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**Article**

# Use analysis of microserves in e-learning system with multi-variant access to educational materials

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# ANALYSIS OF THE SYSTEM OF AUTOMATIC CHANGE MODES OF THE HARDWARE-SOFTWARE COMPLEX OF TRAINING OF INVALIDS OF SIGHT OF BRAILLE

*The object of research is the hardware-software complex of learning Braille. The research is aimed at the analysis of the use of the system of automatic change of modes of the hardware-software complex depending on the results of the user's tasks.*

*As part of the development of the project for the implementation of hardware and software for the training of the visually impaired in Braille, there is a need to analyze the operation of the updated control system for the order of output of letters. The solution was a software bridge that connects devices to a remote database server via smartphones, where learning results are stored. To solve this problem, the algorithm for changing the modes of letter output was modified, the module of connection of the hardware and software complex with the phone was implemented, the file structure for information transfer to the database was developed.*

*After the introduction of updates in the hardware and software complexes of users, an analysis of the training was conducted. Statistics were collected according to the following parameters: selected language, type of game, correct and user answers, mode of output of letters, date-time of answer and operation of changing of the mode of output of letters. The analysis used data on the first and last states of the mode of output of letters for one day without reference to games and languages. The research was conducted over 30 calendar days for 100 users, but the data were reduced to 15 days, as some users were not study every day, and the day of study was taken.*

*The research showed a tendency to change learning to groups of letters of the highest complexity. Less than a third of users stayed at the first level, which provides for the next update of the software to collect data on the age of the user, because children under 5 years do not learn the letters of the third group of complexity.*

**Keywords:** *hardware and software complex, Braille, tactile font, education for the visually impaired, game forms of education.*

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## 1. Introduction

Training visually impaired people is an urgent task not only within Ukraine, but all over the world. Although the percentage of completely blind people according to the statistics of the World Health Organization (WHO) [1, 2] is about 0.5 % (~39 million). According to the same statistics, about 1 % of visually impaired people lose their sight over the years so much, that they are forced to either deprive themselves of exploring of the world and work, or undergo complete retraining based on their disability. The exact number of visually impaired people is unknown for many countries. For example, for Ukraine, even at the level of the Ministry of Health of Ukraine (MHU), only an approximate estimate is known – more than 50 thousand blind people, including more than 10 thousand children.

In today's conditions, the problems of social and labor adaptation of the blind, their employment and training have become more acute [3]. It is obvious that it is necessary to introduce new approaches to the methods of training, correction and rehabilitation of the visually impaired people (VIP). Improving education in educational institutions depends on the technical support of the educational process.

Today, the existing technical support needs to be updated in almost all special schools and preschools for visually impaired children.

One of the tools of learning about the world for children is the ability to read. Several tactile fonts are used for the VIP, but the most popular is Braille [4]. That is why most hardware and special literature for the VIP are developed with the support of Braille.

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The basic cost of these devices is quite high (the cost of a Braille display starts from 1000 EUR). But the existing technical means provide the ability to output and enter information in Braille, but do not have specialized training software. Hardware training is practically not developed, because a small percentage of consumers can not cover the cost of their development.

In the world, almost all developments in the field of education and support for the blind and VIP are carried out at the expense of funds and grants. There are no such grant programs in Ukraine yet, but initiative groups develop independent solutions and disseminate them through public organizations.

One of the projects for teaching blind children Braille is being developed for more than a 5 years ago [5–7] and already has more than 100 users in Ukraine. This research is devoted to the improvement of algorithms of user interaction with the system and software update of this hardware and software complex.

The relevance of the research is due to the need to develop and improve Ukrainian hardware and software solutions for the training of the VIP, because foreign developments [8–10] will not have a Ukrainian localization for a long time. The research will be interesting to scientists from countries that are stuck with the problem lack of educational software packages for the VIP. *The object of research* is the hardware-software complex of teaching Braille. *The subject of research* is the system of automatic change of modes of operation of the hardware and software complex for Braille training of visually impaired people. *The aim of research* is to analyze the implementation of a system of automatic changes in the modes of operation of the hardware and software complex depending on the results of the user.

