AI-driven network security represents a paradigm shift in defending against cyber threats. As AI technologies continue to advance, network security will become more proactive, adaptive, and effective in safeguarding our digital ecosystems.

References:

1. Todor Tagarev, ed., Digital Transformation, Cyber Security and Resilience, Information & Security: An International Journal, vol. 43 (2019)

2. Todor Tagarev, Krassimir Atanassov, Vyacheslav Kharchenko, and Janusz Kasprzyk, eds., Digital Transformation, Cyber Security and Resilience of Modern Societies, in Studies in Big Data, vol. 84 (Cham, Switzerland: Springer, 2021)

3. Velizar Shalamanov, Nikolai Stoianov, and Yantsislav Yanakiev, eds., DIGILIENCE 2020: Governance, Human Factors, Cyber Awareness, Information & Security: An International Journal, vol. 46 (2020)

4. Todor Tagarev, George Sharkov, and Andon Lazarov., eds., DIGILIENCE 2020: Cyber Protection of Critical Infrastructures, Big Data and Artificial Intelligence, Information & Security: An International Journal, vol. 47 (2020)

5. An extended version of the article Vyacheslav Kharchenko, Ihor Kliushnikov, Herman Fesenko, and Oleg Illiashenko, “Multi-UAV Mission Planning for Monitoring Critical Infrastructures Considering Failures and Cyberattacks,” Information & Security: An International Journal, vol. 49 (2021).

BASED ON MACHINE LEARNING ALGORITHMS TO RECOGNIZE UZBEK SIGN LANGUAGE (UZSL)

O.A.Kayumov
Jizzakh Branch of National University of Uzbekistan
N.R.Kayumova
Jizzakh Branch of the National University of Uzbekistan
oybekuzonlined3@gmail.com

Abstract: Sign language recognition has gained significant attention due to its potential to bridge communication gaps between the deaf and hearing communities. This article presents a comprehensive review of machine learning methods employed for the recognition of Uzbek Sign Language (UzSL). The unique visual and spatial nature of sign languages poses challenges that necessitate specialized techniques for accurate recognition. This review surveys various approaches, ranging from traditional techniques to modern deep learning methods, used to recognize UzSL gestures. The article begins by introducing the significance of UzSL recognition and its impact on facilitating effective communication for the Uzbek deaf community. It outlines the complexities involved in sign language recognition, including variations in hand shapes, movements, and facial expressions. The challenges of limited training data, real-time recognition, and capturing dynamic features are discussed in depth. A survey of traditional machine learning methods such as Hidden Markov Models (HMMs), Support Vector Machines (SVMs), and k-Nearest Neighbors (k-NN) is presented,

along with their applications and limitations in UzSL recognition. The evolution of these methods into more sophisticated approaches like Dynamic Time Warping (DTW) and Conditional Random Fields (CRFs) is also explored.

Keywords— Uzbek Sign Language (UzSL), Sign language recognition, Machine learning, Deep learning, Gesture recognition, Deaf communication, Hand gesture analysis, Spatial-temporal features, Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Hidden Markov Models (HMM), Support Vector Machines (SVM), k-Nearest Neighbors (k-NN), Dynamic Time Warping (DTW), Conditional Random Fields (CRF), Transfer learning, Data augmentation, Multimodal recognition, Real-time recognition, Sign language datasets, Communication technology, Deaf community, Human-computer interaction, Interactive technologies, Multilingual sign languages, Gesture-based interfaces.

Introduction

In the mosaic of global languages, sign languages represent a vivid and vital thread, weaving together cultures and communities that communicate through gestures rather than words. Within this diverse tapestry lies Uzbek Sign Language (UzSL), an emblem of communication for the Uzbek Deaf community. As technological ingenuity marches forward, the fusion of machine learning and sign language recognition emerges as a potent force, holding the potential to bridge linguistic divides and enhance the lives of individuals who rely on UzSL for expression. This article embarks on a journey into the realm of machine learning methods tailored for Uzbek sign language recognition, discovering how these algorithms harness data, pattern recognition, and innovation to decipher the intricate dance of UzSL's gestures. From the intricate nuances of feature extraction to the awe-inspiring capabilities of neural networks, join us in exploring how the marriage of machine learning with UzSL can amplify inclusivity, understanding, and cross-cultural dialogue.

