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Motorcycle Theft Prevention and Recovery Security System

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Abstract

Transportation plays a big part of our daily lives. Every year, people in the Philippines are increasingly using vehicles especially motorcycles as their common means of transportation. Together with the increase of motorcycle users, motorcycle theft is also rampant over the years. In this study, a system had been developed for theft prevention and recovery of motorcycle in an easier and faster way. The user of this system will be notified through an alert once the motorcycle has been moved in a long distance or stolen. The user also could view the current location of the motorcycle, shutdown the engine and capture an image of the thief. The system has two components, the hardware and the software modules. The hardware component includes micro-controller, GSM, GPS, and a camera. The software component is the mobile application, which is the medium of communication of the user to the motorcycle and also serve as the main controller of the entire system. Based on the evaluation conducted in terms of usability and functionality it had been found out that most of the users strongly agreed the usefulness of the system.

Keywords: Micro-controller, GSM, GPS, Technology, Theft Prevention System

INTRODUCTION

Background of the Study

Most of our daily activities take place outside our home. Because of this, transportation affects every aspect of our lives especially in doing our daily routines such as going to work, school, mall, bank, gym, etc., and even back to our home. Without transportation, there are many activities we could not take part in. Transportation has contributed much to the development of economic, social, political and cultural fields by uplifting their condition. In the Philippines, one of the easy transportation today is the motorcycle and it has increasingly becoming the most common means of transportation.

Motorcycle is one of the least expensive and a convenient mode of transportation but unfortunately, it is easy to steal, easy to disassemble, and easy to ship as parts (McDono, C, 2011). As motorcycle industry went boom, motorcycle theft in the country has ran rampant over the years and countless of their modus operandi has been recorded.

The Philippine National Police has recorded a periodic increase in cases of stolen motorcycles across the country. The PNP Highway Patrol Group said that in 2013, they recorded 3,701 cases of stolen motorcycles. In 2014, the number of stolen motorcycles was at 7,302. During the first quarter of 2015, the HPG recorded the theft of 2,404 motorcycles compared to the 1,562 stolen motorcycles during the same period last year (Dalizon, 2015). In the year 2015, the PNP recorded 8,203 cases of stolen motorcycles last November 2015, the PNP-HPG recorded an average of 6.2 motorcycles being stolen per day (Dalizon, 2016).

Motorcycle theft indeed has become a big problem of the community. Although, the authorities are said to be doing the best they can to stop these thieves, it still ranks high up in the list of crimes committed in the streets every day.

Security plays a vital role in today's society. Safety of vehicles is extremely essential for every private and public vehicle owner. For this reason, various security systems have been carried out, but most of these security systems are expensive, complicated and best suits to cars. Numerous car security systems have been carried out to improve security system by incorporating Biometric techniques such as Face Detection and Finger Print Detection (Pingat et. al., 2013). Other security systems were equipped with a tracking system using Global Positioning System (GPS) and have the capability to shut down the engine of the vehicle remotely via a text message (Ramadan et. al., 2012). As for motorcycles, basic and affordable security system only gives siren indication and will make a lot of noise that disturb people. But if the person is far from the motorcycle location he will not be able to hear the alarm. Physical type counter measures are also used to prevent theft, such as padlocks, disk break lock and other more which is a preventive action but it is not safe enough.

One of the existing solutions for motorcycle napping available in the market today is the Scorpio Ride “Core” Cellular Motorcycle Alarm and GPS Tracking System. It uses iOS or Android app and a module installed inside the bike. It sends a Short Message Service (SMS) alerts to notify the user for any

tampering of the motorcycle. It has also the ability to track vehicle's location. This system does not have enough preventive measures during theft attempt.

Due to these reasons, this study proposed to adapt the car security system solutions to motorcycles. This study also wished to develop and improve its functions to better suit its purpose. This innovation of a vehicle security system has the ability to turn off the vehicle engine and send real-time alerts to the vehicle owner. Thus, preventing the theft from taking the motorcycle. This security system also features the ability to locate the motorcycle and image-capturing technology to help ease stolen motorcycles search and recovery. This is possible through the use of Global System for Mobile communication (GSM), Global Positioning System (GPS) Technology, sensors, system immobilizer and a camera. The user controls the whole system using mobile application.

