International Journal of Electrical and Computer Engineering (IJECE)
Vol. 15, No. 2, April 2025, pp. 1584~1592
ISSN: 2088-8708, DOI: 10.11591/ijece.v15i2.pp1584-1592

Combined-adaptive image preprocessing method based on noise detection

Razakhova Bibigul Shamshanovna[1], Nurzada Amangeldy[1], Akmaral Kassymova[3], Saule Kudubayeva[1], Bekbolat Kurmetbek[1], Alibek Barlybayev[1,2], Nazerke Gazizova[1], Aigerim Buribayeva[2]
[1]Department of Artificial Intelligence Technologies, Faculty of Information Technology, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan
[2]Higher School of Information Technology and Engineering, Astana International University, Astana, Kazakhstan
[3]Institute of Economics, Information Technologies and Professional Education, Zangir Khan West Kazakh-Stan Agrarion-Technical University, Uralsk, Kazakhstan

Article Info

Article history:

Received Mar 19, 2024
Revised Oct 19, 2024
Accepted Nov 20, 2024

Keywords:

Contour extraction
Image preprocessing
Image processing
Noise reduction
Segmentation

ABSTRACT

The image processing method involves several critical steps, with image preprocessing being particularly significant. Segmentation and contour extraction on digital images are essential in fields ranging from image recognition to image enhancement in various recording devices, such as photo and video cameras. This research identifies and analyzes the main drawbacks of existing segmentation and contour extraction methods, focusing on object recognition. Not all filters effectively remove noise; some may clear areas of interest, affecting gesture recognition accuracy. Therefore, studying the impact of image preprocessing on gesture recognition outcomes is crucial for improving pattern recognition performance through more efficient preprocessing methods. This study seeks to find an optimal solution by detecting specific features during the preprocessing stage that directly influence gesture recognition accuracy. This research is a key component of the AP19175452 project, funded by the ministry of science and higher education. The project aims to create automated interpretation systems for Kazakh sign language, promoting inclusivity and technological innovation in communication aids. By addressing these challenges, the study contributes to the development of more robust and adaptive image preprocessing techniques for gesture recognition systems.

Corresponding Author:

Nurzada Amangeldy
Department of Artificial Intelligence Technologies, Faculty of Information Technology, L.N. Gumilyov Eurasian National University
Astana, Kazakhstan
Email: nuradaamangeldy@gmail.com

1. INTRODUCTION

The challenge of noise suppression in gesture recognition is complex. Existing methods often target specific noise types, lacking a universal approach to address all forms of noise. This limitation is crucial in applications like sign language recognition, where clarity is paramount. Additive gaussian noise, which adds random values to pixels, and impulse noise, which replaces pixels with fixed or random values due to transmission errors, are common issues. Both types of noise disrupt image quality, hindering accurate gesture interpretation and underscoring the need for more adaptable and comprehensive noise suppression strategies.

Despite numerous advancements in noise suppression techniques, several unresolved issues remain. First, there is no universal approach to handle different types of noise. Second, existing methods often require manual adjustments and are not fully adaptive. Third, there is a need for integrated solutions that can dynamically select and apply appropriate preprocessing techniques based on real-time noise conditions. The goal of this study is to develop a combined adaptive method of image preprocessing that accounts for various types of noise and adapts accordingly to improve the accuracy of gesture recognition. The primary contributions of this research include developing an algorithm for real-time noise detection in video sequences for gesture recognition systems, creating a combined adaptive method of image preprocessing that uses different filters depending on the noise in the input image, and introducing a new mathematical framework for adapting preprocessing methods based on the noise level.

The following sections of the paper will demonstrate how the proposed methods address the described problems. The literature review included in the first section will summarize relevant studies and contextualize the research within the existing body of knowledge. The "method" section will provide a detailed description of the proposed image processing method and noise detection algorithm. The "results and discussion" section will compare the results of the proposed method with existing methods and discuss its advantages. The "conclusion" section will summarize the main findings and suggest future research directions in this field.

To develop an effective image preprocessing method based on noise detection, it is crucial to consider various approaches that have been proposed in the literature. Jin *et al.* [1] demonstrated the use of noise suppression, contrast enhancement, thresholding, and labeling to highlight specific features in images for radiographic testing. They showed that noise reduction is a crucial step in image preprocessing to extract specific features. Similarly, Huen *et al.* [2] emphasized the importance of signal preprocessing methods to enhance image quality and reduce noise in the context of photoacoustic tomography. Tang *et al.* [3] discussed the use of the constant false alarm rate (CFAR) method for ship recognition in SAR images to overcome background clutter and noise, demonstrating that the CFAR method is effective in isolating targets against background noise.

