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THE SUBSTANTIVE USE OF COMPUTERS FOR INTELLECTUAL ACTIVITIES

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PROJECT MAC

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I. INTRODUCTION

In the rather brief history of the automatic data processing industry, we have seen computers come into common use in almost every field of human activity. This is certainly an impressive accomplishment. However, in accessing the true impact of computers on our civilization, we must consider not only their numbers, but also the functions they perform. When we do this, we observe that the computer has been very successful in taking over routine clerical functions such as payroll and billing. It has met with considerable, though noticeably less, success in problem areas calling for decision making in well-structured situations. Process control and inventory management are examples of this type of activity. Beyond this, unstructured problems, which if not the most numerous are certainly the most important, have tenaciously resisted computerization.

Developing computer systems capable of making reasonable decisions in unstructured situations is the general goal of the science of Artificial Intelligence. Some very interesting results have been demonstrated, but a computer capable of replacing a human decision maker still belongs to the future.

In the meantime, we can observe that people and computers have complementary data handling capabilities, and that there might therefore be significant advantages to be gained from building decision-making systems containing both. This paper will report on an on-going research activity at M.I.T. Project MAC aimed at building and studying such man-computer decision systems.

This work began in the summer of 1968 as a small effort to explore the feasibility of using existing computer facilities to aid in the management of Project MAC, itself. By the end of 1969, several programs dealing with various aspects of running a research laboratory were in operational use. At that point, we began gathering objective and subjective data on the use of these programs in order to provide the basis for a second, and much more powerful system. The remainder of this paper will be devoted to a discussion of this new system which we hope will serve as a prototype for a class of computer-based facilities capable of providing substantive aid to managers and other people faced with complex, unstructured problems.

II. OBJECTIVES

Our research has two inter-related sets of goals: one concerned with the prototype system itself, and another dealing with its impact on the decision-making process. Obviously, if such a system is to be justified, it must be on the basis of an improvement in the quality of decisions. There are at least two reasons why better decision-making processes are urgently needed. The first is the very rapid growth in both the size and complexity of the systems (be they space vehicles or cities) with which man must deal. The second is that our ability to tolerate incorrect, or even just sub-optimal, decisions is declining rapidly. A comparison of some of today's urgent problems with the resources available to solve them makes it very clear that there is little margin for error.

Our objectives for the system itself are generated by looking at the type of person with whom it will have to work, and the tasks that he will ask of it. First of all, we envision a user who is highly paid, well respected, and entrusted with considerable responsibility. Examples would include major government officials and high corporate officers. We also assume that the problems he is working on are significant ones to his organization. Therefore, performance becomes a far more important criterion than cost. Secondly, we assume that this user will not be willing to alter his own mode of behavior to suit the computer. Such a person is used to having things done his way, and will be very intolerant and unsympathetic toward the problem of computers. In operational terms, this means that virtually the whole burden of supporting the man-machine interface must fall on the machine.

III. TECHNIQUES

In assembling a decision system containing both a man and a computer, we hope to couple the creativity of the former with the large information processing capacity of the latter. A sophisticated data management facility is therefore a very important part of our system. It must be capable of storing an effectively unlimited quantity of information, as well as representing relations of arbitrary complexity. Such a system has been designed and programmed, and is discussed in detail elsewhere[1]. This data management facility offers unique capabilities for access control and information sharing which are considered vital to our objective.

We feel that one of the reasons computers have generally not been successful in attacking unstructured problems is that the information available to them is both too little and too specialized. One reason for this is that normally an explicit action is required in order to enter a piece of information into a computer. We hope to experiment with the use of a number of automatic approaches to gathering information such as libraries and news wire services, in order to expand the breadth of experience available to our computer.

A large, complex data base is only one of the components of our system. A second is a set of tools for deriving useful conclusions from the raw data. These tools include statistical routines, mathematical programming capability, a set of models, and several programming languages of various kinds to enable the user to build additional models, or perform other, non-standard manipulations of the data. It is anticipated that three such languages would be supported. One would be PL/1, since that is the language in which the system itself is implemented, and because of its very powerful capabilities. However, we would not expect the typical user of our system to be a PL/1 programmer. If he knows any programming language at all, it is much more likely to be APL or BASIC. We therefore plan to provide at least one of these languages in our system. Finally, an interactive simulation language will be included for the building of special-purpose models. In each case, the language compiler or interpreter which we will use has been developed by other groups for other purposes. All that is necessary for us to do is to provide an appropriate environment and interface to our data base.

The third major building block of our system, and in some ways the most important, is the interface to the user. Although this part does not contribute directly to the problem-solving operation, its importance stems from the fact that the effectiveness of the person in the decision-making process may depend to a large extent on the quality of this interface. Naturally, both hardware and software are involved. The design of the user station hardware is based only very slightly on previous computer terminals. Instead, we took the more basic approach of examining man's various input and output devices to determine which could be effectively used for communication with a computer.

