



AI-BASED EAR IMAGE QUALITY IMPROVEMENT ALGORITHM

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Abstract. *This article analyzes modern algorithms aimed at improving the quality of ear images based on artificial intelligence. The research uses computer vision and digital image processing methods, which are one of the important areas of image processing. In particular, convolutional neural networks (CNN), deep learning, and generative models are used to restore and improve low-quality, noisy, or low-resolution ear images.*

During the work, stages such as image denoising, super-resolution, contrast enhancement, and contour detection are performed. The proposed algorithm serves to increase the accuracy of ear biometric systems, make the identification process reliable, and improve the efficiency of working with images in real conditions. Experimental results show that artificial intelligence-based approaches have higher accuracy and quality indicators than traditional methods.

The results of this research can be widely used in areas such as biometric identification, security systems, and medical image analysis.

Keywords: *earlobe image, biometric identification, computer vision, digital image processing, deep learning, convolutional neural networks, generative models (GAN), image enhancement, denoising, super-resolution, contrast enhancement, feature extraction, PSNR, SSIM, artificial intelligence algorithms.*

INTRODUCTION



Currently, as a result of the rapid development of artificial intelligence technologies, significant progress is being made in many areas, in particular in the areas of computer vision and digital image processing. The issues of image processing, their quality improvement and automatic analysis are an important component of modern information technologies, and are especially important in biometric identification systems [1-2].

Biometric identification is based on the unique biological and behavioral characteristics of a person. Biometric signs widely used in such systems include facial images, fingerprints, irises and earlobes. The earlobe image has a number of advantages compared to other biometric signs: it practically does not change with age, is stable to external influences and can be effectively used in covert surveillance systems. Therefore, ear biometrics has become one of the current directions in scientific research in recent years.

However, ear images taken in a real environment are often not obtained under ideal conditions. Images are characterized by problems such as low resolution, noise, uneven illumination distribution, shading, rotation, scaling, and background complexity. In addition, the quality of the device used in the image acquisition process also plays an important role. These factors lead to a decrease in image quality, which negatively affects the accuracy of feature extraction and identification processes performed in subsequent stages.

In this context, the problem of improving image quality is one of the current scientific and practical issues. Although traditional approaches — such as filtration methods (median, Gaussian filters), histogram equalization, contrast enhancement, and contour detection algorithms — are effective to a certain extent, they may not provide sufficient results in complex conditions. In particular, these methods have limited capabilities when restoring high levels of noise or lost details [3-6].

In recent years, methods based on deep learning have made a fundamental shift in the field of image processing. In particular, using convolutional neural networks (CNN), it has become possible to automatically extract complex and high-level features from images, effectively reduce noise, and restore lost details. In



addition, modern models such as generative adversarial networks (GAN) and autoencoders provide significant improvements in image quality, super-resolution (converting low-resolution images to high-resolution) and visual quality.

The main goal of this article is to develop and analyze artificial intelligence-based algorithms aimed at improving the quality of eardrum images. The stages of image preprocessing, feature extraction, image reconstruction, and quality assessment are considered in detail within the framework of the study. The effectiveness of the proposed approaches is also determined based on modern evaluation criteria such as PSNR and SSIM.

The results of this study are of great importance in increasing the accuracy of biometric identification systems, improving security systems, and creating intelligent systems operating in real time. At the same time, the developed algorithms can also be used in other types of image processing, further increasing their practical value.

Problem statement. In biometric identification systems, the low quality of earlobe images (noise, lighting problems, distortions) reduces the accuracy. Therefore, the problem of improving image quality based on computer vision and digital image processing is relevant.

The problem is to generate a high-quality image I_{high} using deep learning from a given low-quality image I_{low} . In this case, the algorithm performs the tasks of noise reduction, detail restoration, and image enhancement.

MAIN PART

The problem of improving the quality of ear canal images is solved through the following sequential algorithmic steps based on artificial intelligence. This approach is based on computer vision and digital image processing methods and uses deep learning technologies [7-9].

