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# ANALYSIS OF SELECTED METHODS FOR PATTERN RECOGNITION

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**ABSTRACT**
*The general goal of the presented research is to develop a system for recognition and classification of digital images. Classical and artificial intelligence methods were applied and several tests were conducted. Among others, the capabilities of procedures implemented in LabView package were tested. The paper deals with some examples of image classification application in machine technology. First, a concept of hand gesture classification for machinery control and diagnostics is discussed. Then, recognition of cutting tools is presented. Also, noisy images of machine tools are considered for classification. Analysis of obtained results summarises the paper.*
**Keywords**: image processing, image analysis, computer vision, machine technology

## 1. INTRODUCTION

Machine vision is the application of computer vision to industry and manufacturing. Machine vision systems are programmed to perform defined tasks such as counting objects, reading serial numbers or searching for surface defects. Computers do not 'see' in the same way as human beings are able to and cameras are not equivalent to human optics. While people can rely on inference systems and assumptions, the computing devices must 'see' by examining individual pixels of images, processing them and attempting to develop conclusions with the assistance of knowledge bases or pattern recognition engines. Image classification is the part of image recognition, but some people defined classification as recognition. It is a process in which analysed objects of image are selected and assigned to a defined class.
This paper is focused on the problem of object classification in images. Such an approach could be used in diagnostics of machine tools [2, 3]. First, a concept of hand gesture classification for machinery control and diagnostics is discussed. Then, recognition of cutting tools is presented. Also, noisy images of machine tools are considered for classification. Analysis of obtained results summarises the paper.

## 2. SELECTED TESTS

The first analysed problem is related to aiding diagnostics or control of machine tools (Fig. 1). While diagnosing a machine tool different information is necessary for revealing reasons of malfunctioning. The machine tool operator must frequently access different databases or must communicate with expert systems that would be helpful in making proper decision. We assume that visual communication with databases or expert systems would be very desirable and could substantially simplify the operator activities.
Within the presented research we tested possibility of gesture recognition as a way of visual communication. In the first part of the research, images of hand in RGB scale were tested. There were 5 classes of gestures (Fig. 2). Each class contained 20 samples, i.e. 20 images of hand kept in close

distance to the camera and in far from the camera. In the conducted tests, 25% of each class of gesture was randomly selected and kept as a training set while the remainder was used for testing.

