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RFID-Based Vehicle Monitoring System

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***Abstract*— This paper is about the development of RFID-based vehicle monitoring system that provides a database for all registered vehicles using 13.56 MHz RFID module; sends SMS notification to the database using SIM900A GSM module; an integrated barrier gate using Tower Pro MG966R Servo Motor; an integrated HC-SR04 ultrasonic sensor to detect those vehicles entering the specified area and an integrated Arduino camera module that captures vehicle images. It also addresses security constraints in terms of the functionality, usability, and reliability through several tests. Flowchart, block diagram, and wiring diagram were used to document the requirements, analysis and design of the system. In addition, the performance of the system was done through the perception of respondents using questionnaire. Convenience sampling was used for the selection of the respondents who are the registered vehicle owners. The results showed that RFID-Based Vehicle Monitoring has satisfied its functional requirements by providing its user-desired functions and specifications. The system is functioning well for all technical test. The system was also perceived to be functional, usable, and reliable.**

Keywords*— *RFID, Vehicle, Transportation, SMS, GSM, Arduino, Servo Motor.

I. INTRODUCTION

The unending cycle of technology innovation brings satisfaction and impart an exquisite outcome to the people. As technology evolved, everyone has been open in living with several state of the art control systems. Examples of which is the security at home, mobility and remote supervision applications. Security, nowadays, is the most important for us people that is why the search for a safe and sound living still remain around the need of everyone. Aside from home, schools are also in the main lists when it talks about safety especially public schools because of the number of vehicles moving into and out of the school premises.

Today, transportation has the important role in our society. However, as we notice, human population is growing bigger along with vehicles are also growing in number. Monitoring today is becoming a big challenge for everyone in securing their own properties. In many areas that vehicle passes, there are problems encountered when it comes to security. A lot of vehicles that enters and exits in one place to another is one of the realistic circumstances. It has been raised that there is difficulty of managing the entrance and exits of the vehicles manually. Manual monitoring makes the assigned guard difficult to monitor every vehicle that is entering the area from time to time as well as maintaining the records of vehicles are a complicated task. The plate number is only recorded information for the vehicle entering and exiting the gate.

The primary aim of this study is to design and establish a vehicle monitoring system that is RFID-Based.

Specifically, it aimed to design a vehicle monitoring system that provides a database for all registered vehicles using 13.56 MHz RFID module, provide SMS notification to the database using SIM900A GSM module, construct an integrated barrier gate using Tower Pro MG966R Servo Motor, establish an integrated HC-SR04 ultrasonic sensor for vehicle detection and create an integrated Arduino camera module for capturing vehicle images.

The Impact of Security Technologies to Transportation

With the growing and continuous improving state of technology today, it was not surprising that everyone deals with technologies most especially in securing their life and properties. It rapidly changed the economy, the society, and the way people live, work, and interact with each other.

Transportations become the most technology's integrated part throughout the industry, especially in investing security technologies historically and over the years had passed, great improvements in the transportation systems are being made and created with the help of numerous advances in science and technology [1]. The researchers concluded that having changes in transportation technologies have impact in the society as well.

Security Technologies Used in Vehicles

RFID is a technology that gathers and capture data about an object without the need of touching or seeing the data carrier. This is done through the application of inductive coupling or electromagnetic waves [2]. This is also an emerging technology that uses wireless radio in order to identify objects from a distance without requiring a line of sight or even substantial contact [3].

With the use of Servo motors, barrier gates are well known in terms of securing road gates. Servo motors are best known for their rapid acceleration and deceleration capability, made possible by delivering high-peak torque in conjunction with a high torque-to-inertia ratio.

Arduino is a tool and an open-source platform for making systems usually applied for controlling another system. It is a physical computing platform that is based on a simple microcontroller board and has a development environment for writing software for the board. Arduino projects can be stand-alone, network based or and can communicate with software running on other computer systems such as LabVIEW, Matlab and may others.

Communication processes between human and devices were also renewed through the use of GSM modem.

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SMS notification, unlike its common purpose, is also used in warning and monitoring security systems.

II. RELATED WORK

Existing Monitoring System for Vehicles

There are vehicle monitoring system are now available and sold in the market. A system was presented to monitor the location of the vehicle along with its parameters, like speed, compartment temperature, fuel consumption, from a centralized location for research and development purposes. This system can also store data for further analysis and records keeping but it uses internet-of-things technology. [4].