The body of the device is printed on the 3D printer therefore at the request of customers at different devices differences in external dimensions which do not contradict the minimum sizes for placement of hardware base is possible.

Software development was based on global trends in the development of educational complexes for the VIP [10–12]. In the previous model, a system of changing the modes of the order of representation of letters depending on the number of mistakes made by the student was introduced [7].

**2.2. Update of the hardware and software complex for Braille training of the visually impaired people.** The latest update, which was passed on to all users, contained a number of changes related to the implementation of the ability to connect the device to smartphones to transfer learning data to a common database (DB) (Fig. 2) and modification of the system algorithm (Fig. 3).

The new_statistic.json file, which is generated on each device during system operation and transferred to the server via an application on the smartphone, is responsible for the transfer of data from devices.

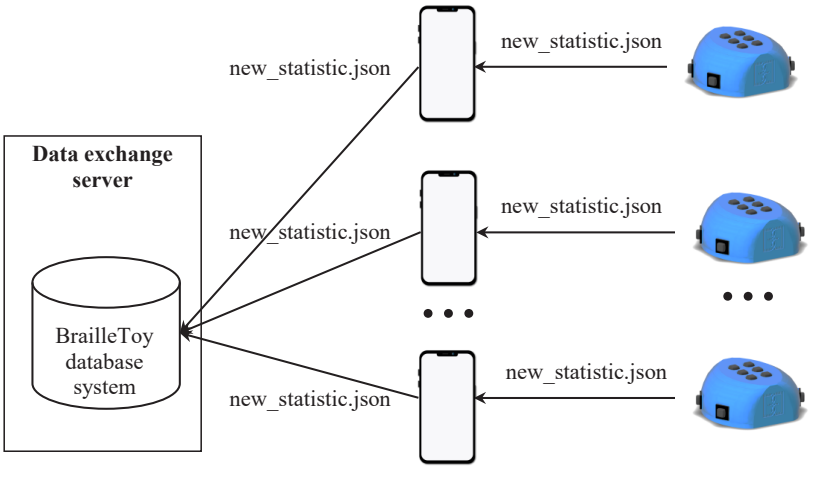


**Fig. 2.** Scheme of data transfer from devices to the data exchange server

## 2. Methods of research

**2.1. Description of the hardware and software complex for teaching the visually impaired in Braille.** The general principle of operation of the educational complex is described in [5–7]. The design of the hardware and software complex is realized in the form of a shell, with a length of 12 cm, a width of 8 cm, and a height of 3 cm (Fig. 1).

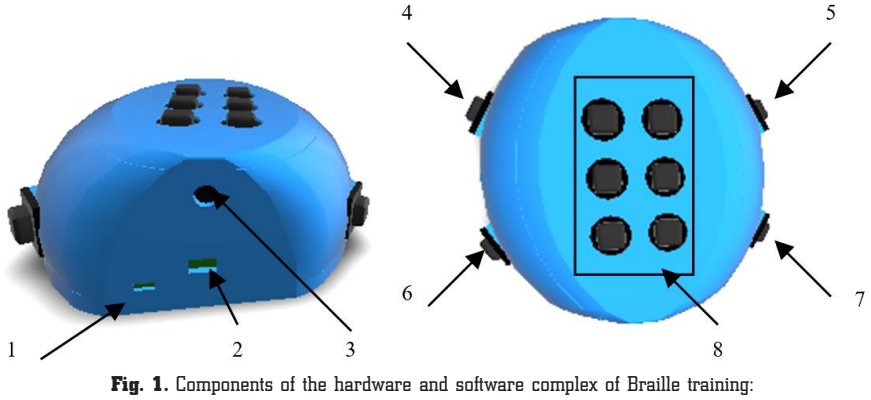


**Fig. 1.** Components of the hardware and software complex of Braille training:
1 – power button; 2 – miniUSB connector; 3 – power connector; 4 – input button; 5 – cancel button; 6 – left navigation button; 7 – right navigation button; 8 – six letter buttons in Braille

