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Facial Emotional Expression Regulation to Control the Semi-Autonomous Vehicle Driving

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***Abstract*— Autonomous vehicular technology has reduced the road casualties by detection of human emotions. This paper describes the role and function of facial expressions in human-computer interaction for the semi-autonomous vehicle. Numerous works of literature are available and studied regarding the driver's behavioral and emotional influences that regulate the state of mind. In order to accomplish control of the intelligent vehicle, this literature introduces a cloud model as a theoretical framework to implicate and analyze various facial expressions to regulate the driving. Recent vehicle interiors have contactless exposure of driver states, concreting the path for promoting the safe driver and passenger behavior through emotion regulation. The current research paper concludes the challenges for cognitive interaction to reveal the technological barriers and procedural deliberations, as well as prospective to improve road safety by recalling driver and passenger into an emotionally balanced state. Cloud modeling analysis foresees the virtuous monitoring possessions, it also validates a series of mental activities such as feeling, cognition, decision and so on are ambiguous and uncertain which will in-turn to control the intelligent vehicular driving.**

Keywords—facial expression, emotion regulation, real-time prediction, semi-autonomous vehicle, state of mind

I. INTRODUCTION

Safety is perhaps one of the most crucial components in the creation of any vehicle. Now a range of top-quality tech inbuilt vehicles ensure not only the driver but also the passengers and other road users are as safe as can be. When a vehicle is in running mode, driving behavior may change according to various emotions which may be the cause of an accident. The current status of the development for emotion recognition systems in vehicles is focused on interaction with human-computer based biometric solutions which consider the front face of the human as the main input data source to identify the state of mind of the driver and passenger. The most immediate and quickest method of human-computer interaction, which is the necessity trend nowadays is biometrics for human identity authentication. There are various methods for biometric recognition, out of these face recognition is one of the most used technique. A face recognition system includes several parts, such as face detection, skin color detection, eye retina detection, and so on. Face recognition is the ability to detect and recognize a person by their facial expression. Face recognition system is necessary nowadays for providing security, user verification, and access control for the devices which require authentication.

A. Documentary Research

Ekenel et al. (2007) [1] given an overview of face recognition research activities which has been done at the interACT Research Centre. The interACT Research Centre mainly worked on the development of a face recognition algorithm and automatic face recognition systems. The face recognition algorithm detects the local facial region then partitions the input face image which is further divided into 8×8 pixels resolution blocks, discrete cosine transform is applied to each individual block.

Savadi et al. (2014) [2] proposed a facial action coding system which measures the facial expressions and movements then allows a distinction among various smiles and laughs, created a YALE database with five different facial expression images and extract the features by applying the logarithmic Gabor filters on each of the individual images. Also used optimal subsets of features that were selected for each facial expression and classification tasks were implemented successfully using the neural network-based technique.

Maria et al. (2019) [3] describes the contact-less method which analyses the facial features with the help of a web camera. The databases are created on the basis of four groups such as active, passive, negative, and positive. Each group contains various emotions, as per the input images the emotions are detected as well as features are extracted using SVM classifier for achieving the optimal accuracy. On the other hand, facial recognition can be used as a contactless device, when it comes to the identification of emotion during any software interaction with the user.

Artificial Intelligent systems can detect several facial emotions by learning what each facial expression means and applying that knowledge to the new information, which is being useful for decision making control system. Emotional artificial intelligence is a technology that is capable of reading, interpreting, and responding to human facial expressions and emotions as per the need. Czubenko et al. (2015) [4] proposed the xDriver system which uses an intelligent system of decision (ISD) making which is used for interaction between user and the car to handle the task. The ISD system works on the model of human psychology with emotions that allow the system to take specific actions. The emotions of the xDriver consist of nine states of facial expression like neutral, anger, anticipation, joy, trust, fear, surprise, sadness, and disgust, on those basis databases are created. The ISD system has the ability to detect the collision situation, the xDriver changes its emotional state and takes the necessary actions such as emergency braking, slow acceleration, reduction of gear. Other features are also included in the ISD system such as changing the lane more than one time.

Several types of research have been focused on detecting and understanding human affective nature, such as emotion

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through facial expression, their interests and behavior with other passengers while driving a car.