METHODOLOGY

System Architecture

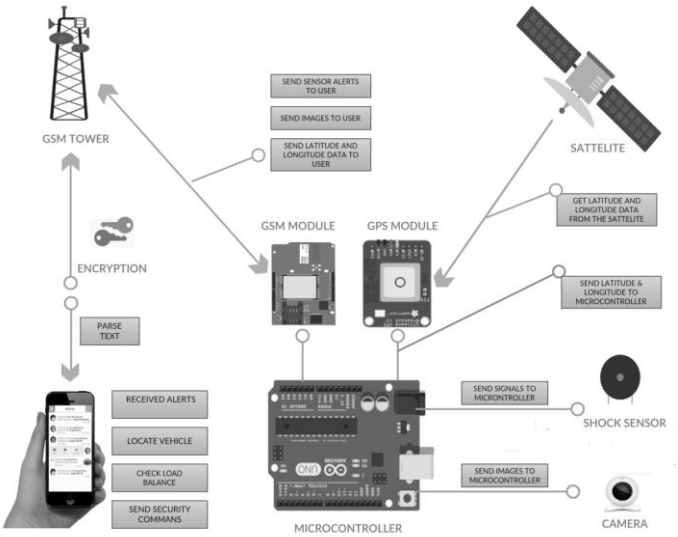

Figure 1. System Architecture of Motorcycle Theft Prevention and Recovery Security System

Figure 1, shows the System Architecture. The system is divided into two: Hardware and Software parts. The hardware module of the system is embedded with Micro-controller, Global System for Mobile (GSM), Global Positioning System (GPS) technology, engine immobilizer or kill switch, a camera, and mobile application. Micro-controller serves as the main control of all the operations of the hardware components. GSM module acts as an intermediate between the vehicle and the owner, providing a two-way communication, and connects the hardware and software modules of the system. It is also responsible for sending and receiving *Short Message Service* (SMS) and *Multimedia Messaging Service* (*MMS*) to and from the user. The GPS module is used to obtain the vehicle's location coordinates (Longitude and Latitude). Shake sensor is used to detect movements and vibrations from the motorcycle. The camera is used in the system to provide the image-capturing technology. The engine immobilizer or kill switch is used to immobilize the vehicle engine upon the Alarm System activation to prevent thief from taking the vehicle or by riding the vehicle. The hardware module will be installed inside the vehicle. The software module of the system is the mobile application, which will be the medium of communication of the user to the vehicle and will also serve as the master control of the whole system.

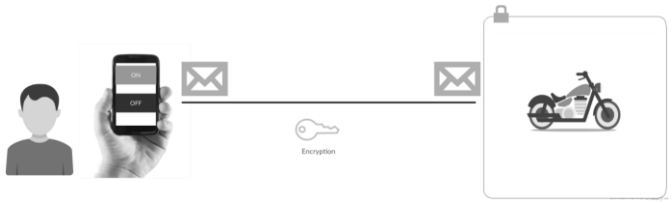

Figure 2. Alarm System Initiations of Motorcycle Theft Prevention and Recovery Security System

Figure 2, shows how the Alarm System initiates. Through the mobile application, the user can activate or deactivate the Alarm system remotely by sending text SMS. The commands are encrypted to avoid unauthorized access of the system using another phone. The sent SMS commands from the user will be received by the GSM module. Upon the Alarm System activation, the system obtains location coordinates (Latitude and Longitude) of the vehicle and enables the engine immobilizer or kill switch in order to avoid thief from riding the vehicle. The only chance of taking the motorcycle is through loading it to another vehicle. Therefore, the system provides the vehicle's location and continually monitors or checks and updates if there is a change of the vehicle's location. The Shake sensor, Audible alarm, and Camera are in standby mode.

Table 1. System parameters of Motorcycle Theft Prevention and Recovery Security System

Notification	Security Level	Parameters
Emergency SMS	Level 0	Vehicle distance > 5m or distance specified by the user.
Alert SMS	Level 1	Vibration.

Table 1, illustrates the parameters to trigger the SMS notifications. For security level 1, vibrations detected from the vehicle must be satisfied to trigger the system to send Alert SMS to the user notifying the user that the vehicle has detected shakes and movements activities.

For the security level 0, if there's a change in location of the vehicle and had traveled a distance greater than 5m or by the distance specified by the user, the system sends Emergency SMS to the user.

Figure 3. Theft Attempt Illustrations

Figure 3, illustrates that when the system detects tampering and vibration in the motorcycle the security level is at level 1, the user is notified via Alert SMS and prompted to activate Emergency Mode or putting the security level at 0. On the other hand, the vehicle location monitoring continually checks for vehicle's location coordinates (Latitude and Longitude) and calculates the change in distance, using the Haversine formula, between the previous locations recorded during the Alarm system initiation. If the distance comparison of two coordinates is greater than 5m or distance specified by the user, the security level will be at level 0 or in Emergency Mode; it indicates that the vehicle has been moved from where it was by unauthorized person or a thief. This will trigger the system to enable audible alarm, and capture images. Emergency SMS together with the captured images, and location coordinates (Longitude and Latitude) will be sent by the GSM module via text SMS and MMS to a registered SIM number of the owner. The owner will receive the text SMS and MMS and will be fed into the mobile application to give a friendly Graphical User Interface. The location coordinates received by the user will also be parsed and fed into the mobile application. The user's mobile phone must be first connected to the internet or at least turned on GPS/GPRS services to display vehicle location to a map via Google maps API. During the Emergency Mode the system continually sends the location coordinates (Longitude and Latitude) of the motorcycle to the user every minute to give user the update of the vehicle's location. Also, the user can locate the vehicle anytime. The commands being sent via SMS by the user are encrypted. The data such as images, vehicle owner and vehicle information, location logs and alert logs are stored into the mobile phone's local storage.

Context Diagram

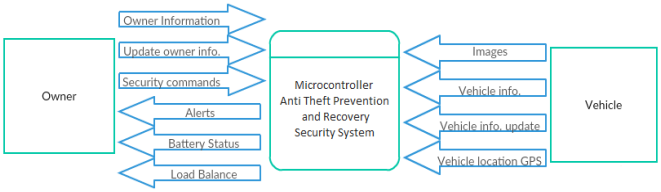

Figure 4. Context Diagram of Motorcycle Theft Prevention and Recovery Security System

Figure 4, shows the general data flow of the Motorcycle Theft Prevention and Recovery Security System. The vehicle owner and vehicle information are fed into the system. The vehicle owner can request for the vehicle's location, load balance, battery status, and capture images. The system sends notification to the vehicle owner when tampering in the vehicle occurs. The vehicle owner can also send security commands.

Use Case Diagram

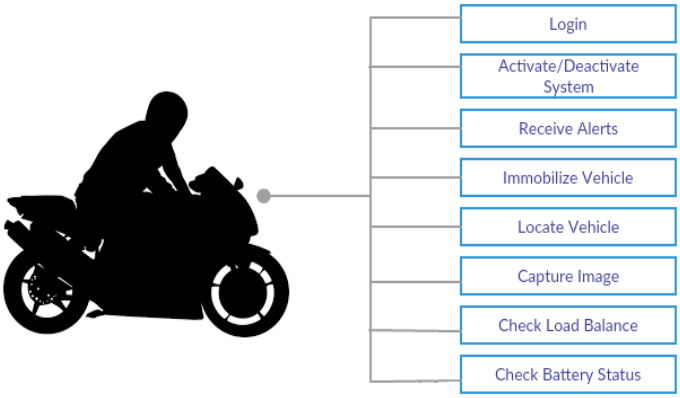

Figure 5. Use Case Diagram of Motorcycle Theft Prevention and Recovery Security System

Figure 5, represents the user interaction with the system. There can only be one user in the system. The vehicle owner can login into the mobile application, activate/deactivate the Alarm system, immobilize the vehicle, locate vehicle, capture images, check load balance, and check battery status.

System Flowchart

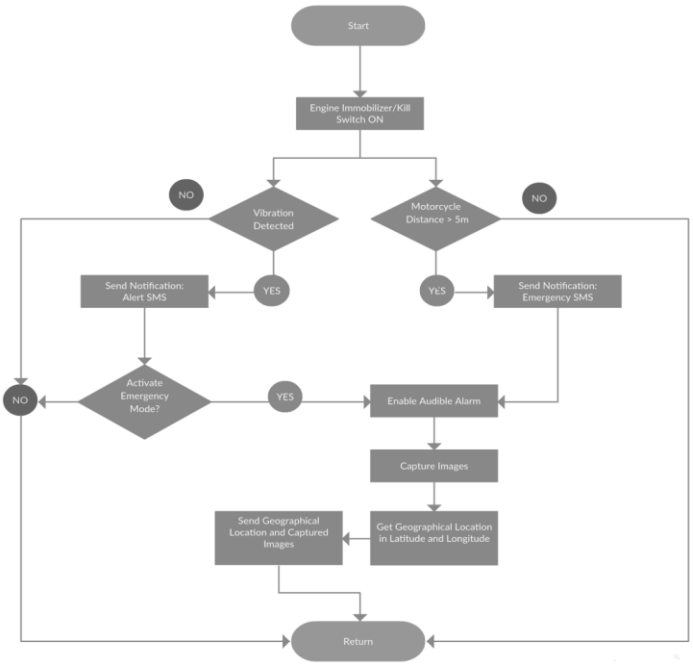

Figure 6. System Flowchart of Motorcycle Theft Prevention and Recovery Security System

Figure 6, illustrates the System flowchart which describes the flow of the processes in the system.

Installation

Figure 7. Hardware Installation of Motorcycle Theft Prevention and Recovery Security System

Figure 7, illustrates installations of the hardware module of the system. The GPS, GSM, Audible Alarm, Shake Sensor, Micro-controller including the power supply are installed into the motorcycle's U-box. The engine immobilizer and kill switch are installed and connected to the motorcycle ignition coil. The camera is installed into the speedometer of the motorcycle.

Circuit Diagram

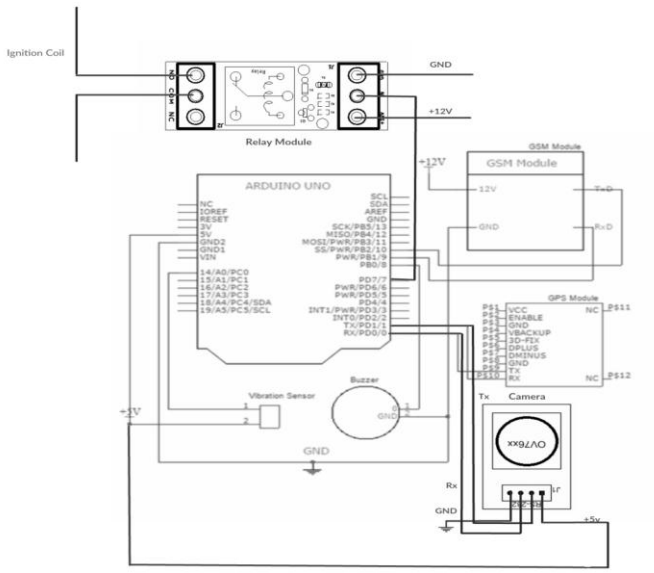

Figure 8. Circuit Diagram of Motorcycle Theft Prevention and Recovery Security System

Figure 8, shows the full circuit diagram of the system. The researchers use the following hardware components: Arduino as the main circuitry of this project where all other hardware components being control. Arduino is powered by a 12V battery of the vehicle that is then regulated to 5V; GPS module a geo-location technology that provides current location coordinates in latitude and longitude is directly stack into the Arduino. The communication between Arduino and GSM module is serial. The connection of the Tx pin of GSM module is connected to the Tx pin of Arduino and Rx pin of GSM module to Rx pin of Arduino and Ground of GSM module to Ground of Arduino. Camera module, it captures images and stores the captured images in an SD Card module. The Camera Rx pin is connected to the Arduino Rx pin, and Tx pin is connected to the ArduinoTx pin. The camera is powered by 5V source through the 5V pin of Arduino. The SD card shield is directly stack into the Arduino. One pin of vibration sensor is connected to Arduino Analog pin A0 and the other to 5V pin; The buzzer is connected to Arduino pin 8 and the other to Arduino GND. Relay Module turns wide range of devices on and off, both AC and DC.The vehicles ignition coil is cut, one wire is connected to the NC (Normally Close) terminal of relay module and the other is connected to COM (Common) terminal. In this connection, the state of the relay when the power is off is Normally Closed. This allows spark plugs to ignite the fuel allowing the motorcycle engine to start. When the relay is powered on the close connection opens and the flow of spark plugs to ignite the fuel is cut disabling the motorcycle engine to start.The Ground terminal and VCC of Relay Module are connected to the Ground and 12Vof the motorcycle's battery.And the Pin 7 of Arduino is connected to the IN terminal of the Relay Module to turn the Relay Module on and off.

Implementation

The system design is divided into two parts. The Hardware Module and Software Module.

Hardware Module

Micro-controller

Gizduino (Arduino Clone) is an open source computing platform based on a simple input/output (I/O) board and the use of standard programming language; in other words, it is a tool for implementing a program one has designed or developed. Gizduino is a program using the IDE (Integrated Development Environment). With Serial RX-TX disable switch. Atmega168P ICs are low power but it has the same functions of ATmega168 IC.

GSM Module

GSM Module is embedded in the motorcycle to establish communication between the user's mobile phone and the

motorcycle. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. It also contains (International Mobile Equipment Identity) number similar to mobile phones for their identification. A GSM/GPRS MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phonebook entries of the SIM.
3. Make, receive, or reject a voice call.

GPS Module

Global Positioning System (GPS) Module is an easy and cost-effective device that accurately calculates geographical location of the motorcycle vehicle by receiving information from GPS satellites. Global Positioning System GPS module is gizDuino (Arduino Compatible) Shield and has buffered UART serial I/O that allows it to be interfaced with any host MCU operating within 3V to 5V range.

Shake Sensor

Piezoelectric sensor device that uses the piezoelectric effect, is used in the system to detect shock, or force that possibly caused by intruders tampering the motorcycle, by converting them to an electrical charge. This device has a high sensitivity and is available at a very low cost.

Serial Camera

Camera is installed in the system for image processing. The serial camera module makes it very easy for the microcontroller circuits to add images captured for various functions or applications. VGA 640x480 image resolution, 115kbps UART rate

Relay Module

Has built-in driver that will allow micro-controllers and logic devices to operate on relays without the need of additional circuit elements.

Software Module

Android Studio

Android Studio is the official Integrated Development Environment (IDE) for developing for the Android Platform. The developer uses the native mobile app development for this suits the need of the system.

Sublime Text Editor

Is a cross-platform source code editor with a Python application programming interface (API). It natively supports many programming languages and markup languages, and its functionality can be extended by users with plugins, typically community-built and maintained under free-software licenses.

Google MAP API

With the Google Maps Android API, the location coordinates, longitude and latitude, obtain from the GPS Module in the system will automatically be display in a mobile version of Google Map on the user's smart phone. The API automatically handles access to Google Maps servers, data downloading, map display, and response to map gestures. Google Maps API gives fast and convenient way of tracking motorcycle vehicles.

NI Multi-simulator

Multisim simulation and circuit design software gives engineers the advanced analysis and design capabilities to optimize performance, reduce design errors, and shorten time to prototype. Intuitive NI tools result in saved printed circuit board (PCB) iterations and significant cost savings. The Multisim design approach helps the researchers optimize printed circuit board (PCB) in designing the hardware module of the system, which is very convenient, time and cost saving.

Arduino IDE

The open-source Arduino Software (IDE) makes it easy for the researchers to write code for the control of the entire system and upload it to the Arduino board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board.

Testing

This study conducted various tests of the system in regards to its functionality. This is to ensure that every function produces correct and accurate outcome according to the design specifications of the system. The following are the test cases executed to test the functionality of the system:

1. Motorcycle is park; the Alarm system is on and the vehicle ignition switch will be turn on using key or by kick start.
2. Motorcycle is park; the Alarm system is on and the motorcycle vehicle will be move with a distance greater than 5m or distance specified by the user.

Evaluation

Usability

For the usability testing of the system, this study used the System Usability Scale (SUS) with 10-item questionnaire with 5 levels of response options answered by 30 motorcycle users as the respondents of the study.

Functionality

The evaluation of functionality of the study is answered by the 3 respondents to tie break their responses. In the survey if a functionality gets 2 yeses responses out 3, it indicates that the functionality of the system works properly.

Scenario 1 evaluates the functionality of the following: the engine immobilizer or kill switch to prevent the engine from turning on: obtaining location coordinates; the vibration sensor in detecting shakes and movements; and if the system sends Alert SMS to notify the user.

Scenario 2 evaluates the functionality of the following: the vibration sensor in detecting movements; the system works in obtaining location coordinates, and if the system calculates the change in distance of the vehicle, sends Emergency SMS to notify the user, enables the audible alarm and camera in image capturing.

RESULTS AND DISCUSSIONS

Login and Registration

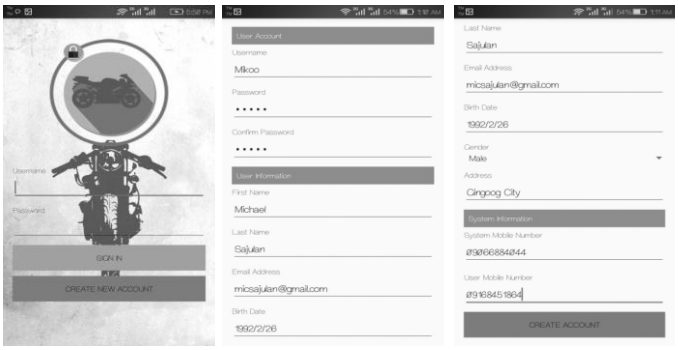

Figure 9. User, Vehicle Registration and Login form

Figure 9, illustrates the user inputs personal information; create account for login credentials, together with the vehicle information. The information is needed before the user can use the system.

Mapping

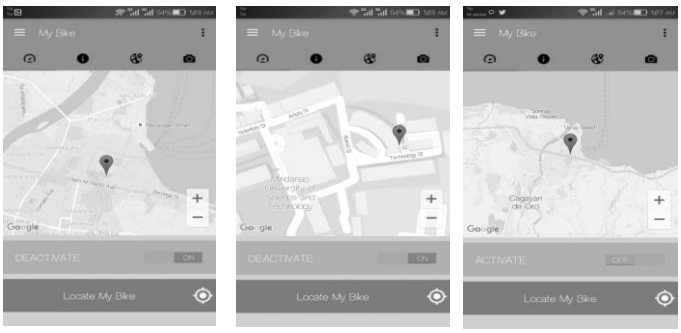

Figure 10. Location logs and Mapping

Figure 10, shows the location logs of the system and the current location of the motorcycle. The location logs can be display to a map in a map or satellite view of the motorcycle location. This is possible through the use of Google maps API.

Notifications

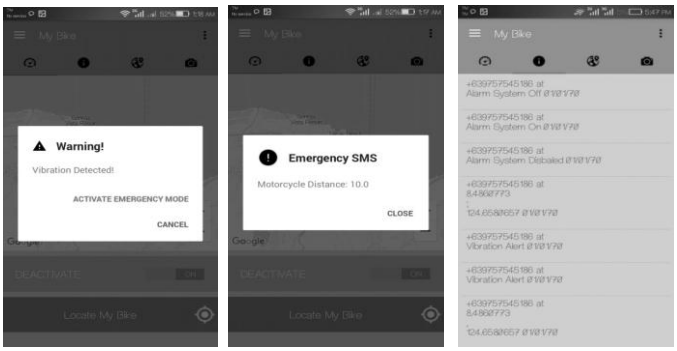

Figure 11. Alert logs and Notifications

Figure 11, shows the different notifications received by the user, and vibrations logs detected by the system.When the motorcycle detects vibrations caused by tempering and movement of the motorcycle, the user will automatically be notified so that immediate response will be taken in action. Also, if the vehicle travelled a distance greater than 5 meters or distance specified by the user and Emergency notification will be send to the user.

Hardware Interface

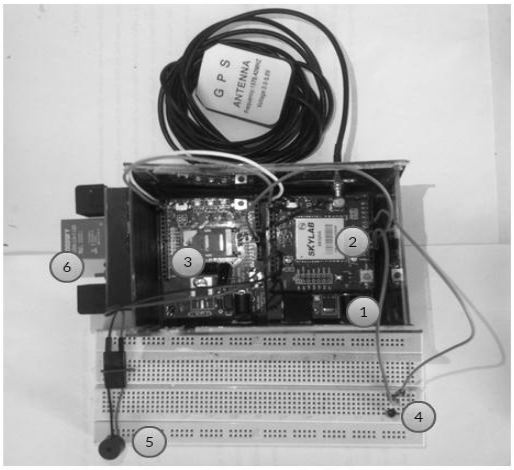

Figure 12. Hardware Interface of Motorcycle Theft Prevention and Recovery Security System

Figure 12, shows the interfacing of the hardware module of the system. Each part is labeled with number. Number 1, is the Gizduino (Arduino Clone); number 2, Global Positioning System (GPS) module with the GPS antenna stack in Gizduino; number 3, Global System for Mobile (GSM) module; number 4, Shake sensor; number 5, Buzzer; number 6, Relay Module.

System Usability

Table 2. Usefulness

	Mode	Adjectival Mean
1. I thought this mobile app was easy to use.	5	Strongly Agree
2. I would imagine that most motorcycle users would be able to use this mobile application for Motorcycle security.	5	Strongly Agree
3. I found this mobile app very useful for motorcycle owners.	5	Strongly Agree

Table 2, shows the respondents' answer on the usefulness test of the mobile application that is connected to the hardware module installed in the vehicle. The respondents strongly agreed that the system can notify if there is any movement or vibration detected in the vehicle and changes of the vehicle's location. In addition, they agreed that the system can generate acquisition locations through map.

System Functionality

Table 3. System Functionality

Functionality	Yes	No
1. Is the system easy to install in the motorcycle?	√	
2. The system enables engine immobilizer or kill switch upon the Alarm System Activation?	√	
3. The system monitors the change in location of the vehicle upon the Alarm System activation?	√	
4. Does the engine immobilizer or kill switch work or does it prevents from starting the vehicles engine by any means?	√	
5. Does the system notify user via Alert SMS for any movements/tampering detected in the motorcycle?	√	
6. Does the system send the user the right notification/message during movements/tampering detected in the motorcycle?	√	
7. Does the system give the user the choice to activate Emergency Mode during movements/tampering detected in the motorcycle?		
8. Upon activating the Emergency Mode, does the system enables the alarm and sends the vehicles geographical location in latitude and longitude?	√	
9. The system gives the exact location of the motorcycle?		√
10. Upon moving the vehicle, the system activates the Emergency Mode if the vehicle passed a distance greater than 5m or distance specified by the user?	√	
11. Does the system notify the user via Emergency SMS if the vehicle passed a distance greater than 5m or distance specified by the user?	√	
12. Does the system send the user the right message or notification if the vehicle passed a distance greater than 5m or distance specified by the user?	√	
13. The system Capture images?	√	
14. The system sends the captured images to the user?	√	
15. The user can request for vehicles location?	√	
16. The system disables the engine immobilizer or kill switch upon the Alarm System Deactivation?	√	

Table 3, shows the overall result of the system functionality test answered by 3 respondents. Most of the system functionality meets the right output that corresponds with the design of the research study. The discrepancy regarding with the accuracy of the motorcycle location are caused by atmospheric disturbances that distorted the signals. Obstruction of high buildings, other large, solid objects and reflections of signals can also lead to GPS accuracy problems.

CONCLUSION AND RECOMMENDATIONS

Conclusion

With the gathered data and results, this study concludes that the Motorcycle Theft Prevention and Recovery Security System is a very helpful and effective measure to prevent motorcