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Driver's Attention Monitoring System with Low Light Capability

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ABSTRACT

The study aims to aid in solving the problems brought by drowsy and distracted driving. The Driver Monitoring System will measure the rate and duration of the driver's blinking, yawning, and head turning. The program would be coded with C++ using QtCreator and compiled with gcc. The processing would be done with a Linux machine where the camera is connected to. The camera is equipped with an infrared illuminator that would serve as the medium for the low-light capability of the system. Additionally, an Android application would be used hand in hand with the program that would not only serve as a control mechanism of the driver for the program, but would also serve as the alarm system to alert the driver of their current condition. The driver's actions and conditions would be determined by the algorithm set by the program. Thresholds and time limits can be set to provide better readings and more consistent readings from each driver using the program. The alarm system would trigger when certain conditions are met, in turn, this would keep the driver alert and reminded how they are faring while driving. With numerous tests, results became much better and over time, the researchers reached an efficiency and effectiveness of up to 95%. These efforts lead to solving the problem tackled by the researchers.

Key words: distracted driving, driver monitoring, drowsy driving, opencv, image processing

1. INTRODUCTION

Technology can be considered as both beneficial and harmful to the society. Advancements in technology contribute a great deal to the society in making life convenient and providing a more efficient way to do things. On the other hand, technology such as cellphones can be harmful, especially to drivers. Distracted drivers are at high risk for vehicular accidents such as those who use their phone while driving. According to the National Highway Traffic Safety Administration (NHTSA) in the United States, 2,910 out of the 30,057 fatal road crashes involved distracted drivers in 2013. Drowsy driving is the act of operating or having control of a motor vehicle while the individual's capacity to drive securely is impaired due to the lack of sleep. A late study by the American Automobile Association shows that two out of each five drivers confessed to having nodded off while driving. The same organization was also able to observe that one out of every eight auto collisions require the hospitalization of drivers or passengers due to drowsy driving. Respectively, that is an approximate of 41% and 16% of individuals being faced with danger. The varying outcomes in terms of damage, injury, and even death may be just as permanent as those from driving under the influence of alcohol or drugs. The danger is evident when an individual nod off behind the wheel and even more so in the event before that. Drivers who are drained and tired have deferred responses and settle on bad decisions. Not only they are placing themselves in peril, but they can also be a risk to other individuals on the road.

Distracted Driving is the act that usually diverts the attention of the driver from driving and it can also be the cause of accidents on the road which can affect the people who are driving normally and crossing pedestrians. Based on the NHTSA's annual report, roughly 17% of the casualties were caused by distracted drivers. The most common act of distraction is texting while driving since it diverts the driver's attention by looking at his phone rather than focusing on the road which can cause road accidents.

The journal on Mobile Wearable Device for Long Term Monitoring of Vital Signs [1] presents a wireless coupled recording device for long-term monitoring of vital signs signal. They were able to record ECG, blood pressure and skin temperature, and include 3d-acceleration sensor for the determination of the movements during recording. The journal of Implement of Face Recognition in Android Platform by Using Opencv and LBT Algorithm [2] suggested the use of connection and local binary pattern histogram algorithm to use optimum software open CV and using hardware platform android to identify faces.

The work done on Driver's Cognitive Distraction Detection Using Physiological Features by the AdaBoost [3] focuses on detecting driver's cognitive distraction, a state which can easily lead to a traffic accidents. It provides a methodology for more precise and faster driver's cognitive detection by using the AdaBoost.

The article on Vision-based Method for Detecting Driver Drowsiness and Distraction in Driver Monitoring System [4] proposes a driver-monitoring method considering both drowsiness and distraction. It uses an eye-detection algorithm using adaptive boosting, adaptive template matching and blob detection with eye validation. It also utilized an eye state-detection algorithm.

The journal on Drowsy Driver Identification Using Eye Blink Detection [5] discusses non-intrusive machine vision-based concepts of simulating drowsiness detection system. Drowsiness is determined by observing the eye blinking action by detecting face, eye and mouth. It is implemented using vision toolbox of Matlab.

The journal on Semi Autonomous Quadcopter for Early Rat Infestation Detection [6] uses thermal pictures taken by the drone to be processed by the code. It uses Phyton for its image processing for detecting rats.