Furthermore, Xi *et al.* [4] and Torres *et al.* [5] demonstrated the use of preprocessing methods for highlighting fuzzy boundaries in deep neural networks, showing the effectiveness of preprocessing techniques in emphasizing essential image features. Kimori [6] proposed an image preprocessing method based on the geometric shape of lesions to improve lesion recognition, highlighting the use of prior knowledge for effective noise detection. Additionally, Qin *et al.* [7] discussed various preprocessing methods for suppressing noise artifacts in image and object detection algorithms, further emphasizing the importance of noise suppression methods.

An alternative approach was demonstrated by Wang *et al.* [8], who used anisotropic diffusion filters for noise reduction during ultrasound image preprocessing, highlighting the importance of noise reduction in medical imaging. Ma *et al*. [9] also applied noise suppression and joint registration technologies as image preprocessing methods to reduce noise in remote sensing images, reiterating the importance of noise reduction for data analysis. Collectively, these studies provide a comprehensive overview of various image preprocessing methods and their significance in noise reduction and image quality enhancement.

Rasti *et al.* [10] offered a review of noise reduction methods in hyperspectral images, highlighting the importance of noise reduction as a preprocessing stage. Liu *et al.* [11] emphasized the use of multi-operator dynamic weighting for image edge recognition, contributing to noise reduction and image preprocessing. Kim *et al.* [12] proposed multilevel feature extraction using wavelet analysis for deep joint demosaicing and noise suppression, demonstrating the potential of advanced preprocessing methods for noise reduction and image enhancement. Moreover, Zhang *et al.* [13] utilized a shape-constrained method for remote sensing monitoring, emphasizing the importance of preprocessing methods for noise suppression and data quality improvement.

In conclusion, the synthesis of these studies underscores the importance of image preprocessing methods for noise detection and reduction. These methods encompass a wide range of techniques, such as denoising, contrast enhancement, and geometrical shape-based preprocessing, all of which are crucial for improving image quality and facilitating accurate noise detection. The analysis of scientific articles has highlighted that adapted methods of image preprocessing used in gesture language recognition tasks, depending on the recognition method, are not reflected in these works.

The analysis of scientific articles has highlighted that adapted methods of image preprocessing used in gesture language recognition tasks, depending on the recognition method, are not reflected in these works. This gap in research raises the following research questions:

a. Which algorithm should be employed to detect noise in datasets, real-time recordings, and video sequences for gesture recognition systems?
b. Is it possible to develop combined adaptive methods of image preprocessing for gesture recognition systems that will use various filters depending on the noise in the input image, and what mathematical framework needs to be involved for this?

2. METHOD
2.1. Image filtration

To find the optimal solution for noise in images, an analysis of various image filtering methods that directly affect the accuracy of gesture recognition was conducted. If the intensity value of each pixel is calculated based on the values of neighboring pixels within a certain vicinity, this transformation is called a local transformation, and the vicinity itself is called a window, represented by a matrix known as a mask, filter, or filter kernel. The values of the matrix components are called mask coefficients. The center of the mask is aligned with the analyzed pixel, and the mask coefficients are multiplied by the intensity values of the pixels covered by the mask. Typically, the mask has a square shape of size 3×3, 5×5.

Filtering an image using a mask of size $m \times n$ is carried out according to (1):

$$frame_{new}\ (x, y) = \sum_s \sum_t w(s, t) frame(x + s, y + t) \quad (1)$$

where s and t are the coordinates of the mask components relative to its center. These transformations are called linear. After calculating the new pixel intensity value $frame_{new}\ (x, y)$, the window in which the filter mask is placed shifts, and the saturation of the subsequent pixel is calculated similarly, so this transformation is called sliding window filtering.

Low-pass spatial filters reduce high-frequency components (areas with sharp changes in saturation) and leave low-frequency elements of the image unchanged. They are used to reduce noise levels and remove high-frequency elements, thereby increasing the accuracy of low-frequency element studies. As a result of using low-pass filters, a smoothed or blurred image is obtained.

Gaussian blur is a linear [14]–[18] transformation of neighboring points to remove noise. The basic idea of the algorithm is to take the arithmetic mean of the pixels in some neighborhood as the new pixel value. Pixels in the sliding window that are closer to the analyzed pixel should have a greater impact on the filtering effect than the outermost ones. Therefore, the coefficients of mask weights can be represented as a bell-shaped Gaussian function:

$$G_\sigma = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2a^2}} = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-x^2}{2\sigma^2}} * \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-x^2}{2\sigma^2}} \quad (2)$$

The larger the parameter σ is, the more blurred the image is. As a rule, the filter radius $r = 3\sigma$. In this case, the mask size is 2_r+1×$_{2r}$+1 and the matrix size is 6_σ+1×6_σ+1. Outside this neighborhood, the values of the Gaussian function will be negligibly small.

