for treatment of and inference on instruction sets for operation and planning of process systems.

A prototype working on the instructions for load share among the power plants in Zealand, Denmark, is to be implemented in the central control room of the light and power company Elkraft Ltd.

Riso is participating in the project together with three other Danish partners, viz. Elkraft, the electronic company, Søren T. Lyngsø, and the engineering company, Ramboll & Hannemann.

Riso has participated in the project since its start in the spring of 1987. In 1988 Risø has done two tasks: First, together with Elkraft personnel, Riso has evaluated and prepared the existing instruction set for the central control room operators for use in a rule-based expert system shell, and Riso has also prepared test examples for off-line test of the VIP prototype. Secondly, together with Søren T. Lyngsø, the interface and interface protocols between the existing command and control system and the VIP system have been constructed.

NKA/INF-600, Use of Advanced Information Technology in Accident and Emergency Management

The Nordic programme has now entered its final phase where the results should be evaluated by means of experiments with the developed prototype systems.

A prototype system has been developed for emergency management in on-site and off-site environments, respectively, to be able to run scenarios in both kinds of environment. Each system will be used to run two different scenarios. As a reference the scenarios will also be performed without the use of the decision support given by the new systems.

Two work stations are involved in each test; one is to be used by the person to be supported by the system, and the other plays the role of the rest of the world to communicate with that person. In the on-site situation the support will be given to the emergency manager at the plant, in the off-site situation the person to be supported will be the outside local authorities, in the Swedish model represented by "Länsstyrelsen".

The main functions of the systems are message handling, reminder functions, and references to important persons in a given situation. Messages to the persons in charge may be delayed, incomplete, and sometimes false and contradictory in order to test whether in difficult situations the actions will be improved by means of the decision support systems.

Evaluation of the systems will be performed by analysis of the number of items carried out in the emergency preparedness plan as well as analysis of the time when they are carried out as compared with the development of the emergency situation. Furthermore, the quality of the status reports will be taken into consideration and, finally, the user's job satisfaction will be judged through interviews with the test persons.

A small version of the experiments mentioned above has already been performed by persons involved in the development of the prototype system to debug the system from obvious faults and inexpediencies. At the final tests people from the nuclear power plant, Loviisa, in Finland will be used for the on-site experiments, and people from "Länsstyrelsen" in Uppsala will be used for the off-site experiments.

IT Support for Emergency Management - ISEM

The end result of the Nordic programme discussed above is prototype systems supporting small parts of an emergency management system to give guidelines and recommendations for development of a complete decision support system usable in real life emergency situations. Therefore, it was decided to start another programme

for which the aim is to develop an integrated information system capable of supporting complex, dynamic, distributed decision making at all levels in the organisation and at all levels of abstraction in the management of emergencies on full scale. Emphasis will here be put on definition of system architecture and on development of an application generator and tools to support the full life cycle of the system. The idea is to develop a general framework usable for tailoring to specific applications. In the end the system will be demonstrated in the service industry and in the nuclear industry.

For this purpose a European consortium has been formed and a proposal has been sent to be taken into consideration in the new Esprit II programme. This proposal has been approved and the new programme has been started 1 January 1989. The structure of the project consortium reflects the cooperation of six partners and seven associated partners representing seven European countries, including two non-EC countries, namely Finland and Sweden.

4.4. Process Simulation

Numerical Problems in Simulation of Power Plants

The physical processes of a power plant are often described from the fundamental laws of physics, expressing conservation of mass, energy, and momentum. The use of the laws leads to a model which consists of a set of N coupled first order ordinary differential and algebraic equations

$$dy/dt = f(t,y,z,u)$$

$$z = g(t,y,z,dy/dt,u)$$

where the y values are the integration variables, the z values are algebraically calculated variables, the u values are input variables coming from outside the model, and t is the time.

A number of problems usually arise in solving these systems of differential equations within the field of power plant simulation: the time constants in the physical system are usually widely varying so that the equations become stiff and notoriously difficult to solve, there is a set of implicit equations, and the functions f and g are non-linear, discontinuous, and computationally expensive to evaluate. In particular, the use of the implicit, multistep, backward differentiation formulation methods (BDF) versus the explicit, one-step Runge-Kutta methods (RK) for solving this type of equations has been tested on PCs using the simulation system Dysim.

