IRSTI 14.29.27 https://doi.org/10.26577/JES2024v81.i4.11

N. Kerimbaev[1], R. Shadiev[2], A. Akramova[1*], K. Adamova[1]

[1]Al-Farabi Kazakh National University, Kazakhstan, Almaty, Kazakhstan
[2] College of Education Zhejiang University, Hangzhou, China
*e-mail: akramova_@mail.ru

POSSIBILITIES OF USING ARTIFICIAL INTELLIGENCE TECHNOLOGY IN DEAF EDUCATION

The fast progress of artificial intelligence (AI) technologies is changing fields like education and healthcare greatly. One promising area for AI is deaf education. A sector that supports education for people with hearing impairments. Traditionally, deaf education has used methods and tools to aid learning and communication, for those who are deaf or hard of hearing. Nevertheless the inclusion of AI in this area presents possibilities to boost educational results and enhance the well being of individuals, with hearing challenges.

Programming of such projects such as sign language recognition improves communication accessibility. However, in addition to the technical aspects, it is important to consider the cultural and social contexts in which sign language is used. The concept of research work for sign language translation is learning and using Python: for Gesture Character Recognition analysis of computer vision and machine learning methods, as well as the development of Python software for image processing for recognition purposes. The development of algorithms based on approaches to deep learning and machine learning of gestures helped to create a system capable of recognizing and translating a language. The main four steps that the project includes: 1) using computer vision, the silhouette of the hand is determined; 2) a letter is indicated with a hand gesture in front of the camera; 3) the definition of the sign using machine learning; 4) the result is displayed on the screen. The developed system allows you to determine the letters to a high degree and display the result on the screen. These results show that machine learning and computer vision have advantages and relevance in society.

Key words: sign language, python (programming language), computer vision, machine learning.

Н.Керімбаев[1], Р.Шадиев[2], А.Акрамова[1*], Қ.Адамова[1]

[1]Әл-Фараби атындағы Қазақ ұлттық университеті, Алматы қ., Қазақстан
[2]Чжэцзян университетінің Педагогикалық колледжі, Ханчжоу қ., Қытай
*e-mail: : akramova_@mail.ru

Жасанды интеллект технологиясын сурдопедагогикада қолдану мүмкіндіктері

Жасанды интеллект (ЖИ) технологияларының қарқынды дамуы білім беру мен денсаулық сақтау сияқты салаларды айтарлықтай өзгертеді. ЖИ үшін перспективті бағыттардың бірі – сурдопедагогика. Білім беруде есту қабілеті нашар адамдар үшін қолдау көрсететін сектор. Дәстүрлі түрде сурдопедагогика толық естімейтін немесе нашар еститін адамдар үшін оқуға және қарым-қатынасқа көмектесу мақсатында әдістер мен құралдарды пайдаланады. Дегенмен, бұл салаға ЖИ мүмкіндіктерін қосу оқу нәтижелерін жақсартуға және есту қабілеті нашар адамдардың әл-ауқатын жақсартуға мүмкіндік береді.

Ым-ишара тілін тану сияқты бағдарламалау жобалары коммуникацияның қолжетімділігін жақсартады. Дегенмен, техникалық аспектілерден басқа, ым-ишара тілі қолданылатын мәдени және әлеуметтік контексттерді де ескеру маңызды. Зерттеу жұмысының тұжырымдамасы ым-ишара тілін аудару үшін Python программасын зерттеу және қолдану болып табылады: ым-ишара таңбаларын тануға арналған компьютерлік көру және машиналық оқыту әдістерін талдау, сондай-ақ қимылдарды тану мақсатында кескіндерді өңдеуге арналған Python-да бағдарламалық құралды жасау. Терең оқыту мен машиналық оқытудың тәсілдеріне негізделген алгоритмдерді әзірлеу ым-ишара тілін тануға және аударуға қабілетті жүйені құруға көмектесті. Жобаны қамтитын негізгі төрт қадам: 1) Компьютерлік көру көмегімен қол сұлбасы анықталады; 2) Камера алдындағы қол қимылымен әріп көрсетіледі; 3) Анықталған нысанның машиналық оқыту арқылы қай әріп екені танылады; 4) Нәтиже экранда көрсетіледі. Әзірленген жүйе іс-қимылмен көрсетілген әріптерді жоғары дәрежеде анықтап, нәтижені экранға шығара

Бұл нәтижелер машиналық оқыту мен компьютерлік көрудің қоғамдағы пайдасы мен өзектілігін айқындайды.

Түйін сөздер: Ым-ишара тілі, python (программалау тілі), компьютерлік көру, машиналық оқыту.

Н. Керимбаев[1], Р. Шадиев[2], А. Акрамова[1]*, К. Адамова[1]
[1]Казахский национальный университет имени аль-Фараби, г. Алматы, Казахстан
[2]Педагогический колледж Чжэцзянского университета, г. Ханчжоу, Китай
*e-mail: akramova_@mail.ru

Возможности применения технологии искусственного интеллекта в сурдопедагогике

Быстрое развитие технологий искусственного интеллекта (ИИ) значительно меняет такие области, как образование и здравоохранение. Одной из перспективных областей для ИИ является сурдопедагогика; направление образования, которое поддерживает образование для людей с нарушениями слуха. Традиционно сурдопедагогика использовало методы и инструменты для помощи в обучении и общении для людей с нарушениями слуха. Тем не менее, включение ИИ в эту область представляет возможности для повышения результатов обучения и улучшения благополучия людей с проблемами слуха.

Программирование таких проектов, как распознавание языка жестов, улучшает доступность общения. Однако, в дополнение к техническим аспектам, важно учитывать культурные и социальные контексты, в которых используется язык жестов. Концепция исследовательской работы по переводу языка жестов заключается в изучении и использовании Python: для распознавания символов жестов анализом методов компьютерного зрения и машинного обучения, а также разработка программного обеспечения Python для обработки изображений в целях распознавания. Разработка алгоритмов, основанных на подходах к глубокому обучению и машинному обучению жестов, помогла создать систему, способную распознавать и переводить язык. Основные четыре шага, которые включает в себя проект: 1) с помощью компьютерного зрения определяется силуэт руки; 2) указывается буква жестом руки перед камерой; 3) определение знака с помощью машинного обучения; 4) результат выводится на экран. Разработанная система позволяет определять буквы с высокой степенью и выводить результат на экран. Эти результаты показывают, что машинное обучение и компьютерное зрение имеют преимущества и востребованность в обществе.

Ключевые слова: язык жестов, python (язык программирования), компьютерное зрение, машинное обучение.

Introduction

Communication is not only a way of transmitting information but also a key aspect of interaction with the outside world (Chakali, 2023: 1394), (Borkar, 2023: 407). The diversity of communication methods reflects the diversity of people's cultures and preferences. In communication, ordinary people frequently rely on sound and visual means, and for people with hearing impairments, visual methods (sign language) are important. It is based on a variety of signals and hand motions (Chakali, 2023: 1394), (Borkar, 2023: 407), (Bora, 2023: 1384), (Sethia, 2023: 307), (Goel, 2023: 83).

In addition to becoming an essential part of the lives of those who have hearing impairments, sign language is an incredible and complex mode of communication that has drawn the attention of numerous scientists as well as members of the general public, (Rajkumar, 2023: 984), (Hasib, 2023), (Rahaman, 2024). It is important to remember that not everyone speaks sign language. Like the national language, every sign language has unique dialects and characteristics that contribute to its richness and diversity (Bora, 2023: 1384), (Hasib, 2023). The majority of the world's languages are covered by sign linguistics technologies that have been created, (Wang, 2024), (Rastgoo, 2024) and several studies have been conducted. Nonetheless, there is still a need to develop tools and techniques for sign language that are adapted to regional dialects (Bora, 2023: 1384).

Education for individuals with hearing impairments has long aimed to utilize cutting edge technologies to enhance learning and societal inclusion efforts in the field of education and communication enhancement. A recent focus has been directed towards exploring the impact of artificial intelligence (AI) technologies in reshaping teaching methods and fostering communication

advancements for those, with hearing impairments. Technology plays an important role in the development of sign language in the modern world (Bora, 2023: 1384), (Goel, 2023: 83), (Srinivasan, 2023), (Ilanchezhian, 2023: 135). The use of video communication, computer vision algorithms, and machine learning will help create innovative systems to recognize and interpret traits, improving the availability of communications for people with hearing impairments.

Hand movements change for each person in shape, size, scale, and image quality, making the task nonlinear. Modern advances in image processing have shown that neural networks can be successfully used to interpret sign language (Sethia, 2023: 307).

The creation of a Python sign language recognition program is an important step in improving the availability and efficiency of communication for audiences (Wang, 2024), (Srinivasan, 2023). This research project shows a thorough grasp of machine learning techniques and their application to the recognition of sign language. It involves data gathering, data processing, model training, and testing. The development of a real-time interactive interface is a significant component of the research, as it creates opportunities for the application of this technology to sign language communication.

Materials and methods

Technology AI can improve communication efficiency and customize offerings to suit each student's needs, and provides instant access to information in real-time scenarios. An instance of this is the use of AI powered systems for recognizing gestures that can convert sign language into written text or spoken words. This study endeavor aimed to create a novel system that could provide efficient and comprehensible interaction based on sign movements using the Python programming language and advanced in-depth learning methods. The goal of the research questions is to create a model that, by accurately identifying and translating movements that correspond to specific letters of the alphabet, opens up new possibilities for everyday communication and education of individuals with hearing impairment.

Machine learning is a broad field of study that covers various methods and approaches for teaching computer systems to perform tasks without explicit programming (Lee, 2024).

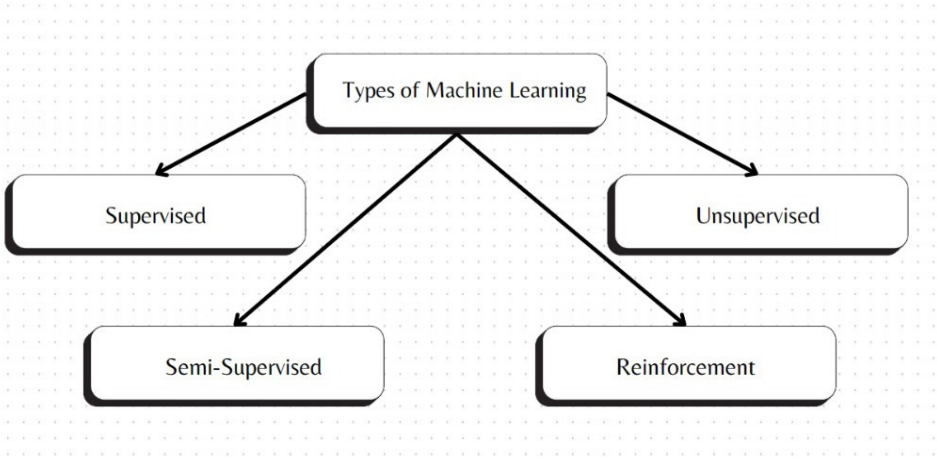


Figure 1 – Types of machine learning

Supervised, unsupervised, semi-supervised, and reinforcement learning are the four categories (Lee, 2024) of machine learning (1-figure). 1) Of all the machine learning types, supervised learning is the most frequently utilized. It requires extensive human supervision in addition to machine and algorithm training. 2) By letting the algorithm handle unclassified, raw data, unsupervised learning lessens the amount of work that humans have to accomplish. 3) The middle ground between the first two learning styles is semi-supervised learning. 4) An artificial intelligence called reinforcement

learning trains a model how to make decisions on its own.

We looked at a Python script that uses the OpenCV computer vision library to recognize hand gestures using a webcam. First of all, we should note the importance of the OpenCV library. OpenCV is an open source library specializing in image processing and computer vision (Rajkumar, 2023: 984), (Rastgoo, 2024), (Lee, 2024). It provides a wide range of tools and algorithms for working with images, including segmentation, object recognition, motion tracking and much more.

The first stage of our script captures video from a webcam using the cv2.VideoCapture() function. This ensures a constant supply of video frames that will be analyzed to recognize hand gestures. After this, we upload an image of the iconic alphabet that will be used in the recognition process. Next comes the stage of displaying the results. The webcam image and various stages of image processing are displayed using the cv2.imshow() function. The user can observe the process of hand gesture recognition in real time. The script exits if the user presses the q key, which is implemented using cv2.waitKey(1)& 0xFF == ord('q'). An important step is also to release resources using the cap.release() and cv2. destroyAllWindows() functions. This ensures that the program terminates correctly and the resources occupied by it are freed.

The process of hand gesture recognition begins with image pre-processing. This involves smoothing, flipping, and cropping the video frame to highlight the area of interest (the hand). The image is then converted to grayscale and HSV color space. For hand gesture recognition, the red color range is determined in HSV. Next comes the gesture recognition itself. This step is based on the evaluation of various characteristics such as area, aspect ratio, convexity defects and angle. Several conditions are used to recognize gestures in sign language and the results are displayed on a video frame.

Literature review

Advancements in the field of educating the deaf have progressed over time with the introduction of technology playing a significant role in recent years too. The incorporation of intelligence (AI), into this area is a new advancement that has displayed promising potential in tackling the distinctive hurdles encountered by people with hearing disabilities.

For those who speak sign language only, there are issues because not everyone can understand them (Rakesh, 2022: 301). In this regard, they face daily difficulties in performing basic tasks. For this group of people, many solutions have been proposed for effective communication and facilitating life (Rastgoo, 2024), (Ilanchezhian, 2023: 135). Scientific articles and research were studied in order to understand the principles of the functioning of these decisions. The literary analyses carried out in 2021 and 2022 (Rakesh, 2022: 301), (Elakkiya, 2021: 7205) were taken into consideration first, followed by an analysis of a number of papers and research released in 2023 and 2024 (Rajkumar, 2023), (Rastgoo, 2024), (Lee, 2024), (Chakali, 2023: 1394), (Borkar, 2023: 407), (Bora, 2023: 1384), (Sethia, 2023: 307), (Goel, 2023: 83), (Hasib, 2023), (Rahaman, 2024).

R. Elakkia (2021) examined over 240 distinct methods for researching multilingual sign language recognition in her studies. The paper also reviewed important research publications and examined studies written by various writers. The author highlighted the outcomes of these techniques and talked about the potential applications of machine learning techniques for automatic sign language recognition. Furthermore, possible issues that need to be resolved in order to apply machine learning techniques for real-world sign gesture detection were taken into consideration.

The study (Rakesh, 2022: 301) offers two approaches for understanding sign language. In the first version, based on the use of gloves, poorly heard people can wear special gloves and gesture their thoughts. The device built into the glove is capable of converting gestures into speech or text, providing understanding to the poorly emitting. The second option is based on computer vision. You can register, interpret, and identify gestures with the camera. The results may be presented as text, speech, or both. Next, the review details the various proposed solutions, analyzes them, compares and discusses methodologies, advantages and disadvantages.

The suggested approach proposed by the authors (Chakali, 2023: 1394) includes the use of the Python programming language, the MediaPipe framework for extracting gesture information, and the deep sign recognition (DGR) model for real-time identification of character movement. This method demonstrates the highest accuracy of 98.81%, using a neural network including long-term memory blocks to recognize sequences.

Pradnya Borkar & Kiran Godbole (2023) created a machine learning model designed to classify and identify hand gestures, such as sign language, in

order to translate interaction into oral and written form. The machine learning model they developed is capable of recognizing hand gestures and converting them into words, which will facilitate understanding of sign language.

Using machine learning methods, the authors (Bora, 2023: 1384) attempted to develop a system for identifying hand gestures in the sign language of the Assamese dialect in India. A combination of two-dimensional and three-dimensional images of Assamese gestures was used to compile the training dataset. The MediaPipe platform was implemented to detect landmarks in images. The resulting dataset was used to train a direct propagation neural network, achieving an accuracy of 99%.

Recognition of American Sign Language (ASL) in motion in real time is carried out using an effective artificial intelligence tool presented in this work (Sethia, 2023: 307) in the form of a convolutional neural network (CNN). A dataset containing 27,455 images representing 25 letters of the English alphabet was used to train and validate the model. The model was tested on 7172 images, which were divided into different classes. The maximum accuracy of model validation using advanced data reached 99.8%, surpassing many existing real-time motion recognition techniques.

This article (Goel, 2023: 83) uses the Transfer Training method. The authors apply a highly accurate pre-trained model and adjust the parameters of its final layer for the task of recognizing sign language. This significantly reduces the learning time required for a dataset with fewer than 20 images per gesture. The authors created their own dataset using the system webcam, tagged it with the LabelImg tool, and applied the Tensorflow object detection API. They downloaded the pre-trained "SSD MobinetNet V2" model and conducted transfer training. The project encountered problems in proper image labeling, installation errors, and lighting and background problems in multiple detections. Despite these difficulties, the authors argue that the proposed method is effective, saves learning time, provides high accuracy, and requires fewer images to learn.

The proposed system (Rajkumar, 2023: 984) was also created in order to establish a connection between hearing and hearing impaired communities. It offers a two-way sign language translator capable of translating speech into sign language and back in real time. Using the Python OpenCV library, the system processes video frame by frame, with the background/foreground segmentation algorithm based on Gaussian blends removing the background from each frame. The contours of the processed image are classified using a convolutional neural network (CNN) to correlate with the written language. To preserve the grammar of sign language in the process of converting it into speech, gTTS (Google Text-to-Speech) and fundamental natural language programming (NLP) are used.

Bangla sign language, or BDSL, is an abbreviation for those with hearing loss and/or those who would rather communicate nonverbally (Hasib, 2023). Images of the bangle's gestures are included in the data set. The BDSL49 collection consists of 49 individual alphabet graphics combined with 29,490 images and 49 categories. Fourteen adults were photographed during the data gathering process, each with a distinct appearance and setting. Various techniques were employed to minimize noise throughout the data preparation process. The dataset used computer vision, deep learning, and machine learning methods to build automated systems. The data was analyzed using two models, one for identification and the other for detection.

In studies, the authors (Rahaman, 2024) focus on improving sign language recognition, overcoming previous limitations. The work uses a convolutional neural network (CNN) called "ConvNeural" to train its data set. They also created their "BdSL_opsa22_static1" and "BdSL_opsa22_static2" datasets, including images of Bangla characters and numbers. The total number of images is 24,615 and 8,437, respectively. The "ConvNeural" model outperforms pre-trained models, achieving 98.38% accuracy for " BdSL_opsa22_static1" and 92.78% accuracy for " BdSL_opsa22_static2"." For "BdSL_opsa22_static1," accuracy, completeness, F1 measure, sensitivity and specificity values of 96%, 95%, 95%, 99.31% and 95.78% were obtained, respectively. In the case of "BdSL_opsa22_static2," indicators of accuracy, completeness, F1-measures, sensitivity and specificity are achieved, which are 90%, 88%, 88%, 100% and 100%.

The authors conducted a study (Wang, 2024) evaluating the impact of eighteen deep learning architectures on vulnerability detection in Python code. Using combinations of three presentation learning models (Word2Vec, fastText, and CodeBERT) and six classification models (random forest, XGBoost, multilayer perceptron network (MLP), convolutional neural network (CNN), long-term memory (LSTM), and Gate Recurrent Unit

(GRGRT) U)), they also compared two machine learning strategies: attention mechanisms and bidirectional learning. According to the studies, the Word2Vec showed better results in accuracy, completeness and F-estimation than representations of a bidirectional encoder from CodeBERT and fastText converters. It was also revealed that bi-directional LSTM and GRU with attention, using Word2Vec, are optimal models for detecting Python code vulnerabilities, medium or high effect compared to LSTM and GRU using only one mechanism. In addition, both presentation learning models and classification models have a significant impact on vulnerability detection in Python code, and bidirectional and attention mechanisms can also affect code vulnerability detection performance.

The authors (Rastgoo, 2024) present the Zero-Shot Dynamic Hand Gesture Recognition (ZS-DHGR) multimodal model, which uses additional capabilities of deep functions combined with skeletal ones. Based on Transformer and C3D, this model uses hand detection and deep function extraction, respectively. To achieve a balance between the dimension of skeletal and deep functions, an auto encoder (AE) is used on top of a long-term short-term memory (LSTM) network. Semantic space is used to correlate visual functions with language implementations of class labels, which is achieved through the Transformers bi-directional encoder representation (BERT) model. Test results on four large-scale datasets: RKS-PERSIANSIGN, First-Person, ASLVID and isoGD. The accuracy of the model is 74.6%, 67.2%, 68.8% and 60.2%, respectively, on the RKS-PERSIANSIGN, First-Person, ASLVID and isoGD datasets.

In this work, the authors (Srinivasan, 2023) have developed a sign detector capable of recognizing signs, numbers and other characters used in sign language. They used OpenCV and Keras modules in Python. This technology allows you to understand sign language expression, which is a non-standard way of communicating. The OpenCV and Keras modules for Python were used to implement this project, providing an approach to interacting with sign language, especially for people with hearing impairments.

To train their models, the authors (Ilanchezhian, 2023: 135) used the TensorFlow object detection API. After completing their training, they performed real-time recognition of hand sign language using the OpenCV-python library. For this approach, they accessed the webcam, downloaded the configuration, and a trained model for real-time sign language detection.

As a result, most of the above models provide English-language feature interpretation to improve accuracy. However, some people do not know the standard signs. Therefore, this can affect the quality of perception, since the system is trained to use standard sign language. There are models that can be used in several regions, offer cheap facilities with sufficient space, but projects require avoiding noise.

Results and discussion

The main part of creating a sign language recognition program in Python includes several main steps, each of which plays an important role in the development and successful operation of the program.

1. Data collection and preparation is an important part of the process – collecting data containing images or drawings of various movements indicated by the corresponding letters of the alphabet. The data is then preprocessed, which includes improving image quality, eliminating noise, and preparing the data for further use.

2. Model processing and training. After data preparation, a suitable machine learning algorithm such as Convolutional Neural Networks (CNN) is selected to enable efficient image processing. Using a Python machine learning library such as TensorFlow or PyTorch, the model is trained on the given data to recognize gestures that correspond to the letters of the alphabet.

3. Testing and evaluation. After training the model, it is necessary to perform testing on the test data to evaluate the accuracy and efficiency of the model. This includes evaluating its motion recognition capabilities and further adjusting model parameters to improve results.

4. Integration and application. After successfully training and testing the model, you need to create an interface that allows you to interact with the model in real time. This may involve developing a GUI or command-line interface for entering data and viewing the results of gesture recognition.

Each step is important to create a fully functional sign language recognition program in Python that ensures accuracy and accessibility when working with sign data. As a result of relevant studies, it was found that there is a lack of sign language translation in educational platforms. For this purpose, this research was carried out in the previous section and

a program was created to implement real-time sign language recognition on the proposed educational platforms.

The program processes the entered information in real time and displays the corresponding result on the screen (2-figure):

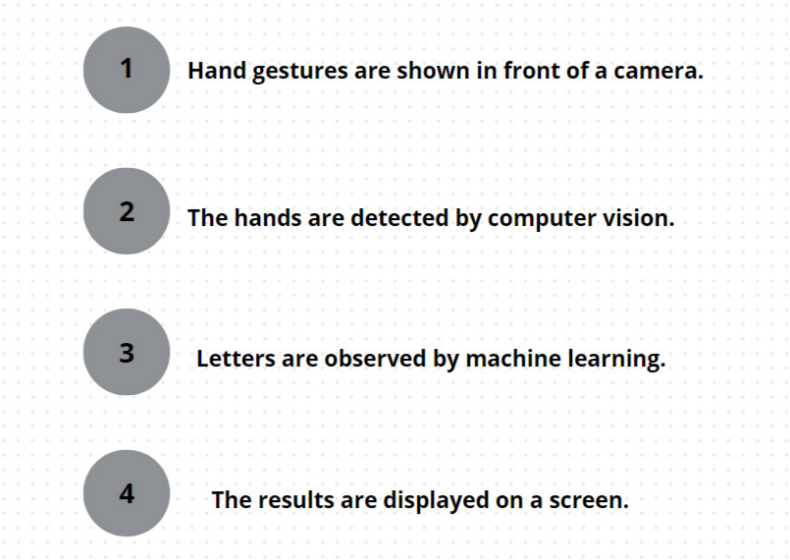
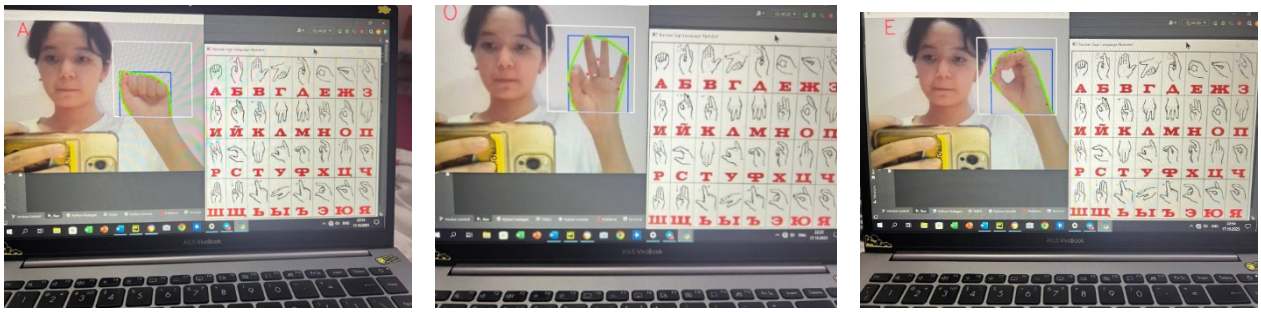


Figure 2 – The main steps of the program

Creating a sign language recognition program in Python involves several basic steps. First you need to collect data – pictures of movements marked with appropriate letters. This is followed by improving the quality of the images and formatting the data to train the model – preprocessing the input data. It then chooses an algorithm, such as using convolutional neural networks, and trains the model using Python and machine learning libraries such as TensorFlow or PyTorch. After training the model, it is tested on test data to assess accuracy and adjust parameters to improve results. Finally, an interface is created to interact with the model and it is tested on real data to verify real-time performance.