The classical median filter uses a mask with unit coefficients [19]. The arbitrary shape of the window can be set using zero coefficients. The intensity values of the pixels in the window are represented as a column vector and sorted in ascending order. The median value in the range is assigned to the filtered pixel. The number of median elements after sorting can be calculated by (3):

$$n = \frac{N+1}{2} \quad (3)$$

where N is the number of pixels involved in sorting.

Median filtering is nonlinear because the median of the sum of two arbitrary sequences is not equal to the sum of their medians, which in some cases can complicate the mathematical analysis of signals. The filter causes smoothing of the vertices of triangular functions. Wiener filtering applies [20] Wiener's adaptive approach, based on statistical data analyzed from the local neighborhood of each pixel. The Wiener filter is often more effective than the median filter. Another advantage of this filter is that it preserves the edges and other high-frequency parts of image objects. However, the Wiener filter requires more computation time than the median filter.

Wiener filtering applies Wiener's adaptive approach, based on statistical data analyzed from the local neighborhood of each pixel. The Wiener filter is often more effective than the median filter. Another advantage of this filter is that it preserves the edges and other high-frequency parts of image objects. However, the Wiener filter requires more computation time than the median filter. In the experiments conducted during the description of the problem, we see that not all filters can work well because the filters can clean the useful areas of the image in Figure 1(a) along with the noise in the image, that is, such errors made during preprocessing directly affect the performance of object recognition, affecting the negative recognition. Binarization by the threshold and Bernsen methods contain a lot of noise in the frame both before and after filtering, but it is worth noting that after removing the white Gaussian noise by the Wiener filter, the Bernsen method clearly separates the hand from the background. Not all filters can remove this kind of noise when dark Gaussian noise and impulse noise (salt and pepper) are added to the frame, but the adaptive binarization method does a good job after applying the median and Wiener filter. Binarization by the Bernsen method [21], [22] highlights the outline of the object very well in all cases, while threshold binarization leaves many objects in the frame.

Almost all known contour extraction algorithms approach the image as a matrix of numbers with values 0...255, integers within one machine byte in Figure 1(b). The considered methods of image outline extraction work well when the image has a homogeneous texture and there is no noise in it. If these conditions are not met, these methods will also detect extra borders, which will be difficult to separate from the main object. For each image, these methods require manual adjustment of thresholds due to different image acquisition conditions, such as illumination. Therefore, the application of these methods is rather limited.

It is possible to conclude that if we have a frame with normal quality without noise on the input, it is enough to apply binarization by the Otsu method. However, if the frame is too bright, all three filtering methods are effective. If the aim is to segment the object in the frame, then adaptive binarization methods should be applied. If the frame is dark and the recording was done at night, these frames can be filtered by the median or Wiener filter, and adaptive binarization methods can be applied. When impulse noise is superimposed on the frame, almost all filtering methods lead to the loss of information. As shown in the table, the median and Wiener filter combined with adaptive binarization will lead to good segmentation. If the goal is to obtain contours without loss of information, the Bernsen method will work well regardless of the superimposed noise.

