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Shape measurements of production details supported by artificial intelligence

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ABSTRACT

The dynamic development of artificial intelligence systems and the implementation of robotic industrial lines require increasingly complex tasks to be solved and simultaneously require the automation of traditional metrological measurements. Machine vision systems can support metrological processes, especially in the field of industrial inspections, ensuring fast and efficient measurements without disrupting production continuity. The use of machine vision in metrology can support quality control in the production process by appropriately adapting the capabilities of vision applications to the specifications and requirements of a given metrological task. This paper presents the use of a selected artificial neural network model to detect the correct shape of parts produced by the spinning method. After training, the CNN model - Xception - was used to classify the shape of correctly and incorrectly manufactured production parts. For this purpose, a database of part images was prepared and used for training, validation, and testing of the selected artificial neural network model. Experimental results from the Xception model demonstrated classification accuracy approaching 100%.

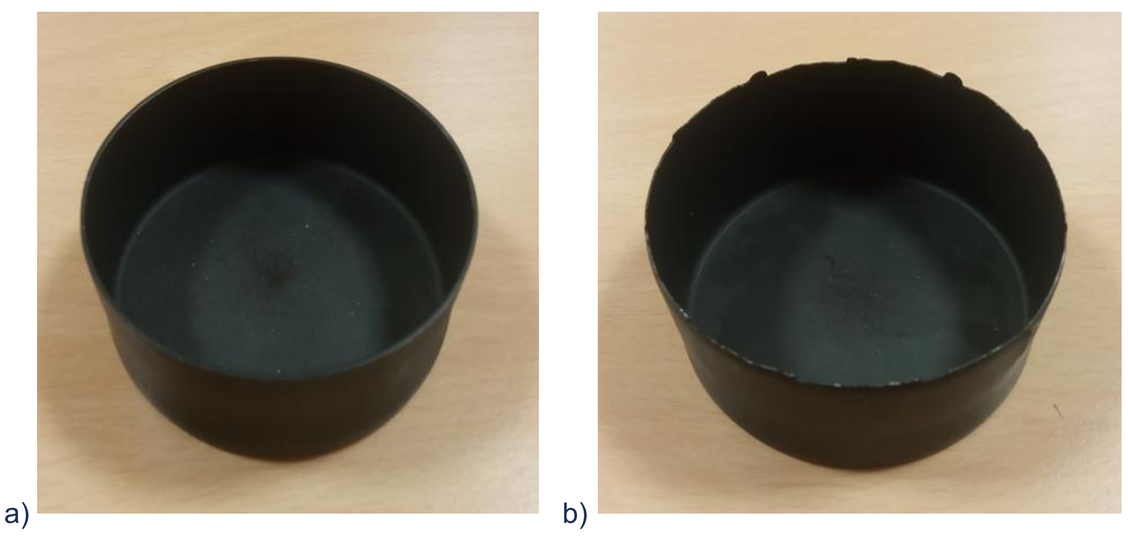
Keywords: industrial metrology, artificial intelligence, vision system, industrial robots, quality control

OBJECTIVES

The task of classifying details of the correct height, but defective, was subjected to experimental studies using the architecture of the CNN - Xception [1] model with the appropriate size of the classification and size of the training image database adapted to the given task. An author's database with a total number of samples of 2652 photos has been prepared (Tab.1). The collected photos (Fig.1) were assigned to two data sets:

Table 1. Number of photos to classify the details correctly made

Data sets	Number of samples
Details made correctly	1998
Details made defectively	1654



a) b)

Figure. 1. Examples of images from the collection: a) details made correctly, b) details made defectively

ACCURACY STUDIES AND ANALYSIS OF MEASUREMENT RESULTS

Proper training of the selected model of the artificial neural network required the division of databases into collections: teaching 60%, validation 20% test 20%. The division into separate collections is carried out in order to avoid the phenomenon of network relearning [2]. In addition, a five-fold validation of the model was used (K-fold cross-validation), using a different part of the database as a validation set each time [3]. The results of the experiments on the classification of the correct shape of the details are presented for the Xception model in Table 2.

The model training accuracy graphs for the learning and validation set are shown in Figure 2. The accuracy metric (1) was adopted as the criterion for assessing the classification, which gives a result describing the operation of the model in all classes. It is calculated based on the ratio of the sum of true positive samples and true negative samples to the sum of all values in the error matrix [4]:

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

Where: sum of True Positive samples (TP), sum of True Negative samples (TN), sum of False Positive samples (FP), the sum of False Negative samples (FN)

ACCURACY STUDIES AND ANALYSIS OF MEASUREMENT RESULTS

Table 2. The result of the accuracy of the detail classification for the Xception model

Average accuracy		
Training set	Validation set	Test set
99,85 %	100,00 %	100,00 %

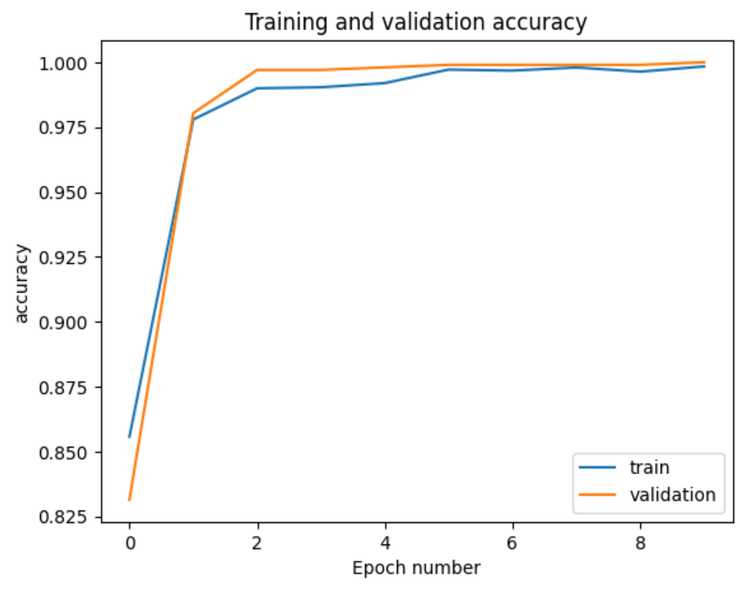


Figure. 2. Recognition accuracy graph for training and validation set – Xception model

The classification results for selected images from the test collection are presented in Table 3.

Table 3. Probability results of recognized details from the test set

Photos of details made correctly/defecively		
Probability of classification (Xception model)	correct = 100 %, defective = 0 %	correct = 0 %, defective= 100 %

CONCLUSION

The obtained results of classifying the shape of parts at the level of 100% accuracy allow the use of a model of a weaved neural network to assess the quality of workmanship of parts whose shape is irregular and the defect occurs in the form of edge degraded by a mechanical tool. The high accuracy score on the training set translated into a high score on the test set, so there was no phenomenon of overtraining the model. The presented solution, integrated with the production line infrastructure, can create a network of interconnected robotic measuring stations [5], the results of which, when sent to a database, would create automatic measurement documentation of the manufactured details.

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