

GAMING PROGRAM FOR THE DEVELOPMENT OF CHILDREN WITH SPECIAL NEEDS

A. Harshyna, V. Hrabovskyi

*Ivan Franko National University of Lviv,
107, Tarnavsky St., UA–79017 Lviv, Ukraine
volodymyr.grabovskyi@lnu.edu.ua*

Using Python and JavaScript, a web application has been created to improve the development of children with special needs, including children with autism and hearing impairments. To implement this task, the best and most effective method of presenting information for children – a game – is chosen. The part of the program designed for the development of children with autism contains games using a technique of visual presentation of cards with accompanying information. These games use real-time videos of children's movements to improve their physical activity and memorize letters of alphabet. In addition to images of pictures, the game used to learn a sign language also employs audio and video materials. During implementation of our application, some of the approaches used in artificial intelligence systems are used. In particular, these are the methods of expert systems and pattern recognition based on computer vision. The databases and the knowledge required to run the program are created in JavaScript, and their application management is implemented using a Django framework. Software implementation of the program also uses the capabilities of specialized computer libraries, including PoseNet and p5.js.

Keywords: JavaScript, PoseNet, p5.js, Django, web-application, computer games.

Introduction

The upbringing of the new generation has always been a priority of any society, because it is decisive in its development and future. Therefore, the methods and paradigms of education used at each level of its development absorb all the best which has been achieved at any given time – both scientifically and technically. Nowadays, when our lives and activities are simply impossible to imagine without computers, information technologies and everything related to intelligent systems and artificial intelligence, more and more attention is paid to their use in the process of raising children. Especially important is the use of new technologies in the education of children with special needs [1, 2]. These include children who have problems with autism, as well as hearing, vision and some other problems. It is important for such children to develop the approaches that would facilitate their entry into society, and accelerate and improve their development.

An important method for children's development is games which are natural and inherent in their age and are best perceived, while the results obtained in any play situation are easily assimilated by children. After all, play is the main form of children's activity [3], a method of immersion and transfer of a child to the world around him, a kind of key to the development of his emotional intelligence. Through games, children learn to communicate with each other, obey certain rules of conduct and communication, and be able to yield, as well as prove their right to choose a game.

According to the tasks that are solved in the upbringing and development of children with their help, games can be divided into creative, mobile and didactic. Their content and features change both with the age of the child and with the main purpose of their use, the plot used and the means of implementation. However, despite a large variety of specific approaches to organization of different types of games, their common feature is that they mainly reflect the surrounding reality and are based on independent activities of children, are emotionally rich and bring children joy, pleasure, and deeper knowledge of the world.

The latest achievements of science are used in the development of games, in particular – pedagogical and psychological [1–3], as well as the possibilities of modern technology, first of all – computer technology. After all, without the widespread use of computer programs, computer analysis today is virtually no field of human activity; moreover, the possibilities of using computer tools and the results achieved with their help are steadily increasing. That is why the world of modern cognitive, educational and developmental games without the use of computer and intellectual technologies is simply unthinkable and their use is constantly growing. The use of modern computer games and memorization exercises has become one of the important methods of child development; they should also be seen as an effective tool for developing and supporting children’s creative activities. Computer games help children to better learn the material, to master the necessary practical and intellectual skills, to acquire new knowledge and identify and overcome gaps in it, to improve their level of intellectual development. And this can be effectively achieved by using new methods of creating such games, using modern advances in science and technology. In particular, artificial intelligence tools are increasingly used in their creation [4] – both through the use of expert systems [5] and with the use of other approaches, including computer vision, natural language recognition, use of elements of augmented and virtual realities, etc.

This paper presents the results of creating a computer program that contains games of several different types that can be used to develop and educate children with and without special needs. In particular, a game has been created for the development of children with autism, in which decisions are made on the basis of the use of expert knowledge; the child’s learning is carried out through the visualization of the corresponding cards, and voice recognition is used to check what has been learned. For children with hearing impairments, a set of sign language memorization games can be used by watching videos that are classified by topic, as well as by searching for the words or letters of the alphabet being studied and presenting them by displaying appropriate pictures. Voice recognition is used to test what has been learned and to improve learning outcomes. A game that uses visual pattern recognition can be used to work with both children with special needs and children without such needs. The game is based on the recognition of key points of the human body that correspond to the position to which the letter of the alphabet is attached (a game for physical activity). The essence of this game is that when moving the child changes position; according to each body position, the letter of the alphabet corresponding to the specified position is displayed on the screen. This game helps to improve both the coordination of movements and mental activity of the child.

