UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

USE OF IMAGE PROCESSING IN DROWSINESS DETECTION AMONG DRIVERS TO REDUCE ROAD TRAFFIC ACCIDENTS IN KENYA

BY

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Research project is submitted in partial fulfillment of the requirements of the Degree of Master of Science in computational intelligence at the University of Nairobi.

DECLARATION

This project, as presented in this report, is my original work and has not been presented for any other award in any other University.

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This project has been submitted as partial fulfillment of the requirements for the degree of Master of Science in Computer Science of the University of Nairobi with my approval as the University supervisor.

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ABSTRACT

Road accidents in Kenya and all over the world have been a major problem for a very long time. Thousands lose their lives and millions of people lose a livelihood annually because of road accidents. Fatigue, which causes drowsiness among other factors, is a key contributor to road accidents;

This study aimed at making use of the available technologies to detect drowsiness among drivers at early stage in order to prevent or reduce the impact associated with accident, this is achieved by warning the driver of his or her state when driving.

Agile development is adopted in the development of the final product that targeted embedded devices. The final product registered good system performance with up to 65% drowsy cases detected by the system

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CHAPTER1: INTRODUCTION

1.1 BACKGROUND

Passenger safety has been a major concern to all societies in any country in the world. Thousands lose their lives daily and many more lose their livelihood because of paralysis caused by accidents. On average traffic, road accidents in the world claim 13 million lives and cause 20 to 50 million disabilities annually (Manyara, 2013). It is approximated that road accidents account for more than 23% of all injury deaths worldwide. This statistics are projected to rise to be the third killer by 2020 (Manyara, 2013) ahead of HIV/AIDS, respiratory infections and wars (Nantulya V.M, 2009).

Developing countries shoulder the largest share of road accidents despite having the smallest share of all registered vehicles. With only 52% of the worlds registered vehicles, they account for over 80% of all world traffic accidents (Manyara, 2013). Currently the annual road traffic fatality rate stands at 20.1 per 100,000 compared to 8.7 per 100,000 in the high income countries (WHO, 2012).

In Kenya, road traffic accidents cost the economy in the excess of US$ 50 million annually (Manyara, 2013) and an estimated 3,000 Kenyans lose their lives annually from over 13,000 traffic road accidents (G. Munala , 2012).These figures are continually growing each day as the economy and population of the country increases. The recent development of a Super Highway has not saved the situation as the accidents continue to increase.

According to Manyara (2013), the researcher attributes 85.5% of road accidents in the country to poor driver behavior. From this, drowsiness cause over 87% of the road traffic accidents associated with poor driving behavior (G. Munala, 2012) and (Manyara, 2013).

In order to counter drowsiness several measure have been put in place for tracks, public service vehicle (PSV) and private vehicle drivers. The most common being presence of rest places and driver relaxing at petrol stations in order to prevent drowsiness from building up. (G. Munala 2012).

Drivers driving under immense pressure, stress, sleep deprivation and those who drive longer for economic reasons contribute greatly to these statistics. This is a common practice in Kenya especially with the “matatu” industry and long distance truck drivers. Despite there being a parliamentary traffic act limiting the driving duration to less than 8 hours in any period of consecutive 24hour, Kenyan’s still push beyond the limits for economic reasons. Enforcing this act has posed a great challenge to the government partly due to lack of commitment from the law enforcers, corruption and ignorance from the public. Of late, several measures ranging from controls in travel time for public service vehicles, installation of speed governors, and use of alcohol blows among other measures have been adopted by the government to curb crushes but drowsiness remains a challenge.

Drowsiness is described as the state/ experience of being “sleepy”, tired or exhausted (G. Munala, 2012). Drowsiness can be physical or mental impairment brought about by having inadequate rest over a period. It can result from lack of sleep; long period of work and the time of day when work is being done. Drowsiness leads to loss of alertness, which is accompanied by poor judgment, slower reaction to events and decreased skills leading to accidents (G. Munala, 2012). According to Williamson A. M. (1992) drowsiness, negatively affect driving performance with slower reaction times, poor steering and poor gear selection and change. This affects the efficiency, effectiveness and safety of a driver carrying out the driving task resulting to accidents (G. Munala 2012).

Driver drowsiness is difficult to control especially in cases where drivers are reluctant to accept their mental state. This is most prevalent when they are under pressure to perform. Establishing the mental state of a driver can help prevent the losses by warning the driver of his or her state, an alert can also be sent to the freight managers. From several symptoms, which manifest in a drowsy person, drowsiness can be detected and alerts generated. This area has triggered great interest among researchers in attempt to develop solutions to reduce road crashes associated with drowsiness.

Different companies have developed drowsiness detection technologies, however the cost of this systems is high Caterpillar (2008) explaining the reason why they are less common among vehicles in low income countries as compared to the high income countries. Partly, lack of adequate legislations to regulate the kind of vehicles used in most of these counties contributes to manufacturer’s ignorance. However, providing cheaper solutions to serve in the low income regions will help reduce the associated losses.

1.2 PROBLEM STATEMENT

In the 21st century, driver drowsiness has continued to be a major challenge contributing to a large number of accidents on our roads. In Kenya, driver drowsiness especially among long distance truck drivers, public service vehicles drivers and private vehicle drivers is a major concern. This continues despite the government putting in place several measures to address the problem; measures including regulation of the public vehicle travel time, increasing the number of drivers for buses that travel at night, use of alcohol blows to detect drunk drivers among many others.

Providing drowsiness detection system among drivers has not been achieved making it difficult to enforce relevant legislations. A few systems are available in the market however; they are expensive making them a reserve for a few who can afford the cost of the current vehicles fitted with search technologies. There is hence great need to provide drowsiness detection system that are affordable to the many who are low income earners and also public service vehicles to help address the many accidents associated with drowsiness.

1.3 OBJECTIVES

To develop an embedded system that detects driver drowsiness level and warns him or her of his or her state.

1.3.1 SPECIFIC OBJECTIVES

1. To be able to accurately detect a face from an image
2. To be able to detect the region of interest in this case the eyes
3. To accurately classify the state of the eye either closed or open
4. To provide a warning to the driver if drowsiness is detected.

1.4 RESEARCH QUESTIONS

Based on the above research objective, research will aim to answer the following questions.

1. What are various techniques available for detecting drowsiness among drivers?
2. Can we use image processing in drowsiness detection?
3. Do we have enabling technologies to implement these techniques?

1.4 JUSTIFICATION

- Need to predict drowsiness levels among drivers in order to reduce associated losses
- Provide cheaper systems that are affordable to the low income people
- To reduce road accidents associated with drowsiness in the country
- To reduce loss of income and increased dependency ratio due to accidents
- Availability of relevant technologies to address the problem.

1.5 SCOPE OF STUDY

This study aims at collecting the drowsiness symptoms from the driver’s face through analysis of the driver’s eye state. This will be achieved through processing video images obtained through a sensing technology.

The outcome of the video will be used to determine the drowsiness levels and then provide a warning to the driver if he or she is drowsy.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Drowsiness detection poses a big challenge to researchers. In both manual and automatic approaches, researchers highly depend on the symptoms of drowsiness in order to predict a drowsy driver. Manual approaches are however very difficult and totally undependable to prevent traffic road accidents. Manuals approaches are based on the human perception of the situation. Mainly the police use this manual technique to explain that an accident resulted from drowsiness. Several characteristics including: no alcohol in the blood of the driver during accident, vehicle run off the road or at the back of another, no signs of breaking , vehicle has no mechanical defects, good weather with clear visibility and even the police officer at the ground suspects drowsiness to be the cause can be pointers of drowsiness related accidents.

The above techniques however cannot be used in traffic road accident prevention. In order to prevent an accident resulting from drowsiness a method for detecting and measuring drowsiness need to be developed. This will make it possible to warn the driver, slow the vehicle or even halt the vehicle if the driving situation demands. Automatic detection of driver's drowsiness is critical for all this to be achieved. From research, several techniques have been developed, all this techniques attempt to measure the level of driver vigilance and alert him or her of an insecure driving condition (Abhi R. Varma 2012).

Drowsiness detection can generally be divided into the following classes. According to Abhi R. Varma (2012), they include: sensing of physiological characteristics, sensing of driver operation, sensing of vehicle response and monitoring the driver response. To achieve the best result human physiological centered techniques are preferred (Abhi R. Varma 2012). In this, both intrusive and non-intrusive techniques can be adopted. However, intrusive techniques such measuring of physiological change like brain wave, heart rate and body temperature may provide most accurate results. They are however not realistic as they involve implanting of sensing electrodes on the drivers body an act that is annoying and distractive to the driver. Increased perspiration during long driving hours result in sweating which might also interfere with the performance of the implanted gadgets, hence reducing the accuracy of the data they obtain.

Non-intrusive techniques are most suited for real world driving conditions, through use of non-intrusive data collection techniques to obtain physical measures such as sagging posture, learning of the driver's head, open or closed state of the eyes, blink duration, blink frequency, saccade frequency has gained popularity among many researchers.