Javier et al. (2018) [5] was able to develop an algorithm that was able to detect the field of emotion, facial texture and also identifies some physiological which included electro-encephalo-grams (EEG), electro-cardio-grams (ECG), and galvanic skin response (GSR). EEG algorithm has achieved an accuracy of 97%. A K-Nearest Neighbors algorithm using Euclidian distance to predict the emotional state of the subject and created a database of nine facial emotions to detect the mental state of the driver. Data has been collected from questionnaires and facial expression scans.

Mira Jeong and Byoung Chul Ko (2018) [6] proposed a fast facial expression recognition (FER) algorithm for monitoring driver's facial emotions. In order to improve its accuracy, a hierarchical weighted random forest classifier is trained, based on similar types of sample data. This FER based approach utilizes feature representation which is further separated into two categories: appearance features and geometric features. The appearance which mostly focuses on the texture of the front face and geometric features describes the shape of the face.

Rizwan Ali Naqvi and Muhammad Arsalan (2020) [7] has developed a multimodal based technique, in these days aggressive driving has been rapidly increased which mainly reasons why accidents have been increased day by day, used Dlib program to obtain driver's image data from NIR camera which is placed in the dashboard to extract front face, left and right eye images for finding changes in the gaze-based convolutional neural network.

Aimilia Panagiotou et al. (2019) [8] proposed a method which is based on the conventional intelligence collection technique. This new method is used to recognize the overall user psychology through open-source intelligence and machine learning technique. It is using N-Games charts, which notice user sentiments and variations over time and evaluate the user psychology then use this information to predict insider threats.

Driver mood also fractionally depends on passengers' mood which can't be ignored. Marceddu [9] proposed a method for automatic recognition and classification of passengers' emotions in autonomous driving vehicles, the car is able to respond according to the passengers' emotions and varying its driving style.

In some cases, it has been noticed that there is a lack of driver's concentration while driving a car, because of falling asleep at the wheel, researchers have proposed various methods for detecting drowsiness which leads to an increase in a large percentage of the vehicular accidents.

Amit Kumar Chanchal and Maitreyee Dutta (2017) [10] introduced an approach to a human-centered transportation system based on the Fuzzy rule for tracking assistance using emotion recognition and facial texture of the driver simultaneously which is helpful for transportation system safety.

B. *Area of Interest*

Current literature proposes a method which is being implemented in the real-time application for identifying the mood of the person who is sitting on driver's seat, the dataset has been constructed which contains four categories of different emotions of human, such as happy, calm, angry, and sad. Practically, an edge computational unit (ECU) camera is placed to capture the driver's frontal face, body signals, and facial expressions in real-time and identify the state of mind. This information sends to the vehicle central control unit (CCU) which can instruct the vehicle to switch the mode for further driving. Section II of this paper explains the methodology and discussion while the results and conclusion are described in Section III and Section IV respectively.

II. METHODOLOGY AND DISCUSSION

A dataset is constructed and associated with different emotions' images of the driver itself and also another passenger. Initially set the region of interest, cropped the frontal face images from the whole image of the driver and train these images to develop a retrained graph. A retrained graph has been categorized as a separate dataset with cropped images. A real-time driver's facial emotion will be compared with the dataset images and predict the state of mind. This data send to the CCU which decides the driving mode of the vehicle accordingly as elucidated in figure 1.

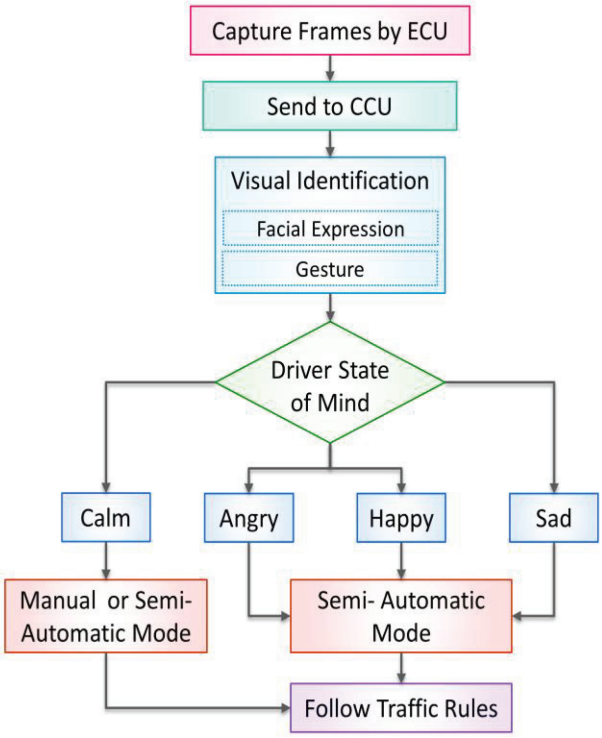

Fig. 1. Process flowchart to decide the semi-autonomous vehicle driving mode based on driver state of mind