The application is implemented in the integrated development environment PyCharm [6], and for convenience and ease of use created as a website. JavaScript [7] and Python [8] are the main drivers of its creation. Python was used to create databases for the program’s games, as well as to connect the machine learning libraries TensorFlow.js [9] and PoseNet Model [10]. PoseNet is a method of computer vision that allows you to identify the poses of people in images and videos and determine the position of key points of the human body [11]. The advantage of this method is ease of use, as its practical application requires only a webcam on a

computer or smartphone [11]. The coordinates of key points of the human body obtained as a result of PoseNet recognition were used to visualize the letters of the Ukrainian alphabet using the p5.js library [12]. The Django web programming library [13], HTML markup language and CSS stylesheets were also used to create the web application.

Program implementation

The application created for the development of preschool children with special needs contains games of three types: games for memorization, learning sign language and to improve physical activity while learning the letters of the alphabet. The principle of operation of games is based on the use of the approach of expert systems, so first it was necessary to create appropriate databases that provide factual information used in games and knowledge, which form links between relevant data and factors that search games .

A. Creating of Databases of Games

Game databases contain images to memorize, as well as audio recordings for better learning, divided by criteria and created using JavaScript. A fragment of the created image database for a game to improve memory is shown in Fig. 1.

```

    title: 'Допоможи',
    text_example: 'Мама каже: Сину допоможи мені з прибиранням',
    img: 'images/Base_cards/допоможи.jpg'
  },
  pictures2:{
    class: 'base',
    title: 'Не хочу',
    text_example: 'Я не хочу пити',
    img: 'images/Base_cards/не_хочу.jpg'
  },
  pictures3:{
    class: 'base',
    title: 'Hi',
    text_example: 'Якщо я чогось не хочу, то говорю "Hi"',
    img: 'images/Base_cards/hi.jpg'
  },
  pictures4:{
    class: 'base',
    title: 'Так',
    text_example: 'Якщо мене питають чи хочу я цукерку, то говорю "Так"',
    img: 'images/Base_cards/так.jpg'
  }
}

```

Fig. 1. Fragment of the image database code for the game to improve children's memory.

The sign language learning database was created using the SQLite library and contains sets of video as well as images of alphabet letters to facilitate sign language learning. The database is managed using the Django library through the administrative panel (Fig. 2). To access the database repository that contains all the added video games, you need to click the "Games" button. You can use the function keys to edit the contents of the repository and add new objects (Fig. 3).

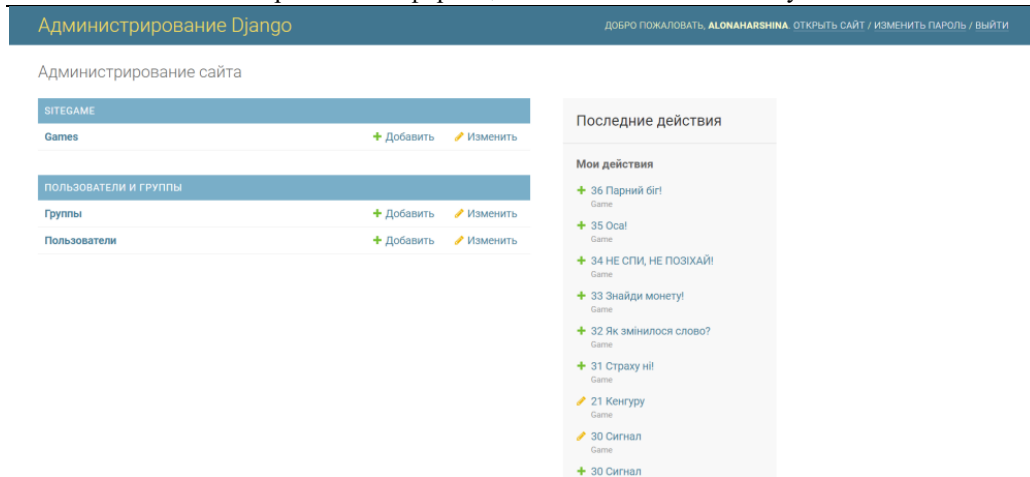


Fig. 2. Django control panel.