The paper on Development of a Face Recognition System Using Deep Convolutional Neural Network in a Multi-view Vision Environment [7] presents the implementation of face recognition system for multi-view vision system consisting of three cameras. The main structure composed of recognizing faces, embeddings computation and database vector comparison. OpenCV, Python dlib, face recognition or Openface and ResNet34 are utilized for this face recognition method.

In this paper, the group aims to incorporate drowsiness detection and create a more effective system that would attempt to alert the driver when drowsiness is observed in order to prevent accidents. In this implementation, image processing will be used to provide observations into the system such as the blinking pattern and yawning, which indicates when the driver is experiencing drowsiness. The use of audio sounds would also serve as the method in waking and alarming the driver in order to prevent drowsiness. In this way, bigger problems like damage to property, injuries, accidents, and deaths can be lessened.

1.1 Statement of the Problem

Safe driving is an important aspect in traffic and road safety. The ideal scenario to be expected when you are on the road is to be alert and cautious so that accidents will less likely to occur. Vehicular accidents can lead to serious injury, trauma and even death of the driver and other drivers involved in a collision. The usual causes of accidents when driving are road rage, slippery roads, reckless driving and drunk driving. At present, distracted drivers which involve the use of cellphones while driving, and drowsy drivers which also commonly occurs at night are becoming a major threat worldwide. The occurrence of accidents related to distracted and drowsy driving are alarmingly increasing each year. According to the National Highway Traffic Safety Administration (NHTSA) in the United States, 3,154 deaths and 424,000 injuries is the estimate due to distracted drivers and 800 deaths and 44,000 injuries is the estimate due to drowsy driving in 2013. Prevention can become a great deal of help, especially at night, in lessening the high incidence rate of vehicular accidents involving distracted and drowsy drivers. This prevention could save many lives and lessen traffic.

1.2 Objectives

The general objective of the research is to create a driver monitoring system using image processing hardware with controls from an android application

This was achieved through the following specific objectives:

- Developing an image processing program that would be able to detect human facial structure in a computer program
- Implementing an algorithm that would determine if the driver is distracted by monitoring the head movements. It monitors head movements on different axes and determines if movement is still normal under different circumstances like looking at side mirrors or rearview mirror.
- Utilizing an algorithm that would determine if the driver is drowsy by monitoring the eye behavior and mouth movements. It checks whether eye movements are still normal behavior based on set algorithm. It also monitors if the mouth movements are still normal behavior in a set period.
- Implement the controls of the system in a Linux application using a touchscreen display. Also,
- Providing a visual feedback and essential measurements through the touchscreen display.
- Achieving 95% accuracy at normal light conditions and 90% accuracy at low light conditions.

1.3 Significance of the Study

Road accidents take thousands of lives each year, where distracted and drowsy drivers are the leading contributors to such phenomenon. According to the Department of Transportation secretary, Mark de Leon, in Metro Manila alone, where 12.9 million people reside, the daily average of road crashes is 262. In this research project, it will subjectively monitor the current conditions of the driver, whether he or she is distracted and drowsy. Through an android device application, it incorporates the use of image processing to detect facial movements and triggers an alarm upon detection of a distracted or drowsy driver. The said application can help lessen the occurrence of distracted and drowsy drivers which in turn decreases the chances of road accidents. This research project can give awareness to drivers to be more attentive and careful whenever they are driving.

2. DESIGN CONSIDERATIONS

The goal of the system is to be able to monitor a driver while on the road using a camera where image processing would be done. In this process, various data would be acquired and presented to the driver via a touch enabled display wherein data output and control of the system is shown.

2.1 System Block Diagram

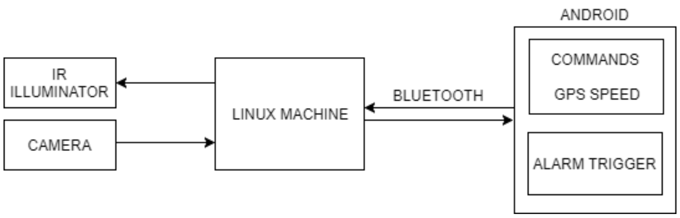

Figure 1: System Block Diagram

Figure 1 shows the block diagram of the whole system. The Linux machine is the main processor of the system. The touchscreen display will be used to display visual feedback and get controls from the driver. The IR illuminator will assist the camera when lighting conditions are compromised. The accelerometer that will be provided by the android device will send its data to the Linux machine to determine whether the vehicle is moving or in stationary and the commands of the android device can power on or off the Linux machine while the alarm will be triggered using the android device to increase the alertness of the driver. Both devices are connected by using Bluetooth.

