Faculty of Electronics and Computer Engineering

FACIAL DROWSINESS SIGNS DETECTION ALGORITHM USING IMAGE PROCESSING TECHNIQUES UNDER VARIOUS LIGHTING CONDITIONS

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Master of Science in Electronic Engineering

2017

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FACIAL DROWSINESS SIGNS DETECTION ALGORITHM USING IMAGE PROCESSING TECHNIQUES FOR VARIOUS LIGHTING CONDITION

NUR FATIN IZZATI BINTI YURI

A thesis submitted
in fulfilment of the requirements for the degree of Master of Science in Electronic Engineering

Faculty of Electronic and Computer Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

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DECLARATION

I declare that this thesis entitled “Facial Drowsiness Signs Detection Algorithm using Image Processing Techniques for Various Lighting Condition” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……..

Name : NUR FATIN IZZATI BINTI YURI

Date : ……..

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APPROVAL

I hereby declare that I have read this thesis and my opinion this thesis is sufficient in term of scope and quality for the award of Master of Science in Electronic Engineering.

Signature : ……

Name : DR. MASRULLIZAM BIN MAT IBRAHIM

Date : ……

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DEDICATION

To my beloved mother, father and siblings

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ABSTRACT

For the past few years, drowsiness signs detection systems have been developed as one of the initiative to reduce car crashes. However, various luminance intensities are one of the major problems in the development of a drowsiness signs detection system. This research studies the suitable image processing techniques to be implemented in a drowsiness signs detection algorithm for various lighting conditions. Four lighting conditions are proposed with the average range of 0 luminance value to 175 luminance value. In this project, the algorithm is developed based on four main algorithms which are the detection algorithm, the tracking algorithm, the preprocessing algorithm and the drowsiness signs analysis algorithm. Viola-Jones algorithm is utilized for face detection. Upon acquiring the face location, the knowledge-based method is implemented to locate the eye and the mouth. After that, Kanade Lucas Tomasi algorithm is applied for tracking purpose. Based on the tracked face and the tracked facial components, the region of interest is selected. Image processing techniques are applied to the eye region and the mouth region to fix the image intensity and to enhance the features of the image. In order to analyse the drowsiness signs portrayed by the eye and the mouth, the operation to determine the eye state and the mouth state is determined. The distance between eyelid is computed to determine the eye state. Meanwhile, the height of the mouth opening is computed to determine the mouth state. There are three drowsiness signs that are analysed for the eye region, namely, the eye blink count, the duration of the eye closure and the percentage of time that the eye is closed. As for the drowsiness sign in the mouth region, the yawning count is computed. This thesis presents a small-scale drowsiness signs database for four lighting conditions. The performance of the algorithm is validated by using the developed database under four luminance intensities and achieved promising results. The performance of the drowsiness signs detection algorithm is fully dependent on the performance of the eye state detection and the mouth state detection. For eye state detection, the proposed technique possessed an accuracy of 98.71 % for 0 luminance value, 97.10 % for 2 luminance value, 98.30 % for 5.2 luminance value and 98.8 % for 174.9 luminance value. As for mouth detection, the proposed technique possessed an accuracy of 99.45 % for 0 luminance value, 98.03 % for 2 luminance value, 99.6 for 5.2 luminance value and 99.7 % for 174.9 luminance value. The proposed technique yielded the overall accuracy of 98.22% for eye state detection and the overall accuracy of 99.23% for the mouth state detection. In conclusion, the proposed technique managed to yield high accuracy for four lighting conditions and could be improved for further research to be implemented in a real time environment.