The implicit BDF methods, suited for solving stiff problems, require Newton iteration of the corrector, thereby involving the Jacobian (partial derivatives) of the system of differential equations. In power plant simulation the Jacobian usually has to be calculated numerically, i.e. the model equations must be evaluated N times for each matrix calculation. For non-linear systems the Jacobian must in principle be calculated to a high degree of accuracy (large storage capacity) in every integration step. The explicit RK methods have small stability regions, i.e. use small step sizes for stiff problems. The methods use a linear combination of f-values (in most cases up to four) within one integration step.

For solving stiff systems of differential equations, the BDF methods are characterised by a stability region where the fast vanishing components of the solution after an initial phase are represented by a stable, but not necessarily accurate solution. These methods therefore work with a much larger step size after the initial integration phase than that of the RK methods. Thus, if one wants to integrate the model for a long time beyond a transient phase into a steady state, the BDF methods are to be chosen. However, in the transient phase, which in power plant simulation will often be the most interesting one, these methods use rather small step sizes and frequent recalculations of the Jacobian. It is our experience that the Jacobian evaluations are very time-consuming, and that the total CPU time used for calculating a transient phase of a large model could easily exceed the CPU time required when using the RK methods.

Implicit loops are often found in the model equations which should be sorted so that these problems do not occur due to simple misordering. This could be impossible, though, in a modular model. If one attempts to integrate with large step sizes using BDF methods, it will be necessary to solve the implicit algebraic equations in each integration step, thereby reducing the advantage of these methods. Explicit methods use small step sizes for other reasons, and therefore it may not be necessary to solve the algebraic set of equations.

Discontinuities in the model equations can be caused by the user in order to study the model response to some external perturbation or can be

caused, e.g. from the modelled control system. If the discontinuities can only be located by the accuracy control, the computational time wasted in rejecting calculated time steps is much smaller for explicit methods; using the implicit methods leads to many failed convergence tests and recalculations of the Jacobian.

According to our experience the solution is to use the explicit RK methods for integration of large simulation models of power plants with very computationally heavy model equations on PCs. If the computation of the model equations could be distributed to several parallel working processors according to some modular model reflecting the functional logical structure of the real plant and dedicating one processor to each module, the simulation speed would increase substantially.

5. Research Professor Jens Rasmussen

Associated with the department is research professor Jens Rasmussen who has cognitive engineering as the central topic of his interests. Therefore, it is appropriate to give a short résumé of Jens Rasmussen's activities in this report.

In addition to the activities mentioned below, he has also taken part in some of the Sicos work reported above.

5.1. Conceptual Development of Models and Methods

Models of Distributed Decision Making and Organisational Structure

Material and data collected at Skanderborg Hospital as part of a project sponsored by the Technical Research Council under the programme for technical development (FTU) have formed the basis for development of models of cognitive processes in complex work environments. In particular, it has been possible to develop the models to cover also cooperation between several people in a work situation. This extension has been formulated as a model of distributed decision making (refs. 36,37) and was used as the basis for structuralisation of an international workshop on New Technology and Distributed Decision Making with participation of scientists within the fields of control theory, industrial psychology, sociology, and organisation. This cooperation is of importance to the possibility of evaluating the organisational changes which, consciously or unconsciously, will result from the introduction of advanced information systems and is thus of importance to the possibility of obtaining a satisfactory design of such systems.

Analysis of Accidents and Industrial Risk Management

Analysis of human errors and the formulation of a taxonomy applicable to analysis of industrial accidents have been finished and reported in a review article. The work has resulted in two directions of theoretical development.

First, the work has revealed a number of fundamental problems in connection with the common definition of causality which will immediately affect the validity of causal decision sequences and the definition of human errors in analysis of accidents. Similar problems have concurrently been identified in connection with medical diagnostics (ref. 39).

Second, together with development of the conceptual basis for the model to also include organisational situations the work has resulted in a review of the influence of organisational and management situations on the causes of industrial accidents (refs. 40,41).

The combination of the control theoretic and social scientific angles of approach in connection with organisational evolution or self-organisation seems to be profitable. Another aspect which our model development seems suitable for elucidating is the influence of cultural differences on work organisation and industrial safety. It is not merely a question of differences between industrial countries and developing countries, but also a question of "cultural difference" between various professions.

