Facial Micro-Expression Detection under Variable Road Condition for Evaluation of Driver's Performance

Submitted by

Aleema Moin Shaikh

(NUST-00000275065)

Supervisor

Dr. Syed Omer Gilani

BIOMEDICAL SCIENCES

SCHOOL OF MECHANICAL & MANUFACTURING ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

ISLAMABAD

2022

Facial Micro-Expression Detection under Variable Road Condition for Evaluation of Driver's Performance

Submitted by

Aleema Moin Shaikh

(NUST-00000275065)

A thesis submitted in partial fulfillment of the requirements for the degree of

MS Biomedical Sciences

Thesis Supervisor:

Dr. Syed Omer Gilani

Thesis Supervisor's Signature:

____

BIOMEDICAL SCIENCES

SCHOOL OF MECHANICAL & MANUFACTURING ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY,

ISLAMABAD

2022

THESIS ACCEPTANCE CERTIFICATE

It is certified that the final copy of MS Thesis written by NS Aleema Moin Shaikh (Registration No. 00000275065), of SMME (School of Mechanical and Manufacturing Engineering) has been vetted by undersigned, found complete in all respects as per NUST statutes / regulations, is free of plagiarism, errors and mistakes and is accepted as partial fulfillment for award of MS/MPhil Degree. It is further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporated in the thesis.

Signature with stamp: ______________________

Name of Supervisor: Dr. Syed Omer Gilani

Date:______________________

Signature (HOD) with stamp: ______________________

Date: ______________________

Countersigned by

Dean/Principal

Signature:______________________

Date: ______________________

FORM TH-4

MASTER THESIS WORK

We hereby recommend that the dissertation prepared under our supervision by Aleema Moin Shaikh (Registration No: 00000275065), Titled: **Facial Micro Expression Detection under Variable Road Condition for Evaluation of Driver's Performance** be accepted in partial fulfillment of the requirements for the award of MS degree. Grade ______

Examination Committee Members

1. Name: Dr. Muhammad Jawad Khan Signature:________________
2. Name: Dr. Amer Sohail Kashif Signature:________________
3. Name: Dr. Hasan Sajid Signature:________________
4. Name: Dr. Kashif Javed Signature:________________

Supervisor's name: Dr. Syed Omer Gilani Signature:________________

Date:____________________

______________________________ _____________

Head of Department Date

COUNTERSINGED

Date:__________________ ________________ Dean/Principal

Declaration

I certify that this research work titled "*Facial Micro Expression Detection under Variable Road Condition for Evaluation of Driver's Performance"* is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

Aleema Moin Shaikh

MS BMS 00000275065

Plagiarism Certificate (Turnitin Report)

This thesis has been checked for Plagiarism. Turnitin report endorsed by Supervisor is attached.

Aleema Moin Shaikh

MS BMS 00000275065

Thesis Supervisor:

Dr. Syed Omer Gilani

Proposed Certificate for Plagiarism

It is certified that PhD/M.Phil/MS Thesis Titled Facial Micro Expression Detection under Variable Road Condition for Evaluation of Driver's Performance by Aleema Moin Shaikh has been examined by us. We undertake the follows:

a. Thesis has significant new work/knowledge as compared already published or are under consideration to be published elsewhere. No sentence, equation, diagram, table, paragraph or section has been copied verbatim from previous work unless it is placed under quotation marks and duly referenced.

b. The work presented is original and own work of the author (i.e. there is no plagiarism). No ideas, processes, results or words of others have been presented as Author own work.

c. There is no fabrication of data or results, which have been compiled/analyzed.

d. There is no falsification by manipulating research materials, equipment or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.

e. The thesis has been checked using TURNITIN (copy of originality report attached) and found within limits as per HEC plagiarism Policy and instructions issued from time to time.

Name & Signature of Supervisor

Name: Dr. Syed Omer Gilani

Signature: ___________________

Copyright Statement

Dedicated to

My Mom & Sister!

Acknowledgements

First of all, I am thankful to my Creator Allah to have guided me throughout this work at every step and for every new thought which He setup in my mind to improve it. Indeed I could have done nothing without His priceless help and guidance. Whosoever helped me throughout the course of my thesis, was His will, so indeed none be worthy of praise but Him.

Next, I would like to thank my mother and sister for supporting and encouraging me throughout my journey. It really helped me in staying positive and motivated to achieve my goal. They made sure that they offer help to overcome any obstacle that I encountered. Moreover, they believed in me that I can do this. This all mattered a lot.

I would also like to express my gratitude for my supervisor Dr. Syed Omer Gilani and co-supervisor Dr. Muhammad Jawad Khan for the guidance throughout the course of research. Their knowledge helped me in completing my thesis successfully. I would also like to acknowledge the support and presence of my GEC members Dr. Amer Sohail Kashif, Dr. Kashif Javed and Dr. Hasan Sajid.

I would also like to pay special thanks to the individuals who contributed in this research. Their time and effort is greatly valued. Their interest in the research and willingness to contribute is worth mentioning.

Finally, I would like to thank all of my friends & family members who kept checking upon me. Their motivation did make it easy for me to achieve my goal.

Contents

List of Figures

List of Tables

ABSTRACT

The emotional state of the driver has a direct impact on driving. Hence, to ensure road safety, it is important to monitor driver's emotional state. This challenging task can be achieved through analyzing micro-expressions as they are linked with a person's emotional state and emerge on face even under situations where a person is trying to conceal true emotions. Moreover, it's easy to acquire facial data while driving than any other stress signal. This research focuses on identifying micro-expressions linked with stressful emotional state in drivers. The physiological parameters like heart rate and stress value based on heart rate variability are also monitored as they fluctuate easily under emotional changes within the body. This research considered the emotions of happiness, sadness, surprise, anger, fear and disgust. To evaluate stress within drivers, the dominant emotion behind detected micro-expression is found through an emotion detection open source code. The results show a high F1 score for the identified micro-expressions i.e. 1.00, 0.947, 0.933 and 0.85. These findings can help in face readings where stress detection is required and can contribute towards better systems in cars to ensure road safety and manage stress.

Keywords: Micro-Expressions, Stress, Driver's Fatigue

CHAPTER 1: INTRODUCTION

Micro-expressions are considered as the fleeting and involuntary facial expressions that are usually observed in situations where a person tries to mask the true feelings. This is also explained as involuntary emotional leakage. It can result from any stimulus that can cause a change in person's emotional state of mind. The duration of such expressions is usually short i.e. 1/25 to 1/2 s. [1] Humans use facial expressions as a natural response to situations and hence, they hold a great importance when it comes to communication. Humans naturally learn to understand each other's expressions for their effective communication and interaction, but observing them in detail can be of great help in face readings. According to Albert Mehrabian, 7% of the communication is verbal, 38% of the communication is vocal and 55% of the communication is visual. So, understanding the non-verbal part can be of great use in different areas. The micro-expressions are produced as a result of movement of facial muscles known as Actions Units. Under a stimulus, the action units get impulses from the brain and produce visually distinguishable facial activity. This depicts that a specific set of AUs can be associated with a specific emotional state. The micro-expressions can possess multiple facial movements associated with basic emotions of happiness, sadness, surprise, anger, fear and disgust. This means that a person can be smiling which is associated with happiness, but a sudden frown can appear due to displeasure as a result of sudden change in emotions. So, the facial movements for different emotions may overlap revealing about the complex thought process. The brain areas such as the anterior cingulate cortex, the ventromedial prefrontal cortex and the amygdala have a role in social behavior of human body. These areas are said to be targeted under acute stress response and are involved in basic functions of facial expression recognition. [2] This shows that a person's state of mind also impacts the face reading of another individual.