A RFID-based monitoring system was design for vehicles in Brunei Darussalam primarily to track the speed of vehicles. The RFID kit is associated with Raspberry-pi board and Central Control Unit (CCU) to establish connection with a remote administration server [5]. There is also a Vehicle Monitoring System that uses RFID which generates and maintain daily reports of vehicles under monitor. Through this RFID vehicle monitoring system, information can be collected automatically for efficient and safe vehicle management. Automatic vehicle identification increases the security and hence, can prevent loss of vehicles [6].

Additionally, a similar system was established in Malaysia to track the school children in school vehicles. The design used the Global Positioning System (GPS) as a ways of tracking the school vehicle. A passive RFID technology was integrated for recording the presence of the children in the vehicle. Parents will know the location of the vehicle while their children are on board. Hence, this paper concerns most on the safety on their children with the RFID and GPS technology [7].

An implementation on Vehicle theft alarm and tracking the location using GPS and RFID was also established. The System consists of a microcontroller circuit board, keypad, alarm system and a display board with the combination of RFID and GSM. The key used by the automobile is an RFID card that is convenient, contactless and secure [8].

Vehicle Security System Using Zigbee is designed and implemented to check and secure the car based on combination of Zigbee system, Peripheral Interface Controller (PIC) 16F877A microcontroller, vibration sensor (body), temperature sensor and micro switch (engine), alarm, buzzer, fan and magnetic sensor (door). Users can monitor the status of car remotely using the Liquid Crystal Display (LCD) display which is attached to the controller. The authors concluded that this system is successfully tested for its performance [9].

The system about embedded Vehicle Monitoring system based on Web Technology used level sensor, pressure sensor, tilt sensor, gas sensor, and alcohol detector. These sensors are applied for Liquid Level, State of Vehicle, Pollution by Vehicle, alcoholic taste of driver and so on are being checked. These sensors provide the information to the Arduino (ATMEGA 328P-P0). Web Technology is used to check the information needed. The author concluded that this project can be improved by using a camera and by integrating a mobile based application to get the information from the vehicle in real time [10].

Traffic Monitoring using M2M Communication was developed to monitoring traffic that uses wireless vision sensor network (camera). The camera captures and processes the real-time video image to get the traffic flow rate and vehicle speed. The system displayed the traffic status and can help the drivers to select the best route to avoid probable traffic congestions. The real-time traffic data is processed by a computer at the sub roadway station and the traffic flow rate data is communicated to the main roadway station [11].

An array of RFID sensors for real time tracking of vehicles on a high speed expressway was developed in 2016 as one of then applications of intelligent traffic monitoring system. In this system, RFID sensor networks are better than image processing based systems. An Arduino platform with an Ethernet connection are used as a core controller so that data can be seen on the internet using cloud computing. [12].

Differences with existing system

With the emerging of transportation technologies today, a lot of changes have been made. Most of the literature and studies focused on the automation of vehicle identification, monitoring of vehicle using camera, and tracking using RFID and GSM. Hence, the researchers designed and implemented technologies and systems that are applicable to Automatic Vehicle Identification (AVI), Intelligent Transportation System (ITS), and Internet of Things (IOT) which bring great improvements in solving transportation security problems. The literatures and studies are also different in terms of structure, in areas of study and with the other purposes.

The literatures presents the idea of using RFID technology. It collects, records, maintains, and saves data detected from the vehicles running in road, passing through road gates, monitoring vehicle status, and entering/leaving an area using RFID Tags as well as gathering and sending Tag ID information into a base station in which the researchers would want to incorporate and adapt in this paper. On the other hand, it was identified that the cited works possess the weaknesses that it cannot able to detect if the owner is the driver of his own vehicle or driven by the other. Thee identification card can be swapped with another person's ID or forgot and lost by the vehicle owner making it still possible for an unauthorized person to use it. Thus can now enter the area which lead to another problem. Some of the implemented designs have used sensor-integrated RFID system, Arduino Microcontroller, an alarm system, an integrated camera and a combination of RFID and GSM to notify the vehicle's owner in some instances encountered. These provides brief detailed references on the functionality of each device, mainly the microcontroller used. Thereby, the proponents adapted the combination of RFID and GSM as well as the camera and incorporate a barrier gate system using servo motor in order to secure the implementation scope of the study.