This is because of non-interference with normal state of the drives as they operate without even the knowledge of the driver.

Other non-intrusive techniques involve measuring driver operation and vehicle behavior; they can be achieved through measuring vehicles lateral displacement, braking and acceleration patterns, vehicle speed, steering wheel movements and lateral accelerations (Abhi R. Varma 2012). In this drowsiness interferes with the driver alertness and vigilance leading to changes in both his driving behavior and the vehicle behavior. Being able to establish and measure this changes one can be able to predict a drowsy driver. This system however may provide a very short time span to correct the situation before a crash occurs. However, they have been successful combined with other techniques by different manufactures to develop drowsiness detection systems.

Finally, driver response can continually be monitored by frequently requesting the driver to send a response to the system to indicate his or her alertness. An audio or visual sign can be provided to driver periodically, to indicate his or her alertness the driver can respond to the sign, if the driver fails to respond within a specified time the frequency of the sign can be increased and later provide an alarm or alert of the drivers state. This method however is monotonous, boring and tiresome to the drivers; frequent false alarm may be annoying to drivers making them ignore even when the situation is genuine.

2.2 CURRENT DRIVER DROWSINESS DETECTION AND WARNING TECHNOLOGIES

2.2.1 HEAD- NODDING TECHNOLOGY

When a driver is drowsy and gets sleepy hide muscles relax, hence he or she starts nodding. This symptom can be used to detect drowsiness. The approach however should be used to detect the onset of sleep as head-nodding phenomenon manifests as the last cue before micro-sleep or complete sleep occurs. Although this system appears to be efficient in detecting the onset of sleep the driver might as well drive unsafely leading to accident before he even manifests the head-nodding to trigger an alert as the system warns the driver too late into the drowsiness curve.

The system may also trigger false alarms as the driver may make movements that are not indicators of drowsiness resulting in false alarms. This might be annoying to drivers hence they may ignore genuine warning (Jennifer F.may, 2009).

2.2.2 ROADWAY DESIGNS

Roads can be designed to monitor weaving and alerting drivers when they drive off roads through use of rumble strips that produce a loud noise and vibrations within the car when a driver crosses or drives along the strip. This technology is advantageous as it is available to all drivers. These technologies highly reduce the amount of run off the road crashes (Jennifer F.may, 2009).

2.2.3 LANE DEPARTURE WARNING SYSTEMS

These systems depend on the feed from a camera that monitor the road ahead and establishes the lane boundaries; in the event that a driver veers of the lanes without using, the turn signal an alarm sounds is produced. Lane departure has been can be implemented using different with technologies such as sidetrack (AssistWaretechnology, 2005), Auto vue and many others being adopted by different automotive manufacturers. These systems however do not predict the drowsiness but senses the reputations of drowsiness. (Jennifer F.may, 2009).

Disadvantage

1. The driver may experience false alert, which are annoying and may make him or her ignore future genuine alerts.
2. When dealing with unmarked roads or rural road it will be difficult for the system to detect and warn the driver.

2.2.4 COLLISION AVOIDANCE WARNING

These systems are commonly integrated in high end vehicles to provide warning to drivers of eminent crushes, majorly these systems attempts to reduce severity of a crash. These systems can measure the time of crush, sense when another vehicle or obstacle comes close to a vehicle reducing the collision velocity and minimizing to collision. The systems provide auditory tones and visual icon displays

2.2.5 NON INTRUSIVE ECG

ECG measure can still be implemented in a non-intrusive manner contrary to the common practice of the electrode being in contact with the chest or the head. Intrusive approaches as earlier discussed bring discomfort to the driver.

For the non-intrusive ECG sensors, each half of the steering wheel is wrapped with electrically conductive fabric (ECF) and two ECG electrodes. To correct the heart rates from the hands of the driver.

The method can also be implemented using conductive fabrics fitted with ECG electrodes and placed on the driver seat's backrest.

In all this cases the once the signal is obtained and amplified in is then digitized and transmitted to a computer that will analyze to detect any elements of change of heart rate which indicate drowsiness in the driver.

Disadvantages

1. ECG signals from the electrodes are severely affected by the common mode noise(CMN) from the human body requiring a lot of filtering
2. While using the driver seat, electrodes on the backrest are not in direct contact with the driver skin resulting to high impedance between the electrode and the skin possibly due to the poor permittivity of the commonly available clothes.
3. In both cases they can be affected by body physiological processes, eg sweat reducing their performance.

2.2.5 HYBRID SYSTEMS

Each method used for detecting drowsiness has its own strengths and weaknesses, to overcome the weaknesses different sensors can be combined to support each other in addressing drowsiness detection. Behavior based measures can be combined with vehicle based measure and the results a significantly higher accuracy and reliability than using a single sensor (Arun sahayadhas, 2012).

This approach however will require more system resources to perform to the expected levels. This aspect makes it difficult to implement in embedded environment where resources are constrained.

2.3 VIDEO IMAGE PROCESSING

Vision based real time driver drowsiness systems have been proposed and developed by different institutions; most of the systems are based on eye tracking, head tracking and other facial features that manifest in drowsy drivers. This has been highly motivated by the advancement in video image processing algorithms.

The ability of correctly detecting a human face from a video stream and the demand for high quality and reliable data for intelligent solutions that can be provided through image processing is a major drive towards adoption of vision based systems. Through use of image processing algorithms the regions of interest which are the eyes can be located and analysis done to determine their state (closed or open). This is treated as a classification problem or pattern recognition problem in which supervised learning plays key role. In the first step, a classifier is first trained to classify an image as either a face or non-face. Once a face is detected, another classifier is trained to detect the region of interest in our case the eyes.

2.3.1 FACE DETECTION ALGORITHMS

When driving on the roads in order to detect the state of the driver using facial feature analysis, we will need to detect the face of the driver. Different techniques are in use in order to achieve this. Algorithms such as Viola-jones, Gabor features extraction and classification using support vector machine. (Kristopher Reese, 2011)

2.3.1.1 VIOLA –JONES ALGORITHM

Viola-jones approach is a very common approach for object detection. The algorithm is a machine learning approach for object detection that emphasizes on rapid result generation and high object detection rates with figures of up to 99% detection being registered by different researchers (Kristopher Reese, 2011), the method uses integral images as the image detection structure that guarantees speed in detection. The features are calculated by taking the sum of pixels within multiple rectangular areas. Several adjustments have been made by different researcher to the initial algorithm to enhance its robustness (R. Lienhart and J. Maydt, 2002). Extensions such has addition of Ada boost algorithm allows training of classifiers to detect integral images of the face and those of the background and increase the speed of the detection. A cascade classifier is the used to speed up the detection process; this is by avoiding areas that are most unlikely to be regions of interest and concentrating on highly likely regions.

Gabor Features Extraction is another is feature based approach, Gabor wavelets transformation is run against images and feature points are extracted to make a feature vector. The feature vector is that passed through a trained support vector machine or artificial neural network for classification process (Kristopher Reese, 2011).

Zeng (2010) proposed another approach for detecting faces in thermal spectrum. This approach uses projection profiles Analysis algorithm. In the approach, region glowing segmentation is used to separate the areas of interest from the background noises. This approach has highly been adopted in medical imaging in areas with radiography and magnetic resonance imaging being the center stage. The approach works by segmenting the image into 2 segments, the background and regions of interest. The background is treated as the region with the lowest pixel intensity, which is the region with lowest thermal emissions.

Other methods have been proposed such has principle component analysis, fisher faces, face recognition using Line Edge and Bayesian methods cui (2007) however; viola jones remains the algorithm of choice due to the speed and high detection rates.

2.3.2 EYE DETECTION ALGORITHMS

Kanade-Lucas-Tomas feature Tracker Algorithm is one of the algorithms that is used to track and recognize facial features, the algorithm has been provided as open source code by the Stanford vision Laboratory. This approach makes use of spatial intensity information to direct the search for the position that yield the best match. The technique has been improved by tracking features that are wanted in subsequent frames (Kanade, 1991).

SIFT (scale-invariant feature transform) and SURF (speed up Robust Feature), are other algorithms that are used in object detection. With SIFT being proposed by Lowe in 2004 (P M Panchal, 2013) and SURF presented by Herbert Bay in 2006. They are both excellent in mapping facial features in templates to target images, with the SURF being several times faster than the SIFT. However, the two are highly sensitive to very small changes in illumination. An attempt to overcome this challenge via use of histogram equalization and histogram fitting has yielded little success as this result to very slow algorithms (Eric Chu n.d.).

Hough Transformation is the other approach that is used to extract eye features; this technique detects regular curves like lines, circles and ellipse hidden in large amount of data, during processing large number of lines pass through any given point. The Hough transform determined which of this line pass through a circle or an ellipse in an image. With the eye pupils, being a circle and having the ability to determine the size of the eye pupils we can easily detect the location of the eye, different images will be detected in different locations of the image and by establishing the distance between two pupils we can easily eliminate the associated errors (storkey, 2005). The performance of this algorithm is however affected by the quality of images obtained (Wallace Hung, 2006).

