APPLICATION OF MACHINE LEARNING IN THE ANALYSIS OF SURFACE QUALITY – THE DETECTION THE SURFACE LAYER DAMAGE OF THE VEHICLE BODY

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Abstract

Assessment of the surface of the car's element is an attempt to applythe image processing and machine learning methods for analysis of surface layer quality. In presented experiment set of the images with damaged surface layer of vehicles were used to design and train CNN for detection of scratches. Proposed approach provides promising positive results, and proved that it is possible to performed automatic detection of damaged surface of the vehicle. This experiment shows that there is still a lot of fields of application the image recognition with machine learning methods.

Keywords: Machine learning, object recognition, CNN, quality, surface layer, coating

1. INTRODUCTION

Machine learning methods are a part of artificial intelligence (AI) methods that are widely applied in numerus scientific fields, and became a part of everyday life by many commercial products, like internet browsers, algorithms analyzing our internet activity, due to for example specify the targeted advertisements in line with our interests [1]. Machine learning methods are applied in almost every branch of the science and business. It is dynamically developed in image recognition, partially due to application is security systems. On the base of machine learning methods there are numerous methods of face recognition. *CNN – Convolutian Neural Networks* is the term which is define as the information processing system, the mode of operation and structure of which are modelled on the work of the nervous system. From a biological point of view, we see the similarity in the neurons that make up the entire network. However, the difference here is the combination of neurons itself, which does not correspond to the actual neural structure. These networks have certain features that make them an excellent IT tool [3]. They enable solving problems without prior mathematical formalization. They also do not require the need to refer to theoretical assumptions related to the problem under consideration. Cause-and-effect relationships between input and output do not need to be enforced. The most important feature has become the network's ability to learn by using existing examples and generalizations.

In this research the machine learning methods in detection of damage surface layer of car body were applied. Automation of detecting damage to vehicle bodies and their subsequent classification would be helpful in many areas related to the automotive industry. A vehicle component may be damaged at the stage of its construction. Often the production process reveals defects in the varnish coat or the materials from which the element was made. Frequently the discovery of this fact occurs at the last stage of production, when the vehicle is completely assembled. There is a risk of increased costs due to disassembly, repair or replacement of the element and its reassembly. It is also possible to reduce the quality of the product, because re-varnishing of an element is associated with a change in its structure and thickness, which can be easily detected by a potential customer.

The subject matter discussed in this article is particularly interesting for the automotive industry [4] and related fields [5], but it should also be useful in all those areas where image analysis and object detection are the basis for the assessment and diagnosis of, e.g. in intelligent building construction [6,7], quality assurance systems [8-10], as well as in the surface treatment of materials [11,12]. In the case of research, it is a methodology and tool supporting the observation and ensuring the objectivity of measurements, e.g. in biotechnology [13], material sciences [14] and tribology [15]. The obtained results are a great inspiration for the further development of image analysis algorithms [16] and methods of object detection [17,18].

2. METHODS

The aim of the work was to show the use of machine learning and image recognition in the identification of damage to vehicle body parts. The algorithm was designed in *Python* with the use of the *Tensorflow* and *Keras* libraries. *Tensorflow* library enables the training of models that require large data resources. The *TensorFlow* architecture allows to perform calculations using one or more processors, as well as graphics cards located in the computer or server. *Keras* is the open source library for neural networks written in *Python*, designed to performed fast experiments. It contains implementations of commonly used building blocks such as layers, optimizers, targets, activation functions, as well as tools facilitating work with text and image data, thus simplifying the creation of neural network code. *Mask R-CNN* is a deep neural network that is to help solve the problem of image segmentation in machine learning and image recognition. It is able to separate several objects from one film or image. The operation of the mask is divided into two stages. The first of them generates potential regions in which the object can be located. The RPN network scans the path from bottom to top and then suggests regions that are likely to contain features. Then the objects are associated with the location in the image. In the second stage, a mask is generated with an object bounding box and the predicted class of the detected object. The network generates the object classes by scanning the areas. Both stages are connected by a backbone, which is a deep neural network of FPN. *COCO* - Common Object in Context is a ready-made dataset for object discovery, segmentation, and labelling. It is a JSON file with a specific structure. Thanks to it, the access to processed images with annotations specifying what is what is easy. Finally the *Jupyter* environment provided by Google Research that allows to create and run any code in Python via a browser were used. *Jupyter* is often used in the area of machine learning and data analysis. Technically, it is a *Jupyter* host service that does not require any prior configuration, and provides free work with GPUs, processors and TPUs.

3. EXPERIMENTAL DATASET

Despite the use of a network with the CNN architecture being pre-trained for object detection, it must be adapted to the design in order to minimize the location mismatch in the pixel space. 60 photos of damage to various vehicle components were used for training purposes and 10 for validation purposes (**Figure 1**). The greater the amount of input data, the better the network learning quality. However, this creates a big problem in the form of long-term preparation of photos before entering into the system. For this test he numbers of photos used is sufficient, because on their basis we can obtain satisfactory forecasts.

Supervised learning was used in the project. The model of the R-CNN mask used in the project requires an annotation and an indication of the region where the potential damage is located. This was done using a graphics program that illustrates the edges of the marked regions with polygons (compare the **Figure 2** and **Figure 3**). Then the obtained coordinate points were exported appropriately to a json file. It was possible to mark several regions in one photo. Similar results of detection are expected from the learned network.