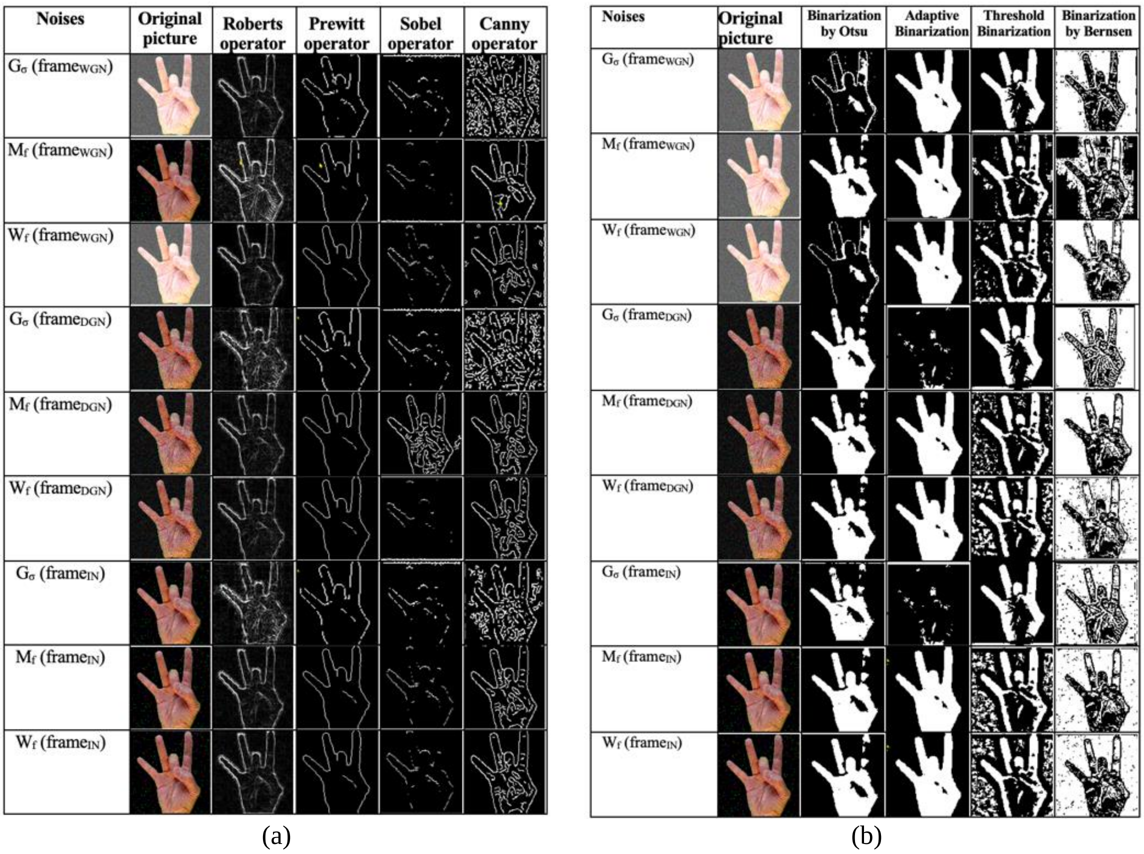


Figure 1. Impact of preprocessing filters on image quality (a) object recognition and (b) influence of texture homogeneity and noise

2.2. Noise detection

Gesture recognition is a classification task, so the data should be divided so that the numerical ratio of objects of different classes in the resulting sets is the same as in the original population. Such a sample, called a dataset, is needed to train the machine learning model to train the system and then use it to solve real-world problems. The experiment used the Kazakh sign language (KSL) alphabet dataset [23], consisting of 42 letters, prepared with 41 classes of datasets, some of which were artificially imposed with random noise. Suppose there is a dataset A, as shown in Figure 2, consisting of 41 KSL letters, each class has 100 frames, and a total of 41 thousand frames are included in the experiment.

$$\mathrm{A} = \{a_1, a_2, a_3 \dots a_{41}\},\ \text{where } |\mathrm{A}| = 41 \quad (4)$$

Next, random noise N was imposed on classes 3,6,8.

$$for\ any\ \ i = 3{,}6{,}8\ \Rightarrow\ a_i = a_i + N, where\ N - noise \quad (5)$$

A'- is a dataset with superimposed random noise.

$$A' = a'|i = 3{,}6{,}8| \quad (6)$$

$\overline{\mathrm{A}}$ – dataset with minus the sets where noise is superimposed.

$$\overline{\mathrm{A}} = \{a_i\ |i \neq 3{,}6{,}8|\} \quad (7)$$

Let's combine the datasets.

$$B = \overline{\mathrm{A}} + A' \quad (8)$$

Next, in order to identify frames with noise, we conduct a normalization of dataset B.

$$B_n = \frac{b_i - b_{imin}}{b_{imax} - b_{imin}}, i = 41 \quad (9)$$

Construct a frequency element for the total dataset B_n.

$$\sum_{i=0}^{i=1} b_{ji}\ , j = 1 \dots 41, i + t, \text{где } t = \frac{b_i - b_{imin}}{b_{imax} - b_{imin}} = 0.03 \quad (10)$$

As a result, we get the following histogram as shown in Figure 3, all frames that are above the set threshold contain noise.

These parameters are used to identify frames where the noise level exceeds the set threshold. The proposed noise detection method enables not only the preliminary checking of noise presence in frames during the creation of video recordings for real-time gesture recognition systems but also the efficient detection of noisy frames in existing datasets [24], [25]. This, in turn, ensures the reliable and successful operation of any object recognition systems.