Viola and jones object detection Algorithm is one of the easiest algorithms and has a high performance when it comes to object detection (Wallace Hung, 2006). The algorithm is based on key feature detection using haar features that are grouped into 3 different categories: 4-rectangle features, 3-rectangle features, 2 rectangle features. Through use integral images, the speed of the execution is increased making the approach ideal for systems that have low processing resources. A classifier is then used to extract the required features from the many obtained, using the concept of Ada Boosting where weaker classifiers help to narrow down to stronger patterns the performance of the algorithm is enhanced (Wallace Hung, 2006).

2.3.3 EYE TRACKING ALGORITHMS

Once the eye is detected in a given frame, the eye can be tracked in subsequent frame in order to determine their state. This can be achieved through detection in each frame however; this approach is intensive and slows down the speed of the eye tracking. This will make it difficult for a system to work in real-time. However, through use of prediction before detection helps reduce the search required in the subsequent image frames. Kalman pupil tracker provides a mechanism for achieving this; this approach is however affected if the pupil is not bright enough making the tracker loose the eye (Zhiwei Zhu, 2004). To address this, the algorithm is augmented with mean shift tracker, which is an appearance based object tracking method. It applies the mean shift analysis to identify a target candidate region with most similar appearance with the target model (Zhiwei Zhu, 2004).

2.3.4 EYE STATE DETECTION

Detection of the eye state (closed/open) is very important in order to be able to detect the changes of the driver eye, which is a key drowsiness indicator. Different approaches have been proposed to address the problem of blink detection. The average duration of an eye blink is 0.5 to 0.6 seconds with a frequency varying from once every 3 seconds up to several a tenth of a second (Mehdy Bohol n.d.). The blink rate can be affected by several external stimuli like fatigue.

Different algorithm have been used to detect the blinks in an eye with template matching being one of them, according to Betke (2005) on online database is developed that contains several images of the eyes indifferent states. The real-time images obtained from the cameras are developed into a template that is correlated with the images in the database. A correlation threshold that indicates an open eye is established. Blinks are detected using a time that is triggered each time the correlation scores falls below the set threshold. A correlation score that lies between -1 and 1 indicate the similarity levels with scores close to 0 indicating low similarity and score close to 1 indicate a close match to the open eye template. The approach is insensitive to changes in ambient lighting conditions. The approach however requires an extensive amount of computation (Haripriya D, 2014).

(Mehdy Bohol n.d.) In his work on computer vision syndrome prevention using real time accurate blink detection proposed a much faster and easier approach of detecting blink. In his work, he uses integral images in differential images of two adjacent frames to detect the intensity difference that is an indicator of blink.

In his work, he describes a blink to being two big dots of changes with the same size and within a defined distance. To determine the change in deferential images a score is computed. When a blink occurs, there are some changes on the eye position that can be seen in the threshold differential image at the same time there is nearly no change in the other face regions, or the regions near the eye (Mehdy Bohol n.d.). This information is used to detect the blink.

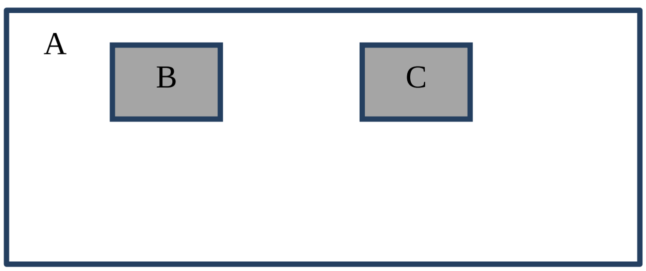

Figure 1: intensity variations

In this approach, it is expected that changes in the gray region be maximized and changes in the white region minimized during eye blink. Hence, the difference between the pixel sum in the grey area and the white area is a good parameter to measure the eye blinks. The values can be obtained with little computations and integral image

Blinkval= $(2*(C_B + C_C) - C_A) / W_A*H_A$

Where C x is the number of pixels in a rectangle x (A, B or C) and W_A and H_A are the width and height of rectangle A respectively. If the Blinkval value exceeds a certain predefined threshold then a blink is registered. The variation in intensity in the eye region is much higher than the surrounding regions (Mehdy Bohol n.d.).

2.4 INDICATORS OF DROWSINESS

Drowsy persons exhibit certain visual behaviors, which can be observed from changes in the facial features such as eye, mouth, head and face (Dhaval Pimplaskar, 2013). Studies have indicated that the eyelid activities are highly related to the levels of intention, alertness, vigilance and needs (Dhaval Pimplaskar, 2013). The eye blink frequency is believed to increase beyond normal rate for a drowsy person. Eye closure duration is also used to detect drowsiness; a drowsy person manifest micro sleeps that last between 3 to 4 second (Abhi R. Varma, 2012). The percentage eyelid closure (PERCLOS) or proportion of time in a minute that the eye is 80% closed has highly been adopted and proven a reliable measure of drowsiness. It measures the percentage of the eyelid closure over the pupil over time and reflects the slow eye movements that are used to predict the drowsiness levels. This method was introduced in 1994 by Wierwille and coworkers as an alert measure. This method later became accepted standard measure for alertness and it was adopted by the United States transportation Department. According to (Udo Trutschel ,2011) in their work, they argue that this approach perform better that other measure such as eye blind measure , head movement and even EEG which is a direct measure that is influenced by Cortical and to some degree also by sub-cortical activities.

PERCLOS a parameter used to widely used to monitor the drowsiness of a driver, it is defined as the proposition of frames in which the driver's eyes are closed over a certain period

PERCLOS[k] $=\left(\frac{\sum_{k-n+1}^{n}}{n}\right) * 100$ where PERCLOS [K] is the PERCLOS value in the k_{th} frame and n is a window size and the total number of frames within the period measuring PERCLOS. Blink[i] is a single binary value that represents the status of the eye at i_{th} frame. Blink[i] is "0" when the eye is open and "1" when the eye is closed (Jaeik Jo, 2014).

The average eye closure and opening speed (AECS) is another a drowsiness indicator based on the eyelid analysis, when a person is drowsy, the eyes closes/opens slowly due to either tiredness of muscles or slower cognitive processing (Dhaval Pimplaskar, 2013).

Eye closure duration (ECD) is defined as the mean duration of clusters over a certain period, where a cluster is set of continuous frames in which the eyes are closed

ECD[k] = $\sum_{i=1}^{p} duration\ [C[k-n]+1)/p$

Where duration[i] is the number of continuous closed eye frames in i^{th} cluster, n is the total number of frames within the period measuring ECD, p is the total number of clusters in the most recent n frames, and C[k[is the total number of clusters in 0 to k frames.

An EEG-based measure is another measure that is used to detect alertness levels; the approach was developed by Lal et al as cited by (Udo Trutschel, 2011) and was able to detect drowsiness with an error margin of approximately 10%. However, the main drawback in physiological measure is the requirement to attach electrodes into the subject.

To detect the driver level of alertness, individual eye closure duration and eye closure speed are analyzed (Yang, 2002). In their systems percentage eyelid closure (PERCLOS) and average eye closure speed (AECS) at particular time instance are computed over a fixed time interval of 30s. The average eye closure/opening speed is computed as arithmetic average of all eye closure speed is computed over the same period. To increase the accuracy and robustness of their system the average running rate is computed using the current data and data at the previous time instances.

2.5 EYE DATA ACQUISITION

2.5.1 INFRA RED SENSORS

Imaging in the infrared spectrum can be used to detect the eye and provide the status of the eye. In this approaches both the physiological and optical properties' of the eye are used. The eye pupil reflects an infrared beam and depending on the amount of reflectance, a decision is made on the state of the eye. An open eye has a higher reflecting ability than a closed eye (Mohamad Hoseyan sigari, 2013).

2.5.2 CAMERA SENSORS

In this, an image is captured using a charged- couple device (CCD) or Complementary metal–oxide–semiconductor (CMOS) imaging technologies. The captured image is then processed using machine vision algorithms to extract regions of interest. Through extracting and analysis of the eye region features a researcher is able to detect the eye and given regions of interest. This approach assumes that the eye is darker that the face skin (Mohamad Hoseyan sigari, 2013).

2.6 SPECIFIC CASES OF DROWSINESS DETECTION SYSTEMS

2.6.1 PRO-ACTIVE DROWSINESS MANAGEMENT SYSTEM

This is a product developed by ARRB, it tailored to detect drowsiness in mining industry and commercial vehicles, and the system is a stimulus- reaction device that measures the reaction time to the stimuli. The system establishes a baseline performance measure for each operator and test against this measure throughout the work shift. The system has the ability to detect reduction in alertness levels in real time and allow intervention strategies to counter the impact of working drowsy. The system presents an audio and light stimulus every 7 to 10 minutes, slow reaction to the alerts triggers more frequent testing and if the reaction levels are extremely slow an alarm is triggered in the cab and an alert sent to the dispatcher. This system has very positive feedback from operators however it is very expensive costing $9000 per machine on a yearly lease. (Caterpillar, 2008)

Disadvantages

1. It is expensive
2. It requires manually acquisition of the driver data and sleep patterns
3. The system can raise false alerts which are annoying to the users
4. Requires a lot of training to obtain the correct sleeping patterns of the users

2.6.2 VOLVO DRIVER ALERT CONTROL

Volvo uses a camera mounted on the rear view mirror to analyze the road markings together along with combination of inputs from steering wheel movements and use of accelerator and brake pedals to determine drowsiness.