According to the implemented structure of the json file, the following data is transmitted to the server:

– brailletoy_id – a unique identifier of the device;
– id_test – unique for the device question ID (to ensure synchronization and the possibility of data repetition);
– lang – selected language;
– game_type – type of selected game;
– time_answ – time of the result received;
– symbol_question – the symbol required for input;
– symbol_answer – a sign of the correct answer;
– id_change – unique for the device identifier to change the mode of display of letters (to ensure synchronization and the possibility of repeating data);
– time_change – time to change the order of display of letters;
– new_mode_id – system-selected letter display mode.

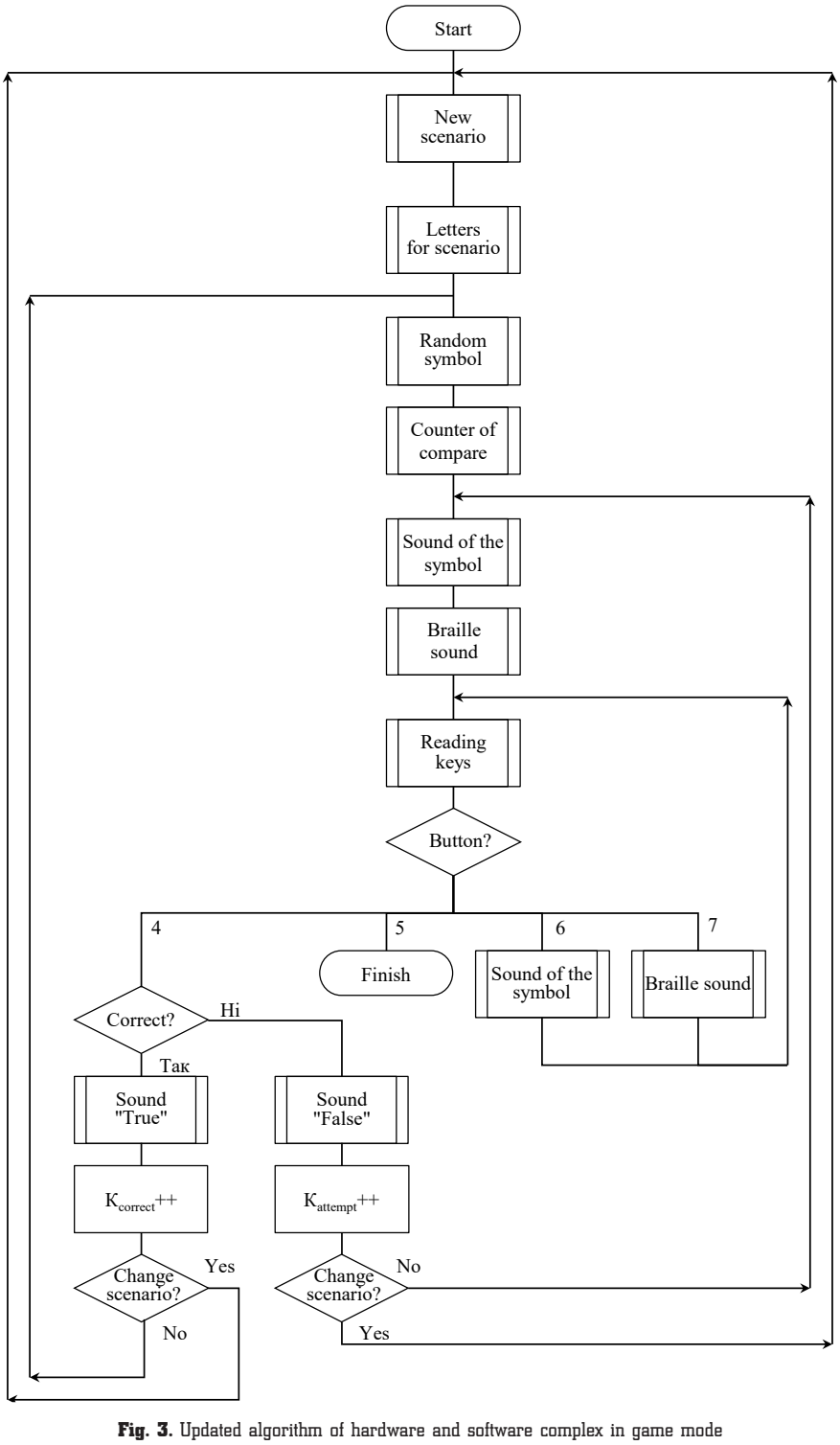


**Fig. 3.** Updated algorithm of hardware and software complex in game mode

An example of a json-file structure is:

{“brailletoy_id”: “00001”,
“test_result”: [
{“id_test”: “12234”,
“lang”: “ENG”,
“game_type”: “1”,
“time_answ”: “2021-06-15 19:51:02”,
“symbol_question”: “A”,
“symbol_answer”: “A”
},
{“id_test”: “12235”,
“lang”: “ENG”,
“game_type”: “1”,
“time_answ”: “2021-06-15 19:51:11”,
“symbol_question”: “Z”,
“symbol_answer”: “Z”
},
{“id_test”: “12236”,
“lang”: “ENG”,
“time_answ”: “2021-06-15 19:51:23”,
“game_type”: “1”,
“symbol_question”: “B”,