Understanding these expressions in a more accurate manner is beneficial for the use in technical world, especially AI based devices, where the human intent is often misunderstood because of the limitations in understanding the non-verbal part of communication. Also, in areas like criminal investigations, business, health, education and security etc. there is a need to analyze the human behavior based on the thoughts and emotional state of mind to separate deceptive expressions from the real ones.

Researches have been carried out to achieve this goal and it is still a work in progress. This research aims to identify the micro expressions being produced in drivers under variable road conditions. In reality, the interpretation of human emotions is usually based on multiple factors that include body movements, posture, voice, body pose, gender, age, surrounding environments, social parameters, and expression etc. So through this research we tried to include factors other than micro-expressions as well i.e. stress before the drive, traffic levels, and heart rate. Combining these factors with micro expressions can reveal much accurate results about the emotional state of mind and hence, stress factor can easily be detected along with the associated micro expressions.

Moreover, most of the researches that have been carried out have the involvement of single person only i.e. the subject under study. The subject's expressions are analyzed by making him/her watch a movie or getting involved in some activity. [1] This research focuses on studying the expressions under more realistic environment that involves multiple people, normal communication while driving, multiple cars, and variable road conditions. Natural interactions will induce more natural and spontaneous emotional responses in terms of facial expressions and micro-expressions.

1.1 AIMS AND OBJECTIVES

The aim of the study is to identify stress within a driver through micro-expressions along with other biological parameters which can help in creating safe and comfortable environments for the drivers to improve road safety. These micro-expressions can also be used in other fields to understand the stressful mental state of a person. These areas include diagnosis and treatment of psychiatric illnesses, personality assessment tests and criminal investigations. Moreover, micro-expressions can also help the user interface and communication of humans with AI based devices and softwares.

The objectives include to:

- Identify the micro-expressions while driving under stress
- To propose a criterion for evaluation of the driver's performance

CHAPTER 2: LITERATURE REVIEW

Various studies have been conducted to understand body responses in case of stress. Though we still lack in developing a system which can evaluate the level of stress by considering all aspects, but research with special focus on each aspect is contributing in achieving this goal. One aspect is the physiological aspect, the studies on which have revealed that it involves changes in hormonal levels of body as a result of increase in SNS activity in case of stress. The physiological changes include muscle activation, increased heart rate and blood pressure, and faster respiration. The voice also changes because of the changes in muscle activity of vocal tract and variations in skin temperature occur. The diameter of the pupil also gets changed in the situations of stress.

The other aspect is behavioral aspect which includes studies with special focus on blink rate, eye gaze, facial expressions and head movements. When it comes to analyzing facial expressions, different researches used different setups to know more about the changes that emerge on a human's face. Some studies involved the subjects in some mental activity like solving analytical problems or driving and some tried to provide visual stimulus through movies or other video clips. [3] Here we will highlight some of the work already been carried in the facial expressions' domain.

2.1 FACIAL ACTION CODING SYSTEM (FACS)

FACS stands for Facial Action Coding System. It was first published in 1978 by Ekman and Friesen, and was then revised in 2002. [4] FACS is an anatomically based system that measures facial movements and recognize them by describing the movement of facial muscles. It breaks down facial expressions into their smallest discernable movements called action units. Each action unit, such as an eyebrow lift or nose wrinkle, creates a specific change in the appearance of face. This system measures the intensity and frequency of facial expressions. The coders of this system are capable of identifying the actions units by viewing images or videos of a person's face. Different researches have used this system to analyze human response for different purposes which include neuropsychiatric disorder, social-emotional development and deception. [5]

The following table shows the actions with respective muscles involved.

AU number	Name of action	Muscle(s) activated
1	Inner brow raiser	Frontalis (pars medialis)
2	Outer brow raiser	Frontalis (pars lateralis)
4	Brow lowerer	Depressor glabellae, depressor supercilii, corrugator supercilli
5	Upper lid raiser	Levator palpebrae superioris, superior tarsal muscle
6	Cheek raiser	Orbicularis oculi (pars orbitalis)
7	Lid tightener	Orbicularis oculi (pars palpebralis)
8	Lips toward each other	Orbicularis oris
9	Nose wrinkler	Levator labii superioris alaeque nasi
10	Upper lid raiser	Levator labii superioris, caput infraorbitalis
11	Nasolabial deepener	Zygomaticus minor
12	Lip corner puller	Zygomaticus major
13	Sharp lip puller	Levator anguli oris (i.e., caninus)
14	Dimpler	Buccinnator
15	Lip corner depressor	Depressor anguli oris (i.e., triangularis)
16	Lower lip depressor	Depressor labii inferioris
17	Chin raiser	Mentalis
18	Lip pucker	Incisivii labii superioris and incisivii labii inferioris
19	Tongue Show	
20	Lip stretcher	Risorius with platysma
21	Neck tightener	Platysma
22	Lip funneler	Orbicularis oris
23	Lip tightener	Orbicularis oris
24	Lip pressor	Orbicularis oris
25	Lips part	Depressor labii inferioris or relaxation of mentalis, or orbicularis oris
26	Jaw drop	Masetter; relaxed temporalis and internal pterygoid
27	Mouth stretch	Pterygoids, digastric
28	Lip suck	Orbicularis oris
41	Lid droop	Relaxation of levator palpebrae superioris
42	Slit	Orbicularis oculi (pars palpebralis)
43	Eyes closed	Relaxation of levator palpebrae superioris, orbicularis oculi (pars palpebralis)
44	Squint	Orbicularis oculi (pars palpebralis)
45	Blink	Relaxation of levator palpebrae superioris, orbicularis oculi (pars palpebralis)
46	Wink	Relaxation of levator palpebrae superioris, orbicularis oculi (pars palpebralis)

The coded numbers are arbitrary and do not correspond to any significant value.

Fig. 2.1: Single action units in the facial action code [4]

2.2 FACIAL EXPRESSIONS: A LEARNED COMPONENT TO THE SOCIAL MANAGEMENT

A study conducted by Matsumoto, D., and Willingham, B. on spontaneous expressions of blind individuals compared the expressions of congenitally blind athletes in the 2004 Paralympic Games with each other and with sighted athletes in the 2004 Olympic Games. There were no differences reported except more facial activity in blind individuals specifically in head and eye movements. This study provided evidence that facial expressions are not a dependent on observational learning, but they are a leaned component to the social management even in blind individuals. [6] So, it can be concluded from the research that facial expressions has a lot to do with mental state of a person.

2.3 DETECTING EMOTIONAL STRESS FROM FACIAL EXPRESSIONS FOR DRIVING SAFETY

Gao H. et al. conducted research on making a system to evaluate driver's emotional state while driving. They considered two negative emotions as stress detectors i.e. anger and stress. The simulated data proved to be ideal for the developed system. The issues like pose mismatch and variation due to camera setup were reported as a hurdle, but they can be resolved by an additional pose normalization step. The main reason to consider facial expressions instead of physiological parameters was the intrusiveness of the later. Previous researches have considered physiological parameters like heart rate, respiration, skin conductivity etc. but it's difficult to acquire such data when a person is driving in real time so a new system utilizing a different input was needed. [7]

2.4 MICRO-EXPRESSION DETECTION IN HIGH SPEED VIDEO BASED ON FACS

Another research work revolved around proposing a computer vision method as a solution for measuring timing characteristic of micro-expressions. This work done by Polikovsky et al. involves a flow approach which involves 3D gradient descriptors to measure changes between following video frames. This research also claims to provide a FACS based database for analyzing micro-expression motion characteristics which can be beneficial for researchers in the field of Psychological and behavioral studies.

2.5 AUTO-EMOTIVE SYSTEM BRINGING EMPATHY TO DRIVING EXPERIENCE

Work on systems which can facilitate the driver during drive is under process. The main aim of such research is to provide assistance to driver in performing primary secondary and tertiary tasks while driving. The primary tasks involve accelerating, braking, steering, and lane, route and distance with other vehicles decisions. Secondary tasks involve operating windscreen wipers, dimming, coupling, changing gears, and blinking. Tertiary tasks involve seat heater, operating air conditioner, phone and radio. It reveals that the secondary tasks are more related to driver's safety while tertiary deal with comfort. [9]

In MIT labs a prototype of such system known as auto-emotive system is designed. It is equipped with camera to record facial expressions, heart rate, respiration rate and heart rate variability and sensors in the steering wheel to monitor electrodermal activity, hand pressure, amount of hand contact and skin temperature. Upon increase in the levels of stress the cars helps the driver by raising individual and social awareness. The features to comfort the driver include adaptive music, empathetic GPS, calming temperature, corrective headlights and communicative paint. [10]

MATERIALS AND MEHTODS

3.1 PARAMETERS

The parameters included in this research to evaluate stress in drivers are micro-expressions, heart rate, fatigue element, age, driving experience, traffic levels, weather, time and stress level based on heart rate variability.

3.2 DATA ACQUISITION

Next step is data acquisition to evaluate stress through above mentioned parameters. 10 subjects are considered for this research. The ages of the subjects are between 25 – 40 years. All the subjects signed a consent form prior to the collection of data. The stress levels of the subjects are recorded before the drive to know if they already are in a stressful state and the facial expressions, traffic levels and heart rate are recorded throughout the drive.

3.3 EQUIPMENT

The facial expressions are recorded through phone's front camera i.e. Vivo S1 Pro (32MP, 720P), and the traffic levels are monitored through back camera of Huawei Y7 Prime (13MP), Sony (13 MP), and Samsung Galaxy A51. For recording physiological parameters like heart rate and stress levels Xiamoi Mi Band 5 is used. The front camera is placed on the dashboard of the car using car mount and the band is tied on the wrist of the subject to acquire data while driving.

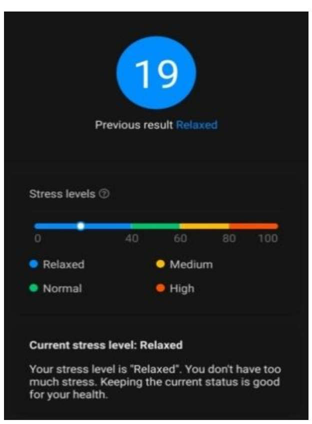

Figure 3.1: Stress level

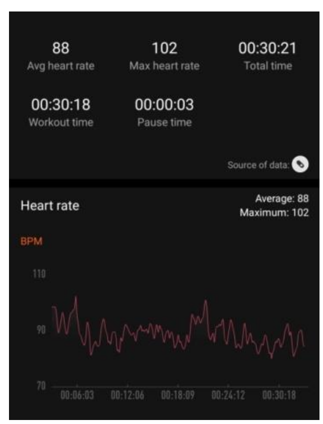

Figure 3.2: Heart Rate graph

3.4 DATA ANALYSIS

The recorded videos are analyzed manually and the change of expressions of a person is saved in the form of screenshots in respective folders. The activity on road i.e. change in traffic levels, road conditions, over taking, U-turns etc. is also observed along with the heart rate peaks shown in the Mi band graph. All this data is then entered in excel sheet in respective columns. The expressions observed are named according to FACS (Facial Action Coding System). [11]

3.5 EMOTIONS INVOLVED

The emotions included in this research for stress identification involve fear, surprise, anger, disgust, sadness, and happiness. These emotions are divided into two categories based on positive and negative emotions. The first five emotions are negative so if the subject experiences them then he/she is considered in a stressful state. The last emotion i.e. happiness is a positive one so if the subject experiences this one then he/she is considered to be in a stress free state.

3.6 IDENTIFICATION OF EMOTION

The identification of emotion for every micro-expressions observed is done through a code Deepface acquired from Github. [12] The code uses an image and gives the values of all the emotions experienced by the subject, based on expressions, in that particular instant. The identification of emotion is also done through FACS guidebook chart given on imotions website [11]. A person is considered in as stressful state if the negative emotions values exceeded the positive ones. In cases where neutral emotional state is dominant, the emotion with next highest score is considered. This data is also entered in the excel sheet with respective expressions.

Figure 3.3: Emotions with respective expressions based on FACS guidebook [11]

3.7 Deepface

Deepface is a lightweight hybrid face recognition framework in python which focuses on facial attribute analysis i.e. gender, age, race and emotion. [12] It wraps up state-o-the-art models: VGG-Face, Google FaceNet, OpenFace, Facebook DeepFace, DeepID, ArcFace, Dib and SFace. [12] The default configuration uses VGG model. It handles the 5 common stages of face recognition i.e. detect, align, normalize, represent and verify. [12] A single line of code can call verification, find or analysis function. For face detection OpenCV, SSD, Dlib, MTCNN, RetinaFace and MediaPipe are wrapped in deepface. The default detector is OpenCV. [12]

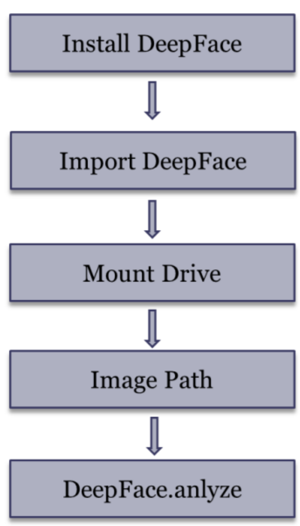

Figure 3.4: Algorithm of Deepface emotion detection code

RESULTS

After data acquisition and analysis, the results are extracted. The micro-expressions are considered as keywords for this research and a count is calculated for each keyword. The following figure shows this keyword count depicting the number of times a micro-expression appeared on the faces of subjects during the drive.

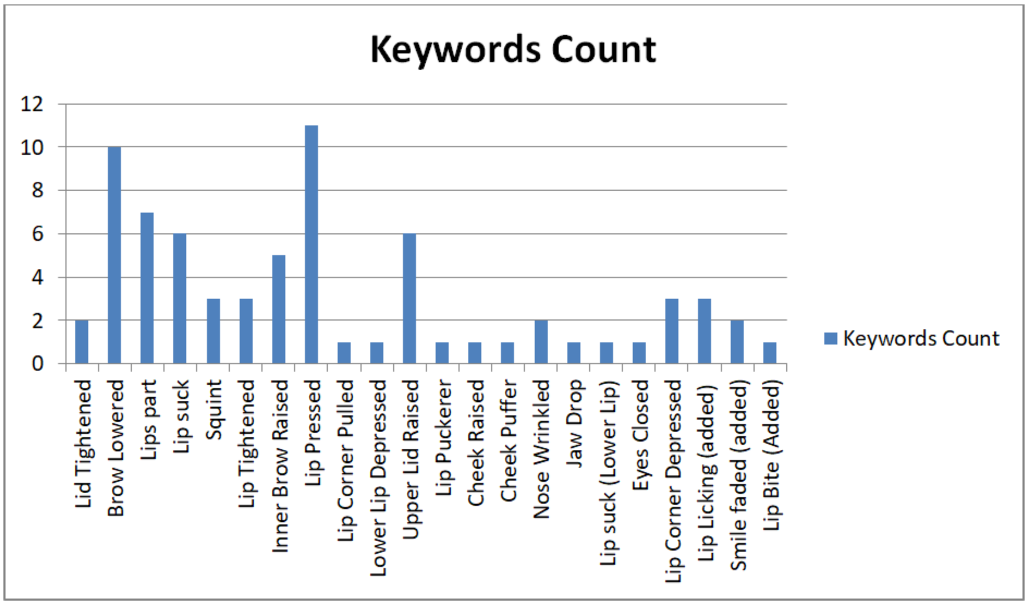

Figure 4.1: The count of micro-expressions observed.

The expressions detected once or twice in the subjects are excluded and the rest are analyzed from stress perspective.

Following are the findings for each subject separately.

4.1 SUBJECT 1

This subject has a total drive time of 25 minutes. The subject has shown expressions as mentioned in the following graph. The data collection is done in daylight with clear weather. The physiological parameters are shown in figure 4.3.

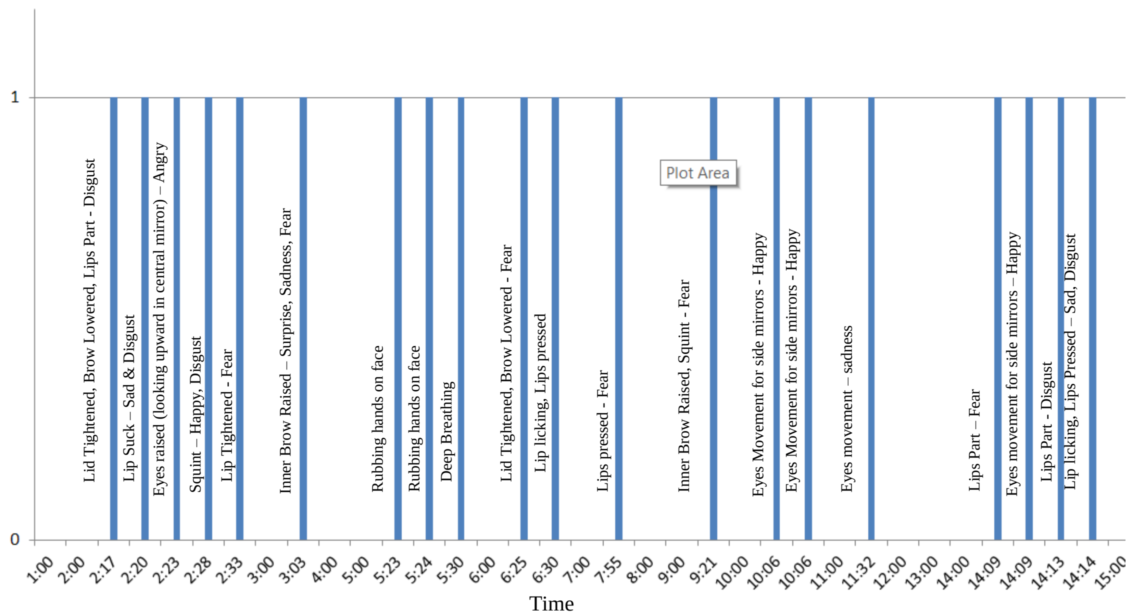

Figure 4.2: Detected Micro-Expression with identified emotions for subject 1

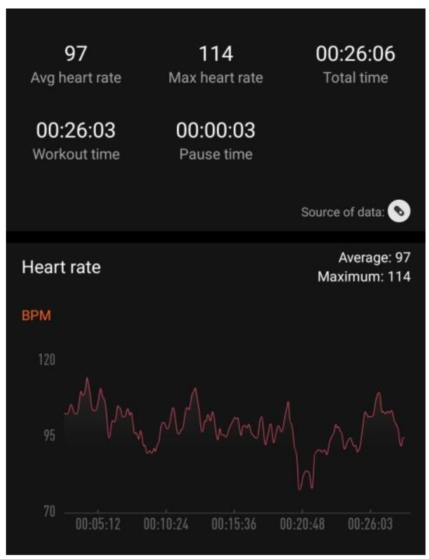

Figure 4.3: Heart Rate data of subject 1

4.2 SUBJECT 2

This subject has a total drive time of 11 minutes during night light and slightly rainy weather. The heart rate is shown in figure 4.5 and the expressions are shown in following graph along with the identified emotions.

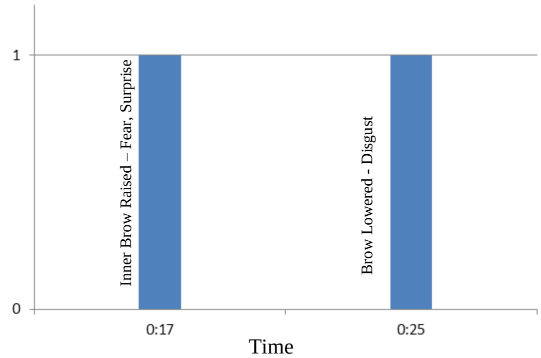

Figure 4.4: Detected Micro-Expression with identified emotions for subject 2

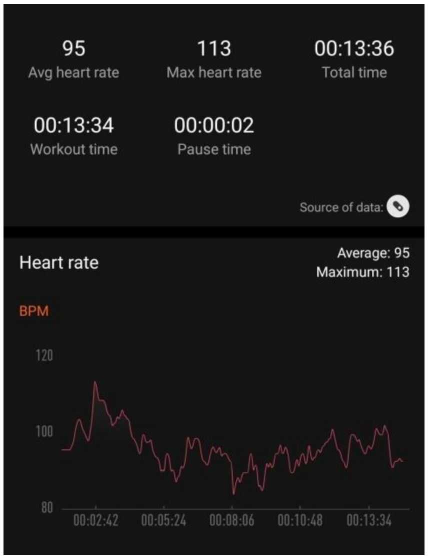

Figure 4.5: Heart rate data of subject 2

4.3 SUBJECT 3

Total drive time for this subject is about 16 minutes during day time and clear weather. The expressions along with identified emotions are shown in the graph below. The heart rate data is collected in two sections for this drive as shown in figure 4.7 and 4.8.

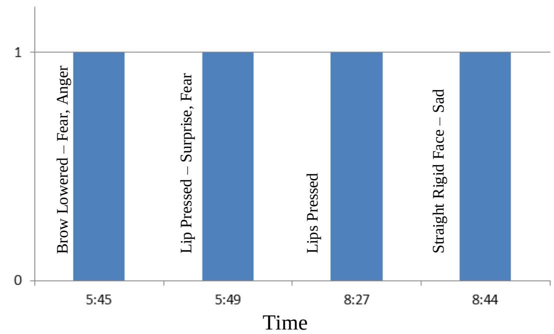

Figure 4.6: Detected Micro-Expression with identified emotions for subject 3

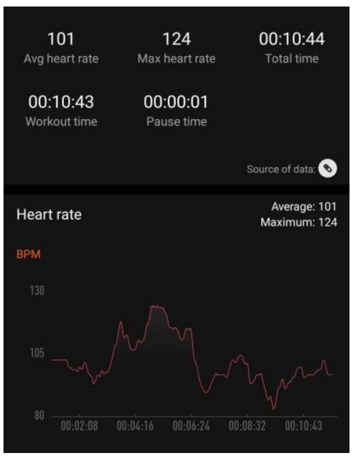

Figure 4.7: Heart rate data for subject 3 (Part1)

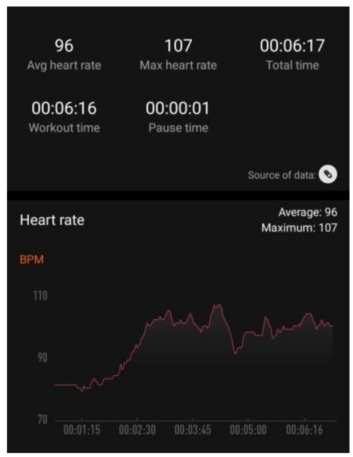

Figure 4.8: Heart rate data for subject 3 (Part2)

4.4 SUBJECT 4

For this subject the data was collected at two different times of the day i.e. Morning and Evening.

4.4.1 Morning Time

The drive time for this ride is 16 minutes and the weather conditions are clear. The following graph shows the expressions detected with emotions identified. The heart rate data is shown in figure 4.10.

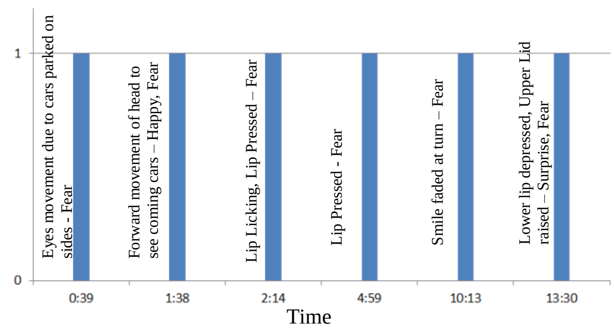

Figure 4.9: Detected Micro-Expression with identified emotions for subject 4 (Morning time)

Figure 4.10: The heart rate data for subject 4 (Morning time)

4.4.2 Evening Time

The drive time for this ride is 11 minutes and the weather conditions are clear. The following graph shows the expressions detected with emotions identified. The heart rate data is shown in figure 4.12.

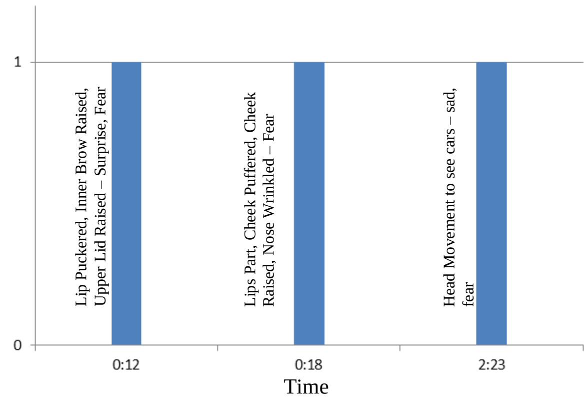

Figure 4.11: Detected Micro-Expression with identified emotions for subject 4 (Evening time)

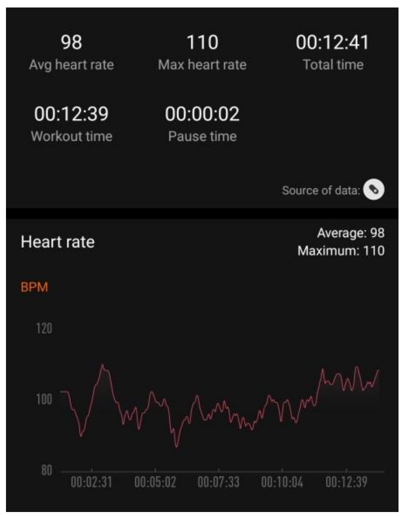

Figure 4.12: The Heart rate data for subject 4 (evening time)

4.5 SUBJECT 5

This is a 30 minutes' drive during daylight under clear weather conditions. The driver for this driver has learner's driving license which means less experience. The following graph shows expressions with identified emotions and figure 4.14 shows heart rate data.

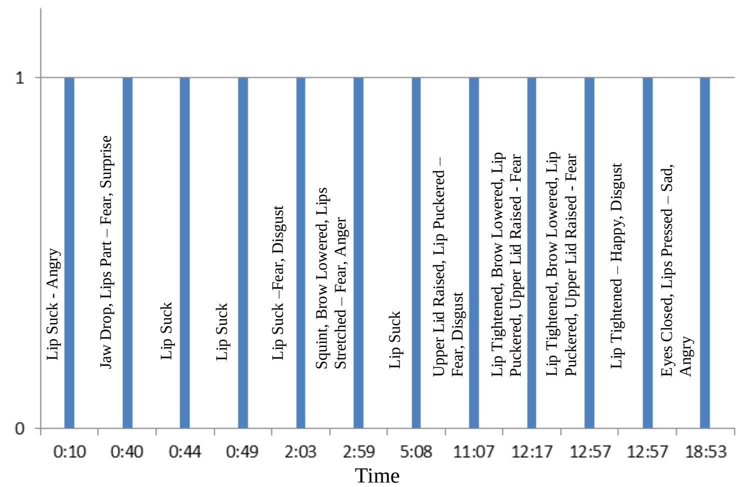

Figure 4.13: Detected Micro-Expression with identified emotions for subject 5

Figure 4.14: Heart rate data for subject 5

4.6 SUBJECT 6

This is a 29 minutes' drive during daylight under clear weather conditions. The driver for this driver has learner's driving license which means less experience. The following graph shows expressions with identified emotions and figure 4.16 shows heart rate data.

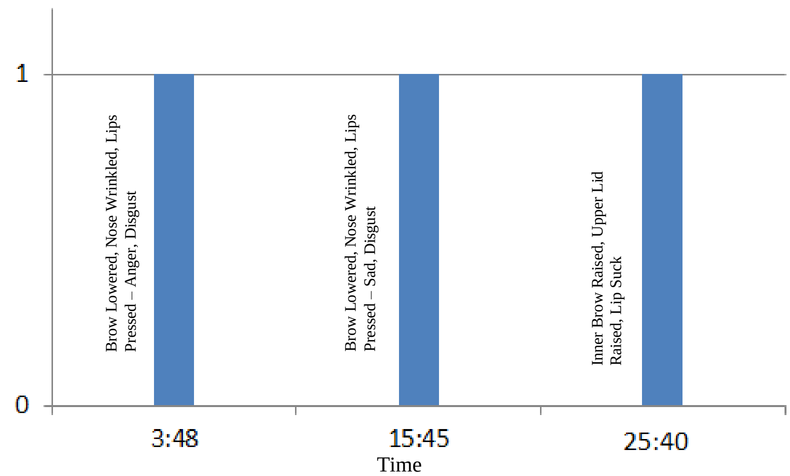

Figure 4.15: Detected Micro-Expression with identified emotions for subject 6

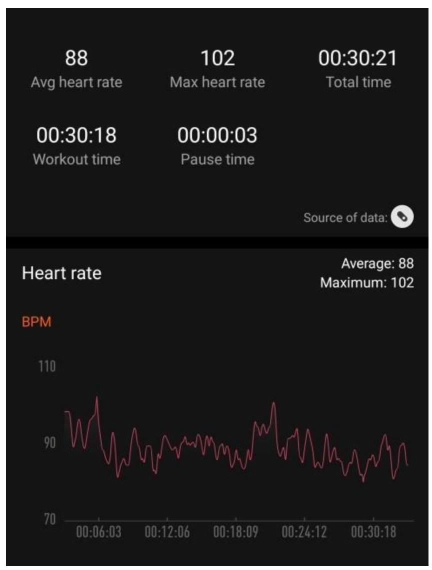

Figure 4.16: Heart rate data for subject 6

4.7 SUBJECT 7

This is a 28 minutes' drive during night time under clear weather conditions. The driver for this driver has learner's driving license which means less experience. The following graph shows expressions with identified emotions and figure 4.18 shows heart rate data.

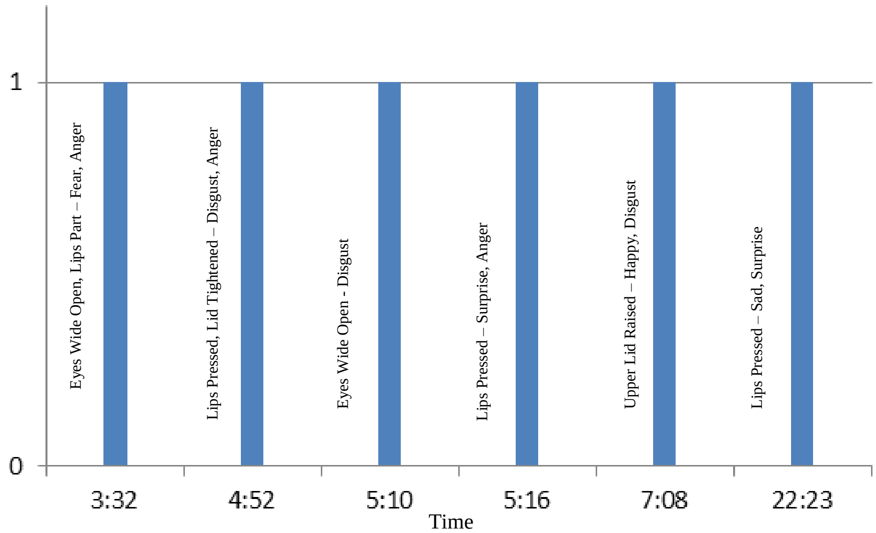

Figure 4.17: Detected Micro-Expression with identified emotions for subject 7

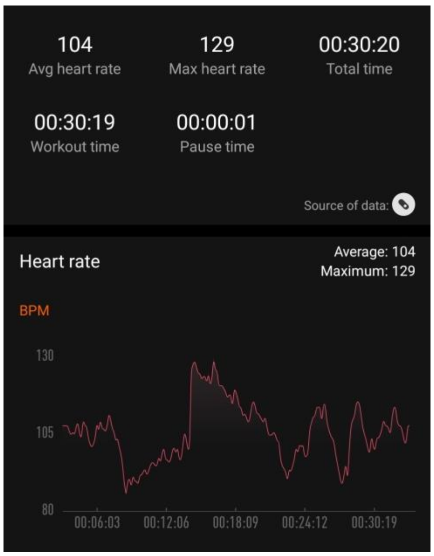

Figure 4.18: Heart rate data for subject 7

4.8 SUBJECT 8

The drive time for this subject is 40 minutes. No visible expressions are detected during the whole ride. The heart rate data is shown in following figure 4.19.

Figure 4.19: Heart rate data for subject 8

4.9 SUBJECT 9

The drive time is about 25 minutes for this subject during daylight and under clear weather conditions. The following graph shows expressions with identified emotions and figure 4.21 shows heart rate data.

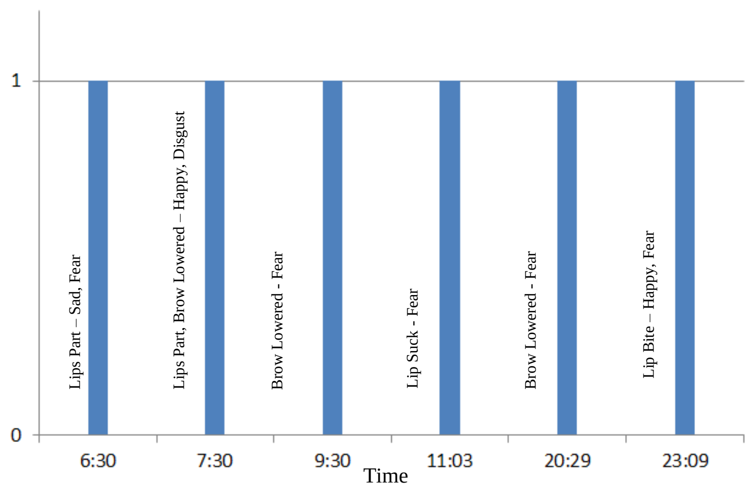

Figure 4.20: Detected Micro-Expression with identified emotions for subject 9

Figure 4.21: Heart rate data for subject 9

4.10 SUBJECT 10

The drive time for this subject is nearly 7 minutes in daylight and clear weather conditions. The graph below shows the detected expressions with identified emotions. Figure 4.23 shows heart rate data.