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ABSTRAK

Tanda-tanda mengantuk boleh ditunjukkan melalui tingkah laku pemandu seperti kerap menguap dan sering berkedip. Keamatan pencahayaan adalah salah satu masalah utama dalam pembangunan sistem pengesanan tanda-tanda mengantuk. Kajian ini mengkaji teknik pemprosesan imej yang sesuai untuk dilaksanakan dalam algoritma pengesanan tanda-tanda mengantuk untuk pelbagai keadaan pencahayaan. Empat keadaan pencahayaan dicadangkan dengan purata nilai 0 nilai keamatan hingga 175 nilai keamatan. Algoritma ini direka berdasarkan empat algoritma utama iaitu algoritma pengesanan, algoritma penjejakan, algoritma pra-proses dan algoritma analisis tanda mengantuk. Algoritma Viola-Jones digunakan untuk pengesanan muka. Apabila memperoleh lokasi muka, kaedah berasaskan pengetahuan dilaksanakan untuk mencari mata dan mulut. Setelah itu, algoritma Kanade Lucas Tomasi digunakan untuk tujuan penjejakan. Berdasarkan wajah yang dikesan dan komponen wajah yang dijejaki, kawasan yang penting dipilih. Teknik pemprosesan imej digunakan di rantau mata dan rantau mulut untuk memperbaiki keamatan imej dan untuk meningkatkan ciri-ciri imej. Untuk menganalisis tanda-tanda mengantuk yang digambarkan oleh mata dan mulut, operasi untuk menentukan keadaan mata dan keadaan mulut ditentukan. Jarak antara kelopak mata dikira untuk menentukan keadaan mata. Sementara itu, ketinggian pembukaan mulut dikira untuk menentukan keadaan mulut. Terdapat tiga tanda mengantuk yang dianalisis untuk rantau mata, iaitu, kiraan kerdipan mata, tempoh penutupan mata dan peratusan masa mata ditutup. Bagi tanda mengantuk di rantau mulut, kiraan menguap dikira. Tesis ini membentangkan pangkalan data tanda-tanda mengantuk dalam skala kecil untuk empat keadaan pencahayaan. Prestasi algoritma disahkan dengan menggunakan database yang dibangunkan di bawah empat kadar pencahayaan dan mencapai hasil yang menjanjikan. Prestasi algoritma pengesanan tanda mengantuk sepenuhnya bergantung kepada prestasi pengesanan keadaan mata dan pengesanan keadaan mulut. Untuk pengesanan keadaan mata, teknik yang dicadangkan mempunyai ketepatan 98.71% untuk 0 nilai keamatan, 97.10% untuk 2 nilai keamatan, 98.30% untuk 5.2 nilai keamatan dan 98.8% untuk nilai keamatan 174.9. Bagi pengesanan mulut, teknik yang dicadangkan mempunyai ketepatan 99.45% untuk 0 nilai keamatan, 98.03% untuk 2 nilai keamatan, 99.6 untuk 5.2 nilai keamatan dan 99.7% untuk 174.9 nilai keamatan Teknik yang dicadangkan menghasilkan ketepatan keseluruhan 98.22% untuk pengesanan keadaan mata dan ketepatan keseluruhan 99.23% untuk pengesanan mulut. Sebagai kesimpulan, teknik yang dicadangkan berjaya menghasilkan ketepatan yang tinggi untuk empat keadaan pencahayaan dan dapat ditingkatkan untuk penyelidikan selanjutnya untuk dilaksanakan dalam persekitaran masa nyata.

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ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my deepest appreciation to my supervisor, Dr. Masrullizam bin Mat Ibrahim and my co-supervisor, Associate Professor Dr. Nurulfajar bin Abd. Manap for their endless supervision and encouragement. Furthermore, their ideas and suggestions are amongst the facts that I managed to complete this thesis.

Not to forget, special thanks to my beloved father, Yuri binYahya and my beloved mother, Farizat bin Abd. Karim for their eternal support and prayers. I am also grateful to my siblings, Muhammad Syafiq bin Yuri and Nur Farah Aqilla binti Yuri, who have supported me along the way with their patience and invaluable understanding. My further gratitude goes to my wonderful friends who have always been there for me to cheer me up. It is my luck to have such a warm and loving family and friends.

Last but not least, highly appreciation to The Ministry of Higher Education Malaysia and Universiti Teknikal Malaysia Melaka (UTeM) for helping and providing the whole study funding.

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LIST OF ABBREVIATIONS

2D	-	Two Dimensional
3D	-	Three Dimensional
CIE	-	Comission Internationale de L'Eclairage
CNN	-	Convolution Neural Network
CSLBP	-	Center-Symmetric Local Binary Pattern
EB	-	Eye Blink
EC	-	Eye Closure
ECD	-	Eye Closure Duration
ECG	-	Electrocardiogram
ECR	-	Eye Closure Ratio
ED	-	Distance between the Center of the Eye
EEG	-	Electroencephalogram
EO	-	Eye Openness
ESR	-	Eye State Ratio
fc	-	foot candle
FCM	-	Fuzzy C-Means
FFT	-	Fast Fourier Transform
FN	-	False Negative
FP	-	False Positive
FPR	-	False Positive Rate
fps	-	frame per second

