Man-computer communication in structural analysis

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Man-Computer Communication in Structural Analysis

Communication homme-ordinateur dans le domaine de l'analyse des structures

Mensch-Computer Kommunikation bei der Berechnung von Tragwerken

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SUMMARY
Present interactive facilities already permit close man-computer communication. The amount of communication necessary for a specific problem can be kept to a minimum by the use of data base techniques, highly expressive problem-oriented language, and by strictly leaving all automatable tasks to the computer. As an example a new approach to automated FE-mesh generation is presented. Upcoming means of man-computer communication are discussed.

RESUME
Les possibilités actuelles de communication offrent déjà un dialogue étroit entre l'homme et l'ordinateur. En faisant appel aux banques de données, aux languages de programmation adaptés et expressifs et en exploitant au mieux les possibilités de l'ordinateur pour les tâches automatisables, l'ampleur de la communication qu'exige un problème donné peut être maintenue à un bas niveau. Une nouvelle approche pour la génération automatique d'une subdivision en éléments finis est présentée à l'aide d'un exemple. Les possibilités futures de la communication homme-ordinateur sont mentionnées.

ZUSAMMENFASSUNG
Bereits die heutigen interaktiven Möglichkeiten gestatten enge Kommunikation zwischen Mensch und Computer. Die Menge der für ein bestimmtes Problem benötigten Kommunikation kann klein gehalten werden durch Verwendung von Datenbanken, durch Einsatz ausdrucksstarker problemorientierter Sprachen und durch konsequente Erledigung aller automatisierbarer Aufgaben durch den Rechner. Als Beispiel wird ein neuer Ansatz zur automatisierten Erzeugung von FE-Netzeinteilungen vorgestellt. Zukünftige Möglichkeiten der Kommunikation zwischen Mensch und Computer werden besprochen.

1. INTRODUCTION

In February 1979 in a televised event, international chess champion David Levy played at a chess board in Hamburg against a Cyber 176 computer in Minneapolis. The program on the machine was CHESS 4.8. Levy's moves were automatically transmitted to the computer via satellite. The moves of his artificial opponent were executed on the board by a robot arm under remote control of the computer. The game ended with a draw after 89 moves.

In chess, the communication between the players consists of their moves on the board only. Due to this very limited amount of information, human-like communication with a computer can be simulated rather easily. In structural analysis, however, the man-computer communication is much more complex. In order to use the computer in design and analysis, communication is necessary to describe the overall situation for preliminary studies, to define structures, to select analysis options, to display and evaluate results, to make modifications, to generate reports, to produce construction drawings and so on. Powerful means of communication exist already today to facilitate man-computer interaction in these areas.

2. PRESENT MEANS OF COMMUNICATION

Fig. 1 shows the typical phases of a structural design and analysis task. A high degree of interaction between the engineer and the computer is desirable when developing the design as well as the conceptual analysis model of the structure, to set up the numerical model and to retrieve, display and eventually postprocess the results of the analysis. On the other hand, the actual solution phase is usually highly automated and low interactivity but high numerical processing capability is required.

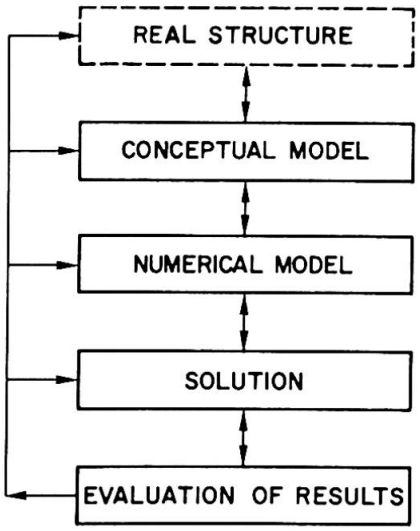

Fig. 1 Phases of design and analysis

Present hardware and software satisfy some of these needs. The interactive processing capabilities of today's minicomputers as well as of some large machines are geared towards a dialogue between man and computer. Interactive graphic systems with digitizers and display equipment allow the design of a structure on the screen and are gradually replacing conventional drawing-boards. With computer networks it is possible to transfer data between interactive decentralized work stations and large machines with high processing capability. Thus interactivity and processing power are available where they are specifically needed.

Technically the present means of communication already permit a high degree of man-computer interaction. However, the amount of communication necessary to accomplish a particular task may be high. It can be reduced by using data base techniques to store information only once and to retrieve it for different purposes, by developing problem-oriented and highly expressive communication languages and by strictly leaving all automatable tasks to the computer. These considerations are illustrated in the following by discussing a current research project [2] for the automated mesh generation in finite element structural analysis.

3. AUTOMATED FE-MESH GENERATION

Conventional mesh generators easily permit the definition of nodes and elements by using interactive graphics. This approach usually requires a large amount of man-computer interaction. The objective of the mentioned research project is the development of a preprocessor program, in which the mesh generation is automated once the geometry of the structure has been defined. The essential role of the engineer is then to influence the generation process rather than to define the mesh in detail. Options exist that permit any degree of influence between fully automated generation and the description of fully predefined meshes.

The geometrical and mechanical properties of the structure are described in a highly expressive problem-oriented language [3]. To define the geometry any scalar and vector operations can be used. Surfaces and bodies are generated by special functions. For example the function

FLAECHE (P1,P2,...PN)

describes a plane surface with polygonal boundaries through points P1 to PN. By similar functions and statements parts are transformed and put together. Materials, boundary conditions and loads are defined in the same manner. The language permits the description of parts in parametric form. When calling the part the actual values of the parameters are substituted. Using this feature and taking advantage of all kinds of repetitiveness in the geometry of the structure further reduces the amount of communication. Comprehensive plotting options allow easy verification of the generated data.

