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Helmet Detection and Monitoring For Two Wheeler Rider Using Advanced Machine Learning Based Automated Model

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Abstract
Most of the two wheeler riders forget to wear helmet at the time of driving. As a result when an accident occurs, there are high chances of head injuries to the riders which sometimes results in death. Conventional methods of detecting and monitoring the rider's helmet during driving are limited to certain conditions like orientation of rider and the two wheeler. To overcome the limitations of conventional methods of detecting two wheeler helmet, a neural network based automated model is proposed in the present study. The proposed model can detect the helmet under varied conditions due to its properties like learning and generalization. The superiority of the proposed model over similar type of models is tested on the real time images which are acquired through automated model. The performance of the proposed model is evaluated using various parameters like user's accuracy (UA), producer's accuracy (PA), Kappa coefficient (KC), Overall accuracy (OA), average computational time (S).

Keywords: *Two wheeler, Helmet detection, Machine learning, Soft Computing and Neural Networks.*

I. INTRODUCTION

Statistically 1,40,000 people are injured per day due to road accidents in the world [11]. Also, more than 3000 die and some 15,000 are disabled because of road accidents in the world. These statistics are more in developing country like India in comparison with developed countries. According to the national crime reports of India, 98,254 persons were killed in 2016 on Indian roads [12]. Among various road accidents, two wheeler accidents have maximum fatality in accident. The major reasons for two wheeler accidents are reckless driving, speeding, and distracted driving and drunk driving. In most of the cases death of the two wheeler rider is due to not wearing helmet. According to the Insurance Institute for Highway Safety of India, in 2016 over 60% of deaths in two wheeler crashes were people who were not wearing a helmet [12]. According to Insurance Institute for Highway Safety of India the number of two wheeler deaths can be reduced by 50 percent if the rider can wear the helmet [13]. The major reason for not wearing the helmet is the rider's negligence. This specifies the necessity of an automated model that can remind the rider to wear the helmet. Conventional methods of detecting and monitoring the rider's helmet during driving are limited to certain conditions like orientation of rider and the two wheeler. These limitations of conventional models can be overcome with machine learning (ML) based models. The advantage of ML based models is learning and generalization ability which can detect the helmet under varied conditions like orientation.

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There exists various type of ML models for helmet detection. Kulkarni et. al. [1], proposed a ML based automated model which detects the helmet from the recorded video. The author has used convolutional neural networks (CNNs) trained with transfer learning for detecting the helmet from the video. Abhijeet et. al. [2], proposed an ML based model for helmet detection. In this study, author has used principal component analysis (PCA) for selecting the features from the images and further ML based model is used identify the helmet from the image. Varon [3], used CNN model for the detection of helmet from the images. The images were acquired from the charged coupled cameras. Mistry et. al. [4], proposed ML based model to detect the person class instead of motorcycle in order to increase the accuracy of helmet detection in the input image. Vishnu et. al. [6], presented a framework for automatic detection of motorcyclists driving without helmets in surveillance videos. The back ground area subtraction was done from video frames to get moving objects. Followed by helmet detection from the video. Similar type of ML based helmet detection models were proposed in the studies [5], [7], [8], [9], [13], [14], [15], [16] and [17]. Most of the models discussed in the literature survey are used for detecting the helmet and the limitation of these models is monitoring system. With this motivation, an ML based neural network model (MLNN) for two wheeler helmet detection is proposed in the present study. The model can detect the helmet and at the same time it can monitor the rider by giving continuous alarm. The advantage of MLNN model is due to its physical implementation using raspberry pi.

II. PROPOSED MODEL FOR TWO WHEELER HELMET DETECTION

A MLNN model is proposed in the present study for two wheeler rider's helmet detection. The functional block diagram of the proposed model is given in Fig.1.

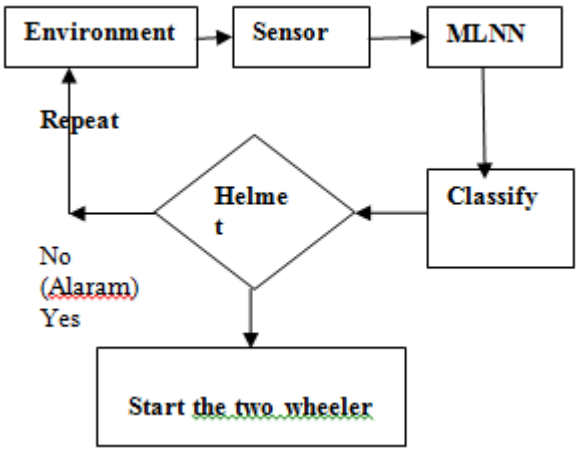

Fig. 1. Functional block diagram of proposed MLNN model.