A set of 5 bars appear on the dash board to indicate the level of alertness, when the bars diminish to two an alarm is raised and a written warning provided requesting the driver to take a break. The alarm provided is a gentle sound that will not scare the driver leading to abrupt reaction that may cause an accident. This system has been fitted into several Volvo make to reduce crushes. This package however comes at a cost of $2100

2.6.3 EYE CHECK

This is a product by MCJ INC. it is based on measuring the pupil reaction to light flashes. At first, the eye is allowed to adapt to dark for 30 seconds and the initial pupil diameter is measured, after a brief flash of light, the device measures reflex amplitude, rate of constrictions, final pupil diameter and the time to minimum diameter. The system is applied widely even in the police departments. It is however also expensive costing $ 8,000 (Caterpillar, 2008).

2.6.4 DROWSINESS WARNING SYSTEM

A device based on stimulus reaction, it checks the operator's alertness using visual signals, and it provides random signals with their frequency increasing with slower reaction time. If no response is provided the system produces audible alarm sound until the operator resets the system. It can be used in wide area ranging from transportation, mining, agriculture and construction. This system is relatively cheap costing $ 1300.

2.6.5 DD850 DRIVER DROWSINESS MONITOR (DFM)

A product Developed by attention technology Inc., which is a real time, onboard driver drowsiness monitor, the system is vision based measuring the speed of the eyelid closures. Drowsiness is measured using the PERCLOS technique where slow eyelid closure indicates drowsiness.

2.6.5.1 ADVANTAGES

1. The DFM can accurately estimate the PERCLOS (percentage eye closure over 80% over a specific period).
2. PERCLOS has been tested and demonstrated in both driving and non-driving environment to be a valid indicator of drowsiness and performance degradation due to drowsiness
3. Availability of adequate technologies to correctly detect and classify the eye state.

2.6.5.2 DISADVANTAGES

1. The success of the bright pupil technique strongly depends on the brightness and size of the pupils, which are often functions of face orientation, external illumination interference, and the distance of the subject from the camera
2. For real-world, in-vehicle applications, sunlight can interfere with IR illumination, reflections from eyeglasses can create confounding bright spots near the eyes, and sunglasses tend to disturb the IR light and make the pupils appear very weak.

2.6.6 LC TECHNOLOGIES, Inc.

The company developed an eye tracking technology that is both an eye operated computer for control and communication and a device for monitoring and recording eye motion and related eye data. The technology can be as a drowsy driver detection and warning system.

The eye gaze system is housed in the vehicle to monitor the eye movement

The goal of the system is to monitor the driver's eye point-of-regard, saccadic and fixation activity, and Percentage eyelid closure reliably, in real time, and under all anticipated driving conditions

2.7 SUMMARY

Several other systems are available but either their use is limited to a certain field or their cost is high with prices extending up to $16,000 making it difficult to acquire. In low income economies government policies are less regulating when it comes to the kind of vehicles imported, in most of this economies safety is always traded for affordability hence manufactures do not equip vehicles meant for search regions with advanced technologies. On the contrary high end economies vehicle safety is very important; governments dictate the kind of safety features to be available in automobiles before they are allowed in these countries. Users are also very concerned about their safety hence willing to pay an extra cost for vehicle with advanced security features.

With this facts, there is growing need to develop safety systems that are cheap and affordable to the many in low income economies. From the symptoms associated with drowsiness and other factors that result in poor driving practices, a warning system can be developed to prevent the possible resulting crushes; the system will have a mechanism of detecting drowsiness/ drowsiness in the driver's eyes and providing a corrective mechanism. The corrective mechanism will be aimed at concentrating the attention and alertness of the driver to the task.

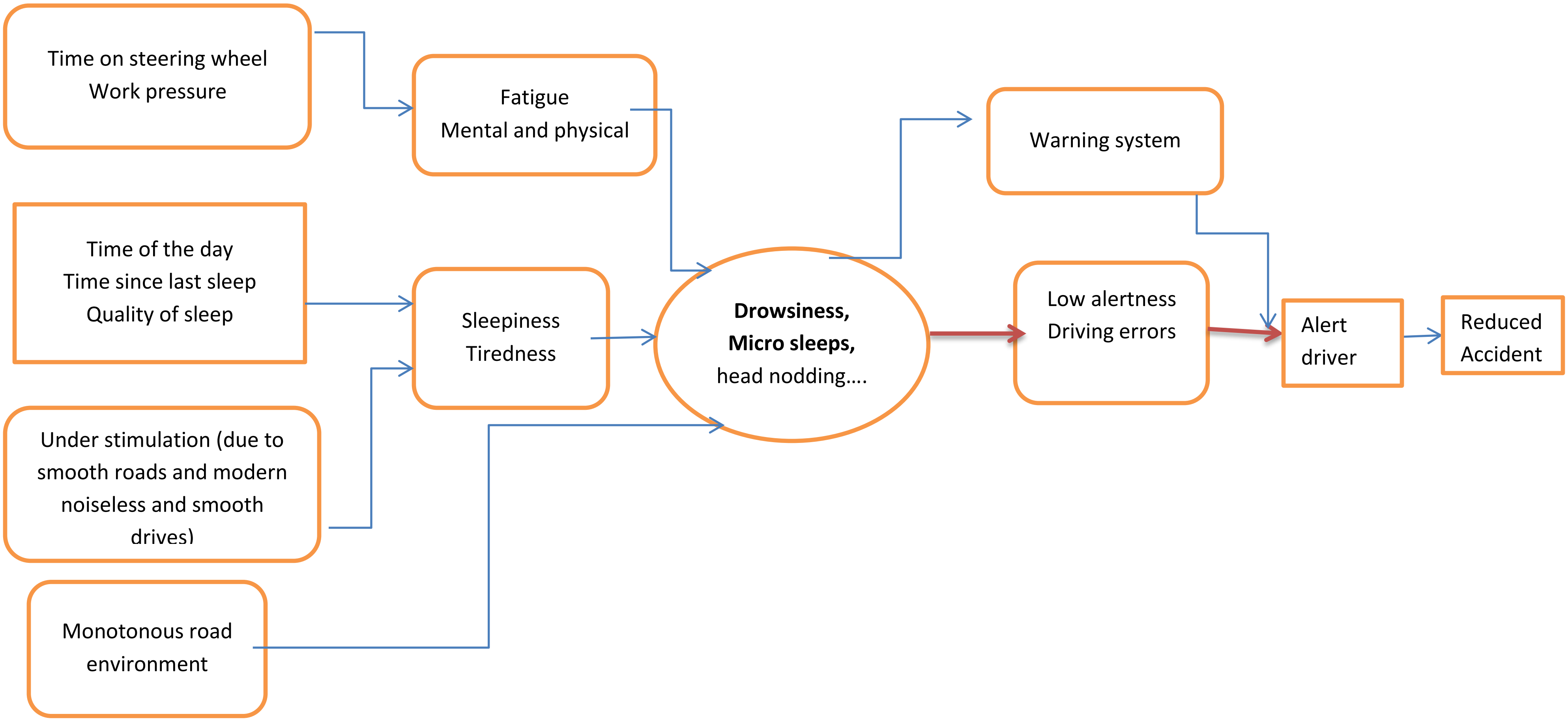

Figure 2: *driver sleepiness detection model*

Chapter 3: METHODOLOGY

Agile development was adopted. This approach combined both the extreme programming XP and scrum methodologies to achieve the desired objectives. The researcher aimed at tapping into the strength from the XP programming especially program refactoring and combining the scrum capabilities in order to overcome the different challenges found in embedded environment.

3.1 REQUIREMENTS ANALYSIS

In order to develop the specific system that will operate in the target environment and meet the specific objectives requirement analysis was conducted. Through observation of the driver behaviors coupled with the research conducted by other researchers in the same and related area a lot of information was obtained.

3.1.2 SYSTEM REQUIREMENTS

This defines how the user expectations will be met by the system, they are classified into:

3.1.2.1 FUNCTIONAL REQUIREMENTS

The system should be able to meet the following functionalities:

1. To detect drowsineness among drivers
2. Issue alert when drowsiness is detected

3.1.2.2 NON- FUNCTIONAL REQUIREMENTS

In order to meet the functional requirements while operating in constrained environment the system had to meet several non-functional requirements that are critical and core to its performance. The non-functional requirements mainly touch on the systems abilities in embedded environment

3.1.2.2.1 EMBEDDED CAPABILITIES

The system is designed to operate under:

1. Limited memory
2. Constrained power supply
3. Low processing power
4. Meet real time capabilities

3.2 SYSTEM DESIGN

3.2.1 ARCHITECTURAL MODEL

The new system is drowsiness detection system for automobile. Driver drowsiness will be determined from several symptoms that manifest in drowsy driver's face. Through analysis of the eye states, the system will be able to tell a drowsy driver from a normal driver. A video stream will be continuously obtained from the driver's faces and feed into a microcontroller for processing. Classifiers will then be used to classify the state of the driver's eye. If a drowsy driver is detected an alarm will be raised, until the system notices the driver is alert.

