A study of low-cost vehicle collision prevention assistance

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Abstract. This paper defines a low-cost tool for calculating the distance from a vehicle to the front. The motive of this study is to define a method for range estimation of vehicles with small price application, particularly in Malaysia. The measuring tool utilizes an ultrasonic sensor and a raspberry pi to determine the range. In addition, the data is stored in Firebase in real-time. The tool is evaluated in real-time, and all outcomes are tabulated. Finally, the study results underline that the measuring tool is possible, but economic variables and communication are of concerns.

1. Introduction
Today, vehicles play a significant role in everyday lives, as they are component of a way of getting to a destination of each person. As a consequence, there is a growing amount of vehicles on the highway [1]. Almost 70% of road crashes are due to the fact that the safety gap between moving vehicles is not practiced. The primary cause of crashes is the driver's inaccurate assessment of safety range [2]. Bloomberg's study cited from the World Health Organization (WHO) statistics says that Malaysia is one of the most risky emerging countries after Thailand and South Africa. Malaysia has recorded a death rate of approximately 23 per 100,000 population, according to the information [3]. According to this data, around 7,000 to 8,000 individuals are killed on the highways every year against the projected population of 30 million Malaysians [4]. Hence, the government takes this accident statistics seriously and deals holistically with the issue of road safety; the Government has taken steps to take 5E interventions. This involves education, enforcement, engineering, environmental and evaluation [5].

In recent time, every country has conducted research to ensure driving safety by using vehicle collision prevention technology. The statistical data suggest that 45% crash can be reduced if road users have more than half a second response time at the moment of a dangerous scenario [6]. As a consequence, vehicles have been fitted all kinds of active and passive safety driving. The objective of the tool is to prevent a vehicle crash and it will become a major part in connected vehicle innovations [7]. According to the studies, vehicle collision warning and vehicle to everything communication are among the most popular demands for safety features characteristics by road users. Senior Vice-President of RDA, Jim Thomas had mentioned that the road users approach to safety technology has changed in recent years [8] [9].

The aim of the study is to create a low-cost measurement tool that able to warn of the distance between vehicles. The measurement tool is intended to handle the behaviour to be warned when the
distance is too near for the driver especially in Malaysia. This paper discusses a distance measuring and warning IoT-based approach. The literature review will be discussed in Section 2. Section 3 focuses on the approach. On execution, Section 4 will demonstrate. The findings and discussion are highlighted in Section 5. The paper is concluded in Section 6.

2. Literature review

2.1. Research development projects

A study proposes a forward collision warning algorithm which can adapt its alarm thresholds in real-time according to modifications in driver’s behaviour, including behavioural variation as well as an individual difference. This adjustable forward collision warning (FCW) algorithm overcame traditional FCW’s limits with traditional risk assessment models and fixed thresholds through continuous monitoring of vehicle driving behaviour in many routes. The recursive least squares technique has used an actual identification algorithm for the alert thresholds. Based on naturist experiment data, offline models demonstrate that this algorithm can fit the driver's behaviour and individual difference in long-term driving conditions and as time moves on, the driver's behaviour adaptability is enhanced gradually thus the FCW false alarm rate decreases [10].

Apart from that, another study proposes an adaptive collision warning algorithm that supports the driver by providing early alerts crash without significantly raising the likelihood of fake alarm in actual driving. This algorithm can also identify the need for an emergency intervention if needed. Compared to the current collision avoidance warning, the proposed alternative hereby triggers warnings with the resolution of an appropriate (speed-dependent) alert limit via vehicle information, road constraint and cyclist models in the linear convex program. By determining viable directional trajectories without changing the longitudinal speed of the vehicle, the risk of a crash is identified [11].

Besides that, a study researched on forward collision warning using one camera with the help of energy-constrained techniques instead of using large computational methods, like optical flow and machine learning. The algorithm uses 2D modelling using time, comparative distance and relative speed to predict the colliding period between vehicles and the object. There are three phases to the proposed algorithm, which are region creation, object location and the time-to-collision estimation [12].

Alongside, this study provides an adaptive forward-collision warning technique with the warning by continually comparing the time headway with a threshold limit. Real-time monitoring of the drivers' reaction against previous warnings using existing indicators, such as braking history, is the core of the proposed threshold limit mechanism. This approach considers the distraction of the drivers in the process, in accordance with the cognitive state, to fine-tune the calculated threshold. A learning strategy is developed in an attempt to integrate the driver’s distraction in the system structure and continually assess the driver distraction by using various available Controller Area Network (CAN) bus time ranges, including pedal position, speed, acceleration and yaw rate. Neural networks are designated to identify driver distraction as a commonly accepted ranking technique [13].

2.2. Vehicle development projects

Many vehicle companies are to develop their vehicle using a collision-avoidance system. Forward Collision Avoidance (FCA) helps to avoid crashes with other cars or passengers in Hyundai by using radar and camera sensors, by decreasing the speed and alerting the drivers to possible collisions on the road. FCA provides more safety with Electronic Stability Control (ESC) by applying the brakes to the tires automatically at the correct moment [14].
In addition, Predictive Forward Collision Warning system is Nissan's separate technological development. The system supports the driver in assessing the scenario outside their typical area of perspective by providing information about it. The relative velocity and range to the vehicle can be analyzed directly ahead of the vehicle and as well as a vehicle traveling in front of the preceding one. The system alerts the driver to potential risks by instilling an immediate alert and display in advance with a signal. These features help to prevent pile-up accidents. The technology perceives dangers outside the view of the driver that lie beyond the ahead. Nissan continuously develops technology to improve safety [15].

On the other hand, a warning system in Honda can alert the drivers of a hazardous scenario in ahead, if it is momentarily distracted. The drivers are warned about a possible collide with a vehicle which was identified ahead by the FCW system using audible and visual warnings. It is possible for FCW to detect vehicles in front of the vehicle. If the distance between the two vehicles is diminishing, the system compares the vehicles current speed to determine the possibility of a collision. FCW alerts with an audible sound and displays an orange ‘brake’ message that warns the driver. The FCW will not operate to avoid unnecessary warnings at speed less than 3 mph [16].

Besides, Ford vehicles have also been intended to provide with a function that can help to alert in the case of a potential collision with the vehicle in front. The front radar detects slower vehicle traveling in the same path and estimates the distance to vehicles ahead. The Forward Collision Warning (FCW) detects the risk of collisions when the driver gets too near to a vehicle and triggers a visual and audible warning. The brake support kicks in to pre-charge and increases the brake sensitivity in order to provide full reaction when braking if the drivers do not respond to the alert and proceed to get nearer the vehicle.
ahead. The pre-charge provides complete braking power even when the brake pedal is applied gently. Thus, the wheels are able to react [17].

![Figure 4. Ford Forward Collision Warning](image)

3. Methodology
The measurement tool is intended to monitor the road users who are custom to tailgating particularly in Malaysia. The tool observes the distance between the current vehicle and the vehicle ahead and ensures to maintain safe driving distance. It also warns road users by providing a message to drive carefully to avoid dangerous conditions. Despite the warnings from the tool, it is still the road users’ responsibility to monitor the traffic and respond in a critical scenario. However, this tool has not been integrated with the automatic emergency brake at this point. To identify the distance between the vehicles, the tool utilizes an ultrasonic HC-SR04 sensor and is placed on the front bumper of the vehicle. An alarm with an audio sound is displayed on the dashboard as an output. Three different colours are used to show the distance of driving, green for a safe distance, yellow for warning distance and red for danger distance. During the hazardous circumstances, the audible sound will be activated. Figure 6 demonstrates the working principle of the measurement tool.

![Figure 5. Working Principle of the Measurement Tool](image)

3.1. Ultrasonic sensor HC-SR04
The HC-SR04 ultrasonic sensor utilizes sonar to determine the distance to an object. It provides outstanding non-contact distance detection with elevated accuracy and stable measurements in an easy-
to-use kit. From approximately 2 cm to 400 cm (while the acoustically soft materials like cloth may be difficult to define) are not affected by sunlight or black materials such as sharp rangefinders. It comes complete with the ultrasonic transmitter and receiver module.

