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Improving Efficienty of Image Recognition Process: Approach and Case Study

Artem Svyrydov [1], Heorhii Kuchuk [2], Olha Tsiapa [3]
[1] Kharkiv National University of Radio Electronics, 14, Nauki Ave., Kharkiv, 61166, Ukraine, svyrydovartem@gmail.com
[2] National Technical University "Kharkiv Polytechnic Institute", 2, Kyrpychova str., Kharkiv, 61002, Ukraine, kuchuk56@ukr.net
[3] Kharkiv National University of Radio Electronics, 14, Nauki Ave., Kharkiv, 61166, Ukraine, olga.tsyapa@gmail.com

Abstract—**The article considers existing algorithms for image recognition and analyzes their shortcomings. Sequences of operation of algorithms are considered, conditions are defined under which existing algorithms of preliminary processing and segmentation can improve the process of image recognition. Based on the research, an approach was proposed to select algorithms for such stages as pre-processing and segmentation, which in turn allows to improve the quality and speed up the process of image recognition.**

Keywords—image recognition, preprocessing, segmentation, neural networks, algorithms, artificial intelligence

I. Introduction and Motivation

Nowadays, image recognition is used for a wide range of tasks. Such tasks can be used in different spheres and have different complexity. The tasks of object detection (as a start point of image recognition) can be classified by purpose in this way:

- searching objects on the image;
- making a decision about the presence of an object on the image.

In the process of image recognition, there is no universal method that will fulfill all the requirements for the task. For example, if you need to find cars on the image, or if you need to recognize handwriting text, sequences of actions will be the same, but the algorithms will be different. That's why existing methods can partially or completely duplicate each other, be modified, unified, or be an exact copy with the replaced parameters [8]. All these actions are carried out to be able to adjust the existing methods for a new type of tasks.

The existing methods of image recognition are rather difficult to group, because the same group of methods can satisfy one requirement and not fulfill the other. Some sources suggest that existing methods can be represented as three main groups [2], [6], [7]:

- methods of comparison with the sample;
- statistical methods;
- artificial intelligence methods.

Such groups as methods of comparison with the sample and statistical methods are most often applied to the problems of making decisions about the presence of an object on image, i.e. tasks of finding the required objects on the image. They are based on finding objects by basic transformations, such as changing the angle of the slope, scaling the image, and so on. Also, these methods use basic segmentation algorithms to analyze the contour of the sought object [3]. Artificial intelligence methods allow to find not only the necessary objects, but also can decompose the image into objects that are presented on it, result presents as a list of such objects. For example, neural network during image recognition is guided by a certain pattern of pixels' sets locations, color values and modifications varieties of such sets [5]. Input image might be not enough segmented, that's why neural networks can use segmentation for restoring contours to identify missing objects.

However, all the above methods use the same sequence of image recognition stages, Fig. 1.

A significant difference between the use of groups of methods of comparison with the sample and statistical methods, as well as a group of methods of artificial intelligence is the use in certain ratio certain stages of image recognition Fig. 1.

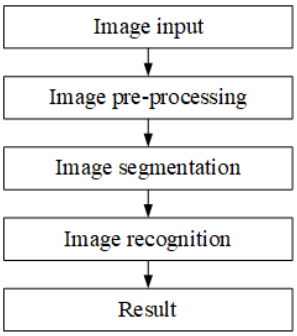

Figure 1. Image recognition stages sequence

The groups of methods of comparison with the sample and statistical methods use classical algorithms in the stages of preprocessing and segmentation. Such

approach is not always a rational solution for the task. Artificial intelligence methods, due to their learning ability, receive more accurate results, but the lack of preprocessing of images and the inefficiency of segmentation algorithms do not always lead to satisfactory results, even if neural network is well trained. Thus, for each new image recognition task, it's necessary to find effective algorithms for preprocessing and segmentation.

II. Goals And Tasks

Analysis of image recognition methods has shown that most of them use classical algorithms on the preprocessing and segmentation stages. The classic preprocessing stage usually consists of image rotating, adjusting the brightness, contrast; segmentation stage is the allocation of useful details, their boundaries and transitions within the image.

However, only some of the existing methods of image recognition use more complex algorithms for the preprocessing and segmentation stages. The choice of such methods passes exclusively for specific tasks, and only if such conditions are met they can increase the speed and quality of image recognition

The aim of this paper is to develop an approach for improving the efficiency of the image recognition process.

III. Image Recognition Process Approach

One of the possible ways to improve the efficiency of image recognition is to develop an approach based on the rational algorithms selection on such stages as preprocessing and segmentation. This approach is based on the information analysis obtained from the image and from all stages, for the further use resulted image and the information obtained in the image recognition process.

The proposed approach differs from the classical by updated stages, such as:

- image analysis;
- preprocessing algorithms selection;
- segmentation algorithms selection.