Development of the system was through agile methodology where the scrum and the extreme programming method were combined. The system was broken into small modules, these modules were developed independently and tested integration was done. During unit, testing refactoring was adopted in order to optimize the units for their intended purpose.

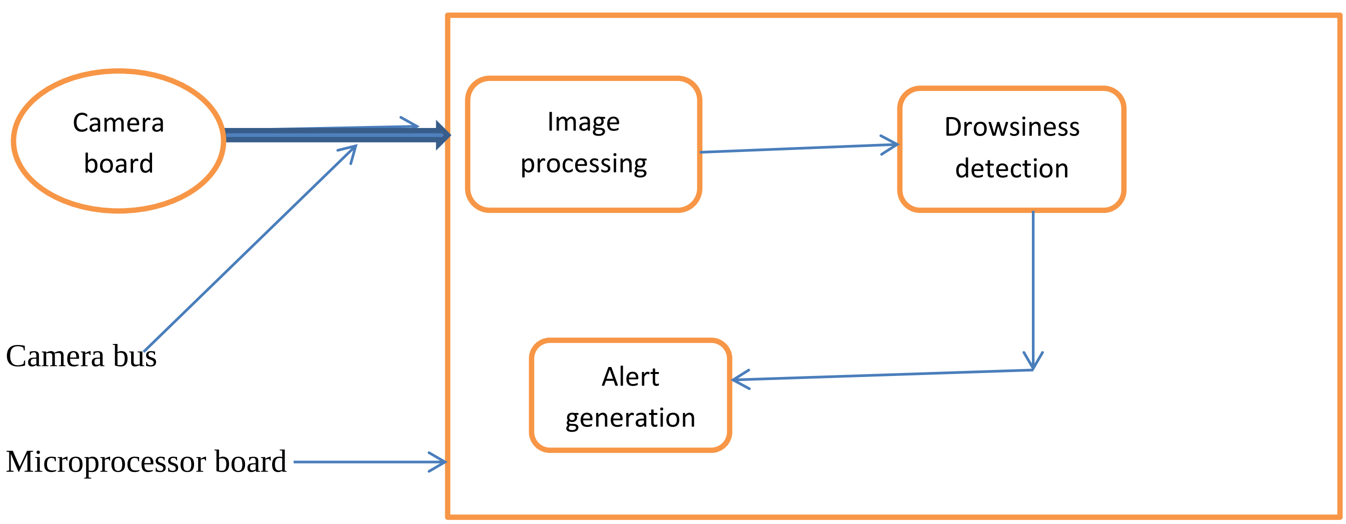

Figure 3: Architectural model

The system stem is made up of an aggregate of several components that are interlinked to produce the final artifact as illustrated by the diagram below.

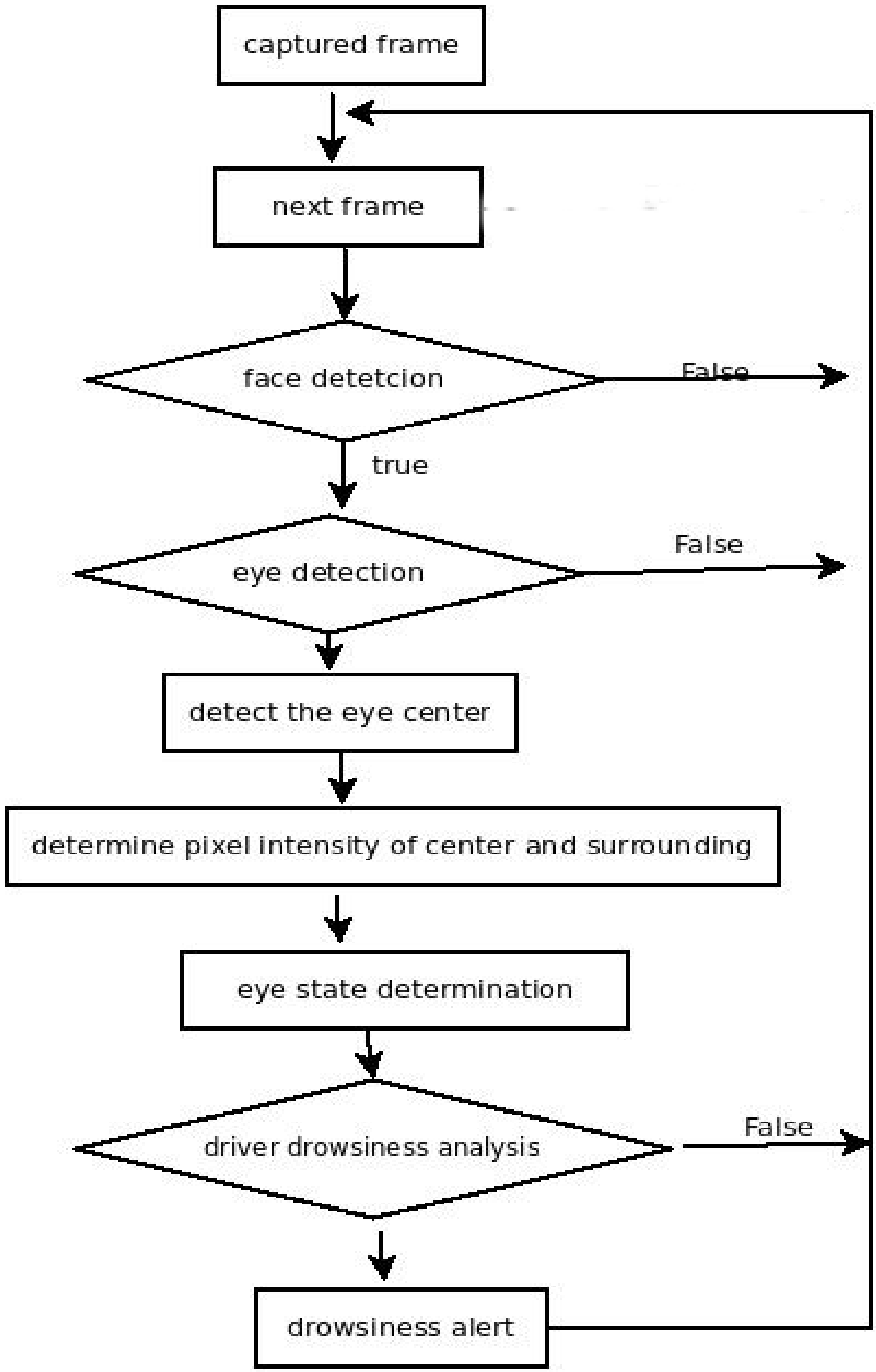

Figure 3: The system flow chart

3.2.1 IMAGE ACCUSATION MODULE

The system being image driven, facial images are captured using CCD sensors. A 5 mega pixel raspicam camera is mounted on the board and used to acquire the relevant image. With opencv's ***highgui*** files, the camera can be easily integrated to the processing component.

Using the function ***CvCapture* capture = 0*** a video will be captured from the camera which can be analyzed to extract the relevant statistical data.

3.2.2 IMAGE PROCESSING MODULE

This module will aim at processing the acquired video images. The processing will target to detect the drivers face from the video stream; once the face is detected, the region of interest that is the eyes will then be located from the facial features. The state of the eye will then be computed using the pixel intensity difference and a threshold value.

The implementation targeted a raspberry pi board with model B+ being selected due to its design and increased input and output USB ports, which allow connection for the control keyboard, and mouse and provide space for other devices to be attached during development. This micro controller board runs on ARM11 Broadcom BCM2835 Soc chip, a 700 MHz low power ARM1176JFS application Process. To optimize the working of the microcontroller board it was over clocked to 1000 MHZ, however this works against the board as it reduces its life span. The board is fitted with 512 megabytes memory and provided for memory card slot for fitting a memory card, which acts as the physical memory for the device. The board was installed with a Linux distribution raspian operating system.

Basic development utilities were installed into the board and opencv also installed into the board, which provides image processing capabilities

3.1.2.1 FACE DETECTION

With eye found in the face region, detection of the face is important to finding the eyes. To achieve this viola and Jones object detection algorithm is adopted in this system. The algorithms uses haar features which are extracted from the acquired images and then a cascade classifier with ada boosting is used to differentiate the face features from background features. The haar feature is digital image features that are similar haar wavelet. They are computed from the pixel intensity value of the image.