Literature review

The intersection of machine learning and sign language recognition has witnessed considerable advancements, empowering diverse Deaf communities worldwide with more inclusive means of communication. Notably, research on machine learning methods tailored for sign language recognition has primarily focused on American Sign Language (ASL) and other widely studied sign languages. However, the exploration of Uzbek Sign Language (UzSL) within this context remains relatively limited, despite its cultural and linguistic significance.

In the broader landscape of sign language recognition, traditional approaches have often relied on hand-crafted features, such as hand shape, motion trajectory, and facial expressions, to train classification models. These methods, although effective to a certain extent, often struggle to capture the intricacies of complex sign languages like UzSL, where gestures are imbued with cultural nuances and context-dependent meanings.

Recent strides in deep learning have revolutionized the field, offering promise in untangling the intricacies of sign language recognition. Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) have demonstrated remarkable efficacy in capturing spatial and temporal information from video sequences of sign gestures. Transfer learning techniques, which leverage pre-trained models on large datasets, have also shown potential in accelerating the training process and improving recognition accuracy.

Sign languages are govern by specific rules and components, with each country having its own unique sign language, similar to natural languages. Dactyl languages such as American Sign Language (ASL), British Sign Language (BSL), Japanese Sign Language (JSL), Arabic Sign Language (ArSL), and Indian Sign Language (ISL) have been develop [1]. UzSL (Uzbek Sign Language) is a sign language based on Uzbek grammar and the Latin script, with numerous methods available for its development and learning. Expert teachers, educational content, and intellectual e-learning resources are widely accessible for learning sign language, which in turn, facilitates and promotes its dissemination [5].

Learning sign language is essential, as it serves as a universal tool necessary for communication among all members of society. It strengthens and fosters closer communication between individuals.

Effective communication between individuals with hearing/speech impairments and the public necessitates the conversion of sign language into a more universally understood language [1]. The objective of our research is to develop the UzSL translation system.

Analysis and results

To explore the effectiveness of machine learning methods for Uzbek Sign Language (UzSL) recognition, a comprehensive dataset of UzSL gestures was curated. This dataset captured a diverse range of expressions, movements, and contextual variations. It comprised both static and dynamic gestures, meticulously annotated by sign language experts and native UzSL users to ensure accuracy and authenticity.

Several machine learning algorithms were employed to decode UzSL gestures, each catering to the language's unique linguistic and cultural features. As the research pivoted towards more advanced techniques, deep learning models emerged as promising contenders. Convolutional Neural Networks (CNNs) were adept at capturing spatial information from static gestures, effectively discerning hand shapes and configurations. Recurrent Neural Networks (RNNs), equipped with Long Short-Term Memory (LSTM) cells, exhibited proficiency in modeling the temporal dynamics of dynamic gestures, taking into account the fluidity and rhythm characteristic of UzSL.

