

Hybrid CNN-SVM Classifier Framework for Driver Emotion Detection System

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Abstract

Many studies have proved that the driver's emotions are the significant factors that manage the driver's behavior, leading to severe vehicle collisions. The ADAS systems can assist various functions for proper driving and estimate drivers' capability of stable driving behavior and road safety. Therefore, continuous monitoring of drivers' emotions can help predict their behavior to avoid accidents. A novel hybrid network architecture using a deep neural network and support vector machine has been developed to predict between six and seven driver's emotions in different poses, occlusions, and illumination conditions to achieve this goal. Our proposed model achieved better performance accuracy of 84.41%, 95.05%, 98.57%, and 98.64% for FER 2013, CK+, KDEF, and KMU-FED datasets, respectively.

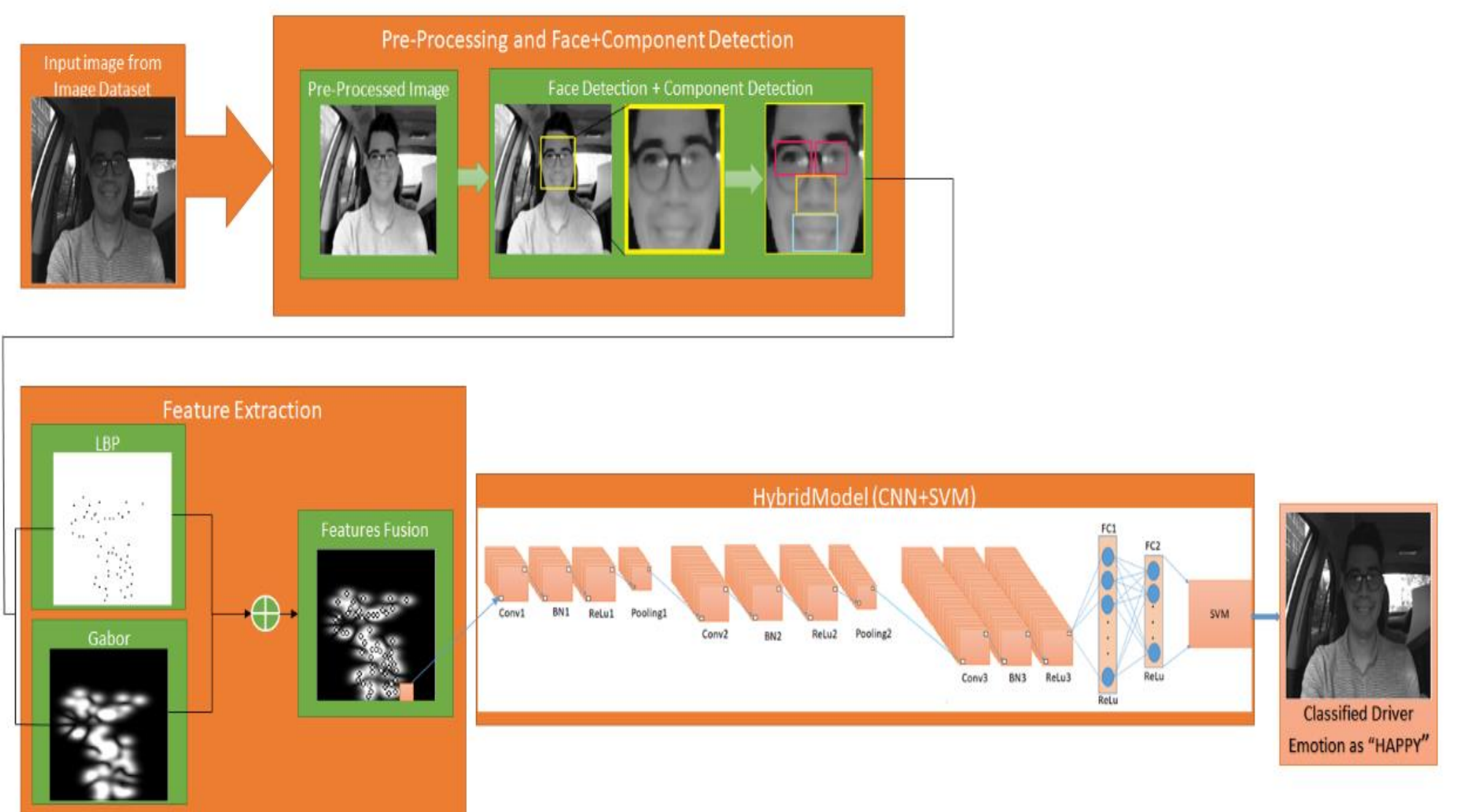
Keywords: Deep Neural Networks; advanced driver assistance systems (ADAS); face detection; facial expression recognition; driver emotion detection; DeepNet; machine learning

