"Plan Table" for Oral Perception of the Page with the Text by Visually Impaired Individuals

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ABSTRACT

The paper discusses the development of a new hardware "Plane Table" for oral perception of the text by visually impaired individuals. The plane table, unlike the Braille display, represents not one line of the text, but 40-60 lines. The reader has a possibility for fluent navigation in the body of a page by ten fingers at once, and subsequently the possibility to form the representation of the image of a page, filled with words and blanks, paragraphs or empty lines. The paper considers 4 (four) new ergonomic phenomena on a blind individual working with the Russian speech computer and the results of its operation and service for many years.

1. INTRODUCTION

There exist 2 technologies of blind people text reading [1]. We understand "technology" as hardware and the methods of its use as software. The first one is by finger skin, perceiving Braille print. The second one is oral, via perception of synthesized speech from a computer.

2. DISADVANTAGES OF THE TECHNOLOGIES

The first technology (such as Braille reading from hard paper or from rising needles of Braille-display computer) can be characterized by two disadvantages:

a) it requires a special skin skill of discerning the profiles of needle corners;

b) it decreases the speed of reading because the unit of perception is a letter and not a word.

The second technology uses the blind person's acoustic perception and usual manipulations of fingers with the keyboard. I blind individual directs oral speech synthesizer to read either a sentence, a word or a letter with his/her finger. Besides, in the synthesizer there is a choice of the speaker's voice, speed of speech, way of intonation, reading with punctuation marks or without them.

The most difficult is oral perception of detached letters. Reading by the way of listening to the synthesized speech is not characterized by these two above-mentioned disadvantages (special education, reading letter-by-letter) which are typical for Braille reading. Nevertheless it has two other defects which create difficulties for reading such as:

a) a word or a sentence sound for a long time. It often takes more time than it is necessary for the brain to understand the sense. That is why, the quick stop of sounding is impossible and the manipulation with the "ray" of attention of the brain goes by inertia. The thought is quicker than the input signal, superfluous speech disturbs the process of thinking.

b) unlike hearing, the tactile Braille reading and the vision of a sentence by a normal-sighted individual suggests the appearance of a "subsequent image" of spatial words arrangement on the page in the working memory during the first touch to the sentence. Unfortunately, the oral sounding of a sentence has no tight connection with the coordinate space of a page. So the subsequent image of a word position in the space cannot stay in the memory after its presentation. That is why the following circulation of the ray-cursor of our attention in the text is difficult. But during the perception of a sentence the process of thinking often asks the ray of our attention to jump back and forward along the orphographic (orfoepic) subsequent image of a sentence [2].

3. ADVANTAGES OF THE TECHNOLOGIES

While comparing the above-mentioned technologies, it is possible to indicate the strong sides/advantages of each of them.

1) Braille reading is convenient when one needs reading or writing with "one letter" exactitude. For example, writing mathematical or physical texts or back jumping to its different places. The work with Braille is preferable in presence of acoustic interference. Braille reading and writing are more comfortable when the position of the text along the line is important [3].

2) Reading with a synthesizer is more convenient in the process of passive linear perception of long parts of a text without formulas and symbols. It has no alternative if a visually impaired individual does not know Braille. Perceiving oral speech one has no need in superfluous information about the format position of the words, lines, paragraphs of a text directing his/her attention only to its subject. Today a speech synthesizer can be put into practice in a computer as a pure program product, i.e. it does not demand special equipment for work of an individual with disabilities in vision. That is why he/she can become a computer user with a usual keyboard like a

normal-sighted person. In this case expensive Braille equipment is not necessary at all.

The visual impairments have significant social-and-psychological consequences for an individual. Therefore, the implementation of scientific achievements in new engineering systems for the visually impaired is the issue of the day. Scientists even did not assume that the lens invention could be able to give rise to other visual aid as glasses which approached the partially-sighted to the normal-sighted. Exactly the same way, scientists did not suspect the speech-synthesizer invention to make such a revolution in the lives of people with visual impairments which made them equal to the normal-sighted in the world of computer technology.

Besides the development of the speech computer, the development of a “visual and speech” robots-guides for the blind people becomes differentiated in the text, on the street, in the flat. As it is known, it is quite complicated or sometimes even impossible for the visually impaired people to move around a flat, street, a garden-plot or a town independently. As usually, the visually impaired are forced to use a white cane, a guide or a guided dog.

Till recently the visual pattern recognition has not been considered with respect to the individuals with visual impairments assistance. In 1996 American scientists initiated such a research. The scientists representing 4 fields of knowledge attempted to create an artificial eye at the Massachusetts Technological University. Opticians, researchers who work with electronic devices, neurosurgeons and psychologists collaborating in the project “Toward an artificial eye”, developed 2 photo-cameras, photo-chips for an eye retina, electrodes placing in the cerebral cortex of the blind individual. As we know, scientific research of such a kind has not given the state-of-the-practice until now.