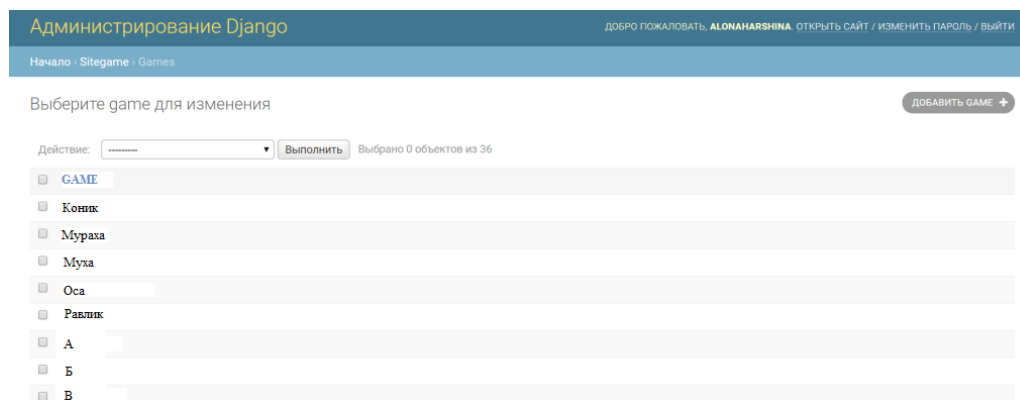


Fig. 3. View of the Django game control panel after pressing the "Games" key.

B. Creating of Knowledge Bases for Games to Memorize and Learn Sign Language

The functional of these knowledge bases is formed in the form of product rules of the "if-then" type ("if-then" rules) and is implemented using JavaScript.

The game's knowledge base, designed to improve the memorization process, uses image data and audio files and is designed to perform voice checks on the correctness of learning. Fragments of database codes using audio and photo data are presented in Fig. 4 (panels *a* and *b*, respectively). The appropriate check begins with entering the appropriate words in the control panel.

```

if (result[0].transcript == "так"){
    window.location = "http://127.0.0.1:63323/audio/%D0%A2%D0%B0%D0%BA.mp3" ;
}
if (result[0].transcript == "ні"){
    window.location = "http://127.0.0.1:63323/audio/%D0%9D%D0%86.mp3" ;
}
if (result[0].transcript == "не хочу" ){
    window.location = "http://127.0.0.1:63323/audio/%D0%BD%D0%B5%20%D1%85%D0%BE%D1%87%D1%83.mp3" ;
}

a)

if (result[0].transcript == "паныра"){
    window.location = "http://127.0.0.1:63323/images/animals/birds/%D0%BF%D0%B0%D0%BF%D1%83%D0%B3%D0%B0.jpg" ;
}
if (result[0].transcript == "опен"){
    window.location = "http://127.0.0.1:63323/images/animals/birds/%D0%BE%D1%80%D0%B5%D0%BB.jpg" ;
}
if (result[0].transcript == "качка" ){
    window.location = "http://127.0.0.1:63323/images/animals/birds/%D0%BA%D0%B0%D1%87%D0%BA%D0%B0.jpg" ;
}

b)

```

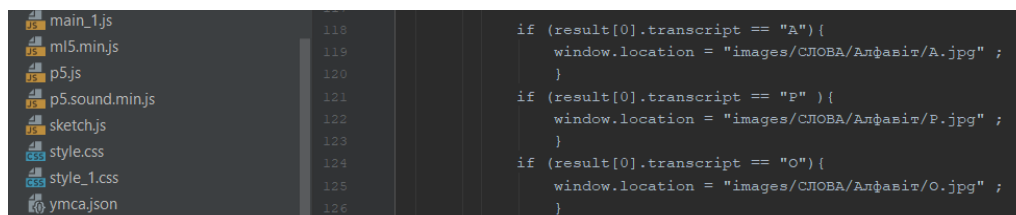
Fig. 4. Some fragments of the knowledge base codes which used in the game to improve the process of memorization: a) fragment of the knowledge base code that uses audio data; b) fragment of the knowledge base code that uses photo data.

The knowledge base for voice and text testing for a set of games for learning sign language forms connections and factors that allow you to look for the right picture during training, as well as allows you to check the material studied by entering the appropriate names of pictures. Examples of rules are presented below (Fig. 5).