Introduction

Basic transportation all over the world still relies on automobiles. To support this, the American Automobile Association (AAA) foundation for traffic safety provided a report on the USA in 2019, stating that the average time spent driving per driver is about an hour every day with a road coverage of 31.5 miles, which is a 5% increase when compared with 2014 statistics. In 2019, Americans spent 70 billion hours driving, which is 8% more than in 2014. This increase in time spent driving shows that the car could be seen as an ambient living space for the people driving on roads. Driver-related risk factors such as cell phone distraction, alcohol consumption and aggressive driving influence the driver's behavior. Along with major road accidents caused by aggressive driving behavior, around half of the injured drivers in minor road accidents were also not fully recovered and prone to slow recovery, which takes them away from work and regular human activities. Emotions are the factors that influence a driver's capabilities towards either the positive side or negative side of driving. To monitor the driver's emotions, face expression recognition technology is used, facial expression analysis is creating a positive impact on the development of human machine interactions for safe driving behavior and road safety.

Proposed Driver Emotion Detection System

Emotions such as happiness and neutrality can put the driver in a good mental state and able to drive the vehicle safely. However, emotions such as sadness, anger, disgust, and fear influence the driver's capabilities to cause road accidents. To avoid this, driver emotion monitoring became a crucial and necessary module in the advanced driver assistance systems in most automotive vehicles. Driver emotion detection in advanced driver assistance systems (ADAS) is accomplished by using facial expression recognition (FER) technology. Our proposed approach is novel in creating a hybrid model with a dedicated pre-processing stage to handle illumination conditions and noise removal. Features are extracted manually using Gabor and LBP methods. These extracted features are fused and fed to CNN, providing more robust features given to SVM for classification. Our objective is to handle the major challenges such as pose variations and occlusions in face expression recognition.



Performance Evaluation

The performance of the proposed algorithms is compared with the state-of-the-art works using FER 2013, CK+, KDEF, KMU-FED, four different benchmark datasets and our system show good performance among them.



Hybrid Model Comparison with State of the art works on FER 2013 Dataset	Accuracy (%)
CNN-MNF [2018]	70.3
CNN-BOVW-SVM [2019]	75.4
KCNN-SVM [2019]	80.3
VCNN [2020]	65.7
EXNET [2020]	73.5
Deep-Emotion [2021]	70.0
IRCNN-SVM [2021]	68.1
GLFCNN+SVM (Our Proposed Approach)	84.4

Hybrid Model Comparison with State of the art works on CK+ Dataset	Accuracy (%)
Inception-Resnet and LSTM [2017]	93.2
DCMA-CNN [2018]	93.4
WRF [2018]	92.6
LMRF [2020]	93.4
VGG11+SVM [2020]	92.2
DNN+RELM [2021]	86.5
LBP+ORB+SVM [2021]	93.2
MDNETWORK [2021]	96.2
GLFCNN+SVM (Our Proposed Approach)	95.1

Hybrid Model Comparison with State of the art works on KDEF Dataset	Accuracy (%)
MULTICNN [2018]	89.5
HDNN [2018]	96.2
RTCNN [2019]	88.1
ALEXNET+LDA [2020]	88.6
MSLBP+SVM [2020]	89.0
DL-FER [2021]	96.6
RBFNN [2021]	88.8
GLFCNN+SVM (Our Proposed Approach)	98.5

Hybrid Model Comparison with State of the art works on KMU-FED Dataset	Accuracy (%)
WRF [2018]	94.0
FTDRF [2020]	93.6
d-RFs [2020]	91.2
SqueezeNet [2020]	89.7
MobileNetV3 [2020]	94.9
LMRF [2020]	95.1
CCNN [2019]	97.3
VGG16 [2021]	94.2
GLFCNN+SVM (Our Proposed Approach)	98.6

Conclusion

Current facial expression recognition research has mostly focused on creating a model by involving a convolutional neural network for feature extraction and support vector machine for classification purposes. Despite that, some models are using dedicated machine learning methods for feature extraction and classification. However, they are still limited, along with the existing challenges such as occlusions, illumination, and pose variation. These challenges have been addressed using the proposed technique.

Reference

Sukhavasi, Suparshya B., Susrutha B. Sukhavasi, Khaled Elleithy, Ahmed El-Sayed, and Abdelrahman Elleithy. 2022. "A Hybrid Model for Driver Emotion Detection Using Feature Fusion Approach" International Journal of Environmental Research and Public Health 19, no. 5: 3085. <https://doi.org/10.3390/ijerph19053085>

