CHAPTER 3

INTELLIGENT IMAGING SYSTEM FOR OPTIMAL NIGHT TIME DRIVING

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3.0 INTRODUCTION

In the recent era, vehicles become a need of public. According to Statistic Portal, in year 2018 alone, more than 81 million vehicles were sold. This results in a large number of vehicles commuting on roads, thus increases the risks of road users. Road safety is the paramount and joint responsibility of all road users, which include pedestrians and travellers using different means of transport. Safety is always a main concern for drivers. It is a complex and difficult task even for an experienced senior driver. Road accident is the most unwanted thing to happen to a road user; it was reported that most of the road users are familiar with the general rules and safety measures when using roads, nonetheless their carelessness are causing the accidents and crashes. Zhang et.al [1] proposed an intelligent driver assist system for urban driving. This system provided smart navigation for its users with intelligent parking assistance to improve driving comfort while ensure the safety of the driver. The investigations of the system performance showed high precisions in the determination of the traffic flow and parking availability.

Driving challenges arise everywhere and anytime especially during the night. One of the main issues when driving at night is poor visibility. A driver’s view is limited to the distance illuminated by vehicle headlights. Furthermore, drivers do not have the advantage of colour and contrast vision compare to the daytime. Driving at night also
reduces driver’s ability to see the other vehicles. Even though a driver may have used a powerful and effective headlight on their car, its function is limited due to the glare of headlights from other vehicles and brightly lit signs or buildings. Most drivers’ eyes recovered from such glare in between three to five seconds or even longer [2].

The time for the eyes of a driver to recover from glare while driving at night increases with age. It was predicted that 90% of the drivers made their decisions based on their instinct. Under this limited lighting, traffic accidents, which may involve pedestrians, vehicles, animals and any other hazards from farther away, are likely to occur [3]. Driving during night is a challenging task for many due to limited and poor visibility at night. However, it is hard to avoid travelling at night. For this purpose, Luo et al. [4] proposed pedestrian detection based on two different sensing technologies: active night vision using near-infrared (NIR) region of the electromagnetic spectrum, and passive night vision that operates with far-infrared (FIR) spectrum.

It must also be mentioned that night vision goggle has recently developed as an image enhancement technology that is able to collect all the available surrounding light, which includes infrared light, before amplifying it. As a result, its users would have a clearer vision in the dark [5]. However, it is impractical for use in road settings owing to its size and weight. In addition, this device costs about RM 5,000 [6]. Meanwhile advanced driving assistance system (ADAS) was invented by Intel to assist its driver and improve one’s driving experience. Its primary function is to ensure the safety of the vehicle, its driver, and other road users. Safety features were designed to avoid collisions and accidents by providing alert to the driver. This technology can be connected to a smartphone to alert other drivers about the danger. In addition, it is also able to notify its users of their vehicle’s blind spot [7]. The limitation of this system is it provides no function for a clear night vision [7]. Therefore, a night vision with an advanced road safety technology is necessary; it would be useful to allow drivers to see and foresee road hazards sooner, and give them more time to react. This topic discussed an intelligent imaging system for optimal night time driving. This is via an in-car safe driving system and inter-vehicle communication platform for sharing of visual information using Google Cloud Platform. Not only does this system allow its drivers to foresee road hazards sooner, giving them sufficient time to react, it also allows sharing of
visual information on the interesting events specifically those related to either criminal activity or concerning road safety in the created network group.

3.1 COMPARISON OF THE LATEST INVENTIONS

In this subchapter, research papers related to this study are discussed.

3.1.1 An Intelligent Night Vision System for Automobiles [8]

This system used infrared cameras and computer vision techniques to enhance road users’ safety. The system was coined as Intelligent Vision for Automobiles at Night (IVAN). The operation of this system began by encoding analog video signals before the corresponding video is enhanced and pre-processed. The processed image would then undergo a series of shape detection analysis, which locates possible road signs in the video frames. The shapes recorded were analyzed to identify for the possible road signs. If a road sign is recognized, it would be displayed on the screen. At the same time, IVAN would alert the driver of the important road signs [8].

3.1.2 Night Vision System in Bayerische Motoren Werke (BMW) [9]

This system installed in BMW branded vehicles is known as night vision camera (NVC). The night vision camera is produced by Autoliv to detect images in the form of electronic signals. The result would be transferred to a Liquid crystal display (LCD) screen. The next generation of the system includes display of enhanced images of forthcoming driving scenes. In the display important objects such as pedestrians and animals, which has been argued to be the primary safety goal of night vision system, are being highlighted [9].

3.1.3 Infrared Night Vision Based Pedestrian Detection System [10]

A camera was set up on the driving car in this work. The input signal is the continuous infrared photographs recorded. An analysis was
performed for the timing and spatial conditions. It was shown that the system is able to detect any pedestrian around the vehicle [10].


This work presented image processing, vehicle detection and tracking using night vision images captured by a Closed-Circuit Television (CCTV). It is hypothesized that this product can be used in crime investigation to either find vehicles that violated traffic rules or those involved in accident in the highway. It was found during the system testing that vehicle headlight’s reflection pose a major concern to the system’s performance. This, however, can be overcome by adjusting the camera settings namely luminous or brightness, contrast and intensity. A comparison of the reported research works is summarized in Table 1.