Fig. 2 shows schematically the steps required to generate a finite element model. It is seen that the different tasks can be accomplished in an iterative way.

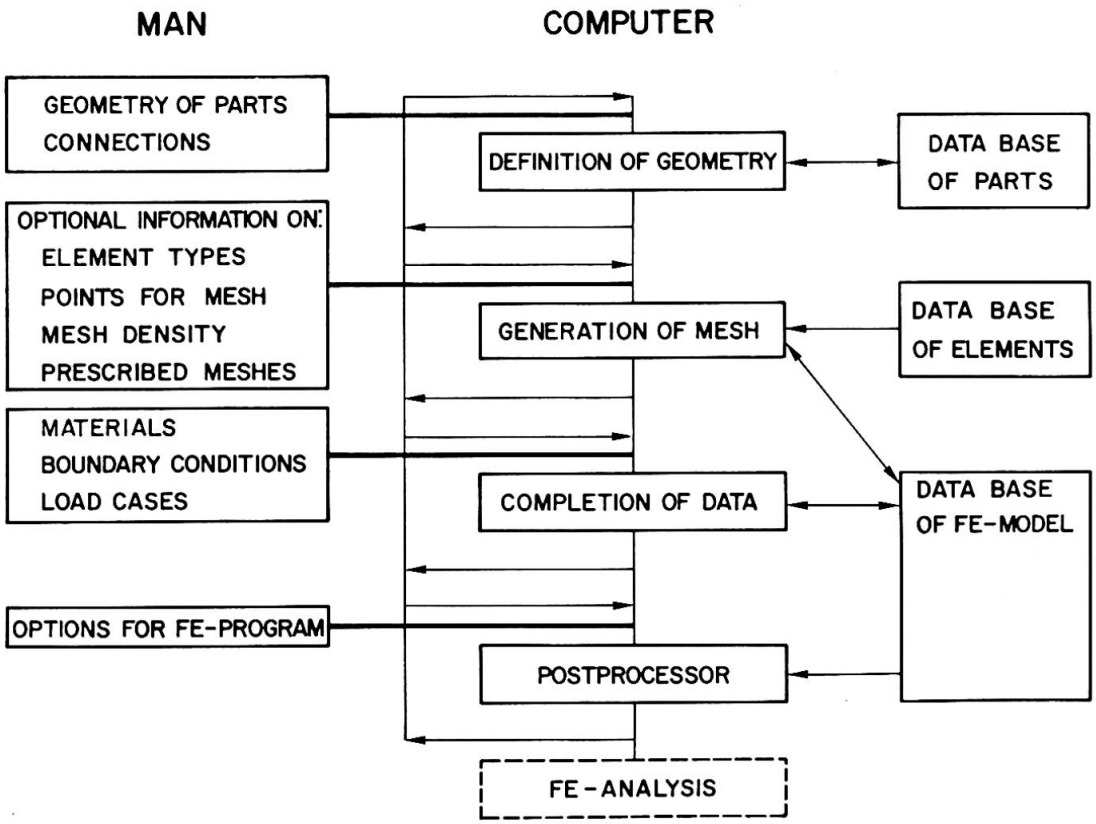

Fig. 2 Automated mesh generation

Modifications can be easily made. The sequence of the steps is flexible. Geometrically defined parts are stored in a data base and are retrieved from there. An element data base contains the properties of the finite elements used for the mesh generation. The numerical data of the FE-model are stored in general form in a third data base. They are then postprocessed into input data of a particular finite element program at the user's option.

Once the finite element analysis is completed, the results have to be displayed and evaluated. The same principles as used for the input generation can be applied to the development of postprocessor programs.

4. EVOLVING NEW TOOLS FOR MAN-COMPUTER COMMUNICATION

The trend for decreasing prices and for increasing power of computer hardware will continue. It can thus be expected, that decentralized interactive systems will be even wider distributed in the future. On the other hand, rapidly developing computer networks will permit the easy exchange of data between decentralized work stations and central large-scale processors. The communication costs are expected to drop due to increasing volume of data communication, by making full use of transmission lines by compression of data and statistical mix, and by using new transmission technologies. Among these high capacity data channels between computers as well as between work stations and computers using fiber optics etc. have to be mentioned. Over long distances packet switching networks based on satellites will offer low cost data transmission facilities.

High capacity mass storage will encourage the development of large central data bases. It is hence expected, that geometrical data bases will be available to design a structure, to generate the analysis model and to produce the construction drawings. Furthermore, the data to control a NC-machine can also be derived from the geometrical data base. Automated digitizers, colour displays together with software for colour graphics, and interactive report generators are some of the upcoming facilities to be used in structural engineering. Modern structural analysis programs permit the solution of rather complex problems. Thus frequently support from an expert is needed. Interactive programs are under development which may in the future guide the engineer to set up the conceptual and the numerical analysis model. In a broader context, computer-based educational systems will be available for many subjects. Much progress has recently been made with synthesized speech. It can be expected, that in the future the means of communication between man and computer for some tasks will be a human language.

5. CONCLUDING REMARKS

The computer revolution has not yet come to an end. Decentralized work stations with network connections to large computers will be widely distributed. New means of communication will permit easy man-computer interaction. The effective use of these modern tools, however, will require new skills and attitudes of the engineer. In structural engineering, the computer can significantly contribute to the design of better structures. In almost all domains the increasing penetration with computerized facilities will in general lead to more and better products and services at decreasing working hours. The task thus remains not only to use the computing facilities in a knowledgable and prudent way but also to master the sociological changes caused by them.

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