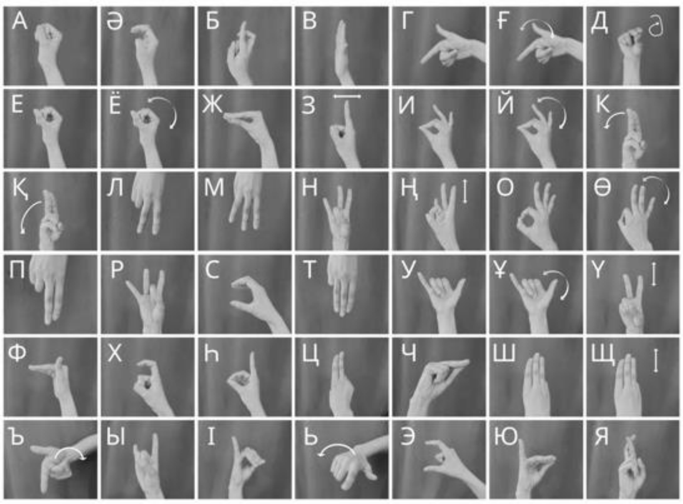


Figure 2. Experimental dataset

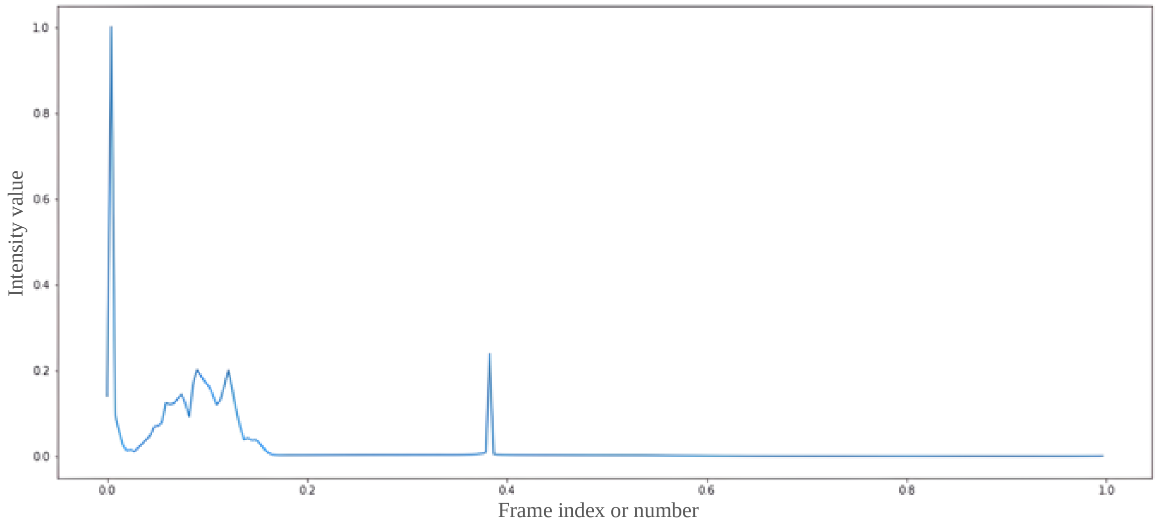


Figure 3. Identification of frames above threshold

2.3. Combined-adaptive image pre-processing method

Modern computer technology allows for the automated analysis of various images. This typically requires the use of methods and algorithms for image preprocessing, their segmentation to select objects, and further study or identification of these objects [26], [27]. However, most of the algorithms used require manual image preprocessing. This paper proposes an adapted method of image preprocessing that will use filters depending on the noise in the input image and the method of object recognition.

To eliminate noise-detected frames for systems where objects on the frames are recognized based on segmentation or value extraction, the following solution is proposed:

$$\begin{cases} \mathrm{T} > 0.3, \;\; \mathrm{cn} \\ \mathrm{T} \leq 0.3 \begin{cases} frame_{WGN}, \;\; (M_f + Prewitt) \; or \; (W_f + Canny) \\ frame_{BGN}, \;\; M_f + Roberts \\ others, \;\; Roberts \end{cases} \end{cases} \tag{11}$$

For a system where the objects on the frames are recognized by selecting the contour, the solution is as (12):

$$\begin{cases} \mathrm{T} > 0.3, \;\; \mathrm{cn} \\ \mathrm{T} \leq 0.3 \begin{cases} frame_{WGN}, \;\; (M_f + AdaptBin) \; or \; \left(W_f + AdaptBin\right) or (M_f + AdaptBin) \\ frame_{BGN}, \;\; (M_f + AdaptBin) \; or \; \left(W_f + AdaptBin\right) \\ others, \;\; ThreshBin \end{cases} \end{cases} \tag{12}$$

Thus, the proposed image preprocessing algorithm for object selection does not assume the presence of prior knowledge about the image, making the algorithm universal. This algorithm can be used in research aimed at developing gesture recognition systems for adaptive preprocessing.

3. RESULTS AND DISCUSSION

The experiment involved a dataset of 4,100 frames, recorded in real-time, with every fifth frame from 500 being used, resulting in 100 frames per class across 41 classes. Three classes were subjected to random noise. To identify noise, a frequency threshold of 0.03 was used; frames above this were classified as noisy. An adaptive preprocessing method was applied, using appropriate filters based on the noise type and object recognition method. The combined approach of adaptive binarization, median, and Wiener filters proved effective, especially for dark gaussian and impulse noise, significantly improving gesture recognition accuracy.

The study found that while generative adversarial networks (GANs) are efficient for noise removal, the adaptive preprocessing method is more flexible and less resource-intensive. This approach can adapt to various noise types without the need for retraining, offering significant advantages in diverse conditions [28]. Additionally, it provides greater control over the preprocessing process, making it a preferable choice for certain applications. Despite its strengths, the adaptive preprocessing method has a level of computational complexity that may require optimization for real-time use. Addressing this challenge would enhance its applicability in time-sensitive systems, ensuring seamless integration.

