The Effect of Smartphone and Vehicle Distance on Vehicle Safety System Time Response Based on the Internet of Things

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ABSTRACT

This paper addresses the prevalent issue of increasing crimes in Indonesia, particularly vehicle thefts. To combat this challenge, we propose the development of an Internet of Things (IoT)-based vehicle security device capable of detecting intruders within the car and subsequently notifying the car owner through smartphone alerts. The implementation of this innovative technology holds the potential to enhance vehicle security and contribute to a safer environment for vehicle owners in the country. In this study, we conducted a series of tests in a rural mountain area to examine the impact of vehicle and smartphone distance variation, as well as internet provider variation, on the response time of a vehicle safety device under limited internet signal conditions. The experiment involved distance variations of 100m, 200m, 300m, 400m, 500m, and 600m, with the internet providers being the most expensive and the cheapest provider in Indonesia. By investigating these factors, we aimed to gain insights into optimizing the response time of the safety device, especially in areas with poor internet connectivity. Utilizing the two-way ANOVA method, this experiment successfully demonstrates that variations in distances and internet providers significantly influence the notification response. The effective combination of the HC-SR501 passive infrared sensor and Nodemcu microcontroller is shown to detect movements inside the vehicle cabin and reliably notify the vehicle owner through their smartphone. These findings underscore the viability and efficiency of the proposed system in enhancing vehicle security and owner awareness.

***Keywords**: Internet of Things, Passive Infrared Sensor, Time response, Safety Device.*

I. Introduction

Crimes often occur in Indonesia like a car theft. Based on official data from Badan Pusat Statistik Indonesia [1], in 2020 there were 18,557 non-violent vehicle thefts recorded. Eforts have been made to reduce the potential in vehicle theft, like installing primary vehicle security such as vehicle door locks and secondary vehicle security such as installing padlocks on the steering wheel, vehicle alarms, and hidden ignition switches. But in applications, those efforts can not detect the thief presence in the vehicle so that they can access the vehicle cabin to grab some stuff or hijack the car.

To overcome this problem, it is necessary to create a vehicle security device based on the Internet of Things (IoT) technology that can detect the presence of thieves in the vehicle cabin, and alert the vehicle owner thru smartphone notification. However, the application of IoT technology has some deficiencies, such as dependency on the internet connectivity, and variance of internet provider service that can affect operational cost.

Related work in IoT based vehicle safety systems has been done previously by Kurniawan [2]. The result of the research is an android application that can turn off the vehicle remotely using a smartphone via the 4G network with the base transceiver tower distance and internet provider variation as its independent variable. However in the previous experiment that has been done by Kurniawan, the vehicle safety device is not equipped with sensors that can detect the presence of a thief in the vehicle cabin. To detect the motion inside the vehicle cabin, the application of passive infrared sensors has proven to be effective in detecting the movement of objects at close range [3]-[5] and has been widely applied in smart home sensor systems [6]-[9].

Based on the mentioned problems above, a solution is proposed. In this experiment we developed an IoT based safety device that can detect movement inside a vehicle and automatically disconnect its ignition system through the ignition key and sends a notification to the vehicle owner's android smartphone using NodeMcu as a microcontroller. This device is using a passive infrared (PIR) sensor as a motion detection sensor. And then we investigate the combined effect of the device to BTS tower distance variation and internet provider variation.

To simulate the lack of internet connection, the experiment has been conducted in a rural mountainous area where the internet signal coverage is limited at Bumiaji, Batu, East Java, Indonesia. The distance variance between the safety device installed in the car and the smartphone is 100m, 200m, 300m, 400m, 500m, 600m and the internet provider variance is Telkomsel and Tri to represent the most expensive and the cheapest internet provider in Indonesia.

II. Experimental Setup

A. Hardware

The experiment and data collection were conducted on a vehicle safety device that has been made. The vehicle safety device consists of Nodemcu microcontroller, HC-SR501 passive infrared sensor and relay driver as the actuator as shown in schematic drawing in figure 1.

The vehicle safety device works by detect the movement inside vehicle cabin, when the movement inside the cabin is detected, it sends a voltage signal to the Nodemcu microcontroller, later it automatically disconnects an ignition system by sending a signal voltage to the relay that is connected to the ignition key wire. Nodemcu microcontroller also writes indicator data to the cloud database.

B. Software

For the smartphone notification system, an android application is made using the MIT android inventor program, a web based android application designer. As shown in figure 2 the android application has several features, including a motion Indicator, ignition key wire indicator, date and time, emergency message button, and reset button. The android application working principal is by reading and writing data to a cloud database, when the data from Nodemcu is written in a database the android application is automatically changing the status of vehicle motion and ignition key indicator and activate a smartphone notification.

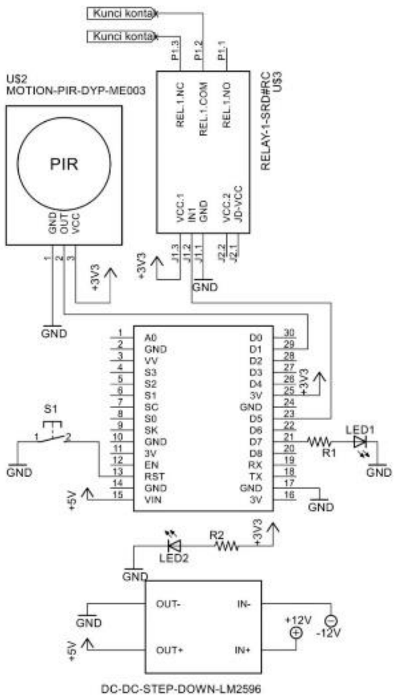

Figure 1 Vehicle Safety Device Hardware Schematic

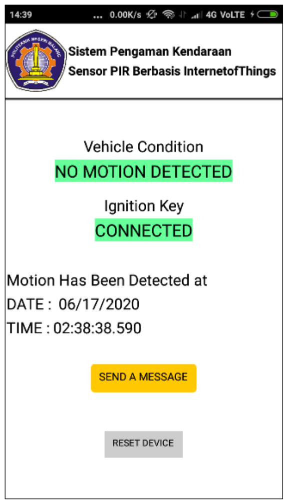

Figure 2 Vehicle Safety Device Android Application Display

C. Data Collection

Data collection is conducted in a rural mountainous area in Bumiaji, Batu city, East Java, Indonesia. As shown in the figure 3 the data collection procedure is done as follows:

1) Install the safety device into car, and place the car next to base transceiver tower
2) For data collection purpose the safety device is connected to Arduino IDE computer program
3) Place the smartphone in predeterminate distance as shown in figure 3.
4) Trigger the safety device sensor to get the internet speed time response.
5) Time response is gotten by comparing the time difference between the safety device trigger time (that shown in Arduino IDE serial monitor) and the notification time indicator in Android application.
6) Data collection is conducted in 100m, 200m, 300m, 400m, 500m, 600m with Telkomsel and Tri as the internet provider.

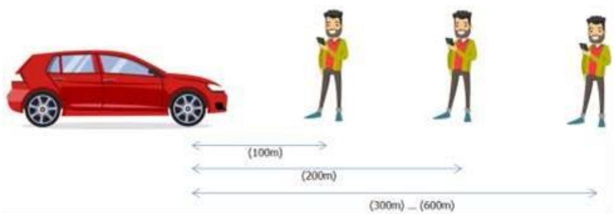

Figure 3 Data Collection Method Illustration

D. Data Processing

Two-way ANOVA compares the means of populations that are classified in two ways or the mean responses in two-factor experiments. In this experiment, Two way ANOVA is used to determine whether that there is significant effect between independent variable (internet provider and distance) against dependent variable (device response time). Two-way ANOVA based on these three assumptions:

1) The observations are random samples from normal distributions

2) The populations have the same variance
3) Observations are independent of each other

The results of a two-way ANOVA are summarized in an ANOVA table based on splitting the total variation SST (Sum of Squares Total) and DFT (Degree of Freedom Total) among the two main effects and the interaction [10]. The general form of the two-way ANOVA is shown at table 1 below:

Table 1. Two-Way Anova Form

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
A	*I - 1*	SSA	SSA/DFA	MSA/MSE
B	*J - 1*	SSB	SSB/DFB	MSB/MSE
AB	*(I - 1) (J - 1)*	SSAB	SSAB/DFAB	J
Error	*N - IJ*	SSE	SSE/DFE	
Total	*N - 1*	SST	SST/DFT	

There are three null hypotheses in two-way ANOVA, with an F test for each. We can test for significance of the main effect of A, the main effect of B, and the AB interaction. Large values of the F statistic lead to rejection of the null hypothesis.