125.jpg	108	if (result[0].transcript == "МУХА"){
index.html	109	window.location = "images/СЛОВА/муха.jpg" ;
index_1.html	110	}
index_1_1.html	111	if (result[0].transcript == "ОСА"){
index_2.html	112	window.location = "images/СЛОВА/оса.jpg" ;
index_3.html	113	}
index_4.html	114	if (result[0].transcript == "РАВЛИК"){
main.js	115	window.location = "images/СЛОВА/равлик.jpg" ;
	116	}

Fig. 5. Fragment of the knowledge base code that uses photographic data to verify the study.

The same methodology is used for better study by entering the appropriate names of objects or letters by searching for the words or letters being studied (a fragment of the relevant knowledge base is shown in Fig. 6).



```
main_1.js 118
ml5.min.js 119
p5.js 120
p5.sound.min.js 121
sketch.js 122
style.css 123
style_1.css 124
ymca.json 126

if (result[0].transcript == "A"){
  window.location = "images/СЛОВА/Алфавит/A.jpg" ;
}
if (result[0].transcript == "P" ){
  window.location = "images/СЛОВА/Алфавит/P.jpg" ;
}
if (result[0].transcript == "O"){
  window.location = "images/СЛОВА/Алфавит/O.jpg" ;
}
```

Fig. 6. Fragment of the knowledge base code that uses photo data for better language acquisition.

C. Use the PoseNet Library in the Game to Improve Physical Activity and Memory.

One of the approaches that are often used in artificial intelligence systems, namely image recognition, was used in the implementation of this game. In particular – the recognition of images by key points of the human body [9].

The essence of the game is that, while playing, the child changes positions when moving; the changed poses are analyzed by the corresponding recognition program and, using positions of key points of a body of the child, to them the certain letter is put; thanks to this, the letter of the alphabet corresponding to a specific pose is highlighted on the screen. Thus, the child, while playing, can consciously learn the alphabet, while also improving their motor skills and improving their own mental activity.

The PoseNet library was used to implement pose recognition [10]. This library is an implementation of the method of computer vision, which evaluates the figures of people in images and videos and determines where the main (key) points of the body.

The definition of posture occurs in two stages [11]:

- input RGB image of body position is fed to the input of the neural network;
- decoding algorithm is used; the assessment of poses and confidence in them is carried out – the condition and confidence in key points from the initial data of the model is estimated.

The assessment of posture confidence determines the overall confidence in the correct recognition of the posture and is in the range from 0 to 1. Key point – part of a person's posture (e.g., nose, right ear, left knee, right leg); it contains both the position itself and the assessment of confidence in it.

PoseNet recognizes 17 key points of the human body [11] and the coordinates of their position (x, y) are exactly the initial data with which the game program works when visualizing letters.

Thus, to implement the game of physical activity, the input data are used, which are video frames that are recorded in real time using a video camera in a browser in the application program. To process them, the PoseNet library is used, the source data of which are the coordinates (x, y) of the corresponding key points of the body of the input image; according to the corresponding position (i.e. the values of the coordinates of the key points of the human body defined by PoseNet), the letter of the alphabet corresponding to the depicted position is displayed on the screen.

The game, designed to develop the physical activity of the child, especially when learning the letters of the alphabet works in real time through the use of the library p5.js. This is a JavaScript library with a special focus on image processing [12], which has a full set of

drawing functions, which allows you to create a large number of options for displaying information - from web format, static images for printing to animated schemes.

Results

The application program contains three types of games used for the development of a child with special needs. For convenience of work, a graphic interface (Fig. 7) allows one to operate the work of our application. In the upper right part of the interface there are navigation tools that allow you to go from the main page to the games.