2.2 Image Processing Block Diagram

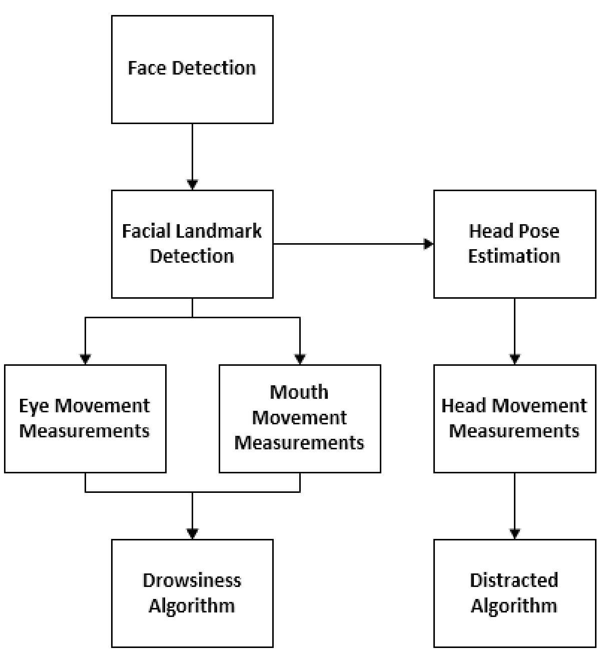

Figure 2: Image Processing Block Diagram

As seen in Figure 2, the video fed from the camera will be subjected to the image processing algorithm. Face detection will be the first step in which the system will be able to locate the position of the head of the driver in the frame. Facial Landmark Detection will be used to provide an accurate mapping of the driver's facial features. Eye movement and mouth movement measurements can be extracted after the Facial Landmark Detection process. Head Pose Estimation will be used to determine the deviation of the driver's head from the road. These measurements will be essential to the drowsiness and distracted algorithms.

2.3 User Interface

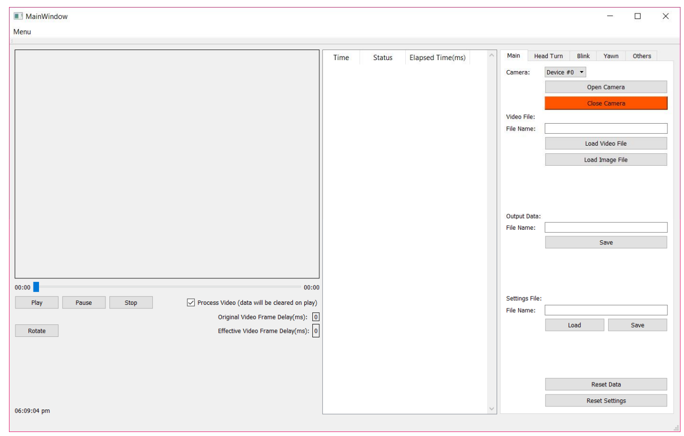

Figure 3: Developed User Interface

A program would provide user control and would give the user/driver to turn the camera on or off, set threshold settings, display the data, and plot the actions being done by the driver in real time. The developed user interface can be seen in Figure 3.

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2.4 Android

Android supported device is used in this project since it will act as a controller to the Linux system. The connection between the two devices is made possible by the means of Bluetooth technology.

The Android Software Developer Kit comes with the required libraries, emulators and tools to program Android applications. The purpose of the Android SDK is to enable the development of applications in the Android system. The group used the Android device to interface the controls to the Linux device making it easier to use.

The Android Native Development Kit is a tool used with the Android SDK which allows the developers to program applications using C++ codes and its purpose in the prototype is to develop program using the QT creator and interface it in Android.

Java Development Kit is a software development environment which is used to develop Java applications. Most of the developed Android applications are built by using the Java Development kit because of the Android SDK uses the JDK to compile its program files.

3. METHODOLOGY

3.1 Implementation

Software development is one of the key points in this study. The input source of the program is a video feed which can either be from a camera or from a recorded video file. Through the use of OpenCV, the video is loaded into the program which acquires its input per frame of the video. These frames will be the main input source to be analyzed by the program to provide its results. There are two types of detection algorithms used in this program. Frontal face detector was the first detection algorithm used to detect multiple faces from each frame of the video, which will be enclosed in rectangles to isolate their location to be passed to the next detection algorithm. Facial Landmark Detection was used to detect different points on an individual's face. It has 68 points which covers the essential parts of the facial structure, and then the program calculates different measurements across the individual's face. 3.1.1

This program focuses on 3 main points to consider, head-turn detection, blink detection, and yawn detection. For the head turn detection, it measures the tip of the nose and the edge of each eye. The ratio of each side can determine the orientation of the person's face whether the head of the person is turning left or right. For the blinking detection, it measures the points on the lower eyelid and the upper eyelid. The measurement can determine the opening of the person's eyes which leads to the detection of a blinking instance. For the yawn detection, the opening of the mouth and the eye levels of the person were the measurements considered. The middle parts of the upper lip and the lower lip were the points used for mouth measurements. These measurements will vary if the person's face is closer or farther from the camera. Scaling was done to compensate for these situations. The main measurement was scaled to a second measurement to acquire constant values upon changes on the distance from the camera.

Threshold levels are set to determine if an instance has occurred based on the measurements from the facial structure of the driver. If an instance occurs, a timer from the QT framework is started to measure the duration of the instance. The duration of an instance is also considered for the drowsiness algorithm and distracted algorithm. The threshold levels and threshold time are displayed in the User Interface. The threshold values can be adjusted by the driver to be fit for detection.

Every instance detected is shown into the User Interface. Each instance is labeled with the time recorded, type of instance and the duration of the instance which are displayed into table using QTableWidget from QT Framework.

3.2 Evaluation

The parameters measured by the program will be from the points by the facial landmark detection of dlib. These points are responsible for knowing when the driver blinked, yawned, and turned their heads. The researchers inquired a diverse group of people to be tested in a room setting and on the field. The researchers instructed the subjects certain actions to verify the accuracy of the program. Subjects inside the rooms simulated the low-light and daylight setting by turning the lights on or off inside the room during night time. The instructions involved were to look up, blink normally, and to close their eyes for a set amount of time. Meanwhile, the subjects that underwent field testing were given the freedom to blink when they want, how long they want, and as much as they want.

The same procedures were done to monitor the other parameters. Inside the room setting, the researchers instructed the subjects when and how long to turn their heads. Additionally, subjects were also instructed to yawn as natural as they can to be properly detected by the program.

4. RESULTS AND DISCUSSION

4.1 Illuminator Efficiency

The researchers asked ten individuals to have their photos taken on different lighting conditions using the prototype, with the equipped infrared illuminator either turned on or off. The images are loaded onto the Linux program to check whether the individual's face is detected by the program. These would help determine the effectiveness of equipping the prototype with an infrared illuminator. Figure 4 shows the illuminator efficiency results.

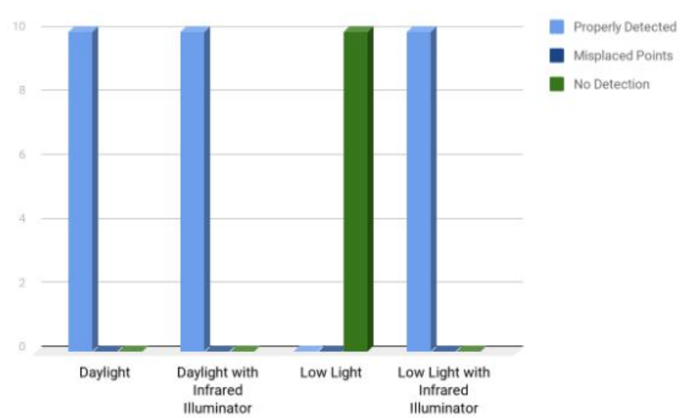

Figure 4: Illuminator Efficiency Results

4.2 Instance Detection

The tests for different room setting was conducted that aims to measure the accuracy of detecting instances such as head turns, blinks and yawns. For tests conducted in daylight conditions inside a room setting, the results of detected yawns and head turns were 100% accurate while the detection rate for blinks had an error rate of 4.4%

However, for room setting tests in low-light conditions, accuracy dropped for all parameters but was still in the range of 90% to 100%. Head turn accuracy had an error rate 3.7%, and blink accuracy is now 91.7%. The accuracy for yawns detected on low-light room settings still yielded a 100%

For Field test, it were captured inside a vehicle. The test aims to determine the accuracy of detecting an instance while the subject is driving.