In this experiment there are three hypotheses:

1) Hypotheses 1
   H0: there's no significant effect between provider variation in notification time response.
   H1: there's significant effect between provider variation in notification time response.
2) Hypotheses 2
   H0: there's no significant effect between distance variation in notification time response.
   H1: there's significant effect between distance variation in notification time response.
3) Hypotheses 3
   H0: there's no significance effect between provider variation and distance interaction in notification time response.
   H1: there's significance effect between provider variation and distance interaction in notification time response.

III. Research Result

Table 2 and table 3 shows the device and smartphone application time responses. The data collection was done by 3 times in each variable and measured in millisecond. The fastest average time response is 334.67ms has been done by Telkomsel internet provider at 100meter distance variance, meanwhile the slowest one is 1198.33ms has been done by Tri internet provider at 500meter distance variance.

Table 2. Telkomsel Provider Time Response

No	Distance (meter)	Telkomsel Provider Time Response (millisecond)			Average
		Sample 1	Sample 2	Sample 3	
1	100	333	425	246	334.67
2	200	776	783	831	796.67
3	300	772	890	790	817.33
4	400	505	450	504	486.33
5	500	447	413	385	415
6	600	918	901	953	924

Table 3. Tri Provider Time Response

No	Distance (meter)	Telkomsel Provider Time Response (millisecond)			Average
		Sample 1	Sample 2	Sample 3	
1	100	333	425	246	334.67
2	200	776	783	831	796.67
3	300	772	890	790	817.33
4	400	505	450	504	486.33
5	500	447	413	385	415
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A. Data Processing

To obtain the result of the independent variable effect, two-way anova data processing has been done using SPSS software.

First, Levene's homogeneity test result is performed to determine the homogenic property of the data. As shown at table 3, significance value of median time response is 0.207 which is greater than 0.05, so it can be concluded that the variables is homogenic and fulfilled the two-way anova test requirement.

Table 4. Homogenity Levene's Test

		Levene Statistic	df1	df2	Sig.
Time Response	Based on Mean	1.470	11	24	0.207
	Based on Median	0.628	11	24	0.788
	Based on Median and with adjusted df	0.628	11	15.025	0.780
	Based on trimmed mean	1.405	11	24	0.234

Table 5. Two-Way Anova Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	3094878.97	11	281352.63	130.63	.00
Intercept	27487301.36	1	27487301.36	12762.36	.00
Provider	2157471.36	1	2157471.36	1001.71	.00
Jarak	400332.47	5	80066.49	37.17	.00
Provider * Jarak	537075.13	5	107415.02	49.87	.00
Error	51690.66	24	2153.77		
Total	30633871.00	36			

R Squared = 0,98

Then two-way anova testing is performed to find out the provider and distance variation effect between safety device and smartphone. As shown at table 4 it can be concluded that:

1) F-value of provider variance is 1001.715, the significance level is 0.000 which is less than 0.05. Based on the first hypotheses in can be concluded that H0 rejected and H1 accepted it means there's a significant effect between provider variance against notification time respond.

2) F-value of distance variance is 37.175, the significance level is 0.000 which is less than 0.05. Based on the second hypotheses in can be concluded that H0 rejected and H1 accepted it means there's a significant effect between distance variance against notification time respond.

3) F-value of provider and distance interaction is 49.875, the significance level is 0.000 which is less than 0.05. Based on the third hypotheses in can be concluded that H0 rejected and H1 accepted it means there's a significant effect between provider and distance interaction against notification time respond.

IV. Conclusion

A Designed and constructed vehicle safety device using Nodemcu microcontroller, HC-SR501 passive infrared sensor, android application and firebase database server as its notification system, has been tested and proven to be able to detect the vehicle cabin breach.

The experiment has been done to find out the provider and distance variation effect between safety device and smartphone. By using two-way anova method in SPSS software, the result of this experiment is a variation in internet provider affects notification time response that produce 1001.715 in F-value, the significance level is 0.000 which is less than 0.05, so it can be concluded that provider variance significantly affects the notification time respond. Meanwhile F-value of distance variance is 37.175, the significance level is 0.000 which is less than 0.05, it means there's a significant effect between distance variance against notification time respond, so it can be concluded that distance variance significantly affects the notification time respond. F-Value in provider and distance interaction is 49.875, the significance level is 0.000 which is less than 0.05, so it can be concluded that provider and distance interaction significantly affects the notification time respond.

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