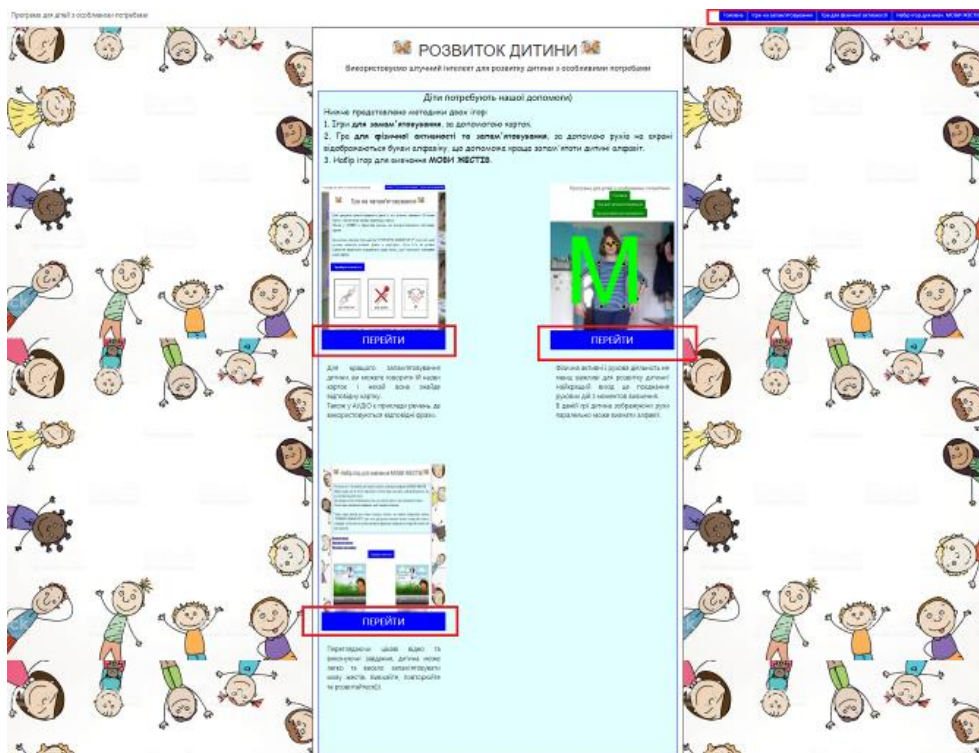


Fig. 7. View of the main page of the application.

When switching to a memorization game (recall that decisions in this game are made on the basis of expert knowledge, and the child's learning in it is carried out through visualization, using cards), the interface of this game will appear on the screen (Fig. 8) explaining the peculiarities of its use. Thus, the transition to the study of other categories of words with the help of cards is carried out using the buttons p. 1. The button "Verification of the studied" (item 2) allows you to check the quality of learning; when you press it through the connected microphone, you need to say a word or letter and a picture with the corresponding image will open, which is very useful for repetition and memory development. The use of the button 3 is required for better memorization of the word; for this purpose audio with examples of sentences in which the given word is used is used.



Fig. 8. Appearance of the page's game to improve memory of child.

When you select a game to improve physical activity, the image of the interface of this game will appear on the screen (Fig. 9), which allows the child, by changing his posture, to learn the letters of the alphabet, each of which corresponds to a certain posture.

Clicking on the last button in the navigation tool (see Fig. 7) allows you to enter the game to learn sign language, watching interactive videos and testing the knowledge gained. The main page of this game is shown in Fig. 10. Here, as in the game of memorization, there is an opportunity to test the knowledge acquired by the child. You can use the input field to enter the words or letters you have learned (Figure 10, point 3) to test your child's knowledge or to memorize them better.

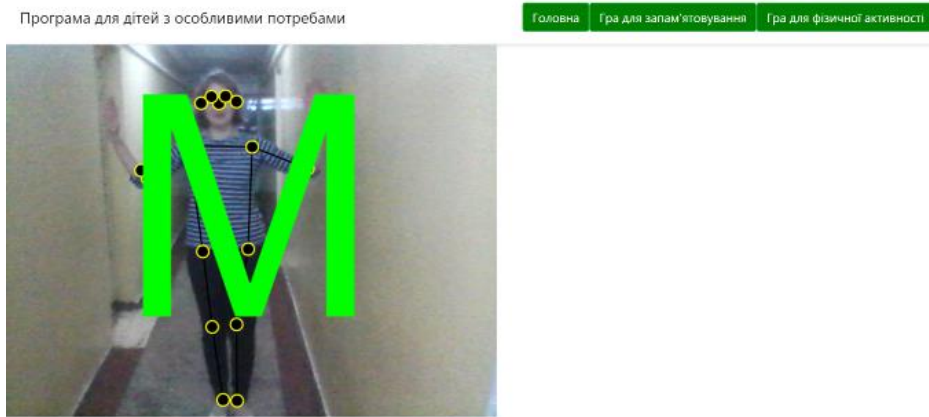


Fig. 9. Appearance of the page's game for physical activity with the image of the letter that corresponds to the position of the child in the picture.