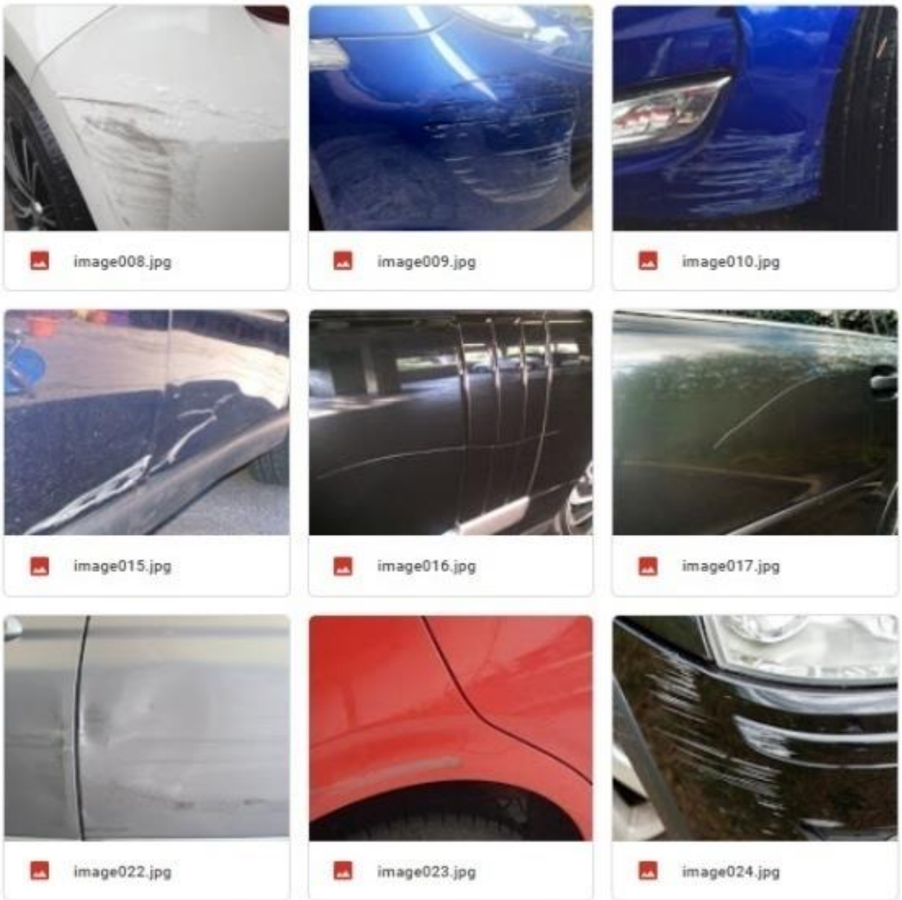

Figure 1 Example set of test images used in the project

Figure 2 An example image of damaged surface

Figure 3 An example image of damaged surface with marked annotation

4. CNN TRAINING

The system is launched in Google Colab due to the high demand for computing power. The process on maladjusted computer hardware could take from several hours to even several days. Data for network training were introduced by a code fragment written for R-CNN mask, whose task is to load training images from the trainData folder and validation images from the valData folder with their annotations in json format.

Then, the entered data is displayed together with the corresponding masks in order to verify the correct operation (**Figure 4**).

Figure 4 Example images and generated masks of damaged surface

Bounding boxes are calculated from the coordinates of the masks and plotted on the entered images (**Figure 5**).

Figure 5 Images with the added Boundig boxes covering detected damaged surface

5. MODEL VALIDATION

After the model training was carried out, it was necessary to perform a validation using previously prepared data in order to confirm the operation of the system in a manner consistent with the assumptions. For tests of the system, photos of a superficially damaged, black vehicle were used. The damaged part of this vehicle is the left rear fender and the adjacent fragment of the bumper. The result of detection for left rear fender (**Figure 6)** is presented on the (**Figure 7**), where detected area is marked by red colored bounding box.

Figure 6 Image of damaged fender

Figure 7 Result of the detection

The conducted research highlighted the imperfections in identifying damages usually caused by the influence of external factors hindering the entire process. One of the problems is interpreting dirt on the car body and its embossing as alleged damage. In order to avoid it, it would be necessary to introduce photos of dirt and creases to the model and to use the learning process with a critic who would negatively evaluate the situation. Another problem is that the car body is covered with water, which causes some of the scratches to be filled with it, giving a temporary illusion of their absence, and the space created by the reflection of light from water drops is interpreted as a detected damage. The paint color is also a problem for the model. The amount of data to be taught is not commensurate with the amount of colors available on the market, which may lead to distorting the results obtained. Test images were grabbed without any professional lightning, which would help to achieve the image without the shade effect, which also is a source of potential detection errors.

6. CONCLUSIONS

The aim of the work was to show the use of machine learning and image recognition in the identification of damage to vehicle body parts. The work shows the possibility of detecting damage in a photograph despite the use of a small amount of training data. However, the system faces many limitations. Improving the operation requires a lot of work, but it seems feasible. The motivation of this experiment was dictated by the increasing market demand for the introduction of artificial intelligence to various industries, which significantly facilitates and speeds up work by reducing time-consuming and repetitive activities carried out by people.

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