In 2001 another project “Blind navigator” started to be carried out at Stanford University which aimed at the telerobot-helmet development for the visually impaired. The person's head, neck, body together with the head-navigator on the head turn looks of 2 TV-cameras forward the visually impaired person's navigation. A baby-sized computer assembled into head navigator can recognize about 100 volatile objects in the room. Afterwards, the speech synthesizer transmits the information about objects in front of a blind walker, which can be collided on his/her way. At the same time the mouse cursor of a "computer" controlled by the person's hand slides along the screen as well as the looks cursor of photo-camera will be controlled by the head and slide along the three-dimensional (3D) space [3,4]. Thus, the project has not produced lasting results, suitable for the further implementation either.

Computers will continue to shrink in size and price while growing in power. As a result, it is inevitable that assistive technology products will be developed that reliably and in real time recognize objects that are important for blind mobility. These products will alert blind users to risks and obstacles, they will assist in finding the desired objects and identifying important navigational landmarks. Unlike the current generation of blind mobility aids, these future products will significantly reduce the blind users’ cognitive workload.

The possibility of creating such products results from the rapid development of machine vision systems, from the increase in reliability of object recognition in 3D space. Such a system will be similar to an accompanying person, who helps to navigate a blind individual in rooms, corridors of a building and outdoors.

It is undoubtedly that devising of the recognition block will be the most research-intensive in the whole system. Besides there is an ergonomic problem: what is the best way to inform a blind person quickly, briefly and unambiguously? Otherwise, the construction of a nicely devised recognition system will be useless in case its messages are not clear to an unsighted individual.

In this paper we would like to discuss a version of a system giving oral warnings to a blind individual about the surrounding situation/environment, recognized by the above-mentioned system. Oral speech, not tactile sensing, is chosen for warnings. According to our previous experience, we can assume that a blind person can be in the same situation when he or she is warned with the help of a computer screen. And it is known that talking systems, like Screen Reader, turned out to be better for navigation than tactile Braille displays.

In anticipation of this eventuality, we believe it is essential to address the linguistic aspects of how the user might interact with the recognition system. We assume that the user will apply speech to command the system, and the system will respond with speech and sound effects.

There is a specific linguistic structure for the conversation between user and system, including vocabulary, syntax and semantics. We expect this initial design to be controversial. We hope that it initiates a dialogue in the blind community that constructively criticizes the design and iterates on it to arrive at a consensus.

The psychology research of intentions, which are typical of blind adults in their studying and working activities, showed that there are three major intentions:

- Search (Find, Select);
- Mobility (Where, Go, Select);
- Putting Something Down [5].

Orientating reflex of any person, including an individual with disabilities in vision as well, creates a motive just to find out (out of curiosity) what kind of objects are located around them, how far and where exactly those objects are situated. At the same time, a blind person is forced to scan the environment not just out of curiosity, but to recognize a) dangerous, b) required, c) inconvenient objects. That is why our first conclusion can be the following: the first stage of research involves an opinion poll. The blind people answer a questionnaire so that we could find out what 50-70 objects need to be recognized in their studies, objects that are a) dangerous, b) required for work and c) inconvenient.

The second stage of research is to find out with the help of a questionnaire what paths a blind individual is able to take (remove, fetch) those objects.

It is possible for us to admit that the visually impaired will tend to avoid walking around dangerous objects. They will look for, take, remove, drop, pick up or put down required objects. They will walk around or put away inconvenient objects.

A questionnaire is also needed for the third stage of the research. Its objective is to find out the places (niches, as George Gibson names) from which and where a blind individual usually has a motive to remove things to.

It is necessary for us to obtain information based on our first experiment: *Question A:* what kind of things appeal to the visually impaired individuals; *question B*: which things a blind individual usually gives a preference in his/her work to, taking and moving them, being at his/her office place. Resulting from the first experiment, receiving the answers to the questions A and B we are able to prepare a list of 15-20 things chosen by 6-7 blind female or 6-7 blind male. Besides we need to find out the following information from the first experiment: characteristics and details of the first list of things; e.g. state of thing (close or open, free or not free, switch on or switch off), color of thing (green, red, yellow).

It becomes necessary for us to know the following piece of information as well regarding the first experiment: It is question C: what environmental objects can have great significance and interest for the blind, (e.g., windows, doors, walls, flour, ceiling, steps, up- and downstairs, ramps, banisters).

The objective of carrying out the second experiment can be understood as indicating actions, transportation paths of objects, called by the visually impaired during the first experiment.

Situation A. Reactions of blind people towards hazardous things will be determined: e. g. the blind individual will turn back, go backward or go around; he/she will not touch these things.

Situation B. Reactions of blind people towards interesting things (landmarks, signs). One of the objectives of the second experiment aims at paths of moving made by the blind individual while working with interesting things through the questionnaire. In accordance with our hypothesis movements can be the following: actions (to find, to take, to move, re-place, to sort, to select, to drop, to pick up). Thus, it is necessary to indicate that in comparison with the first category of hazardous things/objects a blind individual avoids close connection with them. The blind person does not avoid interaction with interesting things/objects that are included into the second category, moreover he/she manipulates, takes and drops them.