For tests conducted on the field with daylight, the instances detected yielded results of 95% upwards. The instance with the lowest detection rate on the road in daylight was the blinking accuracy with a detection rate of 95.3%. The second lowest was the head turn detection with an accuracy of 95.9%. Yawning on the road in daylight still yielded a 100% accuracy.

When it is night time on the field, there is lesser light passing through the camera which will yield low-light photos. On top of that, being on the field, the researchers were not able to control various lighting elements present on the road. However, the detection rate for the instances on low-light conditions still produced a positive detection rate. Head turn accuracy was still 92.4% accurate and blink detection accuracy was at 92.5%. The yawn detection still yielded a 100% accuracy even in low-light field tests.

The results for the instance detection can be seen in table 1.

Table 1: Summary of Instance Detection

Detection	Light Condition	Setting	True Positive	False Positive	False Negative	Accuracy
HEADTURN	Daylight	Room Setting	24	0	0	100%
HEADTURN	Low Light	Room Setting	25	1	0	96.15%
HEADTURN	Daylight	Actual Driving	68	3	0	95.77%
HEADTURN	Low Light	Actual Driving	57	4	1	91.94%
BLINK	Daylight	Room Setting	104	6	0	94.55%
BLINK	Low Light	Room Setting	90	4	5	90.91%
BLINK	Daylight	Actual Driving	408	5	16	95.1%
BLINK	Low Light	Actual Driving	137	10	2	91.95%
YAWN	Daylight	Room Setting	8	0	0	100%
YAWN	Low Light	Room Setting	8	0	0	100%
YAWN	Daylight	Actual Driving	1	0	0	100%
YAWN	Low Light	Actual Driving	0	0	0	100%

4.3 Instance Duration

This test aims to evaluate the accuracy of the timer used in the program. The tests were both conducted on a daylight and low-light condition.

The instance duration tests at low-light conditions for each parameter yielded error rates lower than 10%. For the head turn duration, the highest error rate was 7.01% was detected. For the blink duration, the highest error rate detected was 8.85%.

Additionally, on daylight conditions, the instance duration accuracy was still at par with that of the results from low-light condition tests. Blink duration on daylight conditions had an error rate of 9.05% and below while the head turn duration yielded an error rate of 7.69% and below.

4.4 Speedometer

This test aims to determine the speed of the vehicle while passing into an intersection or a curve. The data gathered in this test seen in Figure 5 was considered for the distracted algorithm.

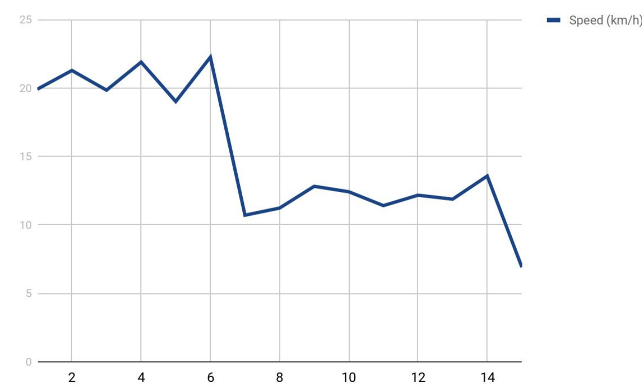

Figure 5: Speedometer Test Results

5.5 Full Driving Test

Table 2: Full Driving Test Summary

Detection	Total	True Positive	False Positive	False Negative	Accuracy
Head Turn	629	594	24	11	94.43%
Blink	3502	3211	232	59	91.69%
Yawn	18	17	1	0	94.40%
Asleep/Distracted	7	7	0	0	100%
Drowsy	159	148	11	0	93.08%

Full driving test can be seen in table 2. This test aims to determine the efficiency of the system when subjected for a long period of time. The group tested the system on a two (2) hour driving trip which represents a full driving trip, see table 2 for the result. The system achieved 94.43% accuracy for the head turn detection, 91.69% accuracy for blink detection and 94.40% for yawn detection.