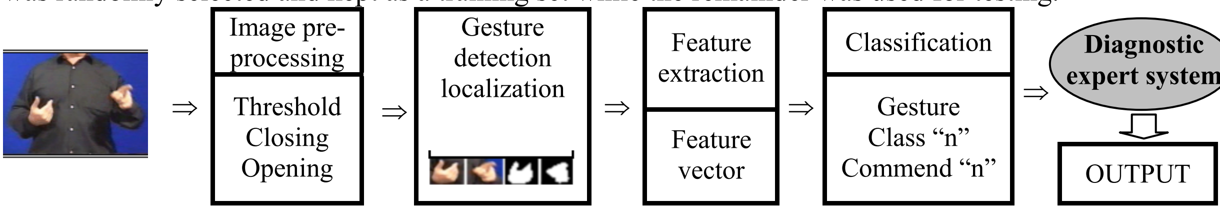


*Figure. 1: Concept of gesture recognition*

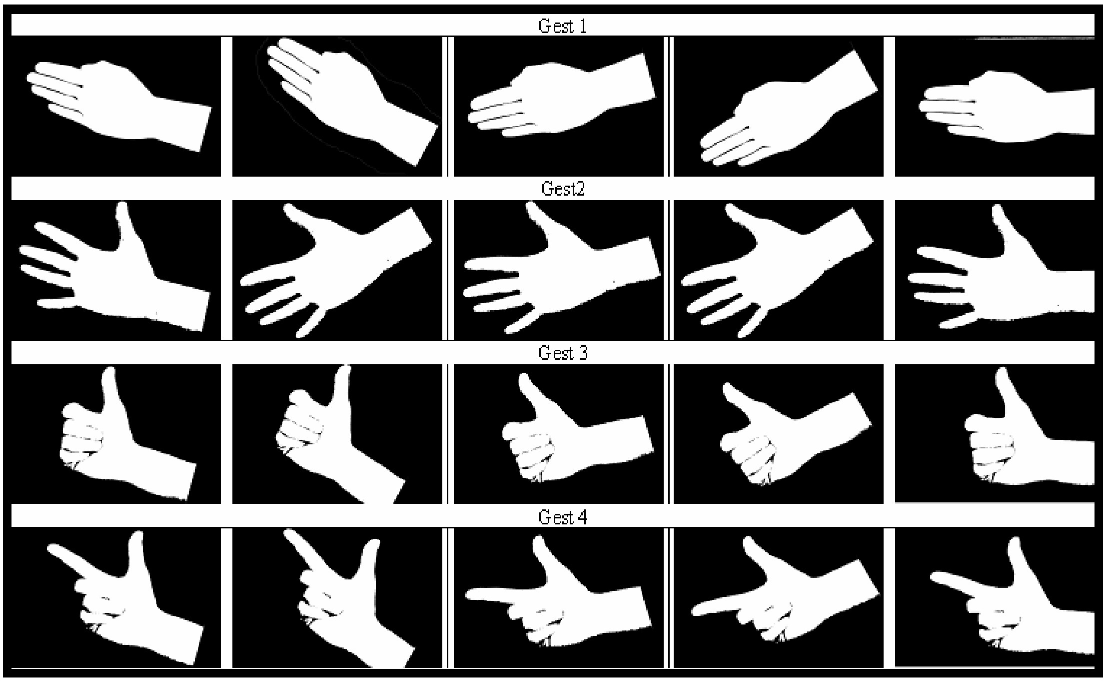


*Figure. 2: Examples of analysed gestures*

The following approaches to gesture recognition were implemented:

- Method consisting in detection of characteristic points in image based on pattern matching.

Here, finger tips were used as patterns. Different values of minimal similarity coefficient were analysed since these values have essential influence on level of gesture recognition.

- Method consisting in distance measurement between centre of hand and characteristic points.

This method applies the calliper function available in LabView package. This function allows making different geometrical measurements based on characteristic points. In the tests, membership to defined classes was decided based on distance between finger tips and gesture centre of mass. The centre of mass was determined by particle analysis. This approach required finding the thumb, first. Then, “straight fingers” were to be determined. A finger was considered as a straight one if the distance from centre of mass to finger tip was at least 90% of such a distance determined for the thumb.

- Method consisting in colour matching.

Colour matching function creates spectrum of all colours appearing in the researched hand images. The classification is done based on comparison of created spectra. Unfortunately colour matching function strongly depends on lighting conditions. Therefore, bright and dark images were frequently misclassified.

- Method consisting in edge length measurement of an object with usage of statistical data.

Tests were conducted based on perimeter of hand measured in image. Gauged values of object perimeter were compared with pattern values, which were obtained from statistical computations done with samples from particular class.

- Distance methods.

In the conducted tests the following classifiers were applied based on LabView package [1]: Nearest Neighbour classifier, K- Nearest Neighbour and Minimum Mean Distance classifier. Also, different distance metrics were applied [1], i.e. Maximum, Sum and Euclidean distance.