There are four moods of the driver considering in this research to control the vehicle driving as presented in figure 1. If the driver state of mind is calm then the driving mode of the vehicle can be either manual or semi-automatic, depends on driver choice. But if the driver is angry, happy, or sad then the vehicle driving mode will be semi-automatic only which prevents the hazard or traffic rule violation. This proposed method is used for monitoring the attentiveness and emotional status of the driver which provides safety and security and gives better performances in handling the mode of the semi-autonomous vehicle (SAV).

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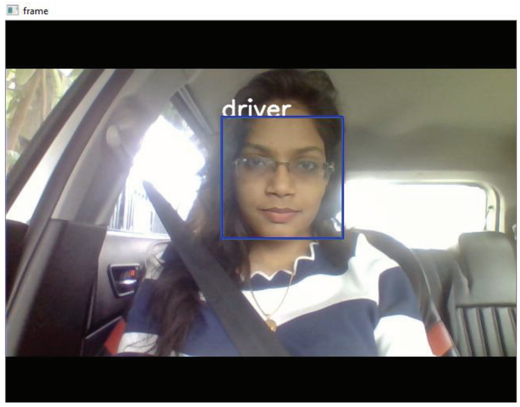

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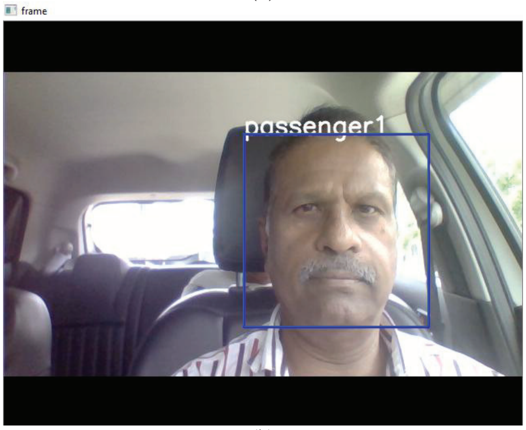


(b)

Fig. 2. Decide the person identity based on sitting space located inside the vehicle (a) driver and (b) passenger1

Initially, the ECU camera captures the frames and real-time face will be detected but it doesn't recognize if the person is either driver or passenger. Based on the space of sitting location inside a vehicle (Indian-standard), the program will identify the person. While capturing the frames, applied the Haar cascade to crop live images and generate the squared layout around the front face frame which is shown in figure 2.

Figure 3 shows the constructed dataset comprising frames of facial emotion with the original size of resolution which needs to train and test to increase the accuracy. Facial emotional expression feature matching will be done with stored images in the database within the ECU.

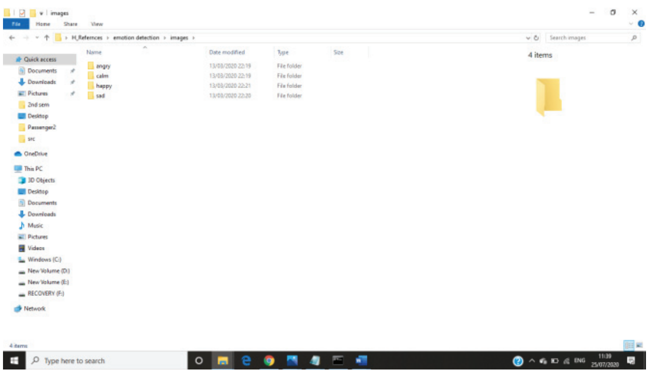
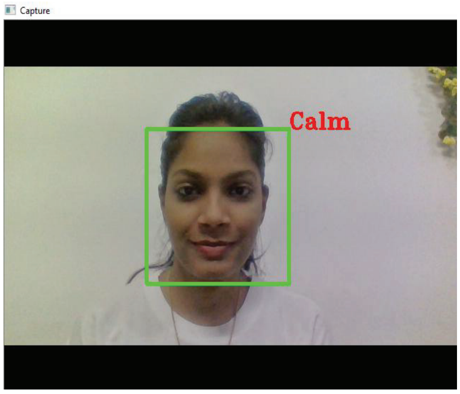
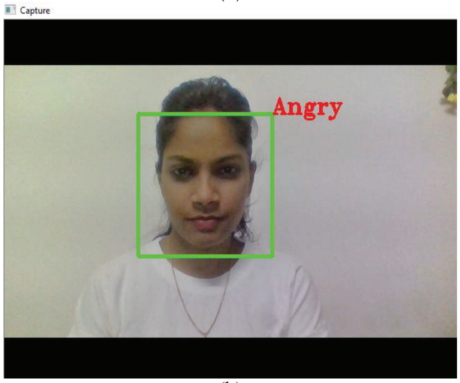


