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RESEARCH ON THE EFFECTIVENESS OF CLASSIFYING THE REMAINS OF DESTROYED BUILDINGS USING MOBILENETV3 NEURAL NETWORK ARCHITECTURE

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In modern conditions, when a significant part of the civil and critical infrastructure is destroyed as a result of military aggression, man-made or natural disasters, there is an urgent need to analyze the remains of destroyed buildings [1]. Rapid assessment of the condition of damaged objects requires the use of technologies that allow for the rapid acquisition, processing and analysis of large volumes of photo data. In this context, robotic ground systems that provide access to hard-to-reach or dangerous areas are of particular value [2].

Previous studies by the authors have confirmed that neural networks [3], in particular deep learning models [4] and convolutional architectures [5], demonstrate high efficiency in image processing due to the ability to accurately recognize objects [6] and classify them by various features, such as type, shape, and material [7].

Thus, the task of implementing software for neural network analysis of photo data of remains of destroyed buildings using robotic technology is relevant in modern conditions. Existing works show a limitation in the number of classes for recognition, which indicates the feasibility of further expanding the volume of training samples and including a larger number of types of remains of destroyed buildings.

The purpose of the work is research on the effectiveness of classifying the remains of destroyed buildings using MobileNetV3 neural network architecture.

The "tkinter" library was used to create a software application for interacting with pre-trained neural networks. A screenshot of the implemented software application is shown in Figure 1.

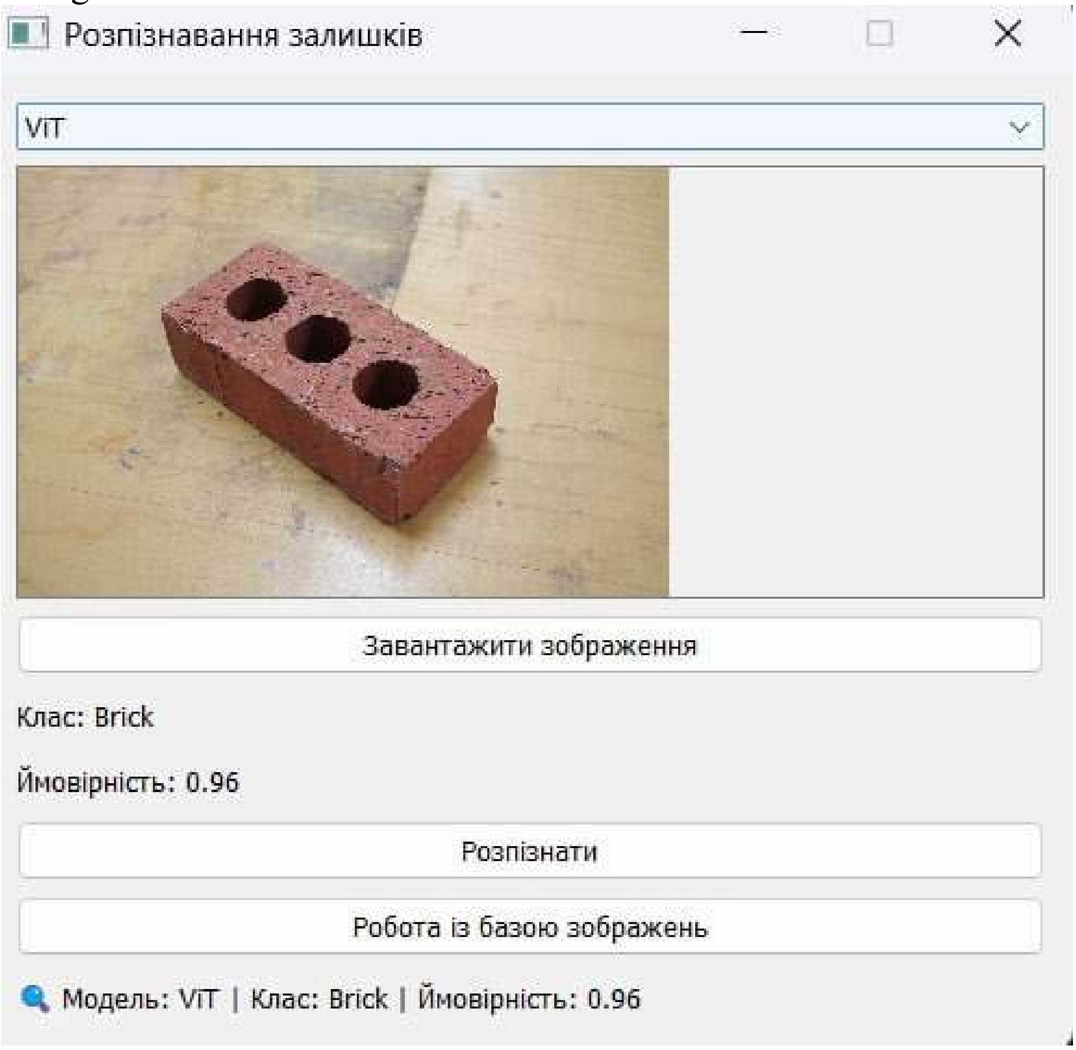

Figure 1. Screenshot of the implemented software application for neural network analysis of photo data of the remains of destroyed buildings

The application for recognizing the remains of building materials is implemented in the form of a graphical interface that provides user interaction with the neural network. The interface allows you to select one of the available models for image classification, after loading the image via the appropriate button, it is displayed in the preview window, which allows you to make sure that the choice is correct.

After clicking the "Recognize" button, the program processes the image and performs classification based on the selected model. The result is a determined class of the object in the image, as well as the probability value with which the model made this decision. Additionally, a button has been implemented for working with image database, which provides access to the functionality for managing saved data.

To test the software for neural network analysis of photo data of remains of destroyed buildings from robotic equipment, the Pytest library was used and unit testing was conducted. The results of the testing are presented in Figure 2.

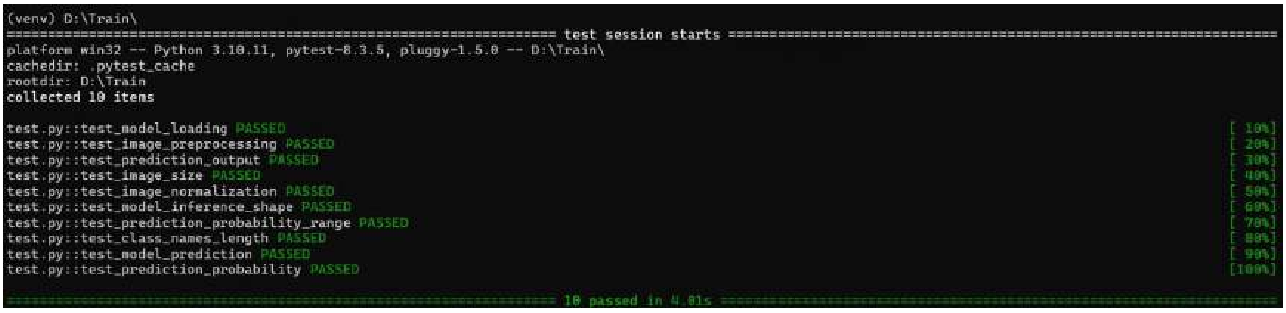

Figure 2. Results of software testing using the Pytest library

As part of the unit testing, a comprehensive test of the key functional components of the developed neural network image classification system was implemented. The testing covered both basic functionality and processing of boundary situations. In particular, the correctness of model loading, correct processing of input images, including resizing and normalization, as well as the accuracy of the softmax function and the output of the predicted class along with the corresponding probability were checked. Special attention was paid to the stability of the system when processing incorrect or non-standard input data, such as images of the wrong size, and the possibility of batch processing of several images simultaneously was checked. The operation of functions for saving classification results and the correctness of deriving probabilities for each class were also tested. The results obtained showed stable operation of all system components in conditions close to real use.

As a result of the research, software was developed for neural network analysis of photo data of remains of destroyed buildings obtained from robotic equipment. A full data processing cycle was implemented - from image preparation and model training to the creation of an application for automated classification of fragments of building materials.

The proposed solution can be used in automated waste sorting systems or monitoring of destruction zones to speed up the process of assessing and disposing of construction waste.

Training of neural network models implements the process of learning models using the following parameters: number of epochs – 6, batch size – 64. Training is performed on a pre-prepared set of images of construction debris. The software application for using neural networks provides interactive user interaction with pre-trained neural networks, in particular, it allows viewing photo images, editing the image database, and performing neural network analysis of photos to classify types of construction debris. First, the input images are prepared according to the requirements of the neural network architecture. For the MobileNetV3 model, this includes resizing the images to 224×224 pixels, converting them to tensors, and normalizing the values in the range from 0 to 1.

The training results (Table 1) of the MobileNetV3 neural network model demonstrate high efficiency in classifying images of the remains of destroyed buildings.

Table 1 – Results of training of MobileNetV3neural network model

Garbage category	Precision	Recall	F1-score
Brick	0.97	0.97	0.97
Concrete	0.98	0.97	0.98
Foam	0.91	0.95	0.93
General_w	0.91	0.92	0.92
Gypsum_board	0.97	0.96	0.97
Pipes	0.81	0.90	0.85
Plastic	0.83	0.76	0.79
Stone	0.99	0.98	0.99
Tile	0.96	0.95	0.95
Wood	0.98	0.97	0.98
Macrometrics			
Accuracy			0.95
Macro avg	0.93	0.93	0.93
Weighted avg	0.95	0.95	0.95

Based on the presented ROC graph (Fig. 2), obtained as a result of the classification of construction waste using the MobileNetV3 neural network, we can conclude that the model has a high discriminative ability. The area under the ROC curve (AUC) values approach 1.00 for all classes, which indicates that the model almost accurately separates positive samples from negative ones within each class. The curves are concentrated in the area of a high level of true positives and a low level of false positives, which is typical for models with high accuracy.

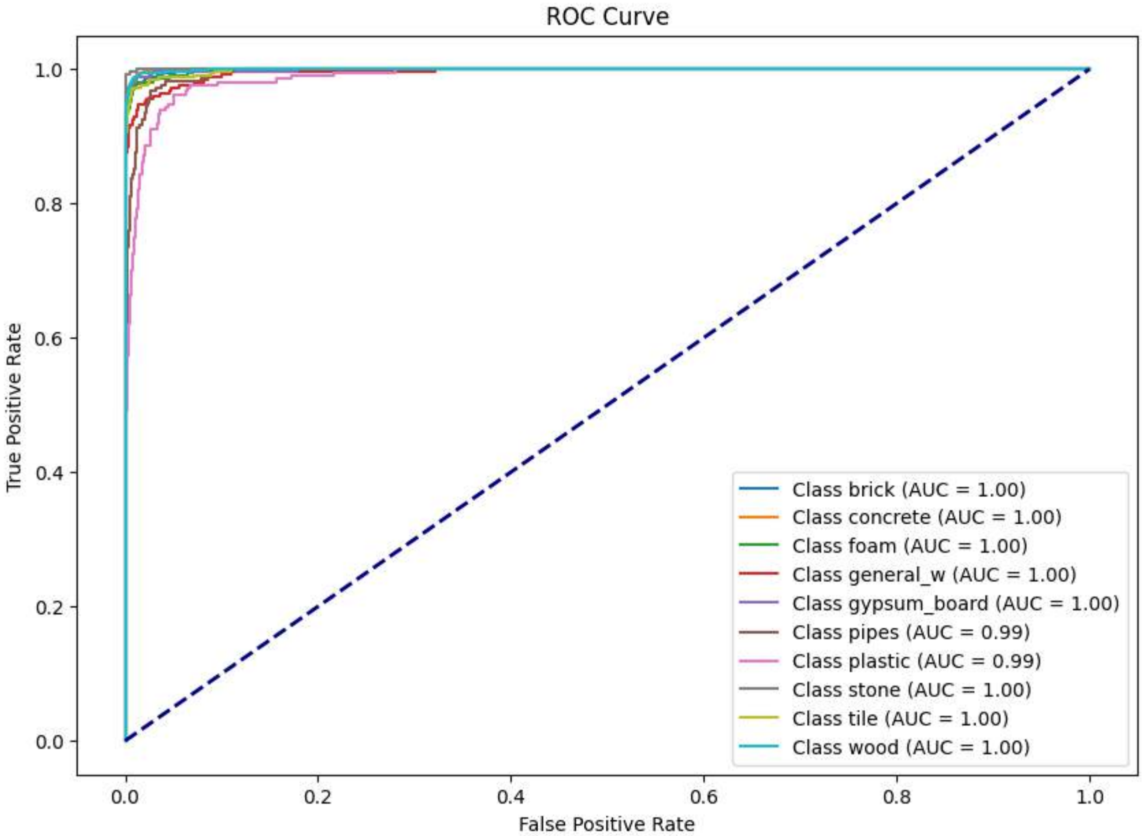

Figure 2. ROC curves for the MobileNetV3 model

A slight decrease in the AUC value to 0.99 for individual classes may indicate the presence of single false predictions or insignificant intersections in the feature space between these classes. This does not significantly affect the overall quality of the model, but may be important in the case of critical applications, where even a minimal number of false positives is unacceptable.

Overall, the results demonstrate the effectiveness of MobileNetV3 as an architecture for multi-class object classification tasks in the field of construction debris image processing. To finally assess the suitability of the model for practical application, it is necessary to additionally consider the Precision-Recall metrics, error analysis, and stability on independent test samples.

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