Moreover, the proponents adapted one of the cited literatures that uses RFID technology for registered vehicles. However, the observed weakness of this study is it detects only those registered plate number of a vehicle and it cannot able to detect those unregistered vehicles. With RFID-Based Vehicle Monitoring, both registered and unregistered vehicles can be detected and monitored. They can enter the area from time to time through the use of RFID reader for tag detection and controller of servo motor. The GSM module sends SMS notification to the database. Servo motor can control mechanism of the barrier gate with the combination of ultrasonic sensor and camera module for vehicle detection and capturing vehicle images, and a button as bypass for those unregistered vehicles.

III. METHODOLOGY

System Flowchart

The flowchart of the RFID-Based Vehicle Monitoring in Figure 1 shows the step by step process of how the system operates. It has two major inputs which are the RFID reader that detects a tag from the vehicle owner and an ultrasonic sensor that detects the vehicle. If the driver is registered, the green LED, GSM, Buzzer, and the camera activates simultaneously and the barrier gate will open at the same time. On the other hand, if the driver is not registered, the camera still captures the vehicle image, but the barrier gate remains close. If the unregistered vehicle wants to enter the area, the assigned personnel can use the button as bypass. If bypass button is used, the red LED, buzzer, and GSM will then be activated. The GSM module will send a SMS notification to the database for record purposes.

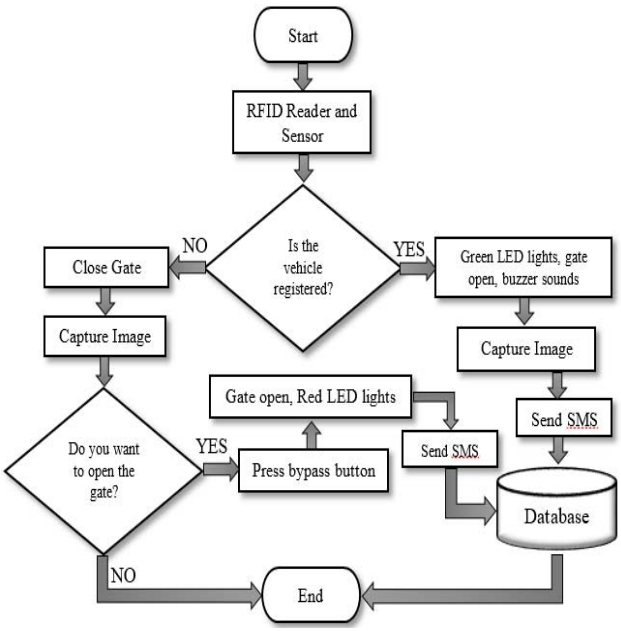

Fig. 1. System flowchart

General System Design

The block diagram A in Figure 2 shows the process of the RFID-Based Vehicle Monitoring. An RFID card tag is issued to every registered vehicle owner with same unique numbers. When this card is placed in front of the RFID Reader, the Arduino board will analyze the information of the tag. When the tag is registered, the green LED activates and the barrier gate will open through the use of a servo motor and will send a SMS notification through the GSM Module with the exact name of the vehicle owner and the exact time that will directly store in the database through the FrontlineSMS software. On the other hand, when there is no tag detected from the vehicle's owner, the assigned guard will press the button or will place a card in front of the reader as a bypass and then activates the red LED and the barrier gate will open so that the vehicle can now enter the area and will send a SMS notification that an unregistered vehicle entered the area and will store in the database for security purposes.

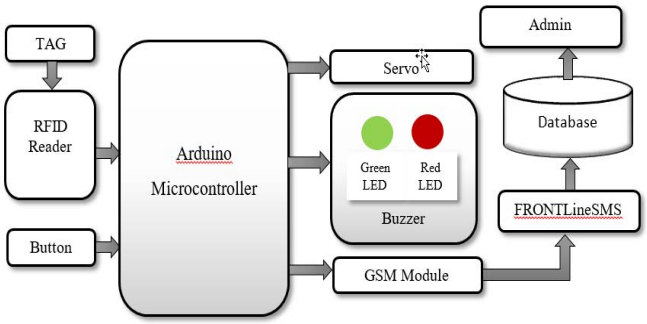

Fig. 2. Block Diagram A of RFID-Based Vehicle Monitoring

Additionally, the block diagram B in Figure 3 shows that camera activates using the ultrasonic sensor that detects a vehicle automatically and then captures the image of the vehicle detected by the sensor and will directly store in a Micro SD Card for future purposes. Real Time Clock (RTC) was used for setting the camera time. Furthermore, the buzzer beeps whenever a card is placed in front of the RFID reader in order to inform the assigned guard and increase the security inside the school premises