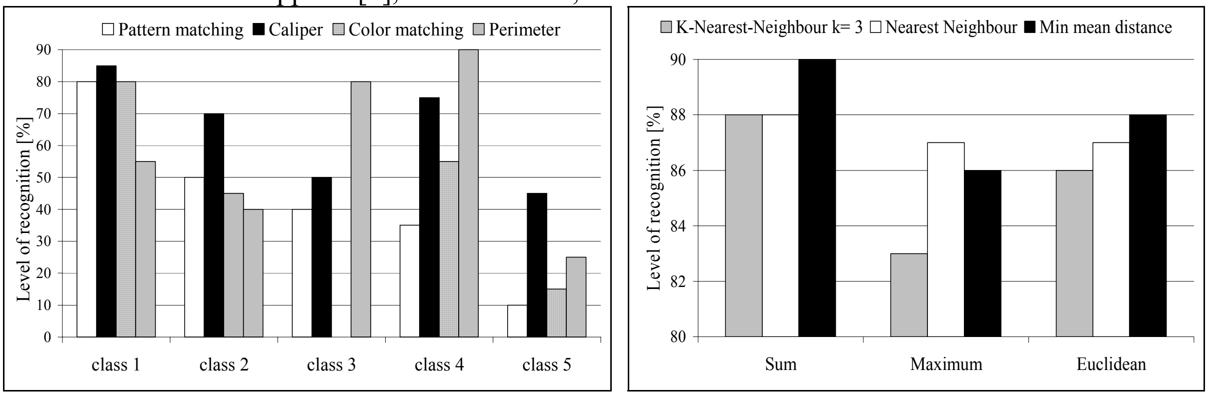


*Figure 3: Results of gesture classification.*

*Figure 4: Examples of analysed cutting tools.*

In the case of gesture classification, the research was conducted in two steps. First the images without pre-processing were analysed. The testing phase indicated that the classifiers do not perform as we expected. After examining the misclassified gesture instances, it was found that most of the misclassifications were caused by small particles in images. Therefore, in the next step of experimental procedure, image pre-processing was done. The goal of such approach was to check morphological transformation influence on improvement of classification quality. It must be underlined that the images were represented in an indirect form the classification purposes. It means that for each image a certain set of features was extracted. Feature extraction should allow distinguishing small differences between sample shapes independent on scale, rotation and mirror symmetry. For the tests, the features related to the Heywood circularity factor and elongation factor were extracted. The extracted features formed the vectors for training and testing of classifiers.
Experimental results, shown in Fig. 3, reveal that Nearest Neighbour classifier is the most appropriate in terms of recognition performance for the gesture set used in our experiment. Results obtained with the binary morphology functions improved classification performance in comparison to those without pre-processing option. Finally, it should be emphasised that the level of correct classification cannot be uniquely considered as satisfying. It is easy to notice that in the best case, 10% of misclassification occurs. From practical point of view it means that in 10% of cases a machine can be wrongly controlled or wrongly diagnose.
Another example discussed in this paper is related to cutting tool classification. The inspection system must allow the classification to be fast and reliable while also assure that the training of the classifier is simple and not time consuming. Tools with adapters (two drills of different diameter and length, milling cutter and centre point) and tools without adapters: milling cutter, turning cutting tools, rack and drill were tested, as shown in Fig. 4. In the first step of experimental procedure, image pre-processing was done. We used grey scale morphology functions to filter or smooth the pixel intensities. Next, we used the Classification Training Interface [1] to teach our application the types of objects, which we wanted to classify. The tools with and without adapters were analysed independently. In the following step, the Classification Training Interface created the classifier files, which we used to classify unknown objects into one of the classes. Both of created classifiers contained a set of 4 classes. The verification set contained 4 examples for each classifier, one for each class. In order to test classification robustness, the tools were rotated in different directions. The

classification was performed with Nearest Neighbour and K – Nearest Neighbour classifiers and the Sum distance metrics. The classifiers correctly classified all tools.

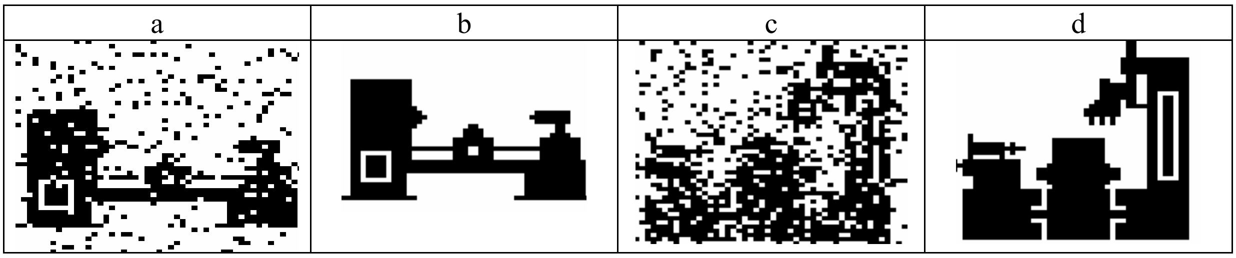


*Figure 5. The standard images with different level of noise: 10% level of noise (a), recognized object: turning lathe (b), 20% level of noise (c), result: machining centre (d).*

- Neural network approach.

Artificial neural networks are widely applied for pattern recognition. In this paper we present an approach of initial correction of digital images with application of Hopfield neural network. Fig. 5 shows noisy and “clear” images of turning lathe and machining centre. Each image is considered as matrix 50 x 50 with binary elements of [1;-1], where 1 was denoted as white area whereas -1 was denoted as black area. For simulations, Hebb law was used as learning method of Hopfield network.
The tests of Hopfield network were conducted with application of two reproduction methods, i.e. synchronous and asynchronous method. The tests included adding noise to each standard image within the range from 0,0% to 45%. With increasing level of noise increases the Hamming distance between the noisy object to recognize and the standard image. It causes that Hopfield network can have more troubles with indicating correctly the standard image. However, during conducted simulations, the Hopfield network always correctly recognized analysed images while the synchronous method was used. In the case of asynchronous approach, correct recognition depended on the number of iterations and the level of noise added to the image. For example, it has been revealed that the minimum number of iterations to avoid misclassification was of 18500 in the case of noise level of 20%.

## 3. CONCLUSIONS

Some examples of classification of objects in images were presented in the paper. Applied algorithms are able to detect objects in frontal, slightly rotated and partially cluttered background. The fundamental aim of presented investigation was an estimation of classical algorithms and artificial intelligence based approaches for classification of objects for machine tool diagnostics. Within framework of this paper minimal distance algorithms were compared and results of tests of cutting tool classification and gesture classification were presented. All tests were conducted in LabView package. In the case of cutting tool classification, good results were obtained for two applied classifiers, i.e. all tools were correctly classified. However, the images contained simple tools were taken in ideal conditions. On the basis of gesture classification we stated that application of the binary morphology functions improved the quality of classification. It was found that size of applied images doesn’t affect quality of classification. However, the number of classes and number of features must be taken into account. Especially, selection of features for proper image representation seems to be principal. Here, several different feature selection techniques can be applied. This problem defines our future work.

## 4. REFERENCES

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