Since the program includes machine learning and computer vision, it was divided into two phases and improved. In the first stage, a hand recognition program was written using computer vision. The program was able to quickly and accurately detect both hands in any movement to a high degree (3- figure).

Figure 3 – The first step of the program (hand recognition)



3.1 3.2 3.3

Figure 4 – The second phase of the program
(3.1 –letter 'A', 3.2 –letter 'O', 3.3 –letter 'E')

In the second phase of the program, machine learning was launched. Machine learning was applied to the program to recognize letters from each other. As a result, full recognition of cyrillic letters was realized. The program consists of two windows: in the first window, the result of the program is displayed. That is, machine learning determines which letter is most similar to the recognized hand gesture and displays the letter in red in the upper left part of the screen. And in the second window, cyrillic letters were released for testing in sign language. The result of the program is shown in the 4-figure.

There are 1920 RGB videos for 32 sign language gestures from 10 people and they presented 6 examples for each sign gesture. The total recording video time is 1.6 hours. The accuracy of the classification algorithms was 98.86 % for 32 sign gestures.

Conclusion

The integration of artificial intelligence into the education of people with hearing impairments opens up new opportunities to enhance the learning process and interaction. As AI progresses further over time its capacity to revolutionize education is expected to grow resulting in the development of more efficient tools and approaches. The existing progress made with AI driven programs for recognizing sign language highlights the role these technologies play in closing communication barriers and offering tailored assistance.

The developed sign language recognition program in Python covers key stages from data collection and processing to real-time model training and performance testing. Machine learning and software development technologies are combined with understanding the features of sign language. It is our hope that the development, taking into account new technologies and research, will significantly contribute to the improvement of communication and support methods for this audience.

The results:

- The developed system successfully recognizes the movements of the letters of the alphabet with high accuracy.
- The project validates the prospects of using deep learning and Python to build such systems.

Our future plan is to create a program that will create words from letters in Python and translate them into other languages.

Acknowledgment

This work was carried out as part of project No. AP19676457 "Modeling and feedback management in educational telematics" due to grant funding from the Ministry of Education and Science of the Republic of Kazakhstan.

References

Bora, J., Dehingia, S., Boruah, A., Chetia, A. A., & Gogoi, D. (2023). Real-time assamese sign language recognition using mediapipe and deep learning. *Procedia Computer Science*, *218*, 1384-1393.

Borkar, P., & Godbole, K. (2023). Sign Language Recognition Using Machine Learning. In *Mobile Radio Communications and 5G Networks: Proceedings of Third MRCN 2022* (pp. 407-414). Singapore: Springer Nature Singapore.

Chakali, G., Reddy, C. G., & Bharathi, B. (2023, April). Sign Language Translation in WebRTC Application. In *2023 7th International Conference on Trends in Electronics and Informatics (ICOEI)* (pp. 1394-1399). IEEE.

Elakkiya, R. (2021). RETRACTED ARTICLE: Machine learning based sign language recognition: a review and its research frontier. *Journal of Ambient Intelligence and Humanized Computing*, *12*(7), 7205-7224.

Goel, L., Karthik, N. P., Naidu, M. J., Sinha, P., & Thota, A. (2023, March). An Improved Real-Time Sign Language Recognition using Transfer Learning. In *2023 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)* (pp. 83-89). IEEE.

Hasib, A., Eva, J. F., Khan, S. S., Khatun, M. N., Haque, A., Shahrin, N., ... & Hussein, M. R. (2023). BDSL 49: A Comprehensive Dataset of Bangla Sign Language. *Data in Brief*, 109329.

Ilanchezhian, P., Singh, I. A. K., Balaji, M., Kumar, A. M., & Yaseen, S. M. (2023). Sign Language Detection Using Machine Learning. In *Semantic Intelligence: Select Proceedings of ISIC 2022* (pp. 135-143). Singapore: Springer Nature Singapore.

Lee, K. D., & Hubbard, S. (2024). Python programming 101. In *Data Structures and Algorithms with Python: With an Introduction to Multiprocessing* (pp. 1-37). Cham: Springer International Publishing.

Rahaman, M. A., Oyshe, K. U., Chowdhury, P. K., Debnath, T., Rahman, A., & Khan, M. S. I. (2024). Computer vision-based six layered convneural network to recognize sign language for both numeral and alphabet signs. *Biomimetic Intelligence and Robotics*, *4*(1), 100141.