In conclusion, the adaptive preprocessing method offers a robust solution for handling noise in gesture recognition. Ensuring reliable performance across various noise conditions. While further optimization and the integration of advanced machine learning techniques are needed for real-time applications, the method's flexibility and effectiveness make it a balanced and practical alternative to GAN-based solutions.

4. CONCLUSION

In this article, to answer the research questions that were asked in the introduction, we conducted a series of experiments and came to the following conclusions: First, to detect noise, you need to define the exact domain of the problem, in order to determine the frequency element, which in turn can provide information about the frames where there is noise. The proposed method is primarily oriented for use in image processing in machine vision systems. In particular, for the selection of the sensitivity threshold when selecting the contours of objects or when segmenting, when selecting features. In contrast to the existing and most popular methods discussed in this paper, it is adaptive, which depends on the value of the noise level. Second, during the experiment, a comparison of image segmentation methods was carried out, since the segmentation in the image along with the segmentation of the object can clear the useful areas of the object itself, this, in turn, affects the result of object recognition. A comparison of methods of outline extraction has shown that these methods work well if the image has a homogeneous texture and there is no noise in it. Next, the well-known filters and re-segmentation of frames were applied. During the comparison, we found out the peculiarities of the application of different segmentation methods after different filters. Based on the data obtained during the experiment and based on observation, an adapted method of image preprocessing was proposed, which in turn proved to be effective in frame processing.

REFERENCES

[1] G. S. Jin, S. J. Oh, Y. S. Lee, and S. C. Shin, "Extracting weld bead shapes from radiographic testing images with u-net," *Applied Sciences (Switzerland)*, vol. 11, no. 24, p. 12051, Dec. 2021, doi: 10.3390/app112412051.

[2] I. Huen, R. Zhang, R. Bi, X. Li, M. Moothanchery, and M. Olivo, "An investigation of signal preprocessing for photoacoustic tomography," *Sensors*, vol. 23, no. 1, p. 510, Jan. 2023, doi: 10.3390/s23010510.

[3] G. Tang, Y. Zhuge, C. Claramunt, and S. Men, "N-YOLO: A SAR ship detection using noise-classifying and complete-target extraction," *Remote Sensing*, vol. 13, no. 5, pp. 1–16, Feb. 2021, doi: 10.3390/rs13050871.

[4] T. Xi, L. Yuan, and Q. Sun, "A combined approach to infrared small-target detection with the alternating direction method of multipliers and an improved top-hat transformation," *Sensors*, vol. 22, no. 19, p. 7327, Sep. 2022, doi: 10.3390/s22197327.

[5] C. Torres, C. I. Gonzalez, and G. E. Martinez, "Fuzzy edge-detection as a preprocessing layer in deep neural networks for guitar classification," *Sensors*, vol. 22, no. 15, p. 5892, Aug. 2022, doi: 10.3390/s22155892.

[6] Y. Kimori, "A morphological image preprocessing method based on the geometrical shape of lesions to improve the lesion recognition performance of convolutional neural networks," *IEEE Access*, vol. 10, pp. 70919–70936, 2022, doi: 10.1109/ACCESS.2022.3187507.

[7] R. Qin *et al.*, "Multiple receptive field network (MRF-Net) for autonomous underwater vehicle fishing net detection using forward-looking sonar images," *Sensors*, vol. 21, no. 6, pp. 1–22, Mar. 2021, doi: 10.3390/s21061933.

[8] Y. Wang, X. Ge, H. Ma, S. Qi, G. Zhang, and Y. Yao, "Deep learning in medical ultrasound image analysis: a review," *IEEE Access*, vol. 9, pp. 54310–54324, 2021, doi: 10.1109/ACCESS.2021.3071301.

[9] W. Ma, Y. Xiong, Y. Wu, H. Yang, X. Zhang, and L. Jiao, "Change detection in remote sensing images based on image mapping and a deep capsule network," *Remote Sensing*, vol. 11, no. 6, p. 626, Mar. 2019, doi: 10.3390/RS11060626.

[10] B. Rasti, P. Scheunders, P. Ghamisi, G. Licciardi, and J. Chanussot, "Noise reduction in hyperspectral imagery: Overview and application," *Remote Sensing*, vol. 10, no. 3, p. 482, Mar. 2018, doi: 10.3390/rs10030482.

[11] J. Liu *et al.*, "Image edge recognition of virtual reality scene based on multi-operator dynamic weight detection," *IEEE Access*, vol. 8, pp. 111289–111302, 2020, doi: 10.1109/ACCESS.2020.3001386.