Table 3.1: Comparison of previous developed devices

<table>
<thead>
<tr>
<th>Reference</th>
<th>Object of interest</th>
<th>Detector used</th>
<th>Image color</th>
<th>Acceptance angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>[8]</td>
<td>Road’s signboard</td>
<td>Infrared Camera</td>
<td>Color</td>
<td>60 degrees</td>
</tr>
<tr>
<td>[9]</td>
<td>All aspects</td>
<td>Far Infrared Camera</td>
<td>Grayscale</td>
<td>Acceptance angle decreases with increased speed</td>
</tr>
<tr>
<td>[10]</td>
<td>Pedestrian only</td>
<td>Not mentioned</td>
<td>Grayscale</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>[11]</td>
<td>Road’s signboard</td>
<td>CCTV</td>
<td>Grayscale</td>
<td>Not mentioned</td>
</tr>
</tbody>
</table>

3.2 SYSTEM DEVELOPMENT

Image processing is a series of computational operations on an image to achieve enhanced signals with improved quality. Image processing is used in different field with its own purpose. This work involves the implementation of image processing operations using Raspberry Pi as its microcontroller, and this platform was operated on
Google Cloud service. The integrated infrared camera was used to capture live video, i.e. a series of images, during nighttime driving. The results were enhanced to identify objects within the images that have been recorded. The processed streaming video was displayed on a monitor for reference of its user.

The developed system saved the records of live videos in a Secure Digital (SD) card; these series of images were uploaded and saved together with its coordinate location to Firebase database shown in Figure 1. The detection of the location was via a Global Positioning System (GPS) module. The safekeeping of such information in cloud-based storage would allow others to access. This would alert other users of the forthcoming dangers or hazards as shown in Figure 2. Even though a user may go offline, the data would keep updated.

In addition, this system was also equipped with anti-collision feature using ultrasonic sensor technology to detect the distance between the vehicle and front object. If the detected distance is less than 500 cm, an alarm would be triggered to notify its user.

![Figure 3.1: Block diagram of system](image-url)
3.3 RESULTS AND DISCUSSIONS

The section is divided into three main parts namely that of imaging system, data sharing system, and anti-collision system as followed.

3.3.1 Infrared imaging system

Infrared camera was used to take image and record live video. The reason of this selection is that this light wavelength range is unaffected by visible light. As a result, camera users can see equally well in both well-lit and total darkness environments [12-13]. The performance of the developed system was evaluated in terms of the calculated image Signal to Noise ratio (SNR) at different driving speed and the system response time. The SNR is measured in decibels (dB).
According to ISO film speed equivalent, excellent image quality needs to have at least 32.04 dB while acceptable image quality needs to achieve 20 dB [14]. The SNR ratio is calculated by:

$$SNR=10\times10^{\log \left(\frac{ima-imi}{ims}\right)}$$

where $ima$ is maximum pixel of image, $imi$ is minimum pixel of image and $ims$ is the standard deviation of image.

This work investigated image SNR for driving speed of 20, 40, 50, 70, 80 and 110 km/h. This image quality metric was evaluated from three sets of experiment that carried out at nighttime. The results are shown in Figure 3.

It can be clearly seen that the SNR decreased with an increased in the vehicle speed. The SNR is determined by the object sharpness and the object contrast. The higher the SNR ratio, the better the quality of image. The image appeared blur when the speed of driving increased. It was shown that the maximum speed to maintain while retaining a relatively clear image is at 80km/h.

![Figure 3.3: SNR value for images taken from three sets of experiment at different travelled speed](image-url)
3.3.2 Online data sharing platform

The time taken in uploading the acquired image into cloud system was also computed based on trials conducted for ten consecutive times. The mean and standard deviation of system response time are defined as follows:

\[
\text{Mean} = \mu = \frac{1}{n} \sum_{i=1}^{n} t
\]

(2)

\[
\text{Standard deviation} = s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (t - \mu)^2}
\]

(3)

where \(\mu\) and \(s\) represented mean and standard deviation of system response time, respectively, while the symbol \(n\) is number of samples. The calculated online data sharing response times are as shown in Figure 4.

![Graph showing response time of the system](image)

Figure 3.4: The response time of the system when uploaded data to Firebase storage and Firebase database.
From Figure 4, the overall response time of the developed system is calculated as $5.6 \pm 1.6$ s. Meanwhile Figure 5 and 6 show the streaming of data into Firebase database and Firebase storage, respectively. Public users can foresee the location coordinates where alert had been reported and its associated images through the link provided: https://final-199013.firebaseapp.com/. The rapid sharing of information among road users would also allow a fast track down of offenders’ vehicle and their whereabouts. This community cooperation and policing would help to speed up necessary responses by relevant authorities, thereof effectively minimizing criminal cases such as abduction and robbery. The driver may disseminate image from inside the car using this system to hint other road users for assistance in case of emergency or life-threatening events.

Figure 3.5: Data sent to Firebase Database
3.3.3 Anti-collision system

The mean and standard deviation in the measurements of separation between vehicle and obstacle for the activation of the alert system are calculated as $440.1 \pm 9.92$ cm. There is a slight mean difference of 12 % is noticed between the set value and that measured distance. This study shown that the performance of the integrated anti-collision system was able to sense and notify the user of objects or obstacles located at mean distance of 440 cm in front of the vehicle which users able to avoid life threatening incident to occur.

3.4 CONCLUSION

Intelligent imaging system for optimal night time driving provides in-vehicle and inter-vehicle interactions by using Google cloud service: Firebase. This system is able to provide a near real-time communication platform, which response time is calculated as $5.6 \pm 1.65$ s and allow road users to share the interesting information and the coordinate where the data was taken. The data sharing can notify other users in case of emergency and let them foresee the hazards on road. The obtained SNR results revealed that this system may not be suitably used for night time driving because of low quality of images taken. This may cause by motion artefacts of moving vehicles. This may be overcome by using an advanced and better performance imaging sensor that has a high frame rate.
REFERENCE


