Chapter 78
Model-Based Approaches for Scanning Keyboard Design:
Present State and Future Directions

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ABSTRACT

Many individuals with speech and motor disorders face problems in expressing themselves in an easy and intelligible way. An array of Augmentative and Alternative Communication (AAC) devices and techniques is used to alleviate their problems. One of the commonly used computer based AAC systems is the scanning keyboards. A scanning keyboard refers to an on-screen keyboard operated with a scanning input method. There are many ways to place alpha-numeric characters on the keyboard interface. Therefore, it is necessary to compare alternative layouts to determine the best one in terms of user performance. Usually, layouts are compared by testing prototypes with physically disabled users. This approach is problematic since it is difficult to get physically disabled users or collect data from those users. An alternative approach is to use models to compute user performance, which can serve as the basis of layout comparison as well as automatic design space exploration. Several of these models and design space exploration algorithms are reported in the literature. A review of these works is presented in this chapter. The chapter is concluded with a discussion on the limitations of the existing works and the issues that can be taken up for further research.

INTRODUCTION

Speech and writing are two of our primary means of communication. However, there are many individuals who face problems in expressing themselves in an easy and intelligible way using either of these means, due to their physical disabilities. Their problems arise because of the non-functional or partially functional body parts, which are responsible for producing speech and motor actions. Such disabilities include Cerebral Palsy, Muscular Dystrophy, Friedrich's Ataxia, Quadriplegia and spinal cord injuries with characteristic symptoms of tremor, spasm, poor motor

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co-ordination, restricted limb movement, reduced muscle strength, slurring of speech or no speech at all. Similar symptoms are also seen among the elderly able-bodied population afflicted with Parkinson's disease, strokes and arthritis. Computer based *Augmentative and Alternative Communication* (AAC) systems and techniques are developed to assist these people in their day-to-day communications (Beukelman & Miranda, 1998).

AAC systems are used as writing tools by persons who fail to control their extremities and also as communication prosthesis by those having speech disorders. The generation of text in both of these cases is a necessary activity. Text generation with computers requires the use of the *direct* input devices like mouse or keyboard. Many individuals with severe motion impairments, however, lack sufficient mobility to reach for these devices or sufficient motor control to switch accurately and efficiently between them. The s*canning keyboards* provide an alternative interface for text generation to them. In this chapter, model-based approaches for *efficient* scanning keyboard design are discussed. The term *efficient* here refers to designs that allow users to achieve high text entry rate with high accuracy. The chapter is organized as follows.

In the next section, a survey on AAC systems is presented. The survey is followed by a detailed discussion on scanning keyboards, including the challenges faced by the scanning keyboard designers. The different model-based approaches are discussed next along with the strengths and weaknesses of each approach and the scope for future research.

SURVEY OF AAC SYSTEMS

There exists wide variation in the physical, cognitive and linguistic abilities of individuals who need AAC. In order to cater to diverse user requirements, different AAC systems and techniques have been developed. The simplest of these techniques include attention calling bell, communication through *yes* or *no*, gestures and message cards. The most sophisticated among these non-electronic means of augmentative communication are the *communication boards*. A communication board can contain alphanumeric characters, words, icons, symbols, phrases or sentences (Worah, 2001). In order to convey a message, users of such boards "point" (with fingers or head-mounted pointers) to the appropriate items present on the board. In addition to these non-electronic techniques, many computer-based AAC systems are also used. Computer-based systems can be classified depending on the nature of the input as the non-text based and text based.

In the non-text based AAC systems, communicative messages are composed with the selection of icons or images from the system interface. An example is the "MinSpeak" system (Albacete et al., 1998), where *ambiguous* icons (i.e. each icon having multiple meanings associated with it) are used as input. In order to form a communicative message, users select two or more of these icons in sequence, which is converted to a textual and/or spoken message. In the "Picture WordPower" by Nancy Inman (http://www.inmaninnovations.com/), messages are constructed with unambiguous icons. Each icon corresponds to a linguistic item. A user needs to select a sequence of these icons following the syntactic word ordering of English to form a message. Another system that uses unambiguous icons is the "iconCHAT" by Patel et al. (2004). In order to compose a message with "iconCHAT", a user needs to first select the verb, and then specify the agent, object, and various other verb-dependent message components. A similar approach was reported by Bhattacharya and Basu (in press) to implement "Sanyog", an iconic system in Indian languages. Apart from icons, symbols and sign languages are also used for non-text based AAC[1].

As opposed to the non-text based AAC systems, textual units such as characters, words or phrases are used to compose messages in the text-based AAC systems. The non-text based systems are