[12] M. C. Kim, J. H. Park, and M. H. Sunwoo, "Multilevel feature extraction using wavelet attention for deep joint demosaicking and denoising," *IEEE Access*, vol. 10, pp. 77099–77109, 2022, doi: 10.1109/ACCESS.2022.3192451.

[13] Y. Zhang, C. Wang, J. Chen, and F. Wang, "Shape-constrained method of remote sensing monitoring of marine raft aquaculture areas on multitemporal synthetic sentinel-1 imagery," *Remote Sensing*, vol. 14, no. 5, p. 1249, Mar. 2022, doi: 10.3390/rs14051249.

[14] J. Flusser, S. Farokhi, C. Höschl, T. Suk, B. Zitová, and M. Pedone, "Recognition of images degraded by Gaussian blur," *IEEE Transactions on Image Processing*, vol. 25, no. 2, pp. 790–806, Feb. 2016, doi: 10.1109/TIP.2015.2512108.

[15] M. A. Rahim, J. Shin, and K. S. Yun, "Hand gesture-based sign alphabet recognition and sentence interpretation using a convolutional neural network," *Annals of Emerging Technologies in Computing*, vol. 4, no. 4, pp. 20–27, Oct. 2020, doi: 10.33166/AETiC.2020.04.003.

[16] R. Rastgoo, K. Kiani, and S. Escalera, "Multi-modal deep hand sign language recognition in still images using Restricted Boltzmann Machine," *Entropy*, vol. 20, no. 11, p. 809, Oct. 2018, doi: 10.3390/e20110809.

[17] L. Kraljević, M. Russo, M. Pauković, and M. Šarić, "A dynamic gesture recognition interface for smart home control based on croatian sign language," *Applied Sciences (Switzerland)*, vol. 10, no. 7, p. 2300, Mar. 2020, doi: 10.3390/app10072300.

[18] A. Ghotkar, P. Vidap, and S. Ghotkar, "Vision based hand gesture recognition using fourier descriptor for indian sign language," *Signal & Image Processing : An International Journal*, vol. 7, no. 6, pp. 29–38, Dec. 2016, doi: 10.5121/sipij.2016.7603.

[19] R. M. Kagalkar and S. V Gumaste, "Mobile application based translation of sign language to text description in Kannada language," *International Journal of Interactive Mobile Technologies*, vol. 12, no. 2, pp. 92–112, Mar. 2018, doi: 10.3991/ijim.v12i2.8071.

[20] R. Kaluri and C. H. Pradeep Reddy, "Sign gesture recognition using modified region growing algorithm and adaptive genetic fuzzy classifier," *International Journal of Intelligent Engineering and Systems*, vol. 9, no. 4, pp. 225–233, Dec. 2016, doi: 10.22266/ijies2016.1231.24.

[21] S. Kudubayeva, N. Amangeldy, A. Sundetbayeva, and A. Sarinova, "The use of correlation analysis in the algorithm of dynamic gestures recognition in video sequence," in *Proceedings of the 5th International Conference on Engineering and MIS*, Jun. 2019, pp. 1–6. doi: 10.1145/3330431.3330439.

[22] S. Kudubayeva, N. Amangeldy, and A. Zakirova, "Kazakh sign language recognition system based on the Bernsen method and morphological structuring," *Речевые Технологии*, no. 3–4, pp. 3–15, 2020, doi: 10.58633/2305-8129_2020_3-4_3.

[23] N. Amangeldy, S. Kudubayeva, A. Kassymova, A. Karipzhanova, B. Razakhova, and S. Kuralov, "Sign language recognition method based on palm definition model and multiple classification," *Sensors*, vol. 22, no. 17, p. 6621, Sep. 2022, doi: 10.3390/s22176621.

[24] N. Amangeldy, M. Milosz, S. Kudubayeva, A. Kassymova, G. Kalakova, and L. Zhetkenbay, "A real-time dynamic gesture variability recognition method based on convolutional neural networks," *Applied Sciences (Switzerland)*, vol. 13, no. 19, p. 10799, Sep. 2023, doi: 10.3390/app131910799.

[25] N. Amangeldy, A. Ukenova, G. Bekmanova, B. Razakhova, M. Milosz, and S. Kudubayeva, "Continuous sign language recognition and its translation into intonation-colored speech," *Sensors*, vol. 23, no. 14, p. 6383, Jul. 2023, doi: 10.3390/s23146383.

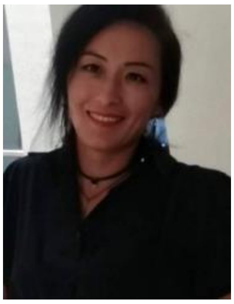
[26] A. Naizagarayeva *et al.*, "Detection of heart pathology using deep learning methods," *International Journal of Electrical and Computer Engineering*, vol. 13, no. 6, pp. 6673–6680, Dec. 2023, doi: 10.11591/ijece.v13i6.pp6673-6680.

