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Influence of speech transmitting methods on velocity of the understanding of deaf-mute by sensory organs

MEČISLOVAS MARIŪNAS, ALGIMANTAS POŠKA, ANGELA SHESHOK

Vilnius Gediminas Technical University, Lithuania

The control algorithm and program were created for information transmitting and coding device, the influence of hearing device information transmitting rate and method on its understanding was analysed.

Keywords: deaf-mute, speech recognition, hearing aid, information code

1. Introduction

People with hearing disorders may be subdivided into two groups: 1. Those who are hard of hearing but have not lost it totally. 2. Those who have totally lost hearing or are deaf-born. There are many signal amplifying hearing devices designed and manufactured for the first group, and their design and technical characteristics are being improved constantly [1]. However, these devices are not suitable for the second group. Other communication means appropriate for the deaf people are based on tactile and sight organs [3]. Device designed by us is suitable for the second group. In our device, we use, the best today, speech recognition software "Naturally Speaking" (IBM and "Dragon Systems" companies) and a computerised Lithuanian dictionary compiled by us.

2. Results of hearing device adaptation time and reliability research

The Lithuanian dictionary was compiled on the basis of "Naturally Speaking" for English. In the primary stage of the research a Lithuanian dictionary comprised 1500 words.

Two experiments were performed on the basis of Lithuanian language recognition program. The goal of the first experiment was to determine the adaptation duration of a Lithuanian modification of speech recognition program to different voices and the suitability of the software for hearing device. The adaptation duration of the modified

"Naturally Speaking" to different voices depends heavily on the age of person and may alter from 28 to 74 words on average. The second experiment was performed to determine the reliability of recognition of Lithuanian speech. Each participant had to say the same 300 Lithuanian words. We observed how many mistakes each person participating in the experiment made after adaptation. Summarised results of the experiment are presented in Table 1.

Table 1. Dependence of mistakes number on the lifetime and sex of people

Factors	Groups of lifetime				Mean value of line $A_{\bullet j}$
	Up to 14	From 14 up to 30	From 30 up to 50	Over 50	
Women	60.2 (~80%)	57.2 (~81.0%)	61.2 (79.6%)	63.4 (78.8%)	60.5 (≈80%)
Men	68 (77.3%)	84.2 (71.9%)	64.4 (78.5%)	65 (78.3%)	70.4 (~76.53%)
Mean value A_{ij}	64.1 (78.6%)	70.7 (76.4%)	62.8 (79.06%)	64.2 (78.6%)	65.45 (78.2%)

The research showed that hearing device investigated by us is able to understand about 80% of words.

3. Analysis of speech elements transmitted to sensory organs. Influence of methods and rate on understanding

The system of hearing prosthetics consists of microphone *1* to which the person communicating with the deaf-mute speaks, personal computer PC *2*, interface connected with tactile matrix *3* and electromagnetic tactile matrix made of needles *4* which "prints" the contours of letters (Fig. 1). Computer has an analogue numerical transformer and sound plate SB that changes analogue microphone signal to the set of numerical codes. "Naturally Speaking" program changes this set of codes to letters of Lithuanian alphabet and words. Device is connected to PC through PC parallel port LPT1 which has such output lines as: data output lines Data 0–Data 7 and control output lines Linefeed, Select In, Initialise and Strobe. Information output lines Data 0–Data 7 are connected with programmable adapters KP580BB55A (Fig. 1, PIO1 and PIO2) of parallel interfaces through buffer register SN74ALS245 (Fig. 1, compatibility block). Control signals are amplified by elements K155LA3 (Fig. 1, control block). Logical unit in Linefeed output line chooses first the interface and then logical zero. Programmable adapters are activated in 0 (asinchronic) regime by control word 80, code 00 is sent to control output lines Select In and Initialise, control word – to output lines Data7–Data 0.

At the same time the adapter control signal $\overline{WR}$ is formed in sending logic unit through PC output line Strobe. The electromagnets of tactile needle matrix are connected to the ports PA1, PC1, PA2, PC2 through transistor amplifier (the base-transistors of KT502 type). Transistors are protected against electromotive influence of electromagnet self-induction by reverse diodes. Unstabilised 12 V source and stabilised 5 V source are used for feed (microscheme KP142EH5).