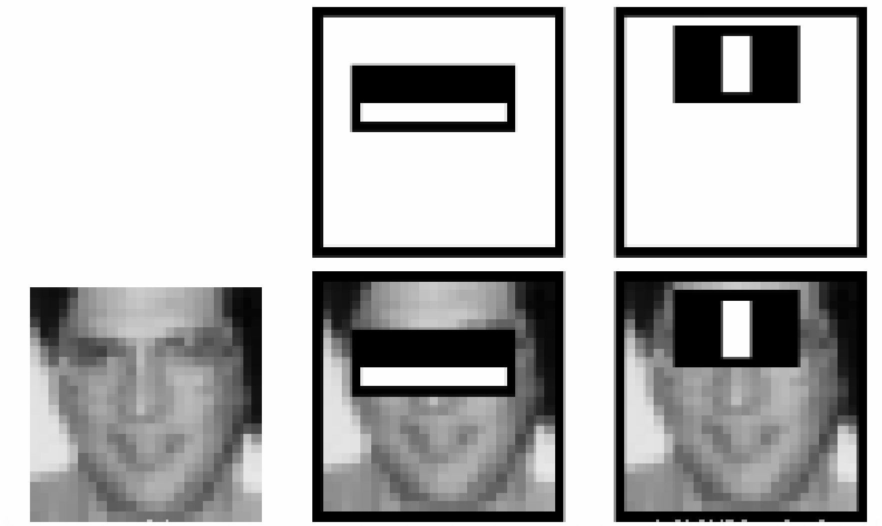

Figure 4: Facial haar features

This algorithm is implemented using integral images a concept that reduces the number of computation that needs to be made in the detection. To increase the speed of the algorithm further ada boosting concept is used. This concept combines different weak classifiers to form a strong classifier the cascade classifier that is used in this system. This approach is useful in speeding up the detection process as the unwanted features are dropped off at early stage of classification.

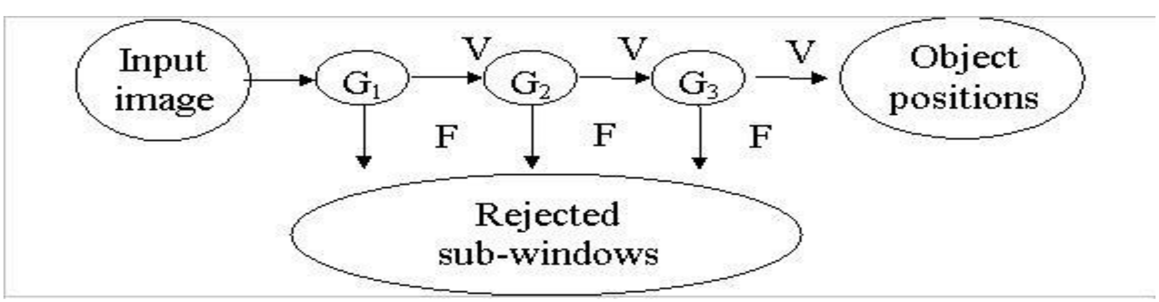

Figure 5: Cascade classifier

This approach has recorded high detection rate with researchers reporting up to 99% detection rate.

The system adopted Implementation of the algorithm that is provided by the opencv package. A classifier is trained and then passed to the opencv's ***CvHaarClassifierCascade*** function for face detection

CvHaarClassifierCascade * face cascade="haarcascade_frontalface_alt.xml

The classifier "haarcascade_frontalface_alt.xml" is adopted from the opencv package to reduce the time required for training of a new classifier and enhance the accuracy in face detection. Once the face is detected and marked as our region of interest, it is cropped and passed to the next level where the eye will be detected.

3.2.2.2 EYE DETECTION

A similar approach is adopted in eye detection, from the face region obtain the haar features are obtained and a cascade classifier used to classify the feature as either eye features or non-eye features. The system use "haarcascade_eye.xml" eye classifier which is also adopted from the opencv package. This helps in reducing the training time required and eliminates the rigorous processes that are involved when testing the performance.

Once the eye region is obtained, it is cropped and moved to the next level where the state (closed/open) of the eye is determined.

3.2.2.3 EYE STATE DETECTION

The two default eye states are open and closed, from the real world set up an eye is open when one can see, however from the computer perspective an eye is considered open when the iris and the white component of the eye are visible. To be able to detect this states color information of different parts both the eye and the surrounding is very important.in order to use color information a color space needs to be selected. Color intensity space is most appropriate for segmenting the eye region. The RGB can also be used but the eye has no enough features of the Red, Green and Blue colors for complete segmentation.

The color intensity space also the HSI model measures the Hue, the saturation and the intensity values of the color.

The Hue refers to the dominant color as perceived by an observer, the saturation referring to the relative purity of the color with pure colors being fully saturated; saturation is inversely proportional to the amount of white light added into a color i.e. if the color blends white color its saturation is low. On the other side, intensity is the measure of brightness. The intensity will measure over some interval of electromagnetic spectrum the flow of power that is radiated from an incident on a surface. These three components can be used to differentiate the skin and the eye region due to the difference in the pixel intensity on the different region.

This algorithm computes the eye center as the region of interest of the image in gray scale. Once the eye center is obtained the pixel value of the region is computed call it q (i,j), the second step is computing the pixel values for three more surrounding regions p(i-1, j+1), k(i,j+1) and m(i+1,j+1). An average of the three is then computed (s).

Once the average s is computed the difference between the q and s is obtained. From the obtained difference, thresholding method is used to differentiate a pixel difference from the eye region and from the skin region. This approach built on the fact that the pixel intensity variation in the eye region is many time that of the surrounding skin regions. Hence, when the eye is closed only the skin is visible but when open the eye regions are visible

3.2.3 DROWSINESS DETECTION MODULE

This module determines the drowsiness levels of the driver based on the statistical information obtained the predecessor stage.

3.2.3.1 PERCENTAGE EYE CLOSURE COMPUTATION

In order to determine the drowsiness level in the driver a percentage of the number of the frames with drowsy eyes is obtain against the total number of detected frames; the percentage is obtained in loops of 200 frames, which represent blocks of 20 sec. A *total_ frame* counter is used to calculate the total number of frames received; another counter *drowsy* counter establishes the total number of drowsy frames that have been detected and then a counter *normal* record the number of frames with eye that are alert.

To establish the percentage of the time the eyes remain closed, the drowsy counter is divided by the total and the outcome multiplied with 100.

Percentage of time eyes remain closed= (drowsy/total_frame) x 100.

The computations are made in blocks of 200 frames, this represents every 20 second because the system is set to operate at a frame rate of 10frames per second. These values however can be adjusted to fit any change that may be required.

In order to compute the time taken by consecutive drowsy frame, the system uses processor clock time to compute the time difference when the first drowsy frame in the block was detected and when the last was detected.

cpu_time_taken = ((double)(stop - start))/CLOCKS_PER_SEC;

From the obtained CPU time the difference between two subsequent ***cpu_time_taken*** is obtained to give us the total time taken by a micro sleep that the driver experiences.

3.2.4 DROWSINESS ALERT MODULE

Once the driver drowsiness levels have been established, the system continually monitor the levels and in the event they hit a certain level currently set at 50% the system will trigger a warning on the display. If the driver notices and takes corrective action, the percentage drops and the warning disappears. If the driver continues to be drowsy and the percentage continues to rise for a period above 30 seconds the system treats this as a micro-sleep and an audio alert is generated by the system to warn the driver he is asleep.

3.3 ALGORITHM OPTIMIZATION

In order to optimize the algorithm that is used in drowsiness detection. Haar cascade classifiers were only used in face and eye detection, this uses integral images hence reducing the number of computations to be performed on an image, Ada boosting and the adoption of a cascade classifier increases the performance and reduces the search area. This is because the weak classifier eliminates the unnecessary regions in the image.

A new approach for detecting the eye state was adopted over a classifier, which would have been both computational and memory expensive for the system. The method as proposed by (Mehdy Bohol n.d.) On his research on computer vision syndrome prevention research proved to be a less expensive on the available resources. The method adopted aimed at computing the pixel intensity of the central part of the Region of interest and testing the pixel intensity difference with the surrounding regions. A threshold value is established and the pixel value of the region obtained is tested against in threshold in order to make a decision whether the eye was closed or not.

3.4 CODE OPTIMIZATION

Several optimization were put in place in order to achieve performance in embedded environment, some of this optimizations include: Reduced code size; this was aimed at taking care of the memory requirements and also cutting on the processing time requirement. The data type selected were aimed at optimizing the execution time and resources need, however this was a little challenging due to the nature of data which are images hence whenever there was an opportunity to use less demanding data type it was seized. Use of pointer is passing data was heavy adopted; this not only optimizes on the memory requirements but also reduces the execution time. Consistency of data types was also observed whenever possible to reduce on the CPU cycles that are required in type casting.

During optimization process, refactoring was used in order to maintain the semantics and logical meaning of the code, even when changes were implemented.

CHAPTER 4 TESTING AND RESULTS

4.1 TESTS

Different tests were conducted both during development of the systems and after the system was developed

4.1 UNIT TEST

Extreme programming test-driven development was adopted in this system development; the developer developed unit tests before development process and used the same test to test resulting code. Refactoring techniques were adopted to optimize the performance of each unit.