5. CONCLUSION

At present times, the usage of automobiles is inevitable and substantial worldwide. In contrast to more car-owners, the rate of road accidents and crashes can undoubtedly increase. One of the leading causes of road accidents are distracted and drowsy drivers. These types of drivers are commonly distracted by their passengers and falling asleep while driving.

This research project was primarily concerned in enabling the image processing software to detect the driver's driving condition and focus. This program can serve as a tool to alert the driver the moment he loses focus on the road. Another feature of this Linux-operated program is that it can monitor a driver on the road even in low light conditions. It also provides the user ease of access of the program through an Android application.

Using C++ with QtCreator to code the program and QtDesigner to design the Graphical User Interface were essential tools in this program. The image processing algorithm started by detecting human faces was made possible by the training data from dlib's facial landmark detection. Through the points given by the landmark detection of dlib, certain parameters can then be measured by the researchers. The parameters checked by the program were the drivers' rate, duration of blinking, yawning, and head turning.

To gather necessary data to refine the program, the researchers conducted several test-runs to get video samples from various individuals. These samples were set in rooms with variable lighting and on the road to test the effectiveness of different low-light circumstances. The variable lighting made it possible for the researchers to simulate a daylight and lowlight scenario on the road. On top of the settings where data obtaining was done, the method used for each was different. The room setting data was obtained by capturing a video of an individual and loading it onto the program. On the other hand, the field test data was obtained by capturing a video of the individual to be loaded on the program, and live feeding the output of the camera directly onto the media player of the program.

The researchers equipped the program with a plot system that is capable of detecting whether a driver is really distracted or drowsy. With all the data acquired, the researchers compared the plot versus the data to determine the accuracy of the data log displayed by the program. This allowed for determination of the average time limit how long a driver should, blink, yawn, and turn their head. Additionally, comparing the two sets of data and averaging it gave the researchers the percent error of each sample and gave the efficiency of the program for daylight and lowlight setting. The determined average for the time limit of certain actions helped in making the program more adapted to the hardware limitations and individual's behavior on the road. Regardless of the parameters' threshold levels to be arbitrary to each individual, the preceding procedures gave the researchers a way to reach the set objectives and conclude the study.

REFERENCES

1. T. Klingeberg and M. Schilling. **Mobile wearable device for long term monitoring of vital signs,** *Computer Methods and Programs in Biomedicine*, Vol. 106, No. 2, pp. 89–96, 2012.
https://doi.org/10.1016/j.cmpb.2011.12.009
2. L. Khobanizad, M. Khobanizad, B. Vaseghi, and H. Chegini. **Implement of face recognition in android platform by using opencv and LBT Algorithm**, *International Journal of Wireless Communications and Mobile Computing*, 2016.
https://doi.org/10.11648/j.wcmc.20160402.13
3. M. Miyaji, H. Kawanaka, and K. Oguri. **Driver's cognitive distraction detection using physiological features by the Adaboost**, *12th International IEEE Conference on Intelligent Transportation Systems*, pp. 1–6, October 2009.
https://doi.org/10.1109/ITSC.2009.5309881
4. J. Jo, S. J. Lee, H. G. Jung, K. R. Park, and J. Kim. **Vision-based method for detecting driver drowsiness and distraction in driver monitoring system**, *Optical Engineering*, Vol. 50, No. 12, 92 References pp. 127202–127202, 2011.
https://doi.org/10.1117/1.3657506
5. R. Ahmad and J. Borole. **Drowsy driver identification using eye blink detection**, *International Journal of Computer Science and Information Technologies*, Vol. 6, No. 1, pp. 270–274, 2015
6. J. C. De Guzman, I. M. Delos Santos, D. A. Pulido, D.T. Renes and M. C. Roque. **Semi autonomous quadcopter for early rat infestation detection,** *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, No. 2, pp. 241-245, 2019.
https://doi.org/10.30534/ijatcse/2019/22822019
7. J. B. Del Rosario. **Development of a Face Recognition System Using Deep Convolutional Neural Network in a Multi-view Vision Environment,** *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, No. 3, pp. 269-274, 2019.
https://doi.org/10.30534/ijatcse/2019/06832019