Situation C. Reactions of the visually impaired towards inconvenient things. During the second experiment ways of overcoming inconvenient things can be solved by avoiding them, walking around based on the first category of hazardous things/objects or operating with them: taking, moving inconvenient things/objects in relation to the second category of interesting things. Therefore we need to obtain the whole information within the second experiment by means of the questionnaire. Thus, that questionnaire can assist us in discovering the manner of movements (verbs) made by the visually impaired from linguistic point of view.

The *third* experiment. The objective of the third experiment includes *paths of things transportation indicated.* In the experiment it is necessary to find out where the blind individual moves and places things/objects from one spatial point to another in his/her room.

Psychologists follow a theory relating to the experiment on the objects manipulation, subspaces in the human space. In particular, the theory proposed by George Gibson [6] on human behavior in space is suggested. The main idea of the given theory considers that mental (psychological) space of a blind individual is subdivided into *psychological niches*.

The human being can hide himself/herself in any of these niches. Therefore unconsciously every human being is willing to room, to have his/her own closed space (niche) in order to separate himself/herself from the external world. Thus, the individual tends to place or conceal favorite, more preferable and most frequently used things/objects in one or several niches.

The surface of a table, its construction, the place of things on it can be represented as a psychological niche. It is well-known that every individual is used to the order on the table and he/she does not accept a replacement on it. One of the characteristics of any individual is his/her isolation of the micro-space in a building or a room as a psychological niche.

It is preferable for every individual not to permit another individual to interrupt into his/her psychological niche. He/she perceives negatively anyone's presence, any operation and intervention in it. Thus, based on this we are able to propose a hypothesis that the blind individual will choose the paths of things move from one psychological niche to another, while operating these things. This is George Gibson's hypothesis that considers the space segmentation of the room into subjective subspaces [6,7].

4. NEW PROPOSALS

Taking into account the pluses and minuses described of the above-mentioned technologies we suggest a considered hypothesis about the possibility of creating a new, third technology in which the idea of Louis de Braille about scanning the text with a finger could be carried into the technology of a speech synthesizer. As a result, a listener will be able to have a possibility to operate the synthesizer according to his/her attention with fingers while reading or writing a text. Let's consider the "Plane Table" suggested and the technology of working with it more in details.

According to the new technology the working computer place of a blind individual will include a special key-board, format A4. There will be a special card in the computer to operate with this keyboard. By its function this board will be like a kind of a display and at the same time an original keyboard. Each key according to a signal from the screen of a computer can rise over the board facial surface or stay sank joining the surface depending on the presence or on the lack of a letter on its sign place in the text at every moment. If a key is risen, potentially it can perceive finger's pressing. Its pressing automatically stops sounding of the previous acoustic signal from a synthesizer and begins sounding the word in which this key is "included" at the moment. Pressing in turn different risen keys on the whole plane table a blind individual is able to synchronously listen to the fragments of a text according to his/her ray of attention comprehending the text. With the help of such a plane board two psychological effects are achieved.

First, hearing is not overburdened by listening to superfluous information and that is why it does not disturb the comprehension of a text, does not "mix up" the thoughts of a person.

Second, risen keys on the page format A4 give a possibility to a blind individual to receive the notion about the position of concrete words of a text (keys of the letters of the words are risen) and of its blanks (keys are sank) in the lines, positions of concrete sentences - in a page.

There is a certain similarity of the new plane board, its keys, sometimes rising or sinking over its surface with a Braille display, i.e. with a ruler of electronic modules in which needles rise or sink informing the code of a letter by Braille. The difference is that in the new plane table the fact of a risen key gives the blind individual less information from the screen about the fact of the presence in the text of some letter or a digit on the sign place of that key, i.e. about the fact of the lack of a blank.

The key does not inform the finger about the code of a letter or a digit unlike the Braille-module. This function will be carried out to the speech synthesizer which is potentially ready to sound a letter (a word) but only after the blind individual's finger has pressed a key.

The device informs a visually impaired individual through synthetic speech similar bleeps. In future trends the speech synthesizer assumes to be used for the implementation of the imagery recognition algorithms and for the navigational information transmission. As a result, the system turns out to be inexpensive and easy-to-replication.

5. CONCLUSIONS

The new plane table is placed on the right side of a usual keyboard which continues to fulfill its standard functions, for example, letter by letter printing a new text, circulation in the text, its edition.

A blind individual can work with a plane table (to pulp rows of keys and to press some of them) not only with one hand, but with two hands at the same time. Unlike the Braille display, the plane table represents not just one but 40 - 60 lines of the text. That is why a reader has a possibility to navigate fluently in the body of a page by ten fingers at once, and subsequently it provides a possibility to form the representation of a special image of a page, filled with words and blanks, paragraphs or empty lines.

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