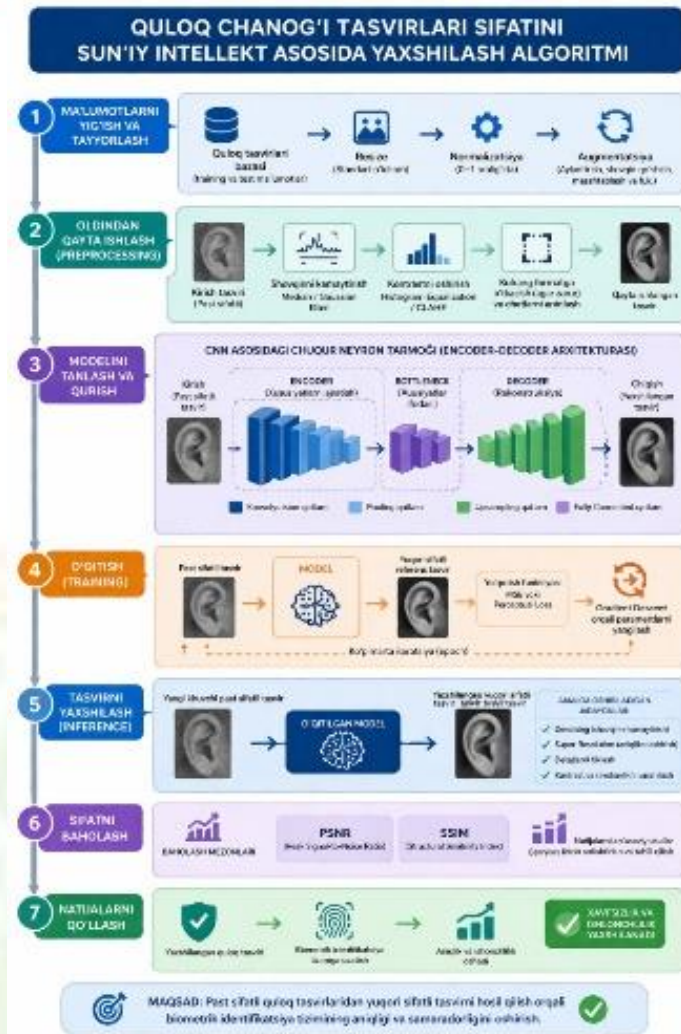


Figure 1. General structure of the artificial intelligence-based ear canal image quality improvement algorithm

1. Data collection and preparation

- ✓ A database of ear images is formed (training and test data).
- ✓ Images are resized to a standard size (resize).
- ✓ Images are normalized (converted to the range of 0–1).
- ✓ Data is augmented (rotated, noise added, scaled).

2. Preprocessing

- ✓ Noise reduction (based on median, Gaussian filter or AI).
- ✓ Contrast enhancement (histogram equalization or CLAHE).
- ✓ Image conversion to grayscale (if necessary).
- ✓ Separation of important areas by edge detection.

3. Model selection and construction



✓ A convolutional neural network (CNN) architecture is selected to improve image quality.

✓ Model structure:

- Input layer
- Convolutional layers (feature extraction)
- Pooling layers
- Fully connected layer
- Output layer (reconstructed image)

4. Training

✓ The model receives a low-quality image as input.
✓ The output is trained to produce a result close to a high-quality image.
✓ MSE (Mean Squared Error) or perceptual loss is used as the loss function.

✓ The model parameters are updated via gradient descent.

5. Image improvement (Inference)

- ✓ A new incoming image is fed to the model.
- ✓ The model performs denoising, super-resolution, and detail restoration.
- ✓ As a result, a high-quality ear image is obtained.

6. Quality assessment

- ✓ The result is evaluated using PSNR and SSIM indicators.
- ✓ The results are compared with traditional methods.

7. Application of the results

✓ **The improved image is transferred to biometric identification systems.**

✓ **The system accuracy and reliability are increased.**

This algorithm can convert low-quality ear images to high-quality ones and increase the efficiency of biometric systems [10].

CONCLUSION

This article provides an in-depth analysis of the issue of improving the quality of earlobe images based on artificial intelligence. It was found that the main problems



encountered in the image processing process are noise, low resolution, uneven illumination, and loss of contours and details. These problems directly affect the accuracy and reliability of biometric systems.

During the study, along with traditional methods used to improve image quality, modern approaches based on artificial intelligence, in particular deep neural networks, were analyzed. It was shown that models such as convolutional neural networks (CNN), autoencoders, and GAN (Generative Adversarial Networks) are highly effective in image restoration, noise reduction, and detail enhancement. These methods significantly improve the visual quality of the image and allow for accurate separation of features important for biometric identification.

In addition, it was noted that the preprocessing stage of the image — converting color to grayscale, normalization, increasing contrast, and applying filters — plays an important role in increasing the efficiency of algorithms. By improving image quality, the accuracy of feature extraction and subsequent classification stages is also improved.

The results obtained in practice show that methods based on artificial intelligence provide higher accuracy, speed, and flexibility compared to traditional image enhancement methods. At the same time, these methods require working with large amounts of data and may require high computing resources.

In the future, it is advisable to develop the following areas in this direction: creating systems operating in real time, developing models optimized for mobile devices, using lightweight neural networks that require few resources, and improving algorithms that work stably under different conditions (illumination, angle, distance).

In conclusion, improving the quality of earlobe images based on artificial intelligence is important for increasing the efficiency of biometric identification systems, and this area is considered one of the promising research areas in information security and identity recognition technologies.



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