5.2. Use of the Models for System Design

The use of the conceptual frame of reference for development of user interfaces which support the functionality of advanced work stations as well as improve the user error tolerance has been continued in the first six months of 1988 (refs 32,33,42,43). This work has been focused on development of user interfaces which are "transparent" in the sense that they permit the user to manipulate his or her work content and which at the same time conform to the guidelines laid down for error tolerance.

5.3 Planning of a Joint European Research Project

In cooperation with a number of institutes in Europe a research project has been planned within the Esprit Basic Research Programme.

The subject of the project is Modelling Human Action in Work Context. It is an ambitious attempt to coordinate a number of different "schools" and research paradigms which during recent years, influenced by cognitive science, are developing in Europe in connection with the use of information technology in work contexts.

In the project it is attempted to integrate the results from field studies (in which the FTU-programme mentioned above is an important contribution) and psychological laboratory experiments with models of decision making in real life work situations. In order to find a joint basis for simulation experiments, it has been endeavoured to adapt models which result from analyses of the hospital service to models which result from laboratory experiments with memory and error mechanisms.

List of Publications:

The Applied Laser Physics Section

1. *Hanson, S. Grüner*, Heisenbergs ubestemthedsrelationer og optikken. DOPS-nyt (1988) (no. 4) p. 6.
2. *Jensen, A. Skov*, Distributed Computer-Generated Holograms, Risø-I-383, November 1988.
3. *Jensen, A. Skov*, Free Space Propagation of Light: Forward and Backward Propagating Fields, Risø-I-397, November 1988.
4. *Jensen, A. Skov*, Volume Hologram Analyzed by Laplacian Transformation, Risø-I-398, November 1988.
5. *Jensen, A. Skov; Rasmussen, E.*, Invariant Processing of Optical Mapped Images with a 1-D Electronic Correlator, 1988 Annual Meeting Optical Society of America, 30 Oct. - 4 Nov. 88, Santa Clara, California, in Technical Digest, paper FDD4, 1988.
6. *Johansen, P.M.; Hanson, S.G.*, Enhanced Phase-Conjugated Beam Produced by Temporal Phase-Shifted Pump Beam in Photorefractive BSO. In: Proceedings of the International Conference on Nonlinear Optics. NLO '88, Cong, County Mayo, Ireland, 3-6 May 1988. Corcoran, V.J. (ed.), (STS Press, McLean, VA, 1988) pp. 272-286.
7. *Lading, L.; Andersen, K.*, A Covariance Processor for Velocity and Size Measurements. In: 4th International Symposium on Applications of Laser Anemometry to Fluid Mechanics. Lisbon, 11-14 July 1988. (Centro de Termodinamica Aplicada e Mecanica dos Fluidos Universidade Tecnica, Lisbon, 1988) Paper 4.8.
8. *Lindvold, L.R.*, New Uses for HOEs. Holographics Int. (1988) (no. 3) p. 33.
9. *Lindvold, L.R.*, Medicinsk laserteknologi. Del 1. DOPS-nyt (1988) (no. 1) pp. 5-7.
10. *Lindvold, L.R.*, Medicinsk laserteknologi. Del 2. DOPS-nyt (1988) (no.1) pp. 20-26.
11. *McKinley, W.G.; Yura, H.T.; Hanson, S.G.*, Optical System Defect Propagation in ABCD Systems, Optics Letters, Vol. 13, No. 5, pp. 333-335, May 1988.
12. *Petersen, P.M.; Johansen. P.M.*, Simple Theory for Degenerate Four-Wave Mixing in Photorefractive Media. Optics Lett. (1988) v. 13 pp. 45-46.
13. *Yura, H.T.; Hanson, S.G.*, Second-Order Statistics for Wave Propagation through Complex Optical Systems. AFSC-SD-TR-88-84 (1988) 45 p.
14. *H.T. Yura and S.G. Hanson*, "Second-Order Statistics for Wave Propagation through Complex Optical Systems", to appear in Journal of the Optical Society of America, March 1989.