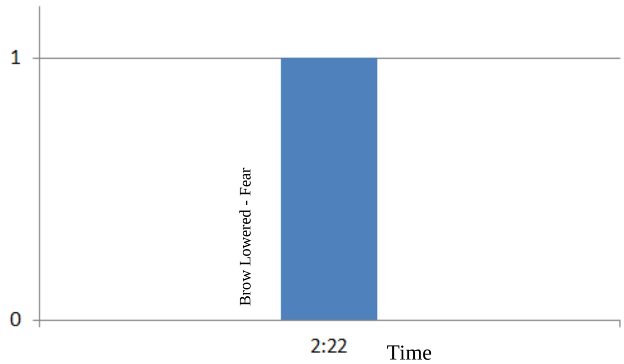

Figure 4.22: Detected Micro-Expression with identified emotions for subject 10

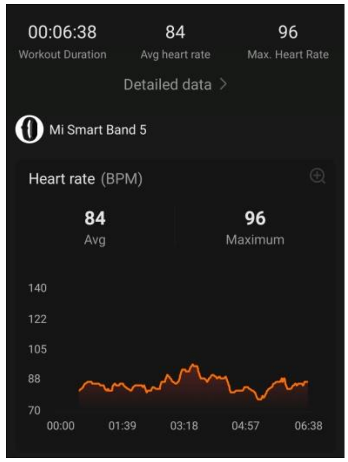

Figure 4.23: Heart rate data for subject 10

4.11 VISUAL REPRESENTATION OF MICRO-EXPRESSIONS

Following are the images for the identified micro-expressions.

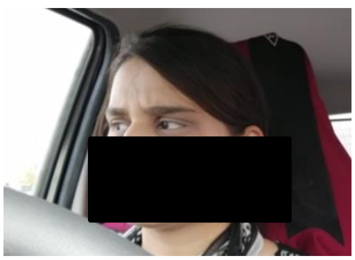

Fig: 4.24: Brow lowered

Fig: 4.25: Inner brow raised

Fig: 4.26: Lid tightened

Fig: 4.27: Lip suck

Fig: 4.28: Lip tightened

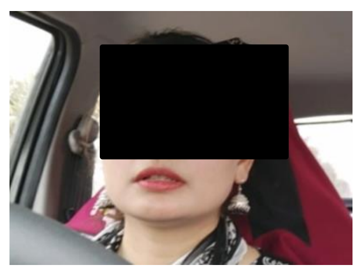

Fig: 4.29: Lips part

Fig: 4.30: Lips pressed

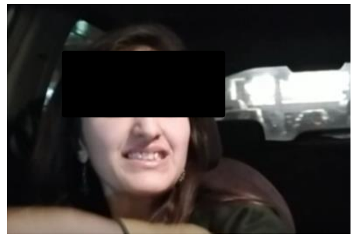

Fig: 4.31: Nose wrinkled

Fig: 4.32: Lip corner depressed

Fig: 4.33: Squint

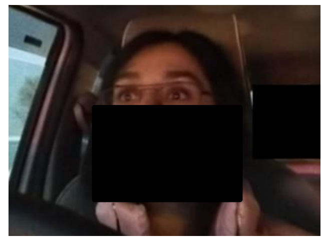

Fig: 4.34: Upper lid raised

4.12 RELEVANCE WITH STRESS

To relate the data micro-expressions with stress, emotions at a particular instant are considered. Following table shows the dominating emotions for the respective expressions.

Micro-Expression	**Emotion**
Lid Tightened	Disgust, Fear
Brow Lowered	Disgust, Fear, Anger
Lips Part	Disgust, Fear
Lip Suck	Sad, Angry, Fear
Squint	Fear, Anger, Disgust
Lip Tightened	Fear
Inner Brow Raised	Fear, Surprise
Lip Pressed	Fear, Sadness
Upper Lid Raised	Fear, Surprise
Nose Wrinkled	Sadness, Fear
Lips Corner Depressed	Fear, Angry

Table 4.1: Micro-expressions observed with the dominant emotions at that instant.

The results show that the micro-expressions shown during the drive are majorly associated with negative emotions which depict a stressful state of the driver. So the above listed micro-expressions can be considered as stress indicators in case of stress analysis or performance analysis of an individual.

4.13 PHYSIOLOGICAL PARAMETERS

The stress levels of the subjects recorded before the drive varied from 19 – 49 that depicts relaxed to mild stress state. This means that the subjects were not in a high stress state before the drive. The average heart rate of the subjects during the drive varied from 81 – 104 bpm. This shows a high heart rate as it lies in the upper limit of the normal range for an adult i.e. 60 – 100 bpm. [13]

4.14 FATIGUE

The subjects who did not sleep well from the past couple of days or stayed under work stress showed more expression than others. This depicts that the emotional load does appear through facial expressions.

4.15 DRIVING EXPERIENCE

The subjects having a learner’s driving license (beginners) showed more stressful expressions like fear. This depicts that the lower experience contributed as a stress factor which appeared on face through micro-expressions.

4.16 TRAFFIC LEVELS

The traffic levels did effect the expressions. The busy areas of roads triggered more stressful emotions within the subject and hence more micro-expressions are detected.

4.17 WEATHER AND TIME

Weather and time did not have much effect on the driver’s performance. If the road is clear the stress factor is seen to be normal and hence no emotional or expressional output is observed.

4.18 VALIDATION

The accuracy percentage and F1 score is calculated for validation of results of each expressions. Following table shows the values.

Micro-Expression	Accuracy	F1 Score
Brow Lowered	90%	0.947
Lips Part	87.5%	0.933
Lip Suck	100%	1
Squint	100%	1
Lid Tightened	75%	0.85
Inner Brow Raised	100%	1
Lips Pressed	100%	1
Lip Licking	100%	1
Upper Lid Raised	100%	1
Lips Corner Depressed	100%	1

Table 4.2: Micro-expressions with accuracy and F1Score

4.19 BODY MOVEMENTS

Some other body movements are also observed during this research. These include forward head movement to see cars coming from the other side. This usually happens when a driver can't see the cars in the mirrors or another lane of cars has blocked driver's view. The next movement observed is of eye ball. When the driver is focusing upon side mirrors then the eye ball either moves left or right rapidly or to the upper center of the dashboard to see the cars behind. It has also been observed that the drivers tried to relax themselves upon signals through deep breaths. This depicts that they are having a tiring ride and they need some rest. The next observation includes the fading of smile. It has been observed that if the driver smiled on any random communication during the drive, but instantly the attention diverted to an event on road i.e. change in road condition, over taking or U-turn etc. then the smile faded instantly. This depicts that such fading of smile is usually because of a stressful thought process.

DISCUSSION

This research revolves around the identification of micro-expressions associated with stress in drivers under real time environment. The physiological data like heart rate is also acquired which further validates if the driver experienced a stressful thought in his mind or event on the road. The human emotions behind the detected micro-expressions are identified as well. The interpretation of human emotions is usually based on multiple factors that include body movements, posture, voice, body pose, gender, age, surrounding environments, social parameters, and expressions etc. So, in this research we collected data in real time environment on busy roads and connected the events on roads with heart rate and micro-expressions to get better and more authentic results.

The results can contribute to the already going work in the research sector for stress identification and management under different circumstances. This research is also significant from road safety perspective as it helps in identifying stress within drivers through visual stimulus i.e. face recording which is considered as an easily acquirable data during a complex activity like driving.

The major part of the communication is non-verbal with a high percentage of visual. The micro-expressions are said to be visible even when a person tries to conceal the true emotions. So, this research also contributes in understanding the visual part of communication in areas like AI, criminal investigations, business, health, education and security etc.