Fig. 3. Captured frames distributed database based on facial emotional expression



(a)



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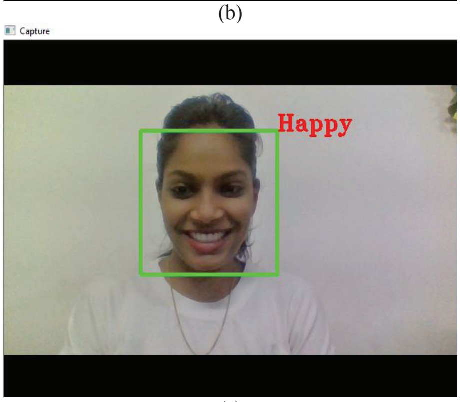

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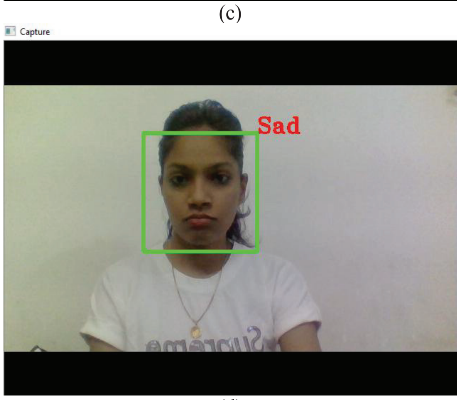

(d)

Fig. 4. Driver emotion evaluation using facial emotional expression (a) calm, (b) angry, (c) happy, and (d) sad

The database has been created with four different emotional expressions like angry, calm, happy, and sad. The driver and passenger frontal face will be captured by the ECU camera, placed on the vehicle dashboard. The driver's current mood will be predicted by facial expression using a

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deep learning algorithm with a squared Euclidean distance classifier as shown in figure 4. Images will be stored into the ECU distributed database which processed through deep learning algorithm and evaluated emotion information send to the CCU to decide the driving mode of the SAV.

III. Results

At every iteration ECU capture and processes the image to identify the facial expression for driver and passenger too. Regularly process the captured frame by ECU and send the information to the CCU to store the time series data with visual identification of emotion as shown in figure 5.