Three basic types of information were identified: textual, pictorial, and positional. Positional information is that which is involved in calling attention to an element within a larger unit. Examples would include a word or letter in a page of text, or a line on a graph. The results of this study are reported in great detail in another paper[2]. In summary, they lead to the user station depicted in Fig. 1. It includes two major subsystems. The chair subsystem provides a physical environment in which the user can work comfortably and with minimal distraction and also houses all of the equipment, primarily input devices, which he must have close at hand during the session with the computer. The input devices include two keyboards for text input, a tablet for line drawings, and a mouse or joystick for positional information. One of the keyboards is a conventional alphanumeric one. The second contains programmable function buttons which can mean different things at different times. One hope is that the user will utilize these function buttons to develop a kind of shorthand to facilitate his communication with the machine. All of the input devices are attached to flexible arms so that their positions can be varied to suit the whim of the user.

The display subsystem serves as the focal point for most of the decision-making activity. Our studies suggest that the visual medium is by far the most effective for information transmitted from the computer to the user, and we suspect that most of the user's activity will be closely related to information appearing before him on the screen. Our display system is a considerably more complex device than the conventional computer-driven CRT. We require, for example, that it be capable of displaying information originating in a number of different forms including digitally-encoded characters and vectors, analog data stored on microfiche, and conventional video signals such as might be received over the recently-inagurated Picturephone network. In addition to being able to accept information in all of these different forms, we want also to be able to combine them in a very flexible manner making use of both superposition and split screen techniques. The most promising approach to meeting these diverse requirements involves the use of a large video monitor as the actual display device. The video format would serve as a common denominator, into which each display image, from whatever source, would be converted. These various video images could then be combined to create the final display using conventional video mixing techniques developed for commercial television.

For reasons discussed in detail in (2), we feel that audio response, including computer-generated voice, is inherently of far lesser importance than visual presentations. Signalling represents the only major purpose for which we expect to use computer-generated audio. We would like very much to be able to use audio, particularly speech, for input. However, a realistic look at the technology does not provide much support for short-term optimism in this regard.

A few words should be said about the software required to support the user station. A substantial amount of processing is required just to operate all of the various input and output devices. To handle this function, each user station includes a small processor and about 150,000 bits of core memory. The actual programming required to support the I/O devices is substantial, but straightforward. The other major function of the user station software is the interpretation of messages received from the user. This is one area which received very heavy attention in our early experiments. In particular, we implemented some fairly simple but effective techniques for recognizing misspellings and abbreviations. The importance of this capability is very great. Our typical user, as outlined in Section II, would not long stand for having messages thrown back at him because of spelling or typing errors when the sense of the message was still perfectly clear to him. This paper is not an appropriate place to discuss our methods in detail, but it might be pointed out that no attempt is made to store expected abbreviations or misspellings. Rather, the user's input is compared to a dictionary of correctly spelled words and phrases that the system understands and it applies various rules describing likely abbreviation techniques and common spelling errors to determine which of the dictionary words the user's input is intended to represent.

Our early experiments also provided much useful guidance as to the desirable style of interaction. That is, our first programs had the computer play the active role. It would ask a question to which the user would respond, and the computer would then take appropriate action. Considerable effort was put into the development of appropriate defaults in case the user failed to respond. This is an interesting problem in general, since no response can indicate either that the user is uncertain about what he wants to happen next, or that he merely wishes processing to proceed in a normal fashion. As our early programs were replaced with later versions, we found ourselves trying to shift the user into the active role by allowing him to issue commands rather than merely respond to questions. This definitely seems superior from the user's point of view. However, it creates interesting difficulties for the system designers since the range of possibilities is now greatly expanded. We also found ourselves trying to remember context from one command to the next. This, of course, is the way people operate and it made for a much more attractive user environment. Implicit in these remarks is the fact that the user is not expected to learn any particular programming language. Command level interactions are carried out in a form that, to the user, looks like ordinary English. The system will correctly interpret many synonyms for operative words in addition to the misspellings and abbreviations referred to earlier. Several points must be made about this language, though. In the first place, full natural language capability is beyond our present capability, and is not even an appropriate activity for our particular group. Furthermore, while natural language might be very desirable if we could interpret spoken input, it is not clear that it is still desirable when the input mechanism is a keyboard. This offers a much lower bandwidth channel suggesting that a considerably more concise language is needed. Concise languages unfortunately have a tendency to be non-intuitive. This creates a problem for us since we believe strongly that the command language should be as natural as possible. We are still uncertain about the optimal solution to this problem, and further experimentation will be undertaken before the command language specifications are finalized. See (3) for further discussion on this point.