4.2 INTEGRATION TEST

After different modules that were tested and integrated, regression tests were be done to check for Compilation, performance or semantic problems, if tests results into error code refactoring was used to correct the existing problems.

4.3 PERFORMANCE TESTING

This test aimed at determining how well the system performs in terms meeting its objectives and robustness of the system to different environments of operation.

In order to ascertain that the system meet the user requirement several tests were performed. As earlier discussed, embedded system poses extreme challenges when it comes to testing of the systems. This is further compounded by lack of test databases for fatigue and drowsiness research.

To overcome the challenges the researchers simulated different states and established the response of the system performance parameters obtained from the terminal, which is the systems point of interface.

Much of the deductions are based on observations made on the system when subjected to a given a test, the process was repeated for different times with different people and for different test parameters.

4.3.1 TEST DESIGN

The system was tested against 20 different people, 10 had eyeglasses on while the rest were without eye glasses. Half of every group pretended to be dozing off to simulate drowsiness, while the rest were alert. The tests were conducted on different lighting conditions to determine the performance of the system under these conditions.

Lighting conditions were divided into three categories, varied with normal illumination representing controlled lighting condition. High illumination represents a situation where bright light irradiated either the camera or the driver.

Low illumination represented a situation where the lighting conditions are poor and even were strenuous to the human eye.

In each case, 1000 frames were observed and the drowsy frames and the normal frame counted. The values obtained in each case were recorded and the average for each category computed and recorded as show in table 1.

4.3.2 RESULTS AND ANALYSIS

High illumination (strong lighting in the direction of the camera)				
Drowsy/alert detected in 1000 frames captured	Drowsy frames detected	Estimated No of un detected drowsy frames	Alert frames detected	Estimated NO of undetected Alert frame
Alert driver	10	990	23	977
Drowsy driver	34	976	43	956

Table 1: Results high illumination

NORMAL ILLUMINATION (NORMAL LIGHTING WITH GOOD VISIBILITY)				
Frames detected in 1000 frame captured	Drowsy frame	Estimated No of un detected drowsy frames	Alert frames detected	Estimated NO of undetected Alert frame
Alert driver	112	888	840	160
Drowsy driver	651	549	346	654

Table 2: Results normal lighting

LOW ILLUMINATION(POOR LIGHTING CONDITION)				
Frames detected in 1000 frames captured	Drowsy frames	Estimated No of un detected drowsy frames	Alert frames detected	Estimated NO of undetected Alert frame
Alert driver	3	997	10	990
Drowsy driver	6	994	4	996

Table 3: Results low lighting

4.3.3 RESULTS AND DISCUSSION

The system performances when evaluations are done under different condition interesting findings were arrived at with different factor identified to be impacting on the performance of the system.

Lighting is a parameter that highly impacts on the performance of the system, when the system is tested on different lighting conditions the results continuously vary depending on the level of external illumination. Under normal lighting condition the performance is high as indicated by the result, under this condition when lighting is controlled the system recorded up to 91% of drowsiness detection however the average drowsiness detection goes down to 65.1% percent. These percentages however vary depending with the prevailing lighting condition.

When illumination increases the performance continuously decreases to a level where there are no detections made. External Illumination affects the brightness of the eye, which in turn leads to changes in the pixel intensity measured. Light from the camera is interfered with by the reflections from the external sources making detection of the target object difficult. This however can be addressed by increasing the light that faces the driver's faces. This helps to fade out the reflections from the other surroundings and to brighten the driver face in order to make it visible from the background through increasing the amount of light the face reflects. However, this approach should be carefully considered so as not to interfere with the drivers eyes, the amount of light emitted in the visible spectrum should be low enough that the driver does not notice or get destructed and ensure that the safety of the eyes is observed.

Reducing the illumination will also diminish the performance of the system, the system makes little detection but as light source becomes darker, the detection levels decrease to zero. This is because the system is depending on the visible light hence not optimized for night vision. To address the night vision the driver cabin can be lite using controlled lighting, there the light does not face the camera to prevent interference of the camera light. At night the human surface is associated with low luminance and low reflectance hence the image that will be captured will be of low contrast. To enhance contrast a low source of light can be targeted to the drivers face however just like when the reflectance from the surrounding in high care should be taken on the amount of light to avoid distracting the driver or causing harm to the driver eyes.

The aspect of lack of detection is also manifested with a person with eyeglasses, eye glasses reflects back the light from the camera. This makes it difficult to capture the intensity differences in the eye region. Eye glasses hence affect the performance of system. When the glasses are darker, the impact will be much higher as some of the light from the camera will be absorbed by the glasses hence the intensity values recorded will be low. The system however does not perform well under occluded eyes; this is because the classifier used in detection of the eye is not optimized for detection of occluded eyes.

The other factor under observation was frame rate, this is important in determining the performance of the system, high frame rates has several advantages, from increasing the levels of accuracy to the amount eye properties to be detected. With very high frame rates, we can be able to determine blink frequency, the blink duration and many other factors. However increasing the frame rates demand for higher memory and processing power, this impacts the performance in embedded environment where these resources are limited. If the frame rate is high and the processing board is very first then the period of detection under study will be very short making the system extremely sensitive. This might lead to constant alerts that might be annoying to the user. This however can be addresses by increasing the number of frames in each loop under observation.

Most embedded systems however have low computational capabilities hence may not be able to handle very high frame rates, in this the number of frames used in drowsiness computation should be reduced to avoid the system taking too long before it arrives at decisions.

4.4 ACHIEVEMENTS

The system performed well registering an average drowsiness detection of 65% , however this might need to be improved in order enhance reliability.

4.5CHALLENGES

1. Lack of well detailed test databases inhibit extensive testing of the system
2. Challenge of addressing the illumination as it impacts on the system, the pixel intensity of the eye region varies with illumination changes.
3. Limited processing resources, image processing is both computation power and memory intensive hence use of a raspberry power with only 512mb Ram and 700mhz was a challenging task.
4. Computing the micro sleep period was also a big challenge.

4.6 RECOMMENDATION FOR FUTURE WORK

To advance this technology further environmental illumination can be addressed through introduction of a module that can estimate the illumination levels and the threshold value for blink detection adjusted accordingly.

In order to advance the performance of the system and incorporate more drowsiness measure parameter, more powerful embedded devices such as FPGA fitted with microcontroller, and more powerful cameras with higher frame rates can be adopted, however the devices in question will be a little more expensive.

To enhance control and more driver situation monitoring a transmission module can be incorporated to transmit the driver state details in real-time to the relevant authorities.

To increase the performance of the system at night or in places with low illumination levels an active method of video capture can be adopted e.g. infra-red camera over the visible light dependent cameras.

In future, the research should be extended to cover more complex user behaviors in front of the camera that indicate drowsiness in drivers, lastly it will be of great benefit to advancement in research in this area if a test databases is developed to help young researchers test their works.

4.7 CONCLUSION

This project details the great potential that image processing has. To conquer most of the world problem human perceive the world through vision, in a similar way adequate cheap technology is available for manipulating images to enable machines interact with their environment through vision. Through this, machine will be able to solve many problems.

The system provides a cheap drowsiness detection method hence providing a solution to millions of Kenyans who are losing their lives and livelihoods in the hand of drowsy drivers both in the public service transport, track driving and in low income private vehicle owners.

Through collaboration with various government agencies, the technology can be used in enforcing the other rules that are found in the Kenyan constitution on fatigue driving. This system demonstrates the great potential that lies in the advancements made in image processing technologies and increased computing power on different board.

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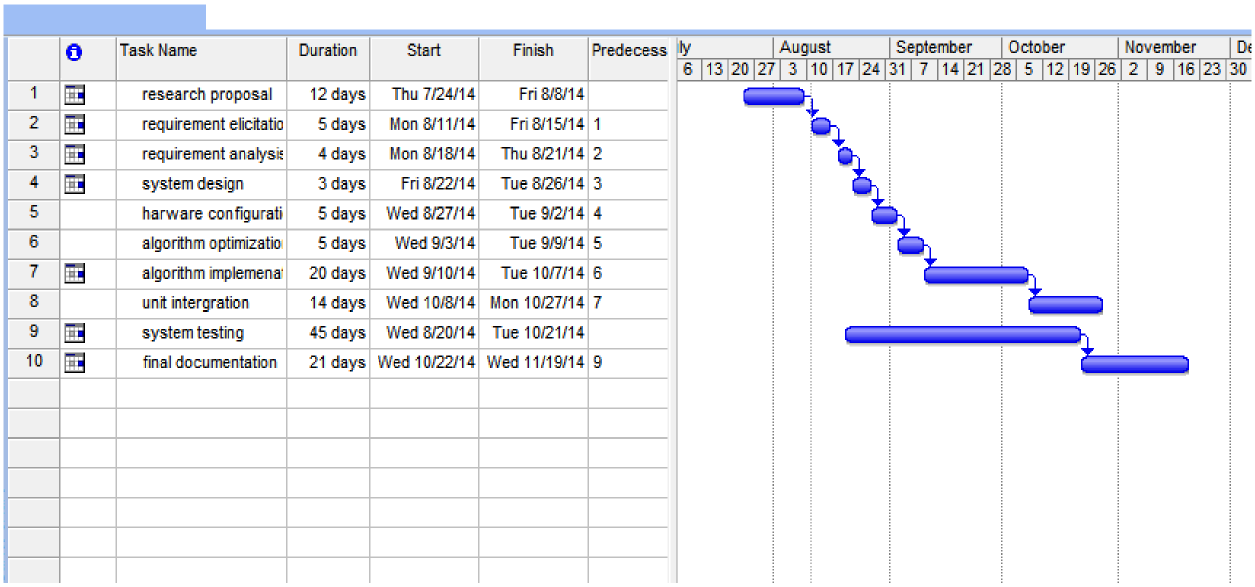
APPENDIX I