Also, at each stage, the rules for choosing an algorithm or a sets of algorithms are used. The stages of the proposed approach are shown in Fig. 2.

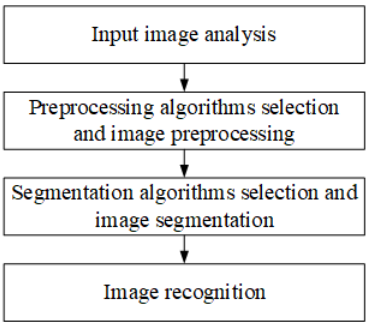

Figure 2. Stages of the proposed approach

The proposed approach includes four main stages, described in Table. 1.

TABLE I. MAIN STAGES OF THE ALGORITHM SELECTION APPROACH

Stage name	Sequences inside of the stage
Stage 1. Input image analysis	1. Image input
	2. Image key characteristic analyses
	3. Obtaining useful information from image
	4. Output the image to the next stage
Stage 2. Preprocessing algorithms selection and image preprocessing	1. Selecting preprocessing algorithms
	2. Application of algorithms to an image
	3. Getting the processed image
	4. Output the image to the next stage
Stage 3. Segmentation algorithms selection and image segmentation	1. Selecting segmentation algorithms
	2. Application of algorithms to an image
	3. Getting a set of segmented images
	4. Combining segmentation results
	5. Output the image to the next stage
Stage 4. Image recognition	1. Checking the recognition system for additional parameters
	2. Image transfering to the recognition system

Stage 1 Input image analysis

If image is loaded successfully, it is checked against the key characteristics (parameters) 1.1-N.N, such parameters as resolution, format, color, etc. Fig. 3. Based on the received image characteristics, information is generated in the form of restrictions on the use of algorithms in the following steps.

The information obtained at each stage is used to reduce the selection error and apply the algorithms in subsequent stages. When ambiguous results occur, an amendment is introduced.

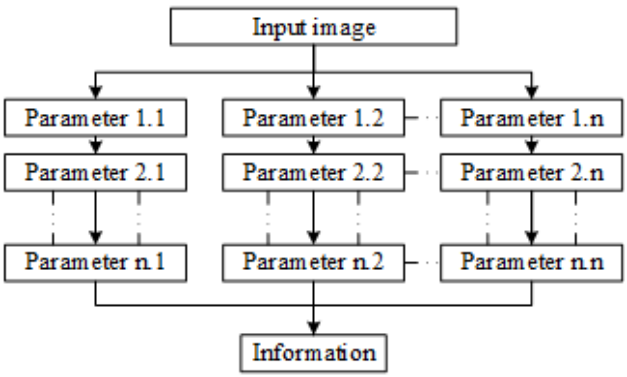

Figure 3. Input image analysis

Stage 2 Preprocessing algorithms selection and image preprocessing

Based on the information obtained in stage 1 and image analysis, are proposed the most suitable preprocessing algorithms. The stage of preprocessing algorithm selection and image preprocessing is shown in Fig. 4. During the execution of this stage, information is generated about the algorithms that have been selected and applied to the image. This information is combined with the information obtained during the analysis of the input image.

As the result on this stage we have processed image, prepared for the next stage.

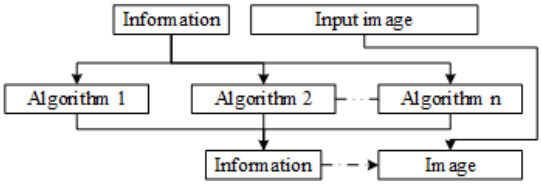

Figure 4. Preprocessing algorithms selection and image preprocessing

Stage 3 Segmentation algorithms selection and image segmentation

At the stage of image segmentation, the information of the previous stages is analyzed Fig. 5. Based on this information, several (n) image segmentation algorithms are selected. Each of the selected algorithms is applied to the image obtained from the previous stage and saved as a separate image. As a result, we have a set of (n) images, each of which is processed by its own algorithm for allocating useful image segments (segmentation).

Then, at the segmentation stage, the algorithm is used to combine the results. All (n) images obtained at this stage are superimposed on each other, using the so-called "overlap", the general results for different segmentation algorithms are highlighted.

As the result of this stage we have a detailed image, as well as information supplemented by the selected algorithms.

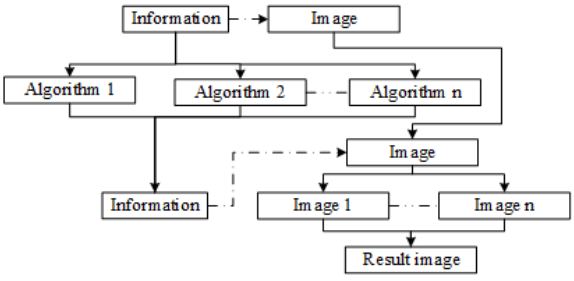

Figure 5. Segmentation algorithms selection and image segmentation

Stage 4 Image recognition

The image obtained as a result of stages 1-3 is transferring to image recognition tools Fig. 6. All additional information about applied algorithms is transferring as additional parameter too.