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HOG	-	Histogram Oriented Gradient
HP	-	Head Pose
HRV	-	Heart Rate Variability
HT	-	Hough Transform
IR	-	Infrared
KLT	-	Kanade-Lucas Tomasi
LBP	-	Local Binary Pattern
LPT2	-	East Coast Expressway 2
lx	-	lux
LDW	-	Lane Departure Warning
MSR	-	Mouth State Ratio
NCC	-	Normalized Correlation Computation
N_{ECR}	-	Normalized Eye Closure Ratio
NSDD	-	Normalized Sum Squared Difference
N_{YR}	-	Normalized Yawn Ratio
PA	-	Pupil Activity
PERCLOS	-	Percentage of Eye Closure
PSO	-	Particle Swarm Optimization
RGB	-	Red Green Blue
ROI	-	Region of Interest
STREL	-	Structuring Element
SVM	-	Support Vector Machine
SWA	-	Steering Wheel Angle
TN	-	True Negative
TP	-	True Positive

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TPR	-	True Positive Rate
VF	-	Variance Filter
YC_bC_r	-	Luminance and chroma component colour space
YR	-	Yawning Ratio

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LIST OF PUBLICATIONS

Y, N.F.I., Ibrahim, M.M., Manap, N.A., and A, N.S., 2016. Analysis of Eye Closure Duration Based on the Height of Iris. Control System, Computing and Engineering (ICCSCE), 2016 6th IEEE International Conference, pp.419–424.

Y, N.F.I., Ibrahim, M.M., S.B. Nur'Afifah, and Manap, N.A., 2017. Development of Yawning Detection Algorithm for Normal Lighting Condition and IR Condition. Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 9(2-13), pp.29 – 34

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Drowsiness is a state of being sleepy, tired, exhausted or feeling weak mentally or physically. A drowsy person possesses a very low attention level, which might be difficult to maintain the level of focus. In addition, a drowsy person might drop the motivation and unable to give fast response. If this is occurring to a driver, a machinery worker who handles heavy machine or a rail operator, it might cause an accident. Car crashes are one of the fatal accidents that is considered as a major problem for the society. Among the many causes of car accidents, 20% of them is coming from drowsy drivers who have lost their attention level on steering wheel or road lane (Singh and Banga, 2013; Tansakul and Tangamchit, 2015; Vijayalaxmi and Rani, 2015). Based on the analysis done by The Malaysia Ministry of Work on the accident statistic for East Coast Expressway 2 (LPT2), a drowsy driver was included among the categories of driver who contributes to the main cause of accidents occurred at the East Coast Expressway 2 for 9 months record, starting from February 2015 to October 2015. According to the statistic, there are a total of 717 car crashes occurred during the 9 months duration and 77% of them are caused by human error which include drowsy drivers. According to the statistic analyzed by Royal Malaysia Police (Polis Diraja Malaysia), there are 240,703 cases recorded from January to June 2015. In comparison with the previous year, an increment of 6,942 cases is analyzed. Out of 45% of the cases, the main cause of the accidents is identified due to the fatigue issue.

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Analysis in drowsiness detection has become an interesting area and many approaches are introduced based on different categories which are intrusive and non-intrusive. Through an intrusive method, subjects are required to attach a sensory device such as electrode on its body to measure signals from part of the body such as brain signal and heart signal. This might cause subjects to feel uncomfortable since any massive movements will affect the signals. On the contrary, non-invasive method is more users friendly, more flexible and acceptable since this approach does not need any connection to the human body. Generally, there are two non-invasive methods that are widely used for research in drowsiness detection, which are by observing the driving pattern and through analyzing driver's behavior. Steering wheel movement, brake patterns, lane changing and speed are the examples of driving pattern that can be observed to indicate drowsiness. However, this method is limited to the vehicle types and road condition. Instead, the existence of camera technology allowed researchers to apply non-invasive technique utilizing image processing approach to detect drowsiness through driver's behavior. This method is more user friendly compared to the intrusive method and is easier to implement. Head rotation, eye blinking pattern, gazes estimation and yawning activities are among the behavior that had always been used as indicators in detecting drowsiness stage. Based on the research done, there are countless algorithms introduced in detecting drowsiness based on driver's behavior, but there are a few major limitations that affect the robustness of the system. One of the major limitations is changes in luminance. In order to overcome with this problem, few researchers introduced algorithms which are tested in various lighting condition. Nevertheless, poor lighting condition degraded the performance of the algorithm.

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