TECHNICAL SCIENCES

AUTOMATION OF ULTRASOUND BREAST CANCER IMAGES CLASSIFICATION USING DEEP NEURAL NETWORKS

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ABSTRACT

The article is devoted to the analysis of ways to improve medical systems, which are used to diagnose breast diseases by ultrasound images. Prospects for the use of neural networks in this area are considered. An analysis of neural network architectures that can be used to automate the classification of ultrasound images carried out. The architecture of optimized EfficientNet B1 networks was chosen. Training and testing of the model showed 81.26% of correct answers according to test results. A program with a graphical user interface in the LabVIEW environment has been created for easy analysis of ultrasound images. The development reduces the influence of subjective factors in diagnosis and improves the overall effectiveness of diagnostic method.

Keywords: deep learning, ultrasound, medical diagnostics, breast cancer.

Introduction

Due to development of science the diagnosis of various diseases is constantly being reviewed and improved. Nowadays ultrasound is widely used for diagnosis in almost all areas of medicine. Their popularity is caused by reliability, availability, simplicity and rapid results. Ultrasonic waves have certain properties that allow them to be used effectively in medicine, like: propagate in a straight line; able to focus; penetrate into the organs; differently reflected from the borders of different densities [1].

Diagnostics and treatment of breast cancer is a vital issue worldwide. In Ukraine and world one of the most common cancers among women is breast cancer. This disease is the cause of death of every ninth woman [2]. Early diagnosis can reduce mortality.

Nowadays computer technologies are widely used in medicine. Analysis and application of artificial intelligence is a promising area and contributes to the accelerated development of medicine. Classification of breast ultrasound images and segmentation methods using convolutional neural networks can be a new effective solution for analysis and diagnosis. The relevance of the use of neural networks is due to their flexibility, adaptability and practicality. The use of deep learning technologies can help the doctor in making a diagnostic decision. Potentially this will reduce the probability of medical error. Therefore, the development of intelligent automated systems for the classification of ultrasound images in medicine is an urgent task.

Review of previous works

Ultrasound diagnostics is a procedure that involves the impact of high-frequency sound waves on the body, followed by obtaining images of internal organs. Ultrasound, unlike X-ray, does not use hazardous ionizing radiation. Because ultrasound imaging is displayed in real time, such diagnostics allow the structure and analysis of the movement of internal organs and blood flowing into blood vessels. According to [3], the advantages of the ultrasound method of diagnosing breast pathology are:

- relative simplicity of research, cost-effectiveness;
- non-invasive and painless, no need to prepare the patient for the research;
- high resolution of modern ultrasonic equipment, high informativeness;
- possibility of use in the differential diagnosis of cancer, detailing the extent of tumor lesions;
- possibility of dynamic observation by fixing the image on video;
- possibility of computer processing, collection of information, its archiving, transmission through communication channels with the receipt of virtual consultations on the telemedicine system and Internet.

All changes in the breast are divided into two main groups: tumor and non-tumor. Diagnosis of breast diseases should always be carried out from the standpoint of cancer vigilance. Early detection of cancer (or its exclusion at the time of the research) is the main task of a doctor-diagnostician, ultrasound specialist. In order to increase the reliability of diagnosis, artificial neural networks are promising to use as part of ultrasonic data processing systems. This class of machine learning models in recent years shows the leading results in the field of image classification [4].

Among the advantages of using neural networks are their resistance to high levels of interference.

During operation neural networks are constantly in a state of self-learning, which is the basis of their adaptation. Neural networks have the ability to simultaneously analyze several informative parameters and can independently identify the most significant diagnostic features. In addition, deep learning models have the ability to work effectively with large amounts of data that do not require pre-processing.

In medical diagnostic tasks, neural networks make it possible to increase the probability of making a correct diagnosis and spend less time on analysis. Services and systems based on neural networks are being developed around the world and help doctors detect various pathologies and diseases including oncology.

Tumor detection is carried out by primary ultrasound or X-ray examination and secondary analysis - biopsy. According to [5], only 10-20% of biopsy results actually confirm the presence of breast cancer. Therefore, the analysis of ultrasound images may not be the only decisive factor in determining the final diagnosis. The use of modern artificial intelligence technologies can reduce the number of erroneous initial conclusions, but is also not a guarantee of correct diagnosis.

Researchers at the Mayo Clinic in Minnesota have taught the neural network to analyze ultrasound images of breasts with malignant tumors. The aim of the work was to create a system for detection and segmentation of malignant neoplasms. It turned out that the network is able to automatically solve the problem with a reliability of 40%, compared with 10-20% for specialists in ultrasound diagnostics. According to the authors, the use of this convolutional neural network allows not to stress many women with benign tumors through biopsy [6].