The proposed model is a physical model which senses the environment through the in-built camera. The sensor senses the environment where the rider sits on the two wheeler. Furthermore, the sensed image is passed to MLNN model. MLNN model is trained model with supervised learning mechanism. The architecture of MLNN model for two wheeler helmet detection is discussed in the following sections.

(a) Architecture of MLNN model

The architecture of MLNN model is given in Fig. 2.

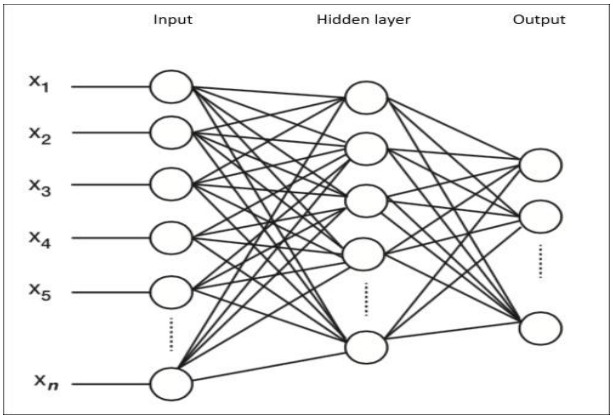

Fig. 2. Architecture of MLNN model with input layer, hidden layer and output layer [10].

The architecture comprises of input layer, hidden layer and the output layer. The number of input layer nodes (NIN) is equal to the number of feature of an image. The numbers of hidden layer nodes (NHN) are taken at random. The number of output layer nodes (NON) is equal to the number of output classes.

The trained MLNN model predicts the presences of helmet or not. If the two wheeler rider's helmet is

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detected then the two wheeler will get started. In other case if the rider is not wearing the helmet then the two wheeler will not get started and an alarm will be given to the rider. Later, the process will be repeated from the beginning. The process get repeated for every 20 seconds duration. In spite of alarm upto four times, if the rider is not wearing the helmet, the two wheeler will get switched off. The details related to the dataset which is used to train the MLNN model and corresponding results as tested with MLNN model on the dataset is given in following sections.

II. DATASET DESCRIPTION

In the present study the proposed model is trained with the dataset which consists of 200 images. These images were acquired from the in built camera of the physical model. A total of 100 images out of 200 belong to with helmet class and the remaining 100 belong to without helmet class. The selection of 100 images with helmet class is based on four criteria (i) Different persons with same helmet, (ii) Person with different helmets, (iii) Different persons with different helmets and (iv) Person with helmet and with different head orientations. Similarly, the selection of 100 images without helmet class is based three criteria (i) Different persons without helmet. (ii) Person without helmet and with different orientation of head. (iii) Person without helmet but with different type of head covers. The sample images of the dataset with different conditions of environment are given in Table 1. Table 1, consist of images which were taken under varied conditions such as : (i) Different persons with same helmet, (ii) Different persons without helmet, (iii) Different persons with different helmets and case (iv) Person without helmet and different head covers.

These images are used to train the MLNN model. The proposed MLNN model is trained using back propagation learning algorithm. Once the model is trained, the respective code is induced into the raspberry pi device. The resultant model is a physical model which is tested under varied conditions of rider's environment. The results obtained in the present study are discussed in the following sections.

III. RESULTS AND DISCUSSIONS

A total of five classification models were considered in the present study. Model 1 is KNN classifier with k=3. Model 2 is support vector machine with linear kernel. Model 3 is linear discriminate analysis . Model 4 is decision tree and model 5 is MLNN with back propagation algorithm. The parameters of MLNN were considered as learning rate (α) = 0.1, momentum (ρ) = 0.000001 and the number of iterations (NOI) = 800. Also, the architecture of MLNN is considered as 1500: 200: 2, whereas NIN = 1500, NHN=200 and NON=2. All the models were trained with 60%, 80% of the dataset and the remaining 40%, 20% of the images in the dataset were used for testing, respectively. The experimental results of the present study are given in Table 2. Also, the overall accuracy of the models followed by the average time taken by the model to classify the image are presented in Table 2. Among all the models decision tree model has produced the lowest OA with 86.8% and the proposed model (MLNN) has produced an OA of 96.54% . The average time taken by MLNN model to classify the image is 0.0124 s which is the best among all the classifier. The OA of MLNN is 1.38 % better than KNN classifier. Also, the OA of proposed model is 3.19%, 2.3%, 9.71% better than SVM, LDA and decision tree.