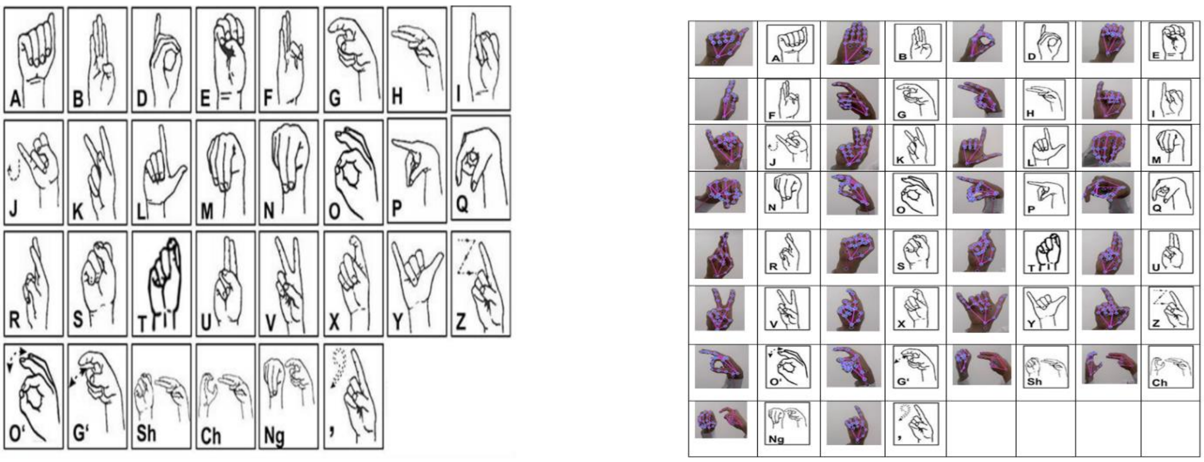


Figure 1. Dactyl alphabet of the Uzbek language based on the Latin script.

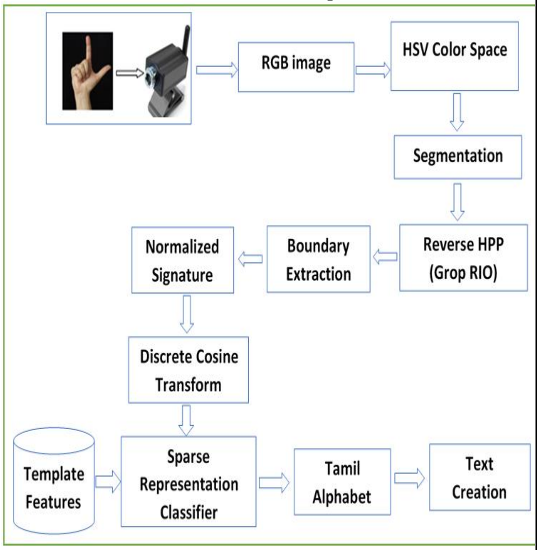
Processing: Uzbek Sign Language (UzSL) is a visual mode of communication utilized by the deaf community residing in Uzbekistan. It is derive from the Russian sign language, which belongs to the French sign language family. While sharing similarities with other sign languages, UzSL also has its own distinctive elements and structure. For our research, we utilized the dataset of the fingerspelling alphabet, consisting of 30 letters, in UzSL.

K points are establish in each frame, with K being the number of frames. Each identified point is represented as $N^{[i,j]} = (N_x^{[i,j]}, N_y^{[i,j]})$, where i = 1, 2, 3, …, N, and j = 1, 2, 3, …, K. For static gestures, all designated points should maintain their coordinates over time. This applies to the dynamic six letters as well, as they are treat as static, and the last frames of their respective videos are take [13]. The evaluation point, $N^{[i,j]} = (N_x^{[i,j]}, N_y^{[i,j]})$, bu yerda $N_x^{[i,j]} = \frac{1}{K}\sum_{j=1}^{K} N_x^{[i,j]}$, $N_y^{[i,j]} = \frac{1}{K}\sum_{j=1}^{K} N_y^{[i,j]}$, was employed. In our study, each hand displays 28 symbols.

Class	Preci-sion	Recall	F1-score	Class	Precision	Recall	F1-score
A	0.68	1.00	0.75	Q	1.00	1.00	1.00
B	1.00	1.00	1.00	R	1.00	1.00	1.00
D	1.00	1.00	1.00	S	1.00	1.00	1.00
E	1.00	1.00	1.00	T	0.83	0.76	0.83
F	1.00	1.00	1.00	U	0.75	0.65	0.75
G	0.71	0.59	0.71	V	1.00	1.00	1.00
H	1.00	1.00	1.00	X	0.69	0.75	0.69
I	1.00	1.00	1.00	Y	0.84	0.72	0.84
J	0.83	0.76	0.83	Z	1.00	0.73	1.00
K	0.86	0.71	0.86	O‘	0.65	0.57	0.68
L	0.76	0.65	0.76	G‘	0.69	0.55	0.68
M	0.81	0.72	0.81	Sh	0.86	0.74	0.86
N	1.00	1.00	1.00	Ch	0.84	0.72	0.86
O	1.00	1.00	1.00	Ng	0.83	0.78	0.88
P	0.74	0.61	0.74	’	0.81	0.82	0.89

Tab. 1. Accuracy measurment for UzSL

Figure 3. UzSL Sign Language Model, a Native Visual Communication Tool for the Hearing/Speech Impaired Community.