The disadvantage of previous work is that the presented algorithm solves only segmentation problems. To solve the problems of classification namely the determination of the type of tumor it is proposed to develop a special automated system based on a separate convolutional neural network with modern architecture.

Results and discussion

To create the software of the diagnostic system the urgent and important task is to determine the architecture of the neural network, which will allow the most reliable detection of the disease. The tasks of image recognition and image processing use a wide range of neural networks, each of which has its advantages and disadvantages.

Each architecture is designed to solve a certain class of data analysis problems (regression, classification, clustering, forecasting) and uses special learning algorithms. For the classification of images, it is most appropriate to use a convolutional neural network [7]. This architecture by using a special convolution operation reduces the amount of information stored in memory. Such a network better processes high-resolution images. Convolutional layers highlight such supporting features as edges, contours, faces, with which it can recognize fragments of textures, which can then be formed into fragments of the image. Also, due to the ability to classify images, convolutional neural networks are actively used in medicine, because we can teach the neural network to classify medical images [8].

One of the best models successfully used in image classification problems is the VGG16 network [9]. The model achieves an accuracy of 92.7% on the test dataset in the ImageNet image recognition task, and it is easy to implement. However, the VGG16 network has two significant drawbacks: slow learning speed and large model size, which further lead to problems with memory and bandwidth.

MobileNet is a small high-speed model with a low-power architecture, which is used in conditions of limited resources [10]. The MobileNet model can be designed to address classification, segmentation, and clustering tasks, like other popular large-scale models. But MobileNet is inferior in reliability, which is only 70.6% for ImageNet dataset classification tasks.

EfficientNets is a series of models used for image classification that can provide up to 95.1% reliability on an ImageNet dataset. The study of the impact of changes in image resolution on the performance of the model made it possible to create a promising class of new models. The development of EfficientNets models is based on an algorithm for complex scaling and balancing of the number of channels of convolutional neural networks. According to a study [11], balancing the width, depth and resolution of the network is important. This balance can be achieved by evenly scaling each value with fixed proportions between them. Based on this, a simple and effective scaling method is proposed. The EfficientNet model achieves much higher reliability compared to previous models, has fewer parameters and learns faster. Based on these characteristics, it is best to choose the EfficientNet model for the task of classifying ultrasonic images.

It is proposed to use the open data set "Breast ultrasound images" to study the neural network [12]. The data set contains 780 ultrasound images of the mammary glands in 600 women aged 25 to 75 years. They are divided into three classes: without pathology, benign and malignant tumors. In the future, by increasing the data set with new ultrasound images, it will be possible to increase the reliability of the system. Examples of images from the training set are shown in Fig. 1.

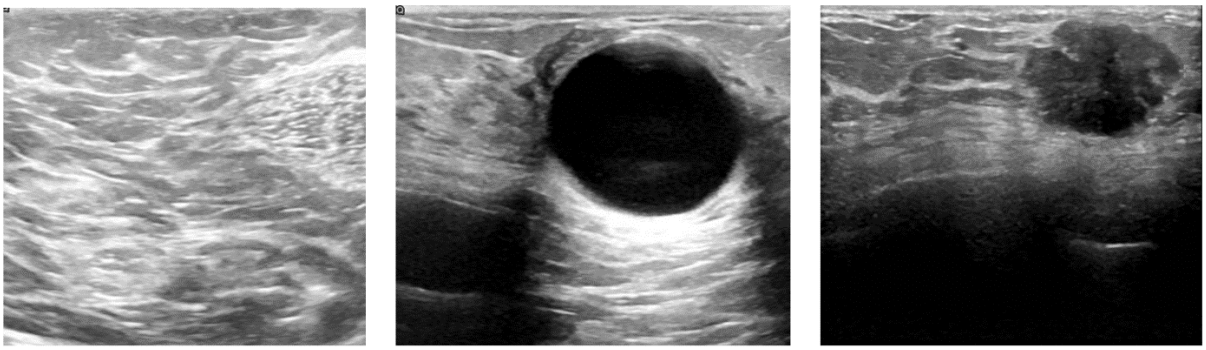

Fig 1. Samples of images from training dataset: a – normal, b – benign, c – malignant

The transfer learning approach was used to speed up the experiment. The EfficientNet B1 network used in the experiment was pre-trained on the ImageNet dataset. Not only its own classifier with 512 neurons, but also the last convolutional layer of the initial EfficientNet network was available for training. Accuracy was chosen as a metric, adam as an optimizer, and categorical crossentropy as a loss function. As a result of the training, the network showed the share of correct answers at 81.26% on test data. This level of reliability cannot be acceptable for a definitive diagnosis. Therefore, the proposed neural network model can be used only as a decision support system. The final diagnosis should be made by a qualified professional based on the results of a comprehensive examination of the patient's health.