PROJECT SCHEDULE



		Task Name	Duration	Start	Finish	Predecess
1		research proposal	12 days	Thu 7/24/14	Fri 8/8/14	
2		requirement elicitatio	5 days	Mon 8/11/14	Fri 8/15/14	1
3		requirement analysis	4 days	Mon 8/18/14	Thu 8/21/14	2
4		system design	3 days	Fri 8/22/14	Tue 8/26/14	3
5		harware configurati	5 days	Wed 8/27/14	Tue 9/2/14	4
6		algorithm optimizatio	5 days	Wed 9/3/14	Tue 9/9/14	5
7		algorithm implemena	20 days	Wed 9/10/14	Tue 10/7/14	6
8		unit intergration	14 days	Wed 10/8/14	Mon 10/27/14	7
9		system testing	45 days	Wed 8/20/14	Tue 10/21/14	
10		final documentation	21 days	Wed 10/22/14	Wed 11/19/14	9

Figure 6project schedule

APPENDIX II

CODE SAMPLE

```
// drowsy.cpp : Defines the entry point for the console application.
/*
drowsiness detection  detection program
*/
// Included header files
#include "opencv/cv.h"
#include "opencv2/highgui/highgui.hpp"
#include <stdio.h>
#include <iostream>
#include <stdlib.h>
#include <string.h>
#include <assert.h>
#include <math.h>
#include <float.h>
#include <limits.h>
#include <time.h>
#include <ctype.h>
int drowsy=0;
int normal=0;
int total_frames=0;
float drowsy_percent=0.0;
int counter=0;
clock_t start, stop;
double cpu_time_taken;
// Create memory for calculations
static CvMemStorage* storage = 0;
// Create a new Haar classifier
static CvHaarClassifierCascade* cascade = 0;
// Function prototype for detecting and drawing an object from an image
void detect_and_draw( IplImage* image );
```

```
void detect_eyes(IplImage* img);
// Create a new Haar classifier
static CvHaarClassifierCascade* cascade1 = 0;
// Create a string that contains the cascade name
const char* cascade_name ="haarcascade_frontalface_alt.xml";
/*    "haarcascade_profileface.xml";*/
const char* cascade_name1 ="haarcascade_eye.xml";
// Main function, defines the entry point for the program.
int main( int argc, char** argv )
{
   // Structure for getting video from camera or avi
   CvCapture* capture = 0;
   // Images to capture the frame from video or camera or from file
   IplImage *frame, *frame_copy = 0;
   // Load the HaarClassifierCascade
   cascade = (CvHaarClassifierCascade*)cvLoad( cascade_name, 0, 0, 0 );
         cascade1 = (CvHaarClassifierCascade*)cvLoad( cascade_name1, 0, 0, 0 );
   // Check whether the cascade has loaded successfully. Else report and error and quit
   if( !cascade )
   {
      fprintf( stderr, "ERROR: Could not load cascade classifier \n" );
      return -1;
   }
   // Allocate the memory storage
   storage = cvCreateMemStorage(0);
      capture = cvCaptureFromCAM(0);
   // Create a new named window with title: result
   cvNamedWindow( "result", 1 );
   // Find if the capture is loaded successfully or not.
   if( capture )
   {
```

```
    // Capture from the camera.
    for(;;)
    {
        // Capture the frame and load it in IplImage
        if( !cvGrabFrame( capture ))
            break;
        frame = cvRetrieveFrame( capture );

        // If the frame does not exist, quit the loop
        if( !frame )
            break;
        // Allocate framecopy as the same size of the frame
        if( !frame_copy )
            frame_copy = cvCreateImage( cvSize(frame->width,frame->height),
                                        IPL_DEPTH_8U, frame->nChannels );
        // Check the origin of image. If top left, copy the image frame to frame_copy.
        if( frame->origin == IPL_ORIGIN_TL )
            cvCopy( frame, frame_copy, 0 );
        // Else flip and copy the image
        else
            cvFlip( frame, frame_copy, 0 );
        // Call the function to detect and draw the face
        detect_and_draw( frame_copy );
        // Wait for a while before proceeding to the next frame
        if( cvWaitKey( 10 ) >= 0 )
            break;
    }
    // Release the images, and capture memory
    cvReleaseImage( &frame_copy );
    cvReleaseCapture( &capture );
}
```

```
    // Destroy the window previously created with filename: "result"
    cvDestroyWindow("result");

    // return 0 to indicate successfull execution of the program
    return 0;
}

// Function to detect and draw any faces that is present in an image
void detect_and_draw( IplImage* img )
{
    int scale = 1;

    // Create a new image based on the input image
    IplImage* temp = cvCreateImage( cvSize(img->width/scale,img->height/scale), 8, 3 );
    // Create two points to represent the face locations
    CvPoint pt1, pt2;
    int i;
    // Clear the memory storage which was used before
    cvClearMemStorage( storage );

    // Find whether the cascade is loaded, to find the faces. If yes, then:
    if( cascade )
    {
      // There can be more than one face in an image. So create a growable sequence of faces.
         Detect the faces and store them in the sequence
        _-------------
/**
 * from the face images recognized this function will detect the eyes and draw a bounder    *
around them */
------------
```

```
for( i = 0; i < (eyes ? eyes->total : 0); i++ ) {
 CvRect* r = (CvRect*)cvGetSeqElem(eyes, i);
        EyeCenter.x = r->x + (r->width/2) - 10;
        EyeCenter.y = r->y + (r->height/2) - 10;

        EyeCenter.width = 20;
        EyeCenter.height = 20;

        //Eye SubImage Creation for Left,
        cvSetImageROI(img,EyeCenter);
        IplImage* EyeSubImageLeft = cvCreateImage( cvSize(EyeCenter.width,
EyeCenter.height), img->depth, img->nChannels );
        cvCopy(img,EyeSubImageLeft);

        int width=EyeSubImageLeft->width;
        int height=EyeSubImageLeft->height;
 //Convert RGB to GRAY Image
        IplImage* LeftGrayEye = cvCreateImage( cvSize( width,height ), IPL_DEPTH_8U, 1 );
        cvCvtColor( EyeSubImageLeft, LeftGrayEye, CV_RGB2GRAY );
        for (i = 1; i<width - 1; i++)
        {
                for(j = 1; j<height - 1; j++)
                {
                        s=cvGet2D(LeftGrayEye,i,j);
                        s1=cvGet2D (LeftGrayEye,i-1,j+1);
                        s2=cvGet2D (LeftGrayEye,i,j+1);
                        s3=cvGet2D (LeftGrayEye,i+1,j+1);
                        s.val[0] = (s.val[0]- (s1.val[0] + s2.val[0] + s3.val[0])/3);
                        if (s.val[0] > max)
                                max = s.val[0];
                }
```

```
            }
//printf("intensity=%d\t",max);
if (max>9){
counter = 0;
stop = 0;
start = 0;

            cvPutText(img1, "Eye Open", cvPoint(10, 130), &font, cvScalar(0, 255, 255, 0));
            if(total_frames<=200)
            {
    total_frames+=1;
        normal+=1;
      }
      else
      {
            total_frames=0;
            normal=0;
            drowsy=0;
      }
      }
else{
cvPutText(img1, "Eye close", cvPoint(10, 130), &font, cvScalar(0, 255, 255, 0));
total_frames+=1;
counter+=1;
start = clock();
    drowsy+=1;
    if(counter < 1){
            stop = clock();
    }
    if(counter > 5){
            cpu_time_taken = (((double)(start - stop))/CLOCKS_PER_SEC)/1000;
```

```
            printf("Time taken for drowsy consecutive frames: %f\n",cpu_time_taken);
            start=0;
            stop = 0;
    }

   if(drowsy%10==0){
        drowsy_percent = ((float)drowsy/(float)total_frames)*100;
   }

    if(drowsy_percent >70){
        printf("Wake up!\n");
        std::cout<<"\a";
    }
    else{
        printf("intensity=%d                    drowsy=%d                    normal=%d                    total=%d
percentage: %f\n",max,drowsy,normal,total_frames,drowsy_percent);
    }

   }

//cvShowImage( "result", img1 );
            cvWaitKey(3);

  }
  }
}
```