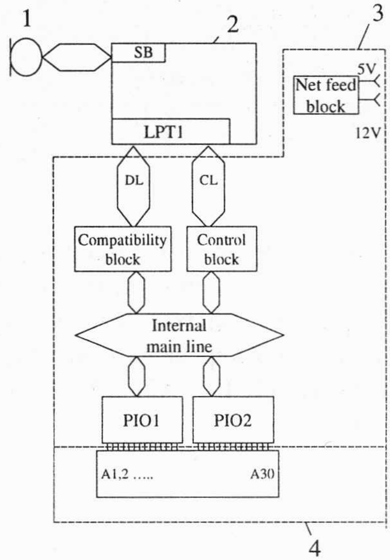

Fig. 1. Structural scheme of hearing device: 1 – microphone; 2 – computer with sound plate (SB–Sound Blaster); 3– interface of connection with tactile matrix; 4 – needle tactile matrix; LPT1 – computer parallel port; DL – data line; CL – control line; PIO1, PIO2 – ports; A1 – 30 – matrix needles

This device is stationary and is made for training. It allows us to see a letter or a word on the computer *2* display and to feel it by sensory organs by means of device *4*. The simplest construction and the smallest dimensions of the device for transmitting information to the sensory organs of the deaf-mute exist in the case when we transmit information by letters. That is why the letters are chosen for the main code of speech recognition and transmission to the sensory organs in the primary stage of research [2]. We decided to transmit the speech information to the sensory organs of deaf-mute by letters following their shape. Letter is transmitted to the sensory organs of deaf-mute by imitating the process of letter writing. The 5×6 rectangular matrix is chosen for letter coding. The device that transmits information to the sensory organs of deaf-mute *3* (Fig. 1) consists of 30 microvibrators. The deaf-mute will put the vibrator on the hand or other body part. For the purpose of letter coding and transmitting to device 3 the program FIRST was developed in the C^{++} Visual language Microsoft Foundation Classes. Additional visual information is used in stationary device: the deaf-mute will be able not only to feel the signal of letter but also to see it on the computer display. The advantage of letter coding by its shape is that the deaf-mute will feel the same what will be shown on the display, he will not need to learn another one code (e.g. as in the case of Morse alphabet).

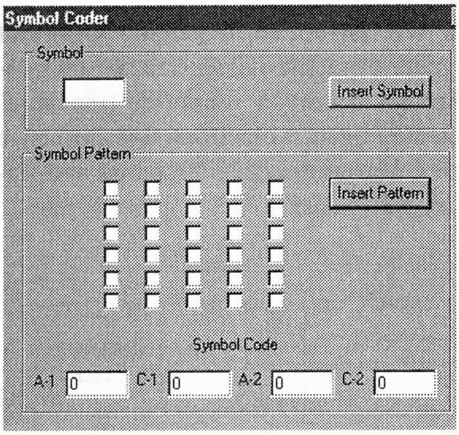

Fig. 2. Symbol coding window

Control program is coded using dialogue window shown in Fig. 2. The symbol being coded is written in the Symbol column. The Pattern squares are signed, they correspond to matrix 4 needles (Fig. 1) which must act. When we sign matrix codes, decimal codes appear in Symbol Code row, they will be transmitted through the parallel ports A1, C1, A2, C2. Algorithm of signal coding control program FIRST is shown in Fig. 3.