The user interface in the NI LabVIEW environment has been created for more detailed and convenient diagnostics. It is shown on the Fig.2. In addition to diagnostic tools, the system interface includes tools for measuring tumor size, density and other parameters. Because LabVIEW includes handy tools for connecting external devices to your PC, real-time diagnostics can be performed.

National Instruments offers a wide range of specialized software libraries and hardware modules. One such technology is the Vision Development (VDM) module, which contains hundreds of functions for the development and implementation of machine vision technologies. With the help of a comprehensive library of functions, you can access a large number of image processing algorithms and machine vision functions. This allows you to improve image quality, detect and identify objects, measure their parameters et.al. VDM also includes Vision Assistant – a tool that allows you to perform various operations on images, which greatly simplifies working with images [13].

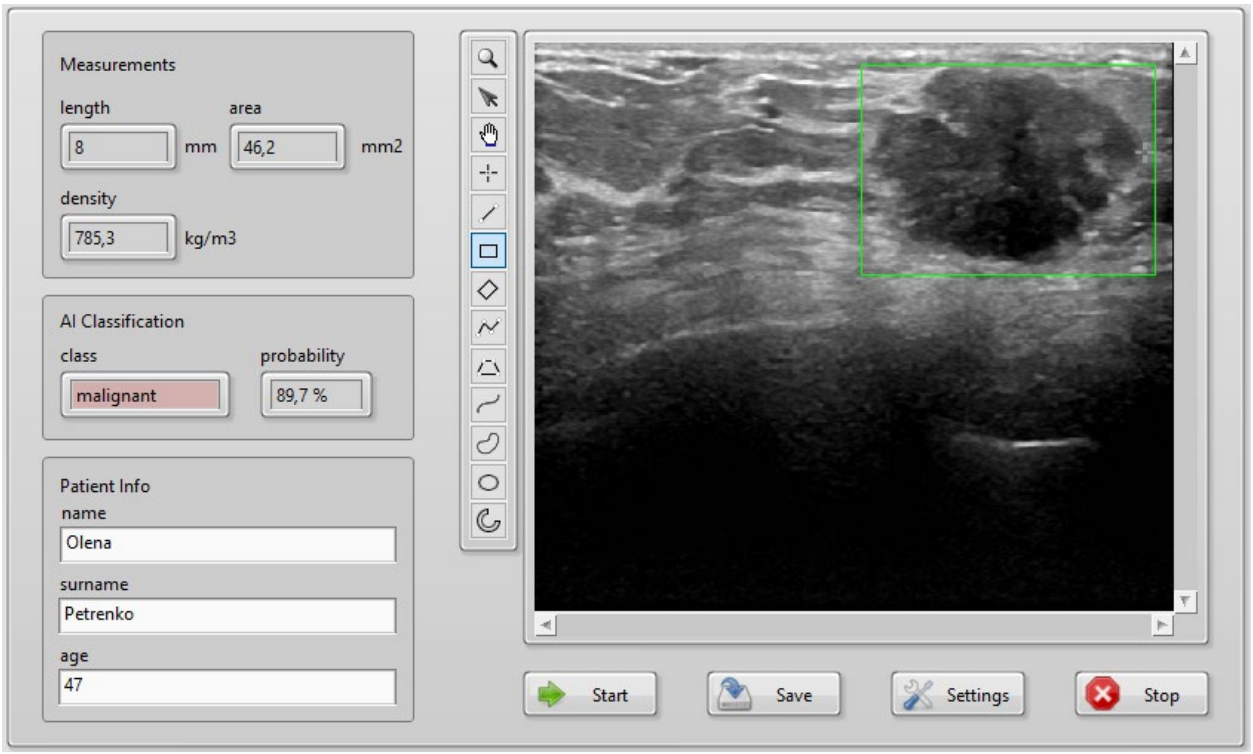

Fig 2. User interface of developed system

The combination of modern neural network architectures and available tools of the NI LabVIEW development environment allows to create a flexible and adaptive diagnostic system. The user-friendly interface will facilitate the doctor's interaction with the neural network module, which does not require special knowledge to use. In addition, NI LabVIEW provides tools for organizing data collecting and storing. This is important for building a base of learning patterns that can be used in the future to train and improve the neural networks.

Conclusion

The use of neural networks in medicine has great potential. The introduction of an automated system for diagnosing breast diseases can simplify the work of doctors and reduce errors in diagnosis, thereby reducing mortality from breast cancer. Neural network models considered in this work are successfully used in image classification tasks. As a result of comparing the characteristics, the EfficientNet model was determined to be the most optimal for medical image processing. This network is able to classify ultrasound images of the breast with an accuracy of 81.26%. To expand the functionality and improve the usability of the system, an interface based on the Vision Development module in the LabVIEW environment has been created. The main task for further research is to develop an algorithm for segmentation of tumors detected in images and combine it with the created classification algorithm to obtain more informative results.

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