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```
        "symbol_answer": "E"
      }                                    ]
    "change_mode":       [
      {"id_change": "234",
        "game_type": "1",
        "time_change": "2021-06-15 20:01:02",
        "new_mode_id": "2"
      },
      {"id_change": "235",
        "game_type": "1",
        "time_change": "2021-06-16 08:11:12",
        "new_mode_id": "1"
      },
      {"id_change": "236",
        "time_change": "2021-06-16 08:15:42",
        "new_mode_id": "2"      }                    ]
}
```


To develop the modes of operation, a classification was chosen according to the complexity of displaying letters in Braille, according to which each of the letters belongs to one of the three classes of complexity [3]. Thus, the whole alphabet was divided into 3 groups of letters – the first group of letters was given to beginners, the first and second groups of letters – to more experienced users and all letters – to experienced. More details on the selection of modes of the order of display of letters in the hardware-software complex of training of the visually impaired in Braille are considered in [7].

The research was conducted among users of the hardware and software complex, who use this tool in their free time under the care of parents. Previous research [7] found a difference in the average time for basic learning of writing letters in Braille with different methods of order of representation of letters:

– for the control group without adaptation of the educational complex to the level of the user mastering the group of letters of each of the levels of difficulty is equal to 6.1 school day;

– for the experimental group using adaptation to the user level – 3.9 training days.

## 3. Research results and discussion

Statistics were collected according to the following parameters:

– selected language;
– type of game;
– right answer;
– user response;
– mode of the order of output of letters;
– date and time of response;
– date and time of operation of change of the mode of output of letters.

In this research, it was decided to take into account the data on the first and last state of the mode of the order of letters during one day without reference to games and languages.

The research was conducted over 30 calendar days for 100 users, but the data were reduced to 15 days (Table 1), as some users were not study every day, and data on the day of the lesson were taken into account of days.

Table 1 highlighted columns that separated the number of transitions to individual modes. For example, the mark «1–2» means a change of mode from the 1st to the 2nd at the end of the training day, «1–3» – from the 1st to the 3rd, «2–1» – from the 2nd to the 1st.

The research showed a tendency to move to a group of letters of the highest category of complexity. Less than a third of users remained at the first level, which provides for the next update of the software to collect data on the age of the user, because children under 5 do not learn the letters of the third group of complexity. This should be taken into account in the new research.