3.2. Raspberry Pi 3 Model B+
With a new, faster processor to enhance its speed, the Raspberry Pi 3 Model B excel to its predecessors with build upon feature. It also has the ability to enhance features and manage to power devices via USB ports through WLAN and Bluetooth's low energy technology.

3.3. Raspberry Pi 7 inch touchscreen
The Raspberry Pi 7inch Touchscreen Monitor gives designers the capability to create integrated apps, such as equipment, systems for the supply of infotainment and embedded projects. The 800 x 480 display connects via a power and signal conversion adapter board. It is really interesting since the latest software drivers support a virtual ‘on-screen’ keyboard so that a keyboard and mouse do not need to be plugged into.

3.4. Firebase
Firebase is a widely known database. It was first purchased by Google in 2014 as an independent company. Firebase is a design structure supporting internet apps, iOS and Android. In this way, not only the designers have connections to a wide range of tools to facilitate their life easier, but also to use Firebase to generate apps running on various operating systems.

3.5. Distance settings
As shown in Table 1, the distance settings are used for the testing. The distance range for the tool is measured in centimetre (cm). For the distance between 100cm to 199cm, it classified as potential collide, between 200cm to 299cm it is classified as keeping some distance and between 300cm to 399cm it is classified as a safe distance.

| Distance               | Alert             |
|------------------------|-------------------|
| 1 m (100cm to 199cm)   | Potential Collide |
| 2 m (200cm to 299cm)   | Keep Some Distance|
| 3 m (300cm to 399cm)   | Safe Distance     |

4. Implementation and result

Figure 6. Prototype Setup
Figure 7. Safe Distance Alert

Figure 8. Keep Some Distance Alert

Figure 9. Potential Collide Alert

Figure 10. Data Stored in Firebase

Table 2. Distance Measurements Result

| Distance Measured (cm) | Alert       |
|-----------------------|-------------|
| 307.6                 | Safe Distance |
| 103.9                 | Potential Collide |
| 108.7                 | Potential Collide |
| 217.3                 | Keep Some Distance |
| 213.8                 | Keep Some Distance |
| 306.8                 | Safe Distance |
| 303.5                 | Safe Distance |
| 110.2                 | Potential Collide |
| 301.9                 | Safe Distance |
| 217.3                 | Keep Some Distance |
| 213.8                 | Keep Some Distance |
| 106.3                 | Potential Collide |
| 214.4                 | Keep Some Distance |
| 202.1                 | Keep Some Distance |

5. Discussion

Ultrasonic sensors produce ultrasonic frequencies that human cannot detect. They are perfect to use in low-noise settings. The sensor responses to ultrasonic do not depend on an object's surface colour or optical mirroring, for example, a glass plate and a shiny aluminium plate. These sensors do not require much electricity, user-friendly and comparatively cheap. The digital 0 and 1 of ultrasonic sensors are very accurate for repetition sensing. Immediate context objects may be ignored even at distance of
processing due to the comparatively small changing magnetic. The ultrasonic sensors have a minimum distance for detecting. Environmental changes such as heat, pressure, moisture and particles influence ultrasonic reactions. Low-density targets like foam and cloth tend to absorb sound energy, which may be difficult to feel in the long distance. In order to obtain an appropriate sound echo, the ultrasonic sensor should be on the immediate line of sight of the surface of the object. In addition, a minimum object surface area is required for the accuracy of these sensors. Sound waves are more efficient on a smooth surface than rough surfaces.

6. Conclusion and future works
This paper describes a low-cost collision prevention assistance that can be adapted for the road users’ environment. Tests were carried out, and the regular behaviour of the sensor was shown. The sensor has an easy and less expensive signal processing without the use of microprocessors. The sensor enables the distance of more than 1m to be achieved under silent circumstances, despite low cost. The sensor output is updated every 5 seconds. Therefore, in future, the readings that have been collected are sufficiently precise for headlight levelling and for providing the active suspension devices significant data.

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