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J. Trimble
J. Doubler
C. Heckathorne

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VOCATIONAL REHABILITATION OF THE SEVERELY DISABLED: VOICE CONTROLLED COMPUTER PROGRAMMING

George Markowsky, IBM T. J. Watson Res. Ctr., NY, NY 10598

Myron Youdin, Co-Dir., REC, IRM-NYU, Medical Ctr., NY, NY 10016

Theobald Reich, Co-Dir., REC, IRM-NYU, Medical Ctr., NY, NY 10016

ABSTRACT

Speech recognition technology has developed to the point where many activities can be controlled by voice. In recent years, this technology has been used to help the handicapped achieve better control of their environment. This paper describes a voice controlled programming system designed to make programming easier for the severely handicapped. The design decisions leading to the construction of the prototype are discussed as well as some of the problems which need further study in order to make the handicapped even more productive as programmers.

INTRODUCTION

This paper describes a joint study, between IBM and the Rehabilitation Engineering Center (REC) of the Institute of Rehabilitation Medicine (IRM) of the NYU Medical Center, to promote the vocational rehabilitaion of the severely disabled utilizing voice controlled computer programming. The goal of this study is to determine the design parameters for voice-contolled programming systems which enable individuals with severe handicaps such as quadriplegia, who cannot use a keyboard, to write computer programs of a complex nature quickly and efficiently. Success in this research would lead to practical systems which enable severely handicapped persons to compete as programmers on an equal basis with able bodied individuals.

It is not unreasonable to assume that a system which facilitates programming will also prove to be good for teaching programming. If the system resulting from this research is useful for programming, but not useful for teaching programming an attempt will be made to identify the additional or alternate features required.

While facilitating computer programming is the goal of this study, we expect that our results will have applicability to the more general problem of securing high quality access to computer systems for various classes of disabled people. As computers become more and more central in all aspects of contemporary life, including such things as information systems, financial systems and office systems, securing adequate access to computers becomes essential for the handicapped if they are to participate in a meaningful way in our society.

The problem of accessing computers complements work already performed at IRM [1-6], where systems using voice to control various devices ranging from wheelchairs to page turners and TV sets have been built. Thus, success in the current endeavor implies the ability to construct a very comprehensive environment supporting domestic activities and offering possibilities for significant employment in the outside world.

COMPUTER PROGRAMMING

Computer programming does not require great amounts of physical dexterity or strength (just that required to operate the access devices). It therefore appears to be a good choice of profession for people with limited physical movement. Furthermore, since most sophisticated human-machine interfaces make use of a computer, it seems reasonable to make the computer the chief focus of the interface. Finally, computer programming is an expanding profession characterized by fairly good pay and good working conditions.

There are a number of good reasons for utilizing speech recognition to control the computer. Computer programming is a sophisticated task requiring a large number of different inputs for efficiency. Speech recognition supports a very complex interface in a fairly natural manner. Furthermore, since most people are capable of speaking for long periods of time, speech recognition is an interface that can be used for long uninterrupted periods of time without undue fatigue.

Some consideration was given to using eye-tracking as an interface. However, the number of options simultaneously available in eye-tracking is limited and smaller than the number available in speech recognition systems. The number of options in eye-tracking is limited by the number of regions that can be designated on a target area. Furthermore, eye-tracking is sensitive to head position and ambient light level. Eye-tracking requires a distracting, constant shifting of the eyes between work area and target area which is fatiguing. Finally, it also requires considerable practice to achieve proficiency. These reasons coupled with the positive features of speech recognition systems caused us to opt for speech recognition.

In attempting to make computers more accessible, there are two sets of problems which must be overcome. The first deals with the human-machine interface, i.e., the means by which a human obtains the necessary response from a machine. These problems have already been discussed briefly. The second set of problems deals with the difficulty of actually composing programs and getting them to run correctly.

Most programmers make extensive use of program printouts to help them debug programs. For severely handicapped individuals, such as persons with quadriplegia, handling physical objects such as printouts is a nontrivial problem. As a first step, APL was selected as the language of the system to help minimize the size of programs.

As is well known, APL is a very compact and powerful language - many useful and high level operations, (e.g., sorting) are primitive operators expressed by a single symbol in APL. This and APL's ability to handle vectors and higher dimensional arrays easily, often allows programmers to write programs very

quickly and compactly. The compact nature of APL also reduces the amount of entry that must be accomplished, thus reducing to some extent the severity of the problems associated with the human-machine interface.

In all fairness, it must be acknowledged that many critics of APL charge that it is difficult to learn and use because of its terseness. However, the use of speech recognition enables one to use APL without the need to be conscious of many of its conventions, e.g., one can name the functions in such a way as to facilitate their use and help one clearly remember their nature. This point will be discussed again in the section dealing with research questions. A more detailed discussion of this point is in preparation.

Finally, another useful feature of APL is that it is interactive. Having powerful operators easily available allows much useful manual manipulation of data both as an aid in composing programs and debugging them. It also provides a very natural approach to the teaching of APL programming by presenting a program as a record of a sequence of operators applied to data.

SYSTEM DESCRIPTION

It was decided to use commercially available equipment with a minimum of modification to initiate this study. There are three main reasons for this decision. First, this allows testing available devices and reduces initial cost. Second, the use of commercially available equipment would allow us to replicate the system easily as well as assemble the prototype quickly. Third, commercially available equipment is generally more rugged and reliable than prototypes assembled in a laboratory.

The initial system, which became operational in mid-March of 1981, consists of an IBM 5100 minicomputer dedicated to APL, a Threshold Technology 680 speech recognizer and a Rockwell Aim 65 microcomputer acting as an interface between the 5100 and the 680. There is a head operated switch which allows one to turn off the microphone so that general conversation does not produce gibberish on the system. The system is arranged so that the 5100 can be controlled either from its keyboard or the 680 acting through the Aim interface. This enables the system to be used effectively for teaching with the student using the speech recognizer and the teacher the keyboard.

The Threshold 680 has been programmed to recognize about 155 words and initial tests of the entire system have gone very well: every aspect of the 5100 operation has been brought under speech control; the error rate has been fairly low; and the flexibility of the system has been excellent, in many cases exceeding the performance of the pure keyboard system.

A compelling reason for selecting the 5100 was to ensure that the system be portable and stand-alone. It was the only portable minicomputer supporting APL which was readily available to us. Although its capabilities are significantly less than that of a mainframe, it is still adequate to teach the rudiments of APL and to provide an adequate test of the capabilities of voice control.

TEACHING PROGRAMMING

The first group of patients will begin using the system in early April of 1981. Tutorial sessions will be held twice-weekly, arranged to not interfere with the regular rehabilitation program. A second group will participate in June.

RESEARCH QUESTIONS

The results of this study have important implications for the able bodied as well as the severely disabled. We hope to produce evidence useful in deciding whether speech recognition can compete with keyboards in general as a method of computer access.

Another question we hope to answer is whether the extra flexibility of voice control can enhance the teaching and use of APL and other languages. In particular, we want to know what special problems, may arise in teaching computer programming by voice control.

We also expect to understand more fully the nature of the difficulties presented by relying on printouts as aids in the programming process. Hopefully, ideas will develop on ways to minimize the impact of this problem.

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