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Classification of the use of safety helmets in construction projects using the Convolutional Neural Network

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ABSTRACT

The implementation of Health, Safety, and Environment (HSE) encounters several problems, including workers who are not accustomed to working on projects that apply Health, Safety, and Environment (HSE) standards will feel uncomfortable using personal protective equipment, especially for head protection in the form of safety helmets. The next problem is that the construction project of buildings or bridges as a work location has certain places that are protected from the sight of the HSE supervisory team so it is not optimal in monitoring the completeness of personal protective equipment at work. Another problem is the high workload factor for the HSE supervisory team to supervise all the workers, which is very large so it is not optimal in supervising the completeness of personal protective equipment for these workers. To overcome these problems, it is necessary to develop an automatic monitoring system for personal protective equipment, especially safety helmets. The way the system works is that perform classification through digital images with a size of 150x150 pixels using the Convolutional Neural Network (CNN) method for the use of safety helmets at the construction project site. The CNN architectural model used is two convolutional layers and a fully connected layer with 3x3 kernel parameters with 80 filters so that it produces 32 feature maps in the 10th epoch, with an accuracy of 63% obtained.

Keywords: HSE, CNN, safety helmet, digital image

1. Introduction

This research focuses on Health, Safety, and Environment (HSE) in construction projects where the HSE Supervisor always checks the personal protective equipment of each worker, especially safety helmets before carrying out project work activities. If there are workers who do not use safety helmets, they need to receive a warning because, in the event of a work accident caused by the negligence of workers who do not use a safety helmet, it will be detrimental to the workers themselves such as death, physical disability, and others. The disadvantage for the HSE supervisory team and the company that owns the construction work are that it can be subject to criminal sanctions based on UU No.1/1970 on Health, Safety, and Environment and financially it is necessary to spend additional funds for medical expenses or death compensation funds [1].

To minimize the risk of work accidents, avoid criminal sanctions and reduce financial losses, it is necessary to develop an automatic monitoring system for the use of safety helmets. It can also help construction companies to comply with UU No.1/1970 which regulates work safety in all workplaces, whether on land, on the ground, on the surface of the water, in the water, or in the air, which is within the jurisdiction of the Republic of Indonesia [2].

2. Material and Methods

This developed system can help classify the use of safety helmets for workers on construction project sites through digital images using the Convolutional Neural Network method. Several studies that have developed a helmet detection system using image classification have been carried out. The method used is Convolutional Neural Network YOLO. The system consists of three main processes, namely the pre-processing process, the training process, and the detection process. Detection system testing is carried out individually or in groups of a maximum of 5 people with an F1-score obtained of 0,79[3]. Detection of helmet head protection equipment through video using the Haar Cascade Classifier method. The system consists of two main processes, namely the data training process and the detection process. Testing the detection system done individually obtained an accuracy rate is 92%, while group testing obtained an accuracy rate of 71%[4]. Automatic detection of helmet use in construction areas using computer vision and machine learning techniques. Color base combination feature extraction and Circle Hough Transform were applied to detect helmets used by construction workers[5]. detection of the use of safety helmets by utilizing face detection based on convolutional neural networks and bounding-box regression. Experimental analysis shows that the method has considerable advantages in detecting the use of safety helmets. The proposed model has achieved 96.2% recall, 96.2% precision, and an average of 94.47% detection accuracy rate[6]. This paper is proposed using a camera sensor as input and the Convolutional Neural Network method as a classification process that allows the classification of categories of wearing or not wearing helmets. System development begins with data collection from the internet, pre-processing of digital image pixel size, construction of CNN model training using a pre-trained model, data testing, and classification conclusions. The stages of this research are presented in figure 1.

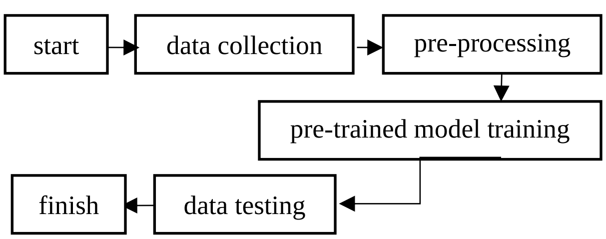

Figure 1: Research method diagram

2.1. Data collection

Data collection is done by searching and downloading images on the internet using Fatkun Batch Chrome Extension for scrapping large amounts of image data at once. After the dataset is collected, it is necessary to clean the dataset to manually check whether the downloaded image is in the appropriate category [7]. The dataset in the form of worker objects in construction projects is prepared with 2 categories, namely using and not using safety helmets. The total dataset consists of 50 digital images for each category. The dataset is divided into 2 parts, namely 70% training data and 30% testing data [8].

2.2. Pre-processing

At the time of data collection through the internet obtained digital images that have varying pixel sizes so it is necessary to do pre-processing in the form of changing the pixel size of the digital image to one size, namely 150x150 pixels so that the process of making the CNN training data model is more optimal.

2.3. Pre-trained model training

The next step is to carry out a learning process to get the best model for the classification of digital images using safety helmets. In this study, the CNN method is used for classification using two convolutional layers and a fully connected layer with 3x3 kernel parameters and using the ResNet-50 pre-training model as transfer learning. ResNet-50 is a pre-trained model that has been trained and classified into 1000 object classes. It is a convolutional neural network that is 50 layers deep [9]. Create model objects using a ResNet50 model that was pre-trained with data training.

2.4. Data testing

After creating the training model according to the Resnet50 architecture. The next process is data testing using fine-tuning 10 epochs [10]. From this process, a confusion matrix is obtained. The confusion matrix is a matrix that stores performance information from the developed model. The CNN process that has been carried out from beginning to end will be analyzed using this confusion matrix. The testing process uses digital images that have been prepared as test data. This test data is then processed with a training model that has been previously developed using the Resnet50 model.

3. Results and Discussions

The following are the results of the training that has been carried out obtained from the CNN architecture that has been designed.

3.1 Data training model

The prediction training model of the safety helmet use monitoring system can be seen in Table 1

Table 1: The prediction training model

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Epoch	Error rate	Accuracy
0	0,013	0,785
1	0,013	0,742
2	0,041	0,600
3	0,010	0,714
4	0,010	0,857
5	0,008	0,785
6	0,014	0,742
7	0,015	0,785
8	0,010	0,771
9	0,011	0,857

The results of the training process carried out with a different number of epochs show that the epoch affects the accuracy obtained. The more epochs, the smaller the error rate, and the accuracy of the result obtained will be higher. In the 10th epoch, the error rate value is 0,011 and the accuracy value is 85%. This shows that the training model that has been constructed can recognize the use of safety helmets well. The results of the training data can be seen in graphical form in Figure 2

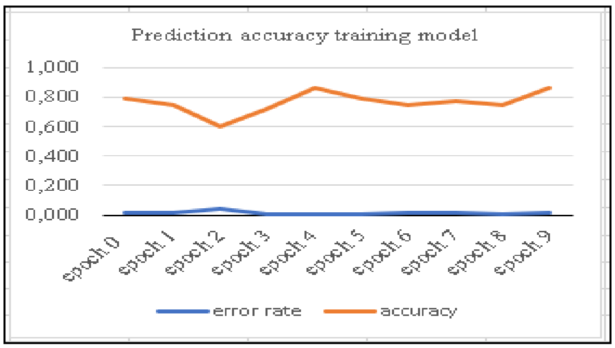

Figure 2: Data training error rate and accuracy

3.2 Data testing evaluation

The confusion matrix can be used as a reference for the performance of the classification algorithm at the data testing evaluation stage [11]. The confusion matrix model of the safety helmet use monitoring system can be seen in Table 2.

Table 2: Data testing confusion matrix

Actual	Predict	
	With helmet	Without helmet
With helmet	8	9
Without helmet	2	11

In table 2 it is known that the number of testing data from the two categories is 30. The image dataset is chosen randomly. The confusion matrix shows the number of True Positives (TP) with a value of 8 and the number of True Negatives (TN) with a value of 11. To determine the accuracy of this model by adding up all TP and TN from all categories and dividing by the total dataset. The accuracy result is 63%. The confusion matrix shows the number of False Positives (FP) with a value of 2 and the number of False Negatives (FN) with a value of 9. To determine the error rate of this model by adding up all FP and FN from all categories and dividing by the total dataset. The result of the error rate is 0.366.

4. Conclusion

In conclusion, we propose an automated safety helmet monitoring system capable of classifying construction project workers who use and do not use safety helmets. The use of Deep Learning utilizes the CNN method. This system can be used to classify safety helmets automatically through image datasets. The test results obtained an accuracy of 63%. The process of monitoring the use of safety helmets will be easier by using this system. Further system development can be done by adding more datasets and changing the parameters of the CNN method so that it can get better accuracy.

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