Rajkumar, T., Dharani, J., Kavitha, A., KM, H. P., & Neha, S. (2023, March). AI based Two Way Sign Language System. In *2023 Second International Conference on Electronics and Renewable Systems (ICEARS)* (pp. 984-991). IEEE.

Rakesh, S., Venu Gopalachari, M., Jayaram, D., Gupta, I., Agarwal, K., & Nishanth, G. (2022, December). A Review on Sign Language Recognition Techniques. In *International Conference on Information and Management Engineering* (pp. 301-309). Singapore: Springer Nature Singapore.

Rastgoo, R., Kiani, K., Escalera, S., & Sabokrou, M. (2024). Multi-modal zero-shot dynamic hand gesture recognition. *Expert Systems with Applications*, 123349.

Sethia, D., Singh, P., & Mohapatra, B. (2023). Gesture Recognition for American Sign Language Using Pytorch and Convolutional Neural Network. In *Intelligent Systems and Applications: Select Proceedings of ICISA 2022* (pp. 307-317). Singapore: Springer Nature Singapore.

Srinivasan, R., Kavita, R., Kavitha, M., Mallikarjuna, B., Bhatia, S., Agarwal, B., ... & Goel, A. (2023, March). Python And Opencv For Sign Language Recognition. In *2023 International Conference on Device Intelligence, Computing and Communication Technologies,(DICCT)* (pp. 1-5). IEEE.

Wang, R., Xu, S., Ji, X., Tian, Y., Gong, L., & Wang, K. (2024). An extensive study of the effects of different deep learning models on code vulnerability detection in Python code. *Automated Software Engineering*, *31*(1), 1-35.

Авторлар туралы мәлімет:

Адамова Қарлығаш – «Информатика» білім беру бағдарламасының докторанты, Әл-Фараби атындағы Қазақ ұлттық университеті (Алматы қ., Қазақстан, эл.пошта: adamovaqarlygash@gmail.com)

Керімбаев Нұрасыл Нұрымұлы (корреспондент автор) – п.ғ.д., профессор, Әл-Фараби атындағы Қазақ ұлттық университеті (Алматы қ., Қазақстан, эл.пошта: nurasil@mail.ru)

Шадиев Рустам (корреспондент автор) – PhD доктор, профессор, Чжэцзян университетінің білім колледжі, (Қытай, эл.пошта: rustamsh@gmail.com)

Акрамова Алия (корреспондент автор) – п.ғ.к., доцент, педагогика және білім беру менеджменті кафедрасының доценті, Әл-Фараби атындағы Қазақ ұлттық университеті (Алматы қ., Қазақстан, эл.пошта: akramova_@mail.ru)

Сведения об авторах:

Адамова Карлыгаш – докторант образовательной программы «Информатика», Казахский национальный университет имени аль-Фараби (г.Алматы, Казахстан, эл.почта: adamovaqarlygash@gmail.com)

Керимбаев Нурасыл Нурымович (корреспондент автор) – доктор педагогических наук, профессор, Казахский национальный университет имени аль-Фараби (г.Алматы, Казахстан, эл.почта: nurasil@mail.ru)

Шадиев Рустам (корреспондент автор) – PhD доктор, профессор Педагогического колледжа Чжэцзянского университета, (Китай, эл.пошта: rustamsh@gmail.com)

Акрамова Алия (корреспондент автор) – к.п.н., доцент кафедры педагогики и образовательного менеджмента Казахского национального университета имени Аль-Фараби (г.Алматы, Казахстан, эл.почта: akramova_@mail.ru)

Information about authors:

Adamova Karlygash – doctoral student educational program «Computer Since», Al-Farabi Kazakh National University (Almaty,Kazakhstan, email: adamovaqarlygash@gmail.com)

Kerimbayev Nurasyl Nurymovich (corresponding author) – doctor of pedagogical sciences, professor, Al-Farabi Kazakh National University (Almaty, Kazakhstan, email: nurasil@mail.ru)

Shadiev Rustam (corresponding author) – PhD, professor in the College of Education at Zhejiang University (China, email: rustamsh@gmail.com)

*Akramova Aliya (corresponding author***) –** *associate professor, Senior Lecturer of the department of Pedagogy and Educational management of Al-Farabi Kazakh National University (Almaty, Kazakhstan, email: akramova_@mail.ru)*

Received 19.05.2024
Accepted 01.12.2024