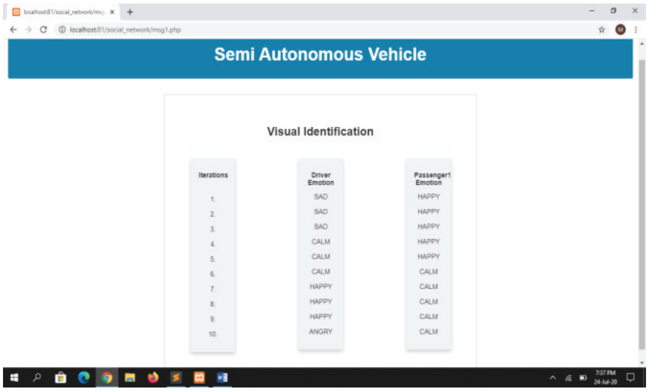
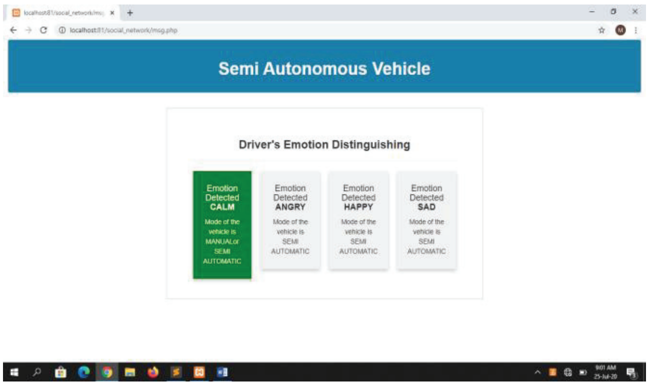
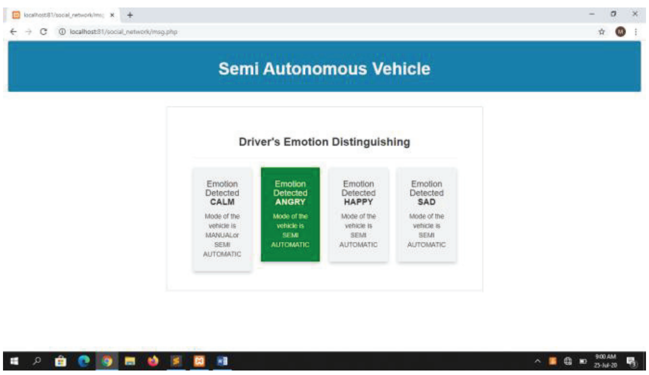


Fig. 5. Time series data with visual identification of emotions on the basis of facial expressions for the driver and passenger

Based on the emotion information, CCU manages the mode of the vehicle according to the evaluated emotion as presented in figure 6.



(a)



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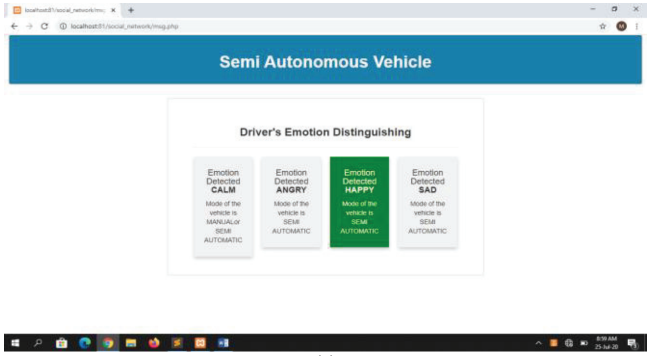

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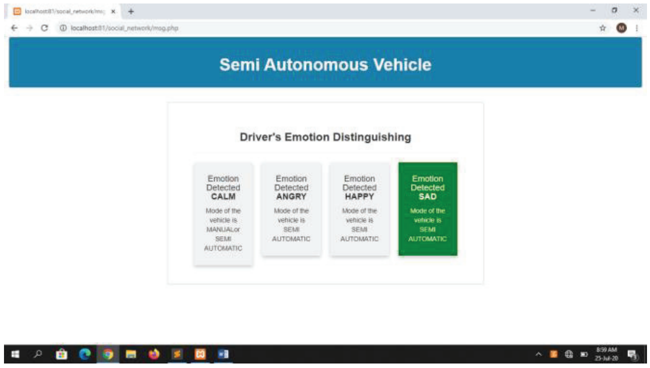

(d)

Fig. 6. SAV driving mode switching based on driver emotion evaluation (a) calm emotion for manual or semi-automatic mode, (b) angry emotion for the semi-automatic mode, (c) happy emotion for the semi-automatic mode, and (d) sad emotion for the semi-automatic mode

The ECU camera is continuously capturing the real-time facial expression, at the moment, the emotion that is very close to the stored facial expressions in the database will predict and send information to the CCU. If the driver state of mind is not normal or calm then vehicle manual mode will be changed to a semi-automatic mode which will limit the speed and follow all the traffic rules.

IV. Conclusion

The documented work has presented a cloud modeling technique to evaluate the mode of the semi-autonomous vehicle while edge computing is done for virtuous monitoring of facial expressions of driver and passenger to validate the cognitive and decisive mental activities which are uncertain while driving. At the initial stage, facial expressions are detected to evaluate the emotion in order to control the real-time intelligent driving. Finally, central computing will instruct the vehicle to regulate the driving mode according to the driver's current emotion. This paper also concludes that while driving, the driver is in an emotionally balanced state for safe traveling along with the passenger.

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