However, there are certain limitations and the future work can further add to this research. The physiological data can be increased and further stress identifiers can be added like measurement of sweat through palms, breathing rate, body temperature etc. In a more complex setup, a system can be designed to acquire brain signals in a way that the equipment doesn’t interfere with the driving of the driver to avoid any risk. Such studies can help in creating car systems which help to lower stress while driving to ensure road safety. Moreover, the research findings can also contribute to the understanding of non-verbal part of communication which is of utmost importance in personality analysis of a person and diagnosis and treatment of patients with psychiatric illnesses.

CONCLUSION

In this work, we have identified micro-expressions for the detection of stress in drivers. For this purpose, we have acquired facial and physiological data of drivers while driving and analyzed it. The negative emotions behind these expressions have been detected by an emotion recognition code on Github.[12] These detected micro-expressions include brow lowered, lips part, lip suck, squint, lid tightened, inner brow raised, lips pressed, lip licked, upper lid raised and lips corner depressed with a high F1 score that ranges from 0.85 to 1.00. These findings can help in face readings where stress detection is required and can contribute towards better systems in cars to ensure road safety and manage stress.

REFERENCES

[1] Zhao, G., & Li, X. (2019). Automatic Micro-Expression Analysis: Open Challenges. Frontiers in Psychology.

[2] Daudelin-Peltier, C., Forget, H., Blais, C., Deschenes, A., & Fiset, D. (2017). The effect of acute social stress on the recognition of facial expression of emotion. Nature.

[3] Alberdi, A. Aztiria, A., & Basarab, A. (2016). Towards an automatic early stress recognition system for office environments based on multimodal measurements: A review. ELSEVIER Science Direct.

[4] Facial Action Coding System. Paul Ekman Group.

[5] Clark E. A., Kessinger, J., Duncan, S. E., Bell, M. A., Lahne, J., Gallagher, D. L., & Keefe S. F. (2020). The Facial Action Coding System for Characterization of Human Affective Response to Consumer Product-Based Stimuli: A Systematic Review. Frontiers in Psychology.

[6] Matsumoto, D., & Willingham, B. (2009). Spontaneous facial expressions of emotion of congenitally and noncongenitally blind individuals. Pers Soc Psychol. PubMed.

[7] Gao, H., Yuce, A., & Thiran, J. Detectig emotional stress from facial expressions for driving safety. CORE.

[8] Plikovsky, S., Kameda, Y., & Ohta, Y. (2013). Facial micro-expression detection in Hi-speed video based on Facial Action Coding System (FACS). IEICE TRANS. INF. & SYST.

[9] Eyben, F., Wollmer, M., Poitschke, T., Schuller, B., Blaschke, C., Farber, B. & Nguyun-Thein, N. (2010). Emotion on the road – Necessity, Acceptance, and Feasibility of Affective Computing in Car. Hindawi Publishing Corporation.

[10] Hernandez, J., McDuff, D., Amores, J., Benavides, X., Maes, P., & Picard, R. (2014). AutoEmotive: Bringing Empathy to the Driving Experience to Manage Stress. MIT.

[11] Farnsworth, B. (2019). Facial Action Coding System (FACS) – A visual guidebook. IMotions.

[12] Serengil. Deepface. Github.

[13] MacGill, M. (2021). What should my heart rate be?. Medical News Today.

ORIGINALITY REPORT

13%	10%	8%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Higher Education Commission Pakistan Student Paper	1%
2	www.ncbi.nlm.nih.gov Internet Source	1%
3	Submitted to University of Wales, Bangor Student Paper	1%
4	Joseph Lee. "Face transplantation for the blind: more than being blind in a sighted world", Journal of Medical Ethics, 2018 Publication	1%
5	METHODS.SAGEPUB.COM Internet Source	1%
6	link.springer.com Internet Source	<1%
7	tampub.uta.fi Internet Source	<1%
8	www.tandfonline.com Internet Source	<1%

9	Florian Eyben, Martin Wöllmer, Tony Poitschke, Björn Schuller, Christoph Blaschke, Berthold Färber, Nhu Nguyen-Thien. "Emotion on the Road—Necessity, Acceptance, and Feasibility of Affective Computing in the Car", Advances in Human-Computer Interaction, 2010 Publication	<1%
10	edepot.wur.nl Internet Source	<1%
11	Submitted to Royal Holloway and Bedford New College Student Paper	<1%
12	Submitted to University of Surrey Roehampton Student Paper	<1%
13	Submitted to Oxford Brookes University Student Paper	<1%
14	Repository.sustech.edu Internet Source	<1%
15	ethesis.nitrkl.ac.in Internet Source	<1%
16	Submitted to University of Wales Institute, Cardiff Student Paper	<1%
17	vtechworks.lib.vt.edu	

Internet Source <1 %

18 Paul Ekman, Wallace V. Friesen. "Measuring facial movement", Environmental Psychology and Nonverbal Behavior, 1976
Publication <1 %

19 espace.library.uq.edu.au
Internet Source <1 %

20 studylib.net
Internet Source <1 %

21 www.politesi.polimi.it
Internet Source <1 %

22 www.susana.org
Internet Source <1 %

23 Senya POLIKOVSKY, Yoshinari KAMEDA, Yuichi OHTA. "Facial Micro-Expression Detection in Hi-Speed Video Based on Facial Action Coding System (FACS)", IEICE Transactions on Information and Systems, 2013
Publication <1 %

24 Xiaobai Li, Xiaopeng Hong, Antti Moilanen, Xiaohua Huang, Tomas Pfister, Guoying Zhao, Matti Pietikainen. "Towards Reading Hidden Emotions: A Comparative Study of Spontaneous Micro-Expression Spotting and <1 %

Recognition Methods", IEEE Transactions on Affective Computing, 2018
Publication

25	nanopdf.com Internet Source	<1 %
26	"Enhanced Living Environments", Springer Nature, 2019 Publication	<1 %
27	Aliya Tastemirova, Johannes Schneider, Leona Chandra Kruse, Simon Heinzle, Jan vom Brocke. "Microexpressions in digital humans: perceived affect, sincerity, and trustworthiness", Electronic Markets, 2022 Publication	<1 %
28	Camille Daudelin-Peltier, Hélène Forget, Caroline Blais, Andréa Deschênes, Daniel Fiset. "The effect of acute social stress on the recognition of facial expression of emotions", Scientific Reports, 2017 Publication	<1 %
29	S L Happy, Aurobinda Routray. "Fuzzy Histogram of Optical Flow Orientations for Micro-Expression Recognition", IEEE Transactions on Affective Computing, 2019 Publication	<1 %
30	doc.rero.ch Internet Source	<1 %

31	dspaces.uok.edu.in Internet Source	<1 %
32	pure.tue.nl Internet Source	<1 %
33	uwe-repository.worktribe.com Internet Source	<1 %
34	www.citethisforme.com Internet Source	<1 %
35	www.pitt.edu Internet Source	<1 %
36	David Matsumoto, Bob Willingham. "Spontaneous facial expressions of emotion of congenitally and noncongenitally blind individuals.", Journal of Personality and Social Psychology, 2009 Publication	<1 %
37	Javier Hernandez, Daniel McDuff, Xavier Benavides, Judith Amores, Pattie Maes, Rosalind Picard. "AutoEmotive", Proceedings of the 2014 companion publication on Designing interactive systems - DIS Companion '14, 2014 Publication	<1 %

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		