[27] M. Yessenova *et al.*, "Application of informative textural Law's masks methods for processing space images," *International Journal of Electrical and Computer Engineering*, vol. 13, no. 4, pp. 4557–4566, Aug. 2023, doi: 10.11591/ijece.v13i4.pp4557-4566.

[28] S. P. Porkodi, V. Sarada, V. Maik, and K. Gurushankar, "Generic image application using GANs (generative adversarial networks): a review," *Evolving Systems*, vol. 14, no. 5, pp. 903–917, Sep. 2023, doi: 10.1007/s12530-022-09464-y.

BIOGRAPHIES OF AUTHORS

Razakhova Bibigul Shamshanovna born in 1972 in the City of Shalkar, Aktobe region, Kazakhstan, is a Candidate of Technical Sciences. She defended her thesis on February 13, 2009, on "Automation of synthesis and analysis of phrases and sentences in the Kazakh Language." Since 2012, she has been a leading researcher for projects funded by the ministry of education and science and the Ministry of Science and Higher Education of the Republic of Kazakhstan. She currently supervises the 2023-2025 research project "Development of technology for creating smart textbooks capable of interactive teaching, consulting, and knowledge assessment on subjects given in kazakh." She can be contacted at email: razakhova_bsh@enu.kz, bibigul.razakhova@gmail.com.



Nurzada Amangeldy born in 1984 in Mongolia, is a distinguished graduate of the L.N. Gumilyov Eurasian National University. She earned her bachelor's degree in Informatics in 2007, a master's degree in informatics in 2009, and a PhD in informatics in 2024. Currently, she is a postdoctoral researcher at the same university, actively participating in various scientific research projects. Her leadership in key projects, including the Kazakh sign language recognition system and the study of detecting personal protective equipment using the YOLOv8 architecture, highlights her innovative approach. She can be contacted at email: nurzadaamangeldy@gmail.com.

Akmaral Kassymova born on February 16, 1967, is an acting professor and associate professor at West Kazakhstan Agrarian Technical University named after Zhangir Khan. With 34 years of experience and a PhD in pedagogical sciences, she specializes in training professionals in information systems and pedagogy. Throughout her career, she has completed over 20 courses on educational technology and programming, receiving recognition for her contributions, including the "*Құрмет грамотасы*" from the Ministry of Agriculture (2023) and an appreciation from the Ministry of Education and Science (2006). She can be contacted at email: kasimova_ah@mail.ru.

Saule Kudubayeva candidate of Technical Sciences of Department of Artificial Intelligence Technologies Eurasian National University named after L.N. Gumilyov. Her Scientific interests includes system analysis, management and information processing, pattern recognition, computer vision, and speech technologies. Scientific grants: "Social innovative service 'Surdoserver' for people with hearing impairment" Author of the site *www.surdo.kz*. Author's courses: Algorithms and their complexity. Human-machine interaction. Statistical methods in natural language processing. Member of the working group in the CLASS – Erasmus+ project. She has over a hundred publications. She may be reached via email at: saule.kudubayeva@gmail.com.

Bekbolat Kurmetbek holds a bachelor's degree from Al-Farabi Kazakh National University in information systems and a master's degree from L.N. Gumilyov Eurasian National University in artificial intelligence technologies. With over three years of experience in machine learning, he has developed and implemented machine learning methods and models, and computer vision on an industrial scale. He can be contacted at email: bigboss990930@gmail.com.

Alibek Barlybayev received the B.Eng. degree in information systems from L.N. Gumilyov Eurasian National University, Kazakhstan, in 2009 and the M.S. and Ph.D. degrees in computer science from L.N. Gumilyov Eurasian National University, Kazakhstan, in 2011 and 2015, respectively. Currently, he is a Director of the Research Institute of Artificial Intelligence, L.N. Gumilyov Eurasian National University. He is also an Associate Professor of the Department of Artificial Intelligence Technologies, L.N. Gumilyov Eurasian National University, and Higher School of Information Technology and Engineering, Astana International University. His research interests are NLP, the use of neural networks in word processing, smart textbooks, fuzzy logic, stock market price prediction, information security. He can be contacted at email: frank-ab@mail.ru.

Nazerke Gazizova is a master's student at L.N. Gumilyov Eurasian National University, specializing in artificial intelligence technologies. She holds a bachelor's degree in information and communication technologies and she is currently working on her dissertation project focused on "Generation of Kazakh sign language dactyl alphabet using neural network models." She can be contacted at email: g.nazerke2755@gmail.com.

Aigerim Buribayeva Ph.D. in computer science, is an assistant professor at the Higher School of Information Technologies and Engineering at Astana International University. With over 10 years of teaching experience in higher education, her research interests include speech technologies, artificial intelligence, and big data. She can be contacted at email: buribayevaak@gmail.com.