Accessible Communication under Users Constraints

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Abstract: The paper identifies potential problems and introduces possible solutions and techniques to optimize and facilitate textual communication for physically challenged people.

Keywords. On-screen keyboards, software keyboard layout, optimized text entry

Introduction

Textual communication has a great impact on cognitive development and social adaptation of all people in any age. Key entry techniques were primarily designed for healthy persons having average fingers dexterity and a normal eyesight. Moreover, visual feedback diminishes some lacks of typing experience and methods. With the advent of touch screen discrete and continuous gestures [3, 11, 15] have augmented the command mode and a vast body of empirical studies on alternative text entry systems have been carried out to provide reliable method that would be easy to learn and universally accessible [1-2, 4, 5, 10]. However, the universality, in a wide sense, is not an acceptable term for people having individual constraints. The technical parameters of the interaction technique should be strictly adaptive to personal cognitive and sensomotor abilities of the user. Meanwhile, any action of the user should be displayed and feedback cues should be unambiguous and exhaustive, taking no extra time. Thus, the universality of the on-screen keyboard as an imaging tool and an external memory aid is apparent when people with diverse needs use any suitable alternative input techniques to produce a command or a textual message.

Talking about on-screen keyboards, we often exclude, for a while, the visually impaired users who cannot benefit directly from techniques based on visual feedback. However, this is not true. Accessible communication methods have been developed as an integration of the techniques and algorithms to support communication and user performance when conventional methods have failed. That is, any approach optimizing computer access for sighted users could be to different extent employed/adapted at designing special input-output methods for blind and visually impaired users as well.

On-screen Keyboard Optimization Concepts

QWERTY layout is not perfect arrangement of software buttons for virtual keyboard. Some of the researchers believed that statistically optimal layout could increase pointing accuracy and speed up typing. A “statistical” optimizing can be based on the language modeling and the linguistic features such as frequencies of the letters and
their combinations (digrams, trigrams, tetragrams, words). Performance and predictive modeling are also widely used. Still, for an individual user a statistically optimal behavior to point and select the letter sequentially with finger or stylus movement may be inconvenient. Making of a specific movement with input device is determined in a great degree by individual capabilities or disabilities of the person. Even the linear motion can be easy in one direction for some person and another one would never use this direction to avoid a pain, spastic involuntary movements or tremor. Diverse optimizations of the on-screen keyboards primarily intended for stylus input have been tested with alternative access techniques. While, it is apparent that both eye- and head-movements are very different of gestures produced with hands. The question is: would it be the benefit when all the letters are presented on the screen? 

In physical keyboards, experienced user can locate any physical key without use of eyesight, due to a primary kinaesthetic feedback and finger’s memory. A virtual keyboard essentially distracts the typist, grabs and spreads attention among software buttons which are out of the current task. Most of the optimization models consider the pointing and selection task to attain the needed key (letter) as a single-target task. Nevertheless, the cognitive loading is enormously increased in a presence of other letters (distractors).

While QWERTY layout was intended to shape the basic behavioral patterns of each finger in reply to each “letter in-mind” through a special training with physical keys, designers of virtual keyboards very often omit or ignore the cognitive and perceptual processes which support text entry. The movements of fingers, hand and eyes play an important role in visual analysis whereas kinesthetic feedback directly follows to the motor cortex - the main integrative structure of the brain. Small travel distances hold kinaesthetic feedback at minimum. A visual field is overloaded with graphical elements which can also dynamically change. The dynamic optimization of the letters layout contradicts with the basic psychological principles and diminishes the meaning of on-screen keyboard as an external memory aid. In order to decrease a cognitive load for systematic visual search of the letter, on-screen layout and its changes should be predictable for the typist. In such a case, the text entry technique will form visual routines, primitive visual operations to identify a target property (letter, its location and surrounding), available to a subject for selecting and manipulating elements of a scene [7, 13]. Presenting all options available with virtual keyboard would impede improvement of typing skills acquired through use of technique.

On the other hand, diverse versions of onscreen keyboards were augmented with a scanning option to choose highlighted areas by using a switch-input device. Cyclicity and hierarchy are two different and opposed parameters, which should provide reliable communication. Cyclicity supposes sequential access to the layout items. Herewith, a huge number of alternatives (27-106) makes difficult not only the navigation itself, but the waiting of the moment when a necessary item will be accessible [2]. Therefore, the methods, when an access to group of the characters, signs or special functions can be realized on demand, are widely used in augmentative alternative communication. It is often added with prediction algorithms which also allow training the user generated language model (Figure 1, on the left) [4]. Figure 1 (on the right) shows UKO-II Emacs text editing interface with ambiguous keyboard and embedded adaptive language model for motor impaired users [5]. The on-screen keyboards, which are based on a special techniques, are not intended to speed up typing for novices and some experience is needed to approach a reasonable typing speed and accuracy.
There are also alternatives based on spelling models, which could be combined with known techniques. For instance, abbreviated text input [12] allows entering text in compressed form using a simple stipulated abbreviation method that reduces characters by about 30%. As stated by authors, using statistical language processing techniques can decode the abbreviated text with a residual word error rate of about 3% and less [12]. Moreover, because text processing is completely independent from the user, the cognitive overload from switching attention to the system’s actions is eliminated. Keystroke saving rate reached during the user tests varied from 30% for French language to 50% for Swedish and German in FASTY project [1]. To increase the prediction accuracy the user and system should coordinate a specific language model or use the same dictionary of abbreviations.