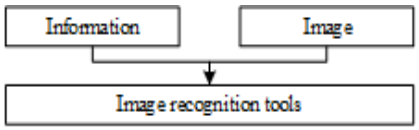

Figure 6. Image recognition

Neural networks, depending on the task, can well cope with the task of recognition. However, the results are good when the neural network was well trained and the image submitted to the input was qualitative. This approach allows preprocessing and segmentation for cases where the neural network does not perform these actions, for cases where the neural network implements image processing, this approach is pre-pre-processing of images. Neural networks are not part of the approach, but are the resultant block at the input of which the approach results are submitted.

The general scheme of the proposed approach for increasing the efficiency of the image recognition process is shown in Fig. 7.

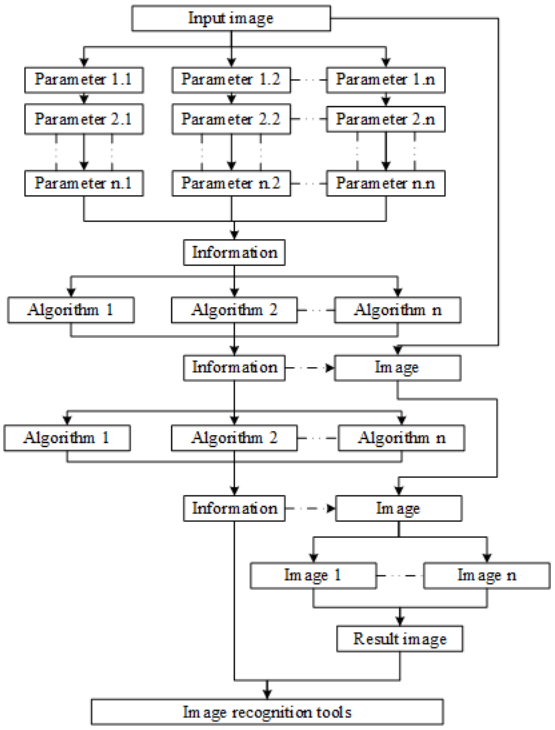

Figure 7. General scheme of the proposed approach

Existing convolutional neural networks allow to some extent present these steps as a "black box", but this approach allows to automate and optimize the choice of

algorithms for a specific image for the pre-processing and segmentation steps, when in turn the "black box" convolutional neural networks will offer algorithms suitable for the task of a neural network. The training process on the incorrect selection of images can lead to the fact that learning the steps of the "black box" will lead to a decrease in the results of this image, in this case this approach will compensate for the error of the "black box" of the neural network.

IV. Case Study

The proposed approach for improving the efficiency of the image recognition process was tested using library TensorFlow. The choice of TensorFlow is due to the fact that its application in the form of program code is quite common, it is used in embedded systems, on all major mobile platforms and on the web. This library is distributed under the Apache 2.0 open source license and developed for machine learning by Google [4]. We will use a MobileNet, input image resolution will be224px, the relative size of the model will be 0.50 and amount of training steps will be 4000. After this we will have the accuracy of neural network value between 85% and 99%.

Such parameters as "evaluation time" and "score" were determined by analyzing TensorFlow library. The "evaluation time" parameter is measured in seconds, the "score" parameter takes values in the range from 0 to 1. In addition, the results of the library's work were verified by adding the same image. When the same image was re-recognized, the results of the parameters were constant. Based on the selected parameters, the output parameters of the proposed approach and the application of the classical methods, were transmitted to the input of the image recognition system. Images without any preprocessing and segmentation were also sent to the library, to obtain the comparative characteristics, the results are shown in Fig. 8, Fig. 9, Fig. 10.

The proposed approach was tested using two neural networks with different levels of training [1].

Neural networks as a tool for recognizing or detecting objects can accept different images, different formats, resolutions, etc., respectively, this approach is not an approach designed for certain specific types of images, but allows to optimize with different degrees' different types images. The selection of images for training could include from one object in the image to a set of objects. For approach results checking, different images were uploaded to the input, containing from one object to several. The first neural network was trained on images set with a wide range of categories, while the selection of images for each category was not complete enough. As a result of this "score" value, shown in Fig. 8, have sufficiently low rates. Despite the low values of the "score", the images for which the proposed approach was applied showed better results of recognition than images without any preprocessing and segmentation algorithms or classic methods.

The second neural network was trained on images set with a narrow range of categories, while the selection of images for each category was complete. In Fig. 9 and Fig.10 show the values of the "score" parameter. Most of the images have a quite good recognition results, because of this it can be concluded that the recognition was carried out quite efficiently. Results obtained with the proposed approach showed values better than the classical methods of preprocessing and segmentation or images without any preprocessing and segmentation.

Fig. 10 is a graph of the time taken to recognize the image. Based on the obtained results, can be concluded that the time taken to recognize the images to which the proposed approach was applied is significantly less than the time spent on recognizing the image without processing or image with classical methods of preprocessing and segmentation.

As a result of the comparison was revealed that images that were not processed, as well as images for which classical algorithms were applied, on average showed results worse than images for which proposed approach was used to.

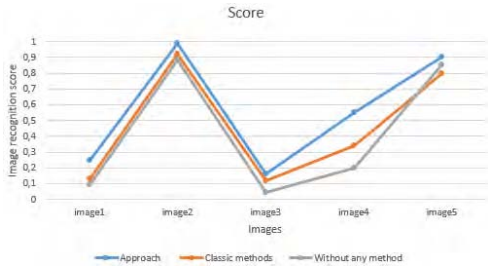

Figure 8. The value of "score" for a neural network with a wide range of categories

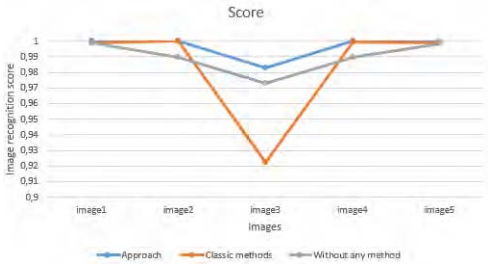

Figure 9. The value of "score" for a neural network with a narrow range of categories

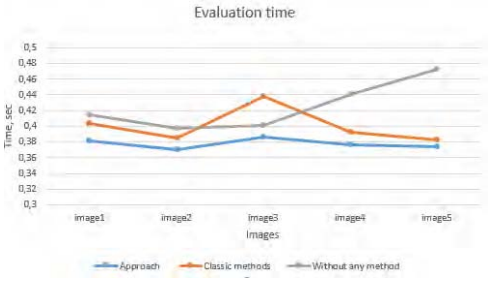

Figure 10. The "evaluation time" value for a neural network with a narrow range of categories

This approach allowed to increase the speed of image recognition, relatively to images that were processed using classical methods of preprocessing and segmentation on average by 5-6%, and relatively to images that were not processed – by 11%. At the same time, the value of the parameter "score" in the proposed approach to classical methods of preprocessing and segmentation increased by 0.5%, and relative to raw images by 1.27%. This approach can be used in recognition systems and get a shorter image recognition time and better quality on a large set of data.

V. Conclusion

In this paper, was proposed an approach to improve the efficiency of the image recognition process. The approach is based on detailed analysis and selection of algorithms in the preprocessing and segmentation stages, by collecting information at each stage. Information obtained on each stage, reduces error of selection and applying algorithms in subsequent stages, in case of occurrence ambiguous results, to introduce a correction for the algorithms already used.

The input data, both for object detection and for recognition, are images. The process of recognizing and classifying objects on an image goes as follows: object detection, analysis, recognition and classification. Despite the fact that the process of object detection and the process of recognizing these objects are two huge areas of knowledge, the proposed approach, by improving the quality of the image, allows to increase the results of object detection, and, directly, recognition and classification.

The application of the proposed approach allows to increase the speed and quality of image recognition, in particular, using neural networks with different degrees of training, by introducing an additional parameter into the neural network in the form of additional information. For example, the speed of images recognition with the proposed method, relative to images that were processed using classical methods, is increased by 5-6%, and relative to images that were not processed – by 11%.

References

[1] Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems”, O'Reilly Media, Inc., 2017, 572 p

[2] Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 738 p, April, 2011.

[3] David Barber, “Bayesian Reasoning and Machine Learning”, Cambridge University Press, 1 edition, 735p, 2012

[4] Nick McClure, “TensorFlow Machine Learning Cookbook”, Packt Publishing, 370 p, 2017

[5] O. G. Rudenko, A. A. Bezsonov, A. S. Liashenko and R. A. Sunna, “Approximation of Gaussian basis functions in the problem of adaptive control of nonlinear objects” Cybernetics and Systems Analysis, Vol. 47, pp 1–10, No. 1, January 2011.

[6] Rafael C. Gonzalez,“ Digital Image Processing (3rd Edition)”, Pearson, 976 p, 3 edition, 2007

[7] Richard O Duda, “Pattern Classification”, BWSTM; 2 edition, 738p, 2007

[8] Yaser S. Abu-Mostafa, Malik Magdon-Ismail and Hsuan-Tien Lin, “Learning From Data”, AMLBook, 213p, 2012