The Computer Section

15. *Hansen, P.; Olsen, J.V.*, GRPLOT. Interaktiv grafik på VAX. Risø-M-2683 (ed. 1) (1988) 98 p.
16. Årsberetning for Regnemaskinesektionen 1987 (Annual Report of the Computer Section 1987), Risø-I-356, Memo nr. 85. 16 p.

Furthermore, the Computer Section has issued six internal notes and manuals in Danish.

Conferences:

17. ICFD (International Conference for Fluid Dynamics, Oxford 21-24 March 1988): Prediction of Turbulent Puff Diffusion by a Nonlinear Integral Equation System, by *Peter Kirkegaard and Leif Kristensen* (presented as a poster by Peter Kirkegaard).
18. The Nordic Section of the Society for Industrial and Applied Mathematics (SIAM) Meeting on "New Methods and Techniques Useful to Industry and Science", Bergen, Norway, 26-27 May 1988: Integral Equations for Atmospheric Turbulent Diffusion and Plume Width Prediction, by *Peter Kirkegaard and Leif Kristensen.* (Paper presented as a talk by Peter Kirkegaard).
19. 8th International Conference on Positron Annihilation, Gent, Belgium, August 1988: PC-PATFIT: A Program Package for Fitting Positron Annihilation Spectra on Personal Computers, by *Peter Kirkegaard, Niels Jørgen Pedersen, and Morten Eldrup.* (Paper presented as a talk by M. Eldrup).

The SICOS Section

20. *Andersen, V.*, Advanced Information Technology. Information Technology for Accident and Emergency Management. Risø-M-2728 (1988) 20 p.
21. *Andersen, V.*, Applying IT to Accident Management: The Nordic Project. Nucl. Eng. Int. (1988) v. 33(405) pp. 65-66.
22. *Andersen, V. et al.*, NKA/INF. Advanced Information Technology: Information Technology for Accident and Emergency Management. In: Artificial Intelligence and Other Innovative Computer Applications in the Nuclear Industry. American Nuclear Society Topical Meeting. Snowbird, Utah, 1987. Majumdar, C.; Majumdar, D.; Sackett, J.I. (eds.), (Plenum Press, New York, 1988) pp. 21-27.
23. *Andersen, V.; Møllenbach, K.; Heinonen, R. et al.*, Accident and Emergency Management. The Nordic Programme. Risø-M-2723 (1988) 16 p.
24. *Andersen, V.; Rasmussen, J.*, Decision Support Systems for Emergency Management. Risø-M-2724 (1988) 34 p.
25. *Christensen, P. la Cour; Kofoed. J.E.; Larsen, N.*, PC-DYSIM. A Program Package for Simulation of Continuous Dynamic Processes. Risø-M-2702 (1988) 96 p.
26. *Christensen, P. la Cour; Kofoed, J.E.; Larsen, N.*, PC-DYSIM. A Modular Simulation System for Continuous Dynamic Processes. In: Numerical Simulation of Processes. SIMS-88 Symposium. 30th Annual Meeting of the Scandinavian Simulation Society, Espoo, 21-22 April 1988. Juslin, K.; Silvennoinen, E. (eds.), (Technical Research Centre of Finland, Espoo, 1988) (VTT Symposium 84) pp. 62-73.
27. *Goodstein, L.P.; Rasmussen, J.*, Representation of Process State, Structure and Control. Trav. Hum. (1988) v. 51(1) pp. 19-37.
28. *Jørgensen, N.*, Decision Procedures for the Modal Propositional Calculus. Preprint. (Risø National Laboratory. Department of Information Technology, Roskilde, 1988) 37 p.
29. *Pejtersen, A.M.*, Search Strategies and Database Design for Information Retrieval in Libraries. In: Tasks, Errors and Mental Models. A Festschrift to Celebrate the 60th Birthday of Professor Jens Rasmussen. Goodstein, L.P.; Andersen, H.B.; Olsen, S.E. (eds.), (Taylor and Francis, London, 1988) pp. 171-190.
30. *Pejtersen, A.M. and Goodstein, L.P.*, Beyond the Desk Top Metaphor: Information Retrieval with an Icon-Based Interface. In: Proceedings of the 7th Interdisciplinary Workshop on Informatics and Psychology on "Visualisation in Human-Computer Interaction", Sharding, Austria 23-27 May 1988, Springer Verlag.
31. *Vicente, K.J.*, Adapting the De Groot Memory Recall Paradigm to Evaluate Interface Transparency. Risø-M-2691 (1988) 44 p.
32. *Vicente, K.J.; Rasmussen, J.*, The Cognitive Architecture of Decision Support Systems for Industrial Process Control. Risø-M-2696 (1988) 42 p. Earlier version presented as an invited contribution to the First European Meeting on the Cognitive Science Approach to Process Control, Marcoussis.
33. *Vicente, K.J.; Rasmussen, J.*, A Theoretical Framework for Ecological Interface Design. Risø-M-2736 (1988) 76 p.