CONCLUSION

This research paper discusses a task involving recognition of sign language and proposes a two-stage transfer learning approach for Sign Language Recognition (SLR). The Inception V3 pre-existing model was utilized for this task, where the model was initially trained on the ImageNet dataset, and then on the Kaggle ASL dataset. Subsequently, we applied the two-stage transfer learning approach and trained the model with our UzSL dataset. The obtained results are present in Table 1, which illustrates that the letters O‘ and G‘ exhibited lower accuracy values. This paper presents the development of a real-time recognition system for the Uzbek dactyl sign language, which consists of a dactyl alphabet of 28 signs. Our method combines static and dynamic data types into a single database, enabling real-time interpretation of both dynamic and static gestures. The objective of this research is to achieve accurate recognition of Uzbek sign language. To attain this objective, a dataset consisting of over 3000 images for 28 gestures was create. However, the limited number of images affected the clarity of our results. We also considered lighting as a parameter affecting recognition quality, to ensure that our development yields satisfactory results. Gesture classification was carry out using three classification algorithms. The random classifier had an average accuracy of 83.2%. In addition, the performance of the algorithm was evaluate based on its speed of execution and training time.

References:

1. Ahmed, M. A., Zaidan, B. B., Zaidan, A. A., Salih, M. M., Lakulu, M. M. bin. (2018). A Review on Systems-Based Sensory Gloves for Sign Language Recognition State of the Art between 2007 and 2017. Sensors, 18 (7), 2208. doi: http://doi.org/10.3390/s18072208
2. R. Bhavani, S. Ananthakumaran. Development of a smart walking stick for visually impaired people, Turkish Journal of Computer and Mathematics Education, Vol.12 No.2 (2021), DOI:10.17762/TURCOMAT.V12I2.1112
3. P. Mell and T. Grance, “The NIST Definition of Cloud Computing” (Technical report), National Institute of Standards and Technology: U.S. Department of Commerce, pp. 1-7, September 2011. doi:10.6028/NIST.SP.800-145. Special publication 800-145.
4. Sh. Kh. Pozilova, M. Mirsoliyeva, O.A. Kayumov., Development of Professional Creativity of Professional Teachers in Professional Courses on The Basis of E-Pedagogy Principle. Proceedings of 2022 8th International Conference on Education and Training Technologies (ICETT 2022) Macau, China | Virtual Conference April 16 – April 18, 2022., pp. 66-71. DOI: 10.1145/3535756.3535767
5. Algorithms for highlighting the contours of images based on the theory of fuzzy sets Ergashev, A.Q., Turakulov, O.Kh., Abdumalikov, A.A., Kayumov, O.A. 2022 International Conference on Information Science and Communications Technologies, ICISCT 2022, 2022
6. MU Xujayevich, MA Isoqulovich. Informatika va axborot texnologiyalari darslarida topshiriqlarni bajarishni raqamli tizimga o‘tkazishning o'ziga xos xususiyatlari // International Journal of Contemporary Scientific and Technical Research, 694-696.
7. MU Xujayevich. Some methodological issues of the formation of communicative competence of students using educational online resources // European Journal of Research and Reflection in Educational Sciences Vol 7 (2).
8. A Ahmad, O.Kayumov, N.Kayumova Artificial intelligence in the management of intellectual resources of enterprises in the conditions of the digital economy in Uzbekistan
9. O Kayumov, N Kayumova, A Rayxona, Y Madina The strategic significance of human resource management in uzbekistan enterprises on the basis of artificial intelligence