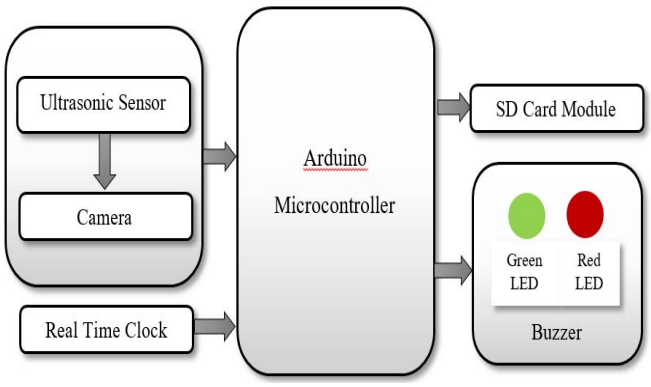

Fig. 3. Block Diagram B of RFID-Based Vehicle Monitoring

Wiring Diagram

The wiring diagram A of RFID-Based Vehicle Monitoring in Figure 4 acts as a guide in connecting each of the components for the design. The main device used in the design is the Arduino Uno microcontroller that serves as the brain and heart of all components connected. Whereas RFID reader serves as a controller that activates each components such as the GSM module that sends notification to the database, servo motor that controls the barrier gate, buzzer, and LEDs. The button activates only when an unregistered vehicle tries to enter the area in which the assigned personnel will operate it. All sensors and modules are connected in the microcontroller in order to achieve its design objectives and its intended functions.

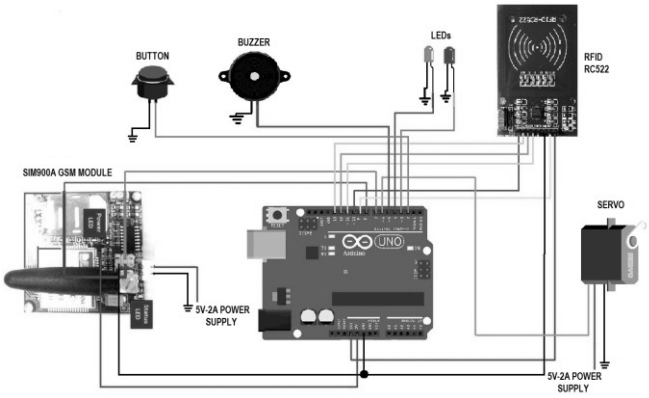

Fig. 4. Wiring Diagram A of Vehicle RFID-Based Monitoring

The wiring diagram B of RFID-Based Vehicle Monitoring in Figure 5 acts as a guide in connecting the components of the design. The main device used is also Arduino Uno microcontroller. The ultrasonic sensor and the camera module serve as the "eyes" of the entire design. These two components will communicate their data to the Arduino Uno in which the microcontroller processes the information. This is in order to achieve the final output - the captured images of the vehicles that enter the area and then will be stored in a Micro SD Card.

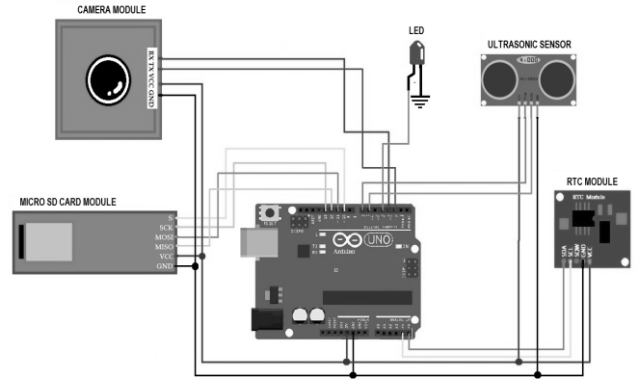

Fig. 5. Wiring Diagram B of RFID-Based Vehicle Monitoring

System Development

The registered vehicles screen shots for the vehicle owners shown in Figure 6 consist of tool strip that contains the GSM database, logout button, and exit button, records of the registered vehicle owners. These records can be modified through adding, editing, and deleting records.