Zhai and Kristensson proposed a new type of shorthand gestures – “sokgraph” – the trajectory which connects the positions of the letters of a word entered through on-screen keyboard [15]. Sokgraph is quite an abstract gesture that can vary being defined on a particular layout of the virtual keyboard. The goal of this innovation was to combine benefits of the traditional shorthand systems, when the whole word or the phrase could be entered with a single gesture, the sequential learning strategy based on the behavioral patterns and the user experience. A special imaging technique was also designed by the authors “to support users’ gradual transition from visually guided tracing on keyboard to recall driven gesturing” [15].

Thus, the user has to learn any text entry technique and memorizing cannot absolutely be excluded. Several new text entry techniques when cognitive load is kept to a minimum during the training phase are introduced in the next sub-sections.

The alphabet compression

The English alphabet can be reduced to 16 letters based on a substitution of the phonetically similar consonants (Table 1). Herewith, the use of the Microsoft Word Spelling cannot identify and restore of about 3.5-5% words printed with modified spelling. For example, there is only a single variant to restore right spelling when instead of the words “question, circular, conventional, dynamical, zooming, discussion” were entered the next modified patterns “kuestion, sirkular, konfentional, tunamikal, sooming, tiskussion”. The problems were detected for identification such the words as device (tefise), windows (fintous), drawing (trauing).

The words were taken from the list of the Words Frequencies [14] according to the recommendations from [8]. The Figure 2 (on the left) shows the brief instruction and the layout used in testing. Through one-hour training the typing speed of the novices
attained 18-25 wpm. The subjects were surprised how easily they can type modified ("wrong") words.

Table 1. The compression of the English alphabet.

<table>
<thead>
<tr>
<th>English letter frequencies* (numbers below letters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
</tr>
<tr>
<td>73</td>
</tr>
<tr>
<td>v</td>
</tr>
<tr>
<td>13</td>
</tr>
</tbody>
</table>

*http://library.thinkquest.org/28005/flashed/thelab/cryptograms/frequency.shtml

Western script has several handwriting styles for elementary school-aged children. The loops and other shapes provide systematic steps for letter analysis and efficient motor and memory cues for children. These basic elements can be employed in a systematic way to yield a relatively small set of segments to be used for assembling letters and other symbols in text entry tasks. Symbol Creator (Figure 2, on the right) in a great degree relies on a previous experience of the user with handwriting pen-based text input [10].

Keyboard In-Mind

Several attempts have been made to build a text entry system based on directional gestures. It is supposed that such a system of gestures can be universal and device-independent [8]. However, a sequence of movements, which has not any graphical analogue with image of the letter, cannot easily be learnt or imprinted in memory. Finally, to code more than 27 signs basic movements have to be done in three or four directions. Such a system has a lot of constraints, as being optimized statistically it cannot be associated logically with a shape of the letters to facilitate learning. Meanwhile, the idea to make a letters’ selection based on hidden targets when user can imagine the needed key in some location is progressive enough. Most of people easy memorize the words and associated characters sets like similar syllabic or phonetic groups. Hence, the task is to associate the number of known locations (or directions) with small groups of the “similar” characters. We built the system and tested it (Table 2). The fonts in a bold style display phonetic groups arranged in columns. The underlined characters have graphic similarity or complementary segments. Shading signifies other connectivity (e.g., TDK, MHz, XYZ, QU, QUBK). The testing showed that after a short explanation of the system presented in Table 2 and a 3-minute
learning of the layout the error rate of reproducing all characters in their original locations was less than 12.7% in average. The first row “ERATIONS...” comprises of 9 characters the occurrences of which are in about 70% of cases. The first row is a homophone to the word “aerations”, that is, 9 characters are memorized at once.

<table>
<thead>
<tr>
<th>Mnemonically associated letters</th>
<th>Sum. freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E R A T I O N S space</td>
<td>70.7%</td>
</tr>
<tr>
<td>C L P D F G M H Z</td>
<td>21.2%</td>
</tr>
<tr>
<td>Q U B K V W J X Y</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

**Conclusion**

Some basic concepts employed in optimizing software keyboards to facilitate textual communication for physically challenged people have been discussed. We hope new ideas introduced will stimulate designing future prototypes and highly adaptive solutions.

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**References**