Fig. 10. Appearance of the page's game, which contains materials for learning and memorizing sign language: 1 – transition to the study of other categories; 2 – by clicking on the "Test" button; 3 – field "Input" to enter the words or letters being studied; 4 – video materials for studying the topic.

The result of entering the name of the corresponding object under study in the field "Input", which is used to enter the studied words or letters, is shown in Fig. 11 (here shows the result of the program when entering the word "snail" in Ukrainian).

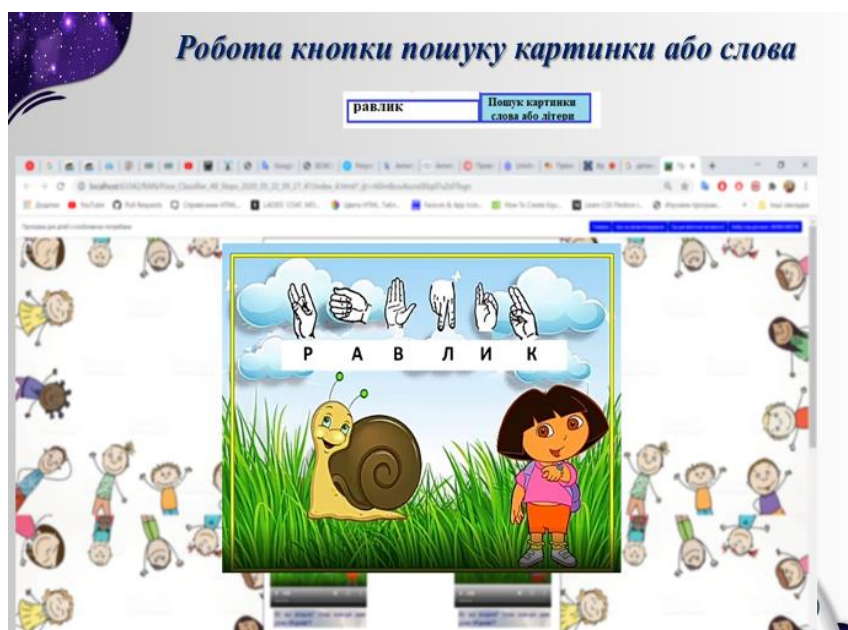


Fig. 11. The result of the data entry in the record field "Input" (the word "snail" was entered).

Conclusion

An application program for the development of children with special needs has been developed. For its implementation, the best and most effective method for presenting information to children (i.e., games) has been chosen.

The application for improving the development of children with autism contains games that use the technique of visual presentation of cards with accompanying information. Voice command recognition was used to check the learning outcomes, which improves its results. The game used a webcam to improve motor activity and memorize the letters of the alphabet, the use of which allows the child to better remember the letters of the alphabet and improve their mobility in the game mode. In the implementation of games (in particular, in the language of signs), along with images of pictures, audio and video materials were also used.

In implementing the work, some methodologies used in applications in the field of artificial intelligence were used. In particular, the methods of expert systems are used in games to improve the memory of a child and the development of children with autism, as well as computer vision is used in the game to recognize images by the position of key points of the human body.

The created program can be used by both parents and educators of children's institutions. Its use can be useful not only for the development of children with special needs, but also to increase the individual abilities of children without such needs.