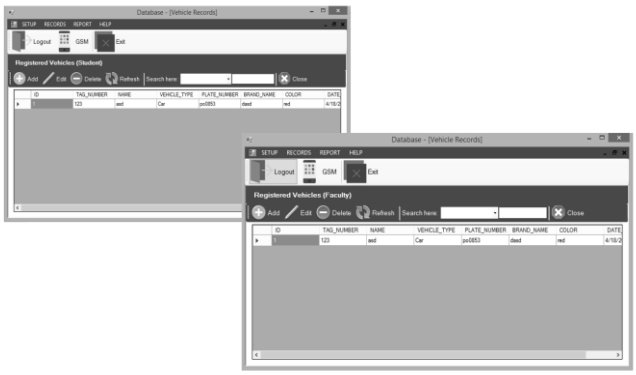

Fig. 6. Database for all Registered Vehicles

Figure 7 shows the developed database for all registered vehicles using 13.56 MHz RFID module. The RFID reader activates when a tag is placed in front of it. Along with, the GSM module sends SMS notification (vehicle owner name and time) to the database for record purpose.

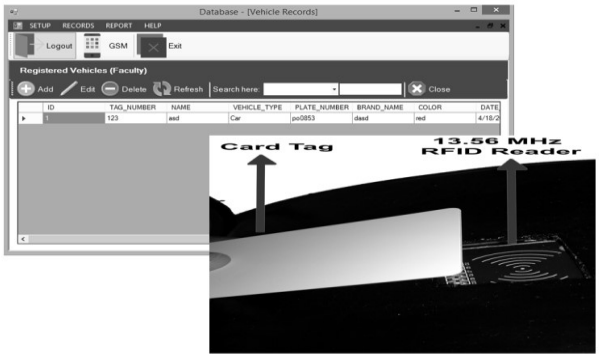

Fig. 7. RFID reader and its database

Figure 8 presents the developed database which stores SMS notifications using SIM900A GSM module for history purpose. The GSM module activates only when the RFID reader detects a tag or when the button is used.

Fig. 8. SMS Database and GSM module of Final Prototype

Figure 9 shows the final design output of the "RFID-Based Vehicle Monitoring". It also shows the labeled location of every component integrate inside of the design. The device will work once it is turned on with the exact supply needed. Every labeled component has its own functions. The design's main body is a large casing which is made of plywood for the protection of the integrated components, because if it is aluminum it will easily absorb heat. This can affect the performance of the prototype and it may destroy the integrated components inside it. The casing comes with a barrier gate controlled by a servo motor, a button, and a camera connected to the entire system. Inside the casing are the materials used such the RFID reader, ultrasonic sensor, LEDs, buzzer, GSM module, real time clock module, Micro SD Card module, Arduino Microcontrollers, and adapters used as power supply.

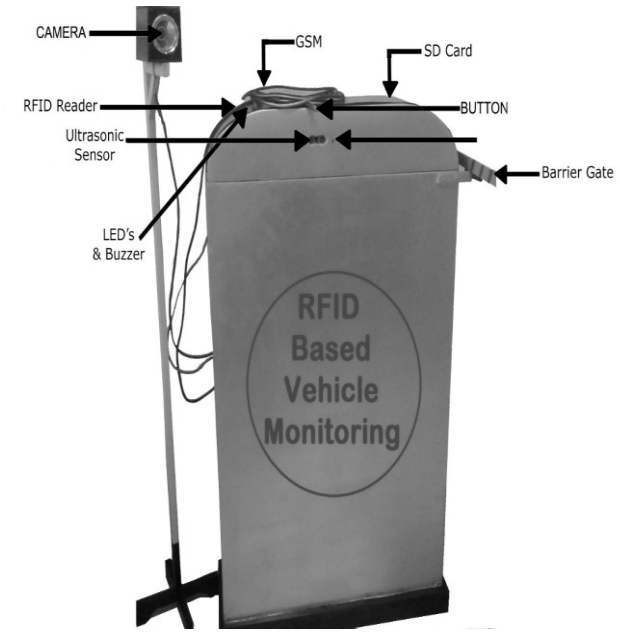

Fig. 9 Final Design output

IV. RESULTS

Test 1: RFID Tags Registration Test

The registration of RFID tags were done in 10 randomly selected vehicles. In the test, "Successful" expected result means that the RFID is registered to a single unique vehicle successfully. On the other hand, "Unsuccessful" expected result means that registered RFID cannot be registered again. Repeat registrations were done in the 10 sample RFID which resulted to "Unsuccessful" remark.

