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A Novel Architecture combining convolutional neural network and support vector machine for expression recognition in driving environment

Mr. SUPARSHYA BABU SUKHAVASI

Dr. Khaled Elleithy, University of Bridgeport

Dr. Elleithy is the Dean of College of Engineering, Business and Education at the University of Bridgeport. He is a distinguished professor of Computer Science and Engineering. His research interests includes wireless sensor networks, mobile communications, network security, quantum computing, and formal approaches for design and verification. He has published more than three hundred fifty research papers in national / international journals and conferences in his areas of expertise. Dr. Elleithy is the editor or co-editor for 12 books published by Springer.

Dr. Elleithy received the B.Sc. degree in computer science and automatic control from Alexandria University in 1983, the MS Degree in computer networks from the same university in 1986, and the MS and Ph.D. degrees in computer science from The Center for Advanced Computer Studies at the University of Louisiana - Lafayette in 1988 and 1990, respectively.

Prof. Elleithy has more than 30 years of teaching experience. His teaching evaluations were distinguished in all the universities he joined. He is the recipient of the "Distinguished Professor of the Year", University of Bridgeport, academic year 2006-2007. He supervised hundreds of senior projects, MS theses and Ph.D. dissertations. He developed and introduced many new undergraduate/graduate courses. He also developed new teaching / research laboratories in his area of expertise. His students have won more than twenty prestigious national / international awards from IEEE, ACM, and ASEE.

Dr. Elleithy is a member of the technical program committees of many international conferences as recognition of his research qualifications. He served as a guest editor for several international journals. He was the chairperson of the International Conference on Industrial Electronics, Technology & Automation. Furthermore, he is the co-Chair and co-founder of the Annual International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering virtual conferences 2005 - 2014.

Dr. Elleithy is a member of several technical and honorary societies. He is a Senior Member of the IEEE computer society. He is a member of the Association of Computing Machinery (ACM) since 1990, member of ACM SIGARCH (Special Interest Group on Computer Architecture) since 1990, member of the honor society of Phi Kappa Phi University of South Western Louisiana Chapter since April 1989, member of IEEE Circuits & Systems society since 1988, member of the IEEE Computer Society since 1988, and a lifetime member of the Egyptian Engineering Syndicate since June 1983.

Dr. Abdelrahman Elleithy, William Paterson University

Dr. Elleithy is an Assistant Professor in the Department of Computer Science at William Paterson University, Wayne, New Jersey since September 2017. His research interests include wireless sensor networks, mobile communications and network security. He has published many research papers in international journals and conferences in his area of expertise.

Dr. Elleithy has worked as a Visiting Assistant Professor of Computer Science at Texas A&M University between August 2014 to August 2016 and as a lecturer of the same department from September 2016 to June 2017.

Dr. Elleithy received the BS, MS, and Ph.D. degrees in computer science from the University of Bridgeport in 2007, 2008 and 2013 respectively.

Dr. Elleithy is a member of the technical program committees of many international conferences. He served as a member of the technical program committee of the Annual International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering virtual conferences 2010 – 2014 and the technical program committee of 2016 Annual IEEE Connecticut Conference on Industrial Electronics, Technology & Automation.

Dr. Elleithy is a member of several technical and honorary societies. He is a Member of IEEE, Association of Computing Machinery (ACM), and the honor society of UPE.

Dr. Ahmed El-Sayed, University of Bridgeport

Dr. El-Sayed received the B.Sc. degree in electrical engineering from the Department of Electrical Engineering, Alexandria University, Egypt, in 2003, the M.Sc. degree in engineering mathematics from the Department of Engineering Mathematics and Physics, Alexandria University, in 2006, and the M.Sc. and Ph.D. degrees in computer engineering from the Department of Computer Science and Engineering, University of Bridgeport, Bridgeport, CT, USA, in 2011 and 2016, respectively. Currently, he is Assistant Professor of Electrical and Computer Engineering at the University of Bridgeport. He published articles in the fields of robotics, soft computing, and computer vision. His research interests include robotics, AI, fuzzy systems, soft computing, machine learning, pattern recognition, and computer vision. He is a member of IEEE, ASEE, the Honor Society of Phi Kappa Phi, the Honor Society for Computing and Information Disciplines Upsilon Pi Epsilon (UPE), and a lifetime member of the Egyptian Engineering Syndicate.