Miscellaneous

34. Department of Information Technology. Progress Report 1 January - 31 December 1987. Risø-M-2695 (1988) 80 p.
35. *Goodstein, L.P.; Andersen, H.B.; Olsen, S.E. (eds.)*, Tasks, Errors and Mental Models. A Festschrift to Celebrate the 60th Birthday of Professor Jens Rasmussen. (Taylor and Francis, London, 1988) 342 p.

Research Professor Jens Rasmussen

36. *Rasmussen, J.*, Modelling Distributed Decision Making. Position Paper for International Workshop on New Technology and Distributed Decision Making, Bad Homburg, May 1988.

37. *Rasmussen, J.*, Hierarchical Structures in Models of Complex Systems. Invited contribution to Systems and Control Encyclopedia 1988 Suppl; Pergamon Press, in press.
38. *Rasmussen, J.*, Models for Design of Computer Integrated Manufacturing Systems, Invited Conference Address, Ist International Conference on Ergonomics of Advanced Manufacturing and Hybrid Automated Systems. Louisville, Kentucky, USA. August 1988.
39. *Rasmussen, J.*, Coping Safely with Complex Systems. American Association for Advancement of Science, invited paper for Annual Meeting, Boston, February 1988.
40. *Rasmussen, J.*, Human Factors in High-Risk Systems. In: Conference Record for 1988 IEEE 4th Conference on Human Factors and Power Plants. Monterey, 5-9 June 1988. Hagen, E.W. (ed.), (Institute of Electrical and Electronics Engineers, New York, 1988) pp. 43-48.
41. *Rasmussen, J.*, Safety Control and Risk Management: Topics for Cross-Disciplinary Research and Development. In: Preventing Major Chemical and Related Process Accidents. London, 10-12 May 1988. Street, B.F. (ed.), (The Institution of Chemical Engineers, Rugby, 1988) (Institution of Chemical Engineers Symposium Series, 110) pp. 533-551.
42. *Rasmussen, J. and Vicente, K.*, Coping with Human Errors through System Design: Implications for Ecological Interface Design. International Journal of Man-Machine Studies, 1988, in press.
43. *Vicente, K. and Rasmussen, J.*, On Applying the Skills, Rule, and Knowledge Framework to Interface Design. Presented at 32nd Annual Meeting of the Human Factors Society, Anaheim, California; Also in: Engineering Psychology Research Lab., University of Illinois at Urbana-Champaign Tech. Rep. EPL-88-11, 1988.
44. *Rasmussen, J.*, Cognitive Engineering, a New Profession?. In: Tasks, Errors and Mental Models. A Festschrift to Celebrate the 60th Birthday of Professor Jens Rasmussen. Goodstein, L.P.; Andersen, H.B.; Olsen, S.E. (eds.), (Taylor and Francis, London, 1988) pp. 325-334.
45. *Rasmussen, J.*, Human Error Mechanisms in Complex Work Environments. Reliab. Eng. Syst. Saf. (1988) v. 22 pp. 155-167.
46. *Rasmussen, J.; Goodstein, L.P.*, Information Technology and Work. In: Handbook of Human-Computer Interaction. Helander, M. (ed.), (North-Holland, Amsterdam, 1988) pp. 175-201.

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This progress report describes the work carried out in the Department of Information Technology.

The department comprises three sections. The Applied Laser Physics Section works in the areas of holographic optical elements, optical image processing, and the photorefractive effect. The Computer Section is primarily responsible for the central computer facilities and computer networks at Risø. The Section for Information Processing and Cognitive Science, Sicos, is concerned with cognitive science, decision support, knowledge-based systems, and process simulation.

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