Table I
RFID Tags Registration Test

TRIAL	RFID #	Expected Result	Actual Result
1	6026d34f	Successful	Successful
2	1674ca65	Successful	Successful
3	e56ca534	Successful	Successful
4	38cc45a3	Successful	Successful
5	8d4f6312	Successful	Successful
6	aa7b4539	Successful	Successful
7	8eeb4684	Successful	Successful
8	800c3703	Successful	Successful
9	6ccc4079	Successful	Successful
10	4358902a	Successful	Successful
11	1674ca65	Unsuccessful	Unsuccessful
12	e56ca534	Unsuccessful	Unsuccessful
13	aa7b4539	Unsuccessful	Unsuccessful
14	800c3703	Unsuccessful	Unsuccessful
15	4358902a	Unsuccessful	Unsuccessful

Test 2: Vehicle Registration Checking, Filtering and Image Capturing test

This test aims to check if the vehicle entering and exiting the gate are registered in the system. If registered, the green light will lit and the gate will open and the buzzer will make sound. The camera then captures the image. In this test, the system must successfully check the registered RFID to have the system perform the expected action. Steps here include the reading of RFID card, detecting the vehicle through ultrasonic sensor, then expected action must be done according to the status of the vehicle.

Table II
Vehicle Registration Checking, Filtering and Image Capturing test

TRIAL	RFID #	Registered	Green LED Status	Buzzer Status	Gate Action	Capture Image
1	6ccc4079	Yes	ON	ON	OPEN	Yes
2	e56ca534	Yes	ON	ON	OPEN	Yes
3	1674ca65	Yes	ON	ON	OPEN	Yes
4	6ccc4079	Yes	ON	ON	OPEN	Yes
5	8eeb4684	Yes	ON	ON	OPEN	Yes
6	6ccc4079	Yes	ON	ON	OPEN	Yes
7	5ef6390c	No	OFF	OFF	CLOSE	Yes
8	368df64a	No	OFF	OFF	CLOSE	Yes
9	2749fcad	No	OFF	OFF	CLOSE	Yes
10	fe1256da	No	OFF	OFF	CLOSE	Yes

Test 3: GSM Database confirmation of SMS Received and RED LED test

This tests shows if after a vehicle is permitted to enter since it was registered according to the database, SMS information must be sent to the GSM database. Further, the RED LED must not be turned on during this test.

Table III
GSM Database confirmation of SMS Received and RED LED test

TRIAL	RFID #	Registered	Gate Action	Capture Image	GSM Database	Red LED Status
1	6ccc4079	Yes	OPEN	Yes	SMS received	OFF
2	e56ca534	Yes	OPEN	Yes	SMS received	OFF
3	1674ca65	Yes	OPEN	Yes	SMS received	OFF
4	6ccc4079	Yes	OPEN	Yes	SMS received	OFF
5	8eeb4684	Yes	OPEN	Yes	SMS received	OFF
6	6ccc4079	Yes	OPEN	Yes	SMS received	OFF

Test 4: Bypass process for non-registered vehicle, RED LED and SMS Notification test

This testing procedure shows the response of RED LED and the gate when a non-registered vehicle is still allowed to enter or exit the gate through bypassing the gate system. Even when there is bypass operations, SMS notification will still be sent to the GSM database.