Mr. SUSRUTHABABU SUKHAVASI, University of Bridgeport

A Novel Architecture combining convolutional neural network and support vector machine for expression recognition in driving environment

Suparshya Babu Sukhavasi, Susrutha Babu Sukhavasi, Khaled Elleithy
Ahmed Elsayed, Abdelrahman Elleithy*
Department of Computer Science and Engineering
University of Bridgeport, Bridgeport, CT, U.S.A
*Department of Computer Science, William Paterson University, Wayne, NJ, U.S.A

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.

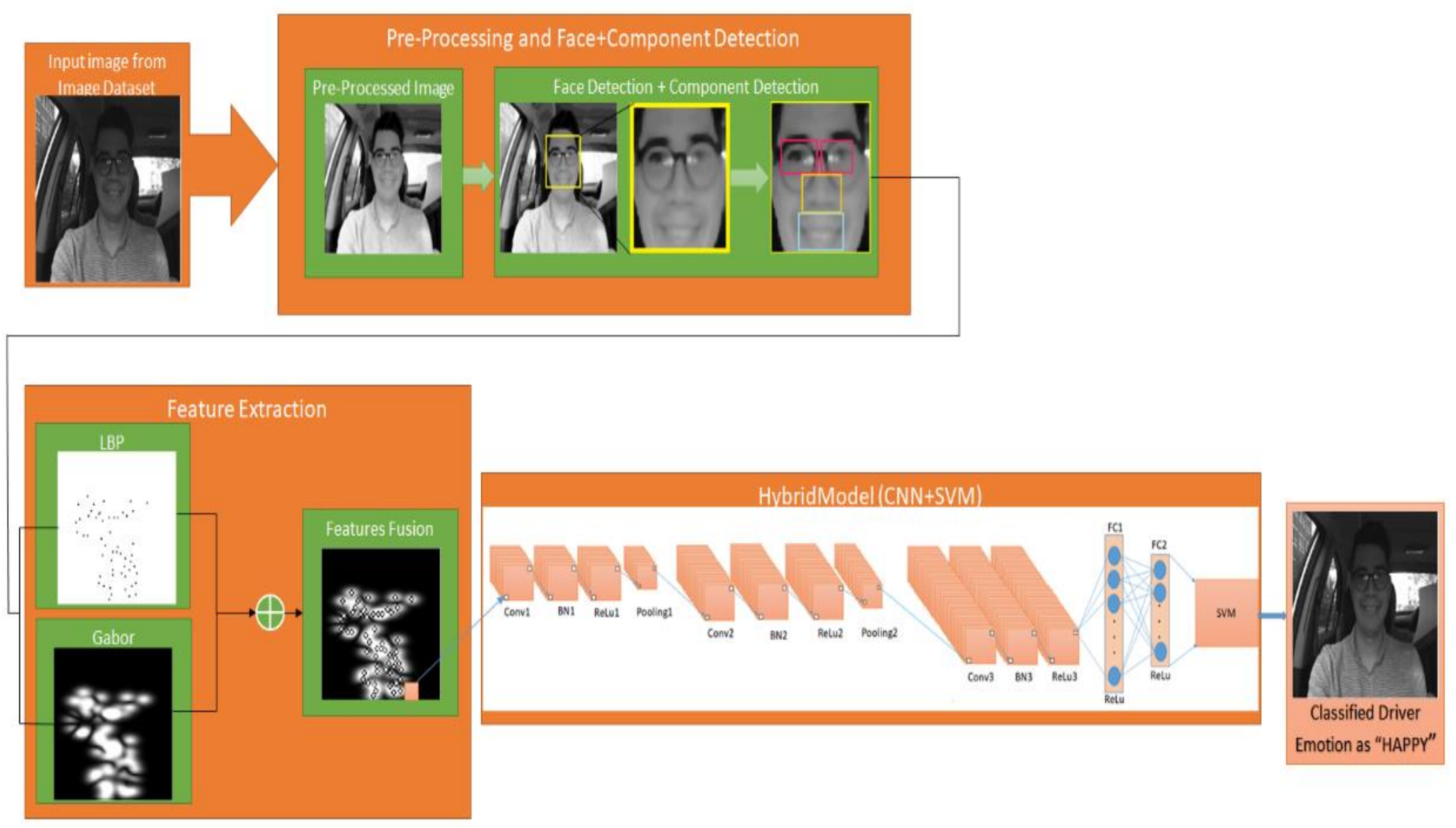
Keywords: Deep Neural Networks; advanced driver assistance systems (ADAS); face detection; facial expression recognition; driver emotion detection; DeepNet; machine learning

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