REFERENCES

- [1] *A. A. Kolupaeva and L. O. Savchuk.* Children with special educational needs and organization of their education. Kyiv: Publishing Group "ATOPOL", 2011 (in Ukrainian).
- [2] *S. V Litovchenko, V. V. Zhuk and O. M. Taranchenko.* Child with hearing impairmen. Kharkiv: Publishing House "Morning", VG "Kangaroo", 2018 (in Ukrainian).
- [3] *I. Yu. Kulagina and V. N. Kolyutsky.* Developmental psychology and age psychology. The full life cycle of human development. Moscow: Academic Project. 2015 (in Russian).
- [4] *S. Russell and P. Norvig.* Artificial intelligence: a modern approach, 2nd Ed. Moscow: Williams Publishing House, 2016 (in Russian).
- [5] *D Jarratano and Mr. Riley.* Expert systems: principles of development and programming, 4th ed. Moscow: Williams Publishing House, 2007 (in Russian).
- [6] *PyCharm.* The Python IDE for Professional Developers. Online, Available: <https://www.jetbrains.com/pycharm/> Accessed March. 18, 2021.
- [7] The Modern JavaScript Tutorial. Online, Available: <https://javascript.info/> Accessed March. 18, 2021.
- [8] *A. V. Anisimov, A. Yu. Doroshenko and S. D. Pogorilyi.* Programming of numerical methods in Python: Kyiv: Publishing and Printing Center "Kyiv University", 2014 (in Ukrainian).
- [9] TensorFlow.js is a library for machine learning in JavaScript Online., Available: <https://www.tensorflow.org/js> Accessed March. 18, 2021.
- [10] Pose Detection in the Browser: PoseNet Model Online., Available: <https://github.com/tensorflow/tfjs-models/tree/master/posenet> Accessed March. 18, 2021..
- [11] Pose estimation in real time directly in the browser with TensorFlow.JS. Online, Available: <https://neurohive.io/ru/tutorial/ocenka-pozy-v-realnom-vremeni-prjamo-v-brauzere-s-tensorflow-js> Accessed March. 18, 2021.
- [12] p5.js. Online, Available: <https://p5js.org> Accessed March. 18, 2021.
- [13] *V. A. Dronov.* Django 2.1. The practice of creating Web sites in Python. SPb.: BHV-Petersburg, 2019 (in Russian).

ІГРОВА ПРОГРАМА ДЛЯ РОЗВИТКУ ДІТЕЙ З ОСОБЛИВИМИ ПОТРЕБАМИ**А. Гаршина, В. Грабовський**

*Львівський національний університет імені Івана Франка
вул. Ген. Тарнавського, 107, 79017 Львів, Україна
volodymyr.grabovskyi@lnu.edu.ua*

Використовуючи мови програмування Python, JavaScript, HTML та CSS, в крос-платформному середовищі розробки PyCharm створено додаток у вигляді веб-сайту для покращення розвитку дітей з особливими потребами, насамперед – дітей з аутизмом та вадами слуху. Для реалізації цього завдання обрано найкращий та найефективніший метод подання інформації для дітей – гра.

При розробці потрібних для розвитку дитини ігор були використані як останні

досягнення педагогічної та психологічної наук, так і можливості сучасної комп'ютерної техніки. В результаті, створений додаток містить ігри декількох різних типів. Зокрема, для розвитку дітей з проблемами аутизму створена гра, рішення в якій приймаються на основі використання експертних знань, а навчання дитини тут здійснюється через візуалізацію відповідних карток з зображеннями. Для дітей з порушеннями слуху може бути використаний набір ігор з запам'ятовуванням мови жестів через перегляд відео, які класифікуються за темами, а також через пошук слів чи літер алфавіту, що вивчаються, з їх представленням шляхом показу відповідних картинок. В основу гри, в якій вивчаються літери алфавіту, покладена ідентифікація ключових точок тіла дитини, що відповідають конкретній позі, яку вона приймає при своєму русі; з кожною з таких поз пов'язана певна літера абетки. Така гра допомагає покращити як координацію рухів, так і розумову активність дитини.

Перевірка вивченого та покращення результату навчання досягається з використанням технологій розпізнавання голосу.

При створенні додатку та для організації його роботи застосовані деякі підходи, що використовуються в системах штучного інтелекту. Зокрема, використовуються експертні знання та розпізнавання образів на основі комп'ютерного зору, а також технології розпізнавання голосу. Бази даних та знань, необхідні для роботи програми, створені в JavaScript, а управління цими додатками реалізується за допомогою фреймворку Django. При своїй роботі програма також використовує можливості спеціалізованих комп'ютерних бібліотек, у тому числі PoseNet (методу комп'ютерного бачення, який дозволяє оцінювати фігури людей на зображеннях та відео і визначає, де знаходяться ключові точки тіла людини) та p5.js (бібліотеки JavaScript із особливим акцентом на обробці зображень, яка надає користувачу набір функцій для малювання та дозволяє створити велику кількість варіантів відображення інформації – від статичних зображень для друку до анімованих схем та веб-формату).

Створений застосунок може бути використаний для розвитку дітей як з особливими потребами, так і без таких.

Ключові слова: JavaScript, PoseNet, p5.js, Django, веб-додаток, комп'ютерні ігри.

Стаття: надійшла до редакції 06.04.2021,
доопрацьована 20.04.2021,
прийнята до друку 22.04.2021