Table IV
Bypass process for non-registered vehicle, RED LED and SMS Notification test

TRIAL	RFID #	Registered	Gate Action	Capture Image	Bypass to open	Red led status	Gate Action	GSM Database
1	5ef6390c	No	CLOSE	Yes	YES	ON	OPEN	SMS received
2	368df64a	No	CLOSE	Yes	YES	ON	OPEN	SMS received
3	2749fcad	No	CLOSE	Yes	YES	ON	OPEN	SMS received
4	fe1256da	No	CLOSE	Yes	YES	ON	OPEN	SMS received

The design provided a database system for all registered vehicles. RFID and Arduino-Based monitoring system are used with the integration of barrier gate using servo motor as control mechanism. It also includes a button as bypass for unregistered vehicles and a GSM module used for SMS notification whenever the reader detects an RFID tag. An ultrasonic sensor is used for vehicle detection while camera captures vehicle images. The RFID reader operating frequency is 13.56 MHz and can detect up to 4 cm. The SD Card capacity can store up to 2 GB of the detected and captured vehicle images.

The counting of number of vehicles and persons entering and leaving the area is not included in the system and it will not require all vehicle owners to have an RFID tag. Thus, the design still requires a human intervention.

This study also looked into the general perception of the respondents regarding the device functionality, usability and reliability through the use of survey questionnaires. The designed questionnaire consists of statements that is patterned from the software quality criteria as defined by ISO/IEC 9126 standard.

V. CONCLUSIONS

Based from the result of the study, it was concluded that the developed RFID-Based Vehicle Monitoring was successfully tested and demonstrated. This is by providing a database for all registered vehicle owners using a 13.56 MHz RFID module, SMS notification using SIM900A GSM module. Included also is the integration of barrier gate using Tower Pro MG966R servo motor, integrated HC-SR04 ultrasonic sensor, and integrated camera module. Further, the developed RFID-Based Vehicle Monitoring is tested and it is working properly as to its purpose. It was also perceived to be functional, usable, and reliable.

VI. RECOMMENDATION

In the light of the findings of the study, recommendations are drawn for future development and improvement of the project. First, the design should add new features, including additional RFID Reader for the exit gate. A long range RFID reader must also be considered. Second, the design should use bigger display to completely view the information of the vehicle entering the campus without looking/checking in the database anymore. Third, the system should use high-end database that can directly store data and images. Lastly, future researchers may include a vehicle counting system for more convenient vehicle monitoring.

REFERENCES

[1] E. Deakin, S. Kim, “Transportation Technologies: Implications for Planning”, Faculty Research, University of California Transporation Center 2001, pp 1-27

[2] E. Ilie-Zudor, Z. Kemény, P. Egri, L. Monostori, “The RFID technology and its current applications”, ISBN 2006, Volume 963, pp 86586-5

[3] S.L. Ting, L.X. Wang, W.H. Ip, “A study of RFID adoption for vehicle tracking in a container terminal”, Journal of Industrial Engineering and Management 2012, pp. 22-52

[4] M. Desai, A. Phadke, “Internet of Things based vehicle monitoring system”, IEEE 2017

[5] M. Sarbini, S. Hassan, T. Jiann, PM. Ahmad, “Design of a RFID-based speed monitoring system for road vehicles in Brunei Darussalam”, IEEE 2014, pp. 219-223

[6] D. Kiranmayi, “Vehicle Monitoring System Using RFID”, Durugu Kiranmayi / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 7 (3) , 2016, pp. 1444-1447

[7] K. Kalid, N. Rosli, “The Design of a Schoolchildren Identification and Transportation Tracking System”, IEEE 2017

[8] C.R. Kumar, B. Vijayalakshmi, C. Ramesh, C. Pandian, “Vehicle Theft Alarm and Tracking The Location Using RFID & GPS”, International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com ISO Certified Journal 2013, pp. 525-528

[9] NMZ Hashim, MHA Halim, H. Bakri, SH Husin, MM Said, “Vehicle Security System Using Zigbee”, International Journal of Scientific and Research Publications 2013, pp. 1-6

[10] M. Kirti, B. Gavali, PRR Bhambare, “Research and Design of Embedded Vehicle Monitoring System Based on Web Technology”, International Journal or Modern Trends in Engineering and Research 2016, pp. 12-17

[11] S. Kumar, Y.O. Jo, J.W. Shin, S.R. Lee, “Traffic Monitoring Using M2M Communication”, General Fall Conference of Korea Information and Communications Society (KICS) 2012, Seoul, South Korea, 2012, pp. 233-234

[12] R. Pendor, P. Tasgaonkar, “An IoT Framework for Intelligent vehicle monitoring System”, International Conference on Communication and Signal Processing, April 6-8, 2016, India, IEEE 2016, pp. 1694-1696