Also, this research did not take into account the basic level of knowledge of users and their experience with this hardware and software complex, which affected the rate of rapid transition of users to more complex levels in the first days of analysis of updated hardware and software.

**Table 1**

The results of the first 15 days of training for the visually impaired

| Class day | Scenario 1 at the beginning of the day | Change the script at the end of the day | | Scenario 2 at the beginning of the day | Change the script at the end of the day | | Scenario 3 at the beginning of the day | Change the script at the end of the day | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1–2 | 1–3 | | 2–1 | 2–3 | | 3–1 | 3–2 |
| 1 | 100 | 7 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 88 | 4 | 3 | 7 | 2 | 1 | 5 | 1 | 1 |
| 3 | 84 | 5 | 2 | 9 | 3 | 1 | 7 | 2 | 2 |
| 4 | 82 | 2 | 2 | 12 | 2 | 2 | 6 | 3 | 2 |
| 5 | 83 | 3 | 1 | 12 | 2 | 4 | 5 | 3 | 1 |
| 6 | 84 | 4 | 1 | 10 | 1 | 2 | 6 | 1 | 2 |
| 7 | 81 | 2 | 2 | 13 | 4 | 4 | 6 | 3 | 1 |
| 8 | 84 | 3 | 2 | 8 | 5 | 3 | 8 | 2 | 1 |
| 9 | 86 | 3 | 2 | 4 | 4 | 1 | 10 | 1 | 1 |
| 10 | 86 | 3 | 2 | 3 | 2 | 1 | 11 | 2 | 0 |
| 11 | 85 | 4 | 2 | 3 | 2 | 1 | 12 | 2 | 0 |
| 12 | 83 | 3 | 3 | 4 | 1 | 2 | 13 | 1 | 0 |
| 13 | 79 | 5 | 2 | 4 | 1 | 1 | 17 | 1 | 0 |
| 14 | 74 | 4 | 3 | 7 | 1 | 2 | 19 | 1 | 0 |
| 15 | 69 | 5 | 2 | 8 | 0 | 1 | 23 | 1 | 0 |
| 8 | 63 | 3 | 2 | 12 | 0 | 2 | 25 | 1 | 0 |
| 9 | 59 | 4 | 3 | 13 | 2 | 2 | 28 | 1 | 1 |
| 10 | 55 | 2 | 2 | 14 | 1 | 2 | 31 | 0 | 1 |
| 11 | 52 | 4 | 2 | 14 | 0 | 3 | 34 | 1 | 1 |
| 12 | 47 | 4 | 1 | 16 | 1 | 3 | 37 | 0 | 0 |
| 13 | 43 | 3 | 2 | 16 | 0 | 1 | 41 | 1 | 0 |
| 14 | 39 | 3 | 1 | 18 | 1 | 2 | 43 | 1 | 1 |
| 15 | 37 | 4 | 2 | 19 | 1 | 2 | 44 | 0 | 1 |
| **Result** | **32** | – | – | 21 | – | – | **47** | – | – |

## 4. Conclusions

The analysis of the market of e-learning complexes for the VIP confirmed the tendency to lack a wide variety of solutions for teaching children with visual impairments in Braille. In the world, standard Braille displays with 40 or 80 letters per line are used for learning, and all other projects are left at the stage of describing an idea or conceptual scheme.

Testing of the updated software of the open source hardware and software complex, which was created by Ukrainian inventors, showed the possibility of its use individually. The research showed a tendency for users to switch to a group of letters of the highest complexity.

On the 15th day of training, less than a third of users remained at the first level, but these data do not indicate the error of the selected type of training with automatic switching of character display modes, and requires the next research to take into account user age and experience with the training complex. The large number of errors in the 3rd group of letter complexity is due to the fact that children under 5 years do not learn these letters and the number of errors on them is greater than on the letters of the 1st and 2nd groups.

To solve this problem, it will be necessary to provide data collection on the age of users and their experience with the training complex in the next software update.

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