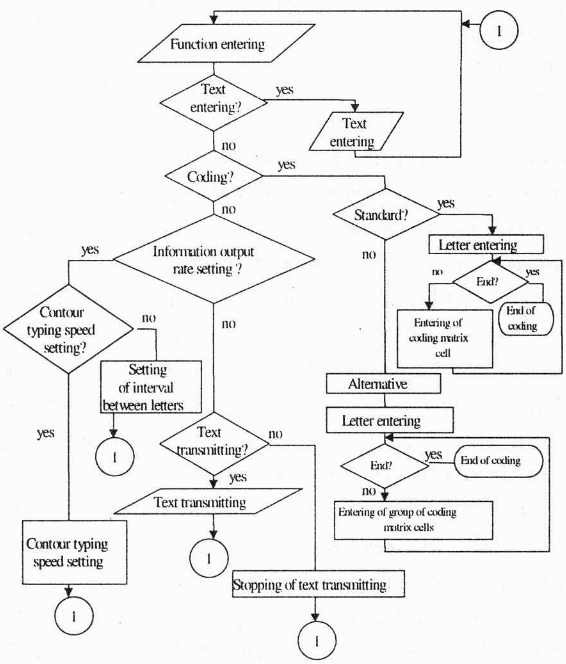

Fig. 3. Algorithm of program FIRST

Program FIRST allows us to keep several versions of letter coding (information in hundreds kB). Two coding versions are used at the moment: standard – one needle of

5×6 matrix acts at one time, alternative – two-three matrix needles act. Deaf-mute may change coding version (if it is not effective, hard to understand). The intervals between needles' actions and letters are programmed in letter output rate changing block. Interval between letters may be changed from 0 up to 10 s, intervals between matrix needles' actions (contour output rate) – from 0 up to 1000 ms. It can be made by deaf-mute himself. Code will be formed in capitals, which should facilitate the understanding of information. When similar symbols are coded (e.g. "B" and "8") we will use the sixth upper row which will show where letter "B" and number "8" are.

Letters were coded by one needle at a time or two needles at a time in the investigation. The intervals between letters and contour output rate were also being changed. The aim of the investigation is to choose the optimum rate of information transmission and the method. The sensibility of various human body parts was also tested. Such places were chosen a priori: back, abdomen, cheek and hand. Investigations have shown that abdomen and back are less sensitive, code merges, contour is unrecognisable. Better results were achieved with hand and cheek. We decided to transmit information to a hand. 10 normally hearing persons took part in the experiment. The number of letters that had to be transmitted to human sensory organs to achieve good tactile understanding was determined during the experiment. The averages of results are shown in Tables 2 and 3. 0.1 s interval between the needle actions was chosen for primary training of persons taking part in the experiment. Participants did not see the word on the computer display during the experiment.

Table 2. Results of letters' transmitting investigation with one needle acting at a time

Age groups, years	Interval between needles actions, s			
	0.01	0.02	0.05	0.1
From 14 up to 30	2	2	2.8	3
From 30 up to 50 m	3.2	3.6	5.2	3.8

Table 3. Results of investigations with two-three needles acting at a time

Age groups, years	Interval between needles actions, s			
	0.01	0.02	0.05	0.1
From 14 up to 30	3.4	3.8	3.4	4.6
From 30 up to 50 m	5	5.2	6.2	5.2

The investigations showed that the speech is better understood when the letters are transmitted by their contours with one acting needle at a time at 0.01 s and 0.02 s intervals between actions.

There is no significant difference between 0.01 s and 0.02 s intervals. However the fewer intervals between needles' actions, the more information we can transmit per minute. Therefore, in further investigations we will use one needle at a time at 0.01 s intervals. Table 4 shows how many words should be said until the participator understands the information transmitted.

Table 4. Results of speech transmitting investigation with one needle acting at a time, interval between needles' actions 0.01s

Age groups, years	Interval between letters, s			
	0.25s	0.5s	0.75s	1s
From 14 up to 30	3	2.6	2.8	2
From 30 up to 50 m	4.8	3	3.8	2.8

At the primary stage we used 1 s interval between letters, later we gradually decreased it. 0.12 s interval appeared to be sufficient. That means that during 1 s we can transmit to the sensory organs of a person being trained 2–3 letters or 150 letters (~20–25 words) per 1 minute on average.

4. Conclusions

- We concluded that more advantageous is transmission of letters according to their contours with one needle in action at a time, because we can follow the contour of letter and it allows us to understand better information.
- 0.05 s intervals between needles' action may be used for primary training of deaf-mutes. Investigation showed that better results were achieved at 0.01 s interval.
- 0.5 s interval between letters was chosen. More skilful persons may use 0.25 s interval between letters. The rate of speech transmission to sensory organs is approximately 20–25 words per minute.
- Young people are more sensitive and understand information with their sensory organs more clearly than elderly people.

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