Table 1: Sample images of dataset: case (i) Different persons with same helmet, case (ii) Different persons without helmet, case (iii) Different persons with different helmets and case (iv) Person without helmet and different head covers.

IMAGE 1	IMAGE 2	Case
		(i)
		(ii)

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		(iii)
		(iv)

The superiority of MLNN model over other models is due to its learning and generalization ability. The superiority of MLNN model is justified with similar type of parameters like UA, PA and KC. The performance of all the five models is evaluated with these parameters and the results are presented in Table 3. In Table 3, the performance of decision tree (worst case) and MLNN (best case) with the metrics like UA, PA and KC. From the Table 3, the UA of Decision tree is 76.00% for class 1 and 87.11% for class 2. The UA of MLNN is 84.43% for class 1 and 91.64% for class 2. These values of UA show the improvement from decision tree to MLNN for both the classes. Similarly, the KC of decision tree classifier is 0.810 and the KC of MLNN is 0.894. KC value near to the value 1 is preferable for classifier. Along with the parameters discussed in present study, the superiority of proposed model is justified with the mean square error (MSE). The superiority of the proposed model over similar type of models is justified with the parameters like OA, UA, PA, KC, NOI and Computational time. The superiority of proposed model is due its advantages like learning and generalization. Also, the proposed model has an additional advantage like detection of helmet and monitoring the helmet in comparison with other classifiers.

Table 2 : Experimental results of five models as tested with the dataset.

Models	Training		OA (%)	Time (S)
	60 %	80%		
KNN	93.76	96.36	95.16	0.0184
SVM	93.49	93.78	93.35	0.0266
LDA	95.17	93.56	94.24	0.0314
Decision Tree	86.78	86.83	86.83	0.0226
MLNN	95.89	98.87	96.54	0.0124

The MSE of the proposed model gradually reduces to zero for NOI reaching to 800. The MSE of MLNN model is provided in Fig. 2.

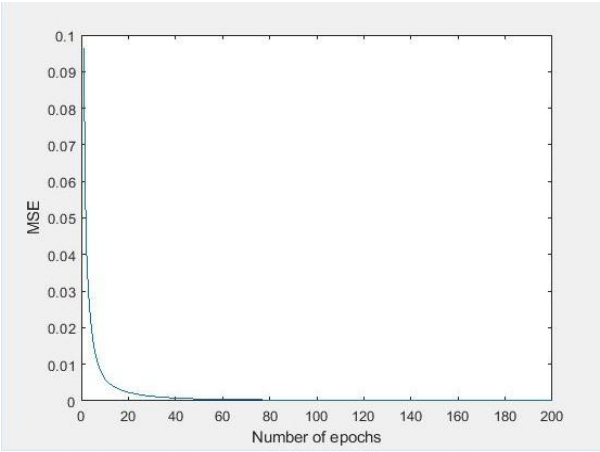

Fig. 2. Mean square error (MSE) of the MLNN model for 700 epoches.

Table 3: Performance of models (i) Decision tree (Worst case) (ii) MLNN (Best case) with the metrics UA, PA and KC for 60% training data.

Models		UA(%)	PA (%)	KC
Decision Tree	Class 1	76.00	56.54	0.810
	Class 2	87.11	92.95	
MLNN	Class 1	84.43	62.52	0.894
	Class 2	91.64	94.26	

IV. CONCLUSIONS

A MLNN model is proposed in the present study for efficient detection of two wheeler rider's study. The model has outperformed similar type of models in detecting the helmet from the environment. MLNN has produced an OA of 96.54% for the dataset in the present study. The superiority of the MLNN model is vindicated with other parameters like UA, PA, KC and NOI. Furthermore, the proposed model can be improved with better selection of input features and also with efficient classifier.

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