IV. PROGRESS AND PROJECTIONS

Since the total project is, of course, very large, we have chosen to implement it in stages. Most of the major elements discussed in the preceeding section are relatively independent of the particular application area. It has therefore been possible to design and program most of these prior to making a commitment as to the specific experimental applications. Initial work was concentrated on the data management system which first became operational in the fall of 1970. Work proceeded simultaneously on the user station hardware and three prototypes have been constructed containing all of the features described in this paper except the video mixing capability. Given the availability of these tools, it becomes possible to gradually evolve an application system. Our first application will again be the management of a research laboratory, as exemplified by Project MAC. This is a natural place for us to begin since the experimental environment is particularly convenient, and we anticipate initial operational use in the spring of 1971. Areas being considered for subsequent implementation include: educational institution administration, health care, and public administration. Detailed planning for these will proceed as personnel and funding are available.

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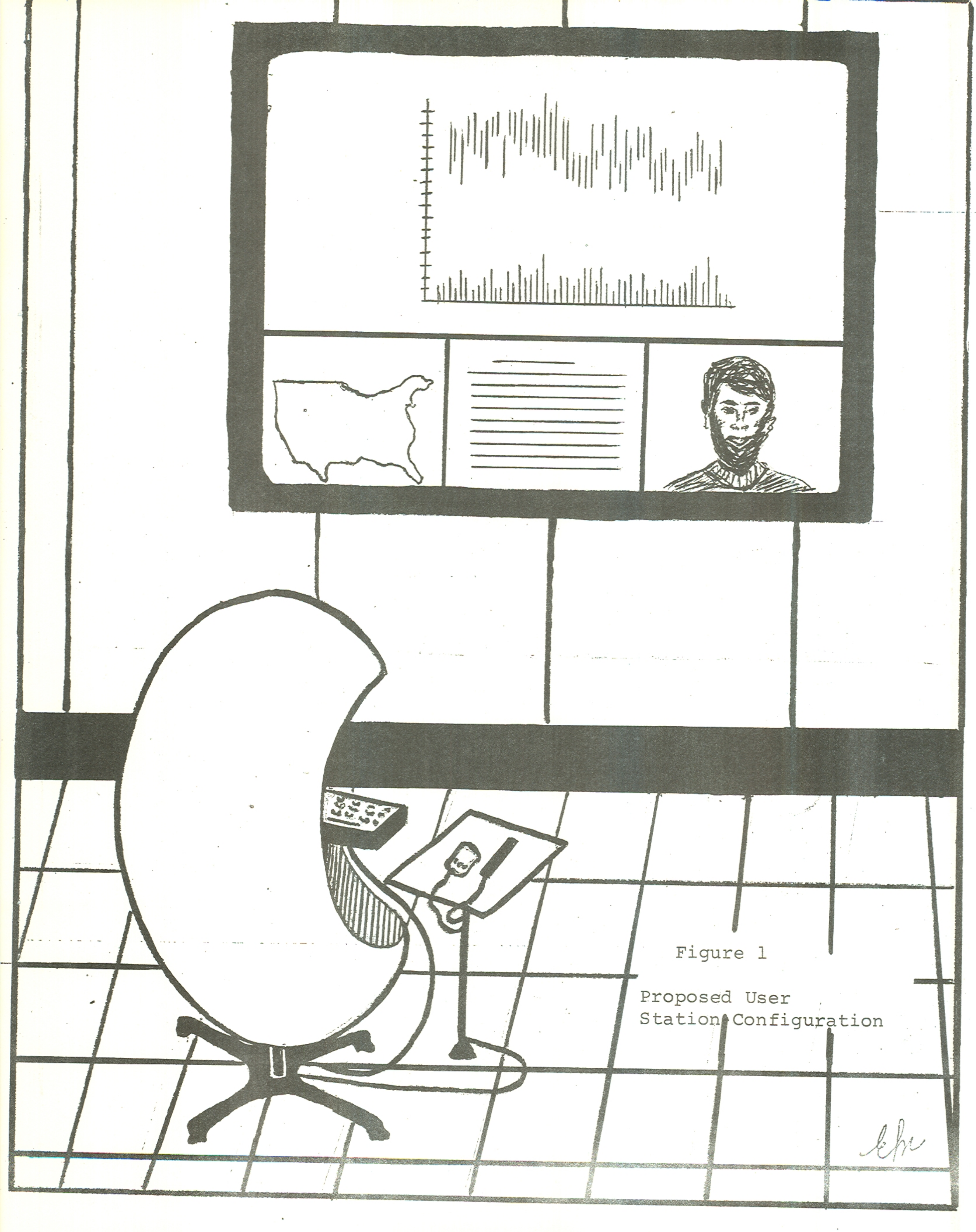

Figure 1

Proposed User Station Configuration