Tire Condition Classification Using EfficientNetB0 for Improved Road Safety

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Abstract.

The quality of tires is also significant in the definition of safety, performance, and efficiency of any vehicle, where any defects in tires become a severe threat to the safety and trustworthiness of roads. This should be done by early identification of such defects in order to avert accidents, to save on maintenance costs as well as vehicle downtimes. This paper introduces an automated tire quality assessment model based on the EfficientNetB0 model which is a Convolutional Neural Network (CNN) with an outstanding accuracy and a high computation efficiency. Through visual inspection, the model categorizes images of digital tires in two classes, which include defective and good state. The model with 1,854 tire images obtained through Kaggle was trained, validated, and tested with a high classification accuracy of 96.72%.

Keywords. Artificial Intelligence, Tyre quality, EfficientNetB0,

1. Introduction

The quality of tires is important in ensuring safety of the vehicles, safety, efficiency, and durability. It has direct implications on the handling, braking, fuel consumption of a car and the entire driving experience. With age, tires (especially when they are in commercial and high-performance cars) wear and tear thus it is important to check and maintain the tires frequently. Low-quality tires (because of manufacturing errors, or environmental factors) can cause unsafe driving performance like the blowout or loss of control. The early identification of defects is crucial to avoid accidents, decrease down time, lower the maintenance costs and increase the tires life.

2. LITERATURE

The quality of tires is central to the safety and the efficiency of the functioning of the vehicles as it is the primary concern which makes the difference between the regular maintenance and the prevention of the car accidents as the timely revealed tire defect can significantly enhance the circumstances. Deep Tread proposed by Degadwala et al. [1] is a pre-trained deep learning model that can be used to classify defective and non-defective tires having a high accuracy at a low cost of computation. Equally, Rajeswari et al. [2] put forward a weighting CNN which puts more significance to various fault kinds during training which improves classification and issues of class imbalance. Singh et al. [3] focused on the significance of the joint use of several DL models to enhance accuracy of fault detection, whereas the role of CNNs in the context of the real-time quality control.

3. INPUT DATASET

The data of this research was obtained on the open source Kaggle site with 1,854 digital tire images in two categories, that is, good and defective. All pictures in the form of a JPEG or PNG are taken of a single tire in the circumstances of the real world by using high-quality digital cameras as shown in Fig. 1.

(a) (b)

Fig. 1 Dataset image for (a) Defective (b) Good condition image type

4. FINE-TUNED EFFICIENTNETB0 ARCHITECTURE

In this work, the convolutional neural network (CNN) EfficientNetB0 that is highly efficient is used because it has been noted to have a high degree of performance in terms of image classification activities. Trained on big data, like ImageNet, EfficientNetB0 is a good extractor of various image features. The model was further modified to evaluate tire quality, where bottom layers were substituted with tailored fully connected layers which are used to classify into good and flawed tires; however, the later layers were still used to extract low-level visual representations such as edges and textures.

5. PROPOSED METHODOLOGY

The study uses the experimental design of the four stages to scientifically and systematically categorize tire quality with the maximum accuracy, efficiency, and reliability of each step with the help of the EfficientNetB0 paradigm. The initial stage is known as Dataset Collection which entails retrieving a rich dataset of 1,854 digital tire images that had been collected and categorized under the open-source Kaggle platform into two distinct classes namely good condition and defect.

6. RESULTS

The four phases of research will be scheduled based on ensure the scientific and systematic approach towards the grouping of the quality of tyres according to EfficientNetB0 model. All these steps are required in the facilitation of adequate classification system as far data is collected in the way of modelling analysis.

A. Classification Report Analysis.

Classification report entails an elaborate analysis of the performance of the model in differentiating between good and defective tires. The model had a good reliability of 96.72 indicating a good accuracy in the classification of tires as shown in Table 1.

Table 1. Classification Report Analysis

	precision	recall	f1-score	support
defective	0.9896	0.9500	0.9694	100
good	0.9425	0.9880	0.9647	83
accuracy			0.9672	183
macro avg	0.9661	0.9690	0.9670	183
weighted avg	0.9682	0.9672	0.9673	183

B. Training and Validation loss Analysis

Figure 2 shows the training and validation loss with 22 epochs. It can be seen that the red line exhibits a slow decrease in training loss, which is a sign of successful learning of the data, whereas the green line is a chart of validation loss that also decreases at first and starts to stabilize with increase in epochs.

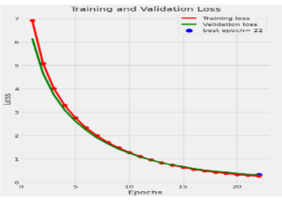

Fig. 2 Training and Validation loss Analysis

C. Training and Validation Accuracy Analysis

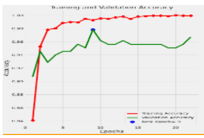

Fig. 3 Training and Validation Accuracy Analysis

Figure 3 presents the training and validation accuracy of 22 epochs. The red line that signifies the accuracy of training increases fast and it is close to 100 percent which is an indication that the model fits the training data rather well.

D. Confusion Matrix Analysis

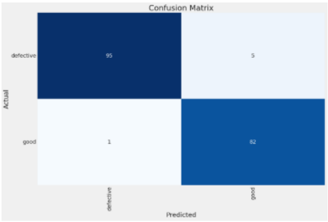

Fig. 4 Confusion Matrix Analysi

The confusion matrix below (Fig. 4) provides the full picture about the performance of the model as regards classification is concerned. In both scenarios, the algorithm results in finding 82 good tyres (true negatives) and 95 problematic tyres (true positives) and therefore is a good performance.

7. CONCLUSION

The given paper introduces a tire quality classification system based on advanced EfficientNetB0 convolutional neural network (CNN) model, which was performed automatically. The proposed method achieves the classification of tires based on two classes of defective tires and good condition varieties with a dataset containing 1,854 tire images (digital). The system was proved effective and strong because through fine-tuning the existing pre-trained EfficientNetB0 model, the system reached impressive overall accuracy of 96.72% that indicated its capability and strength in tire quality inspection. Automating this process drastically lowers the reliance of this method of human inspection, which limits the human error, labor intensity and time of inspection. It, therefore, increases road safety and reliability of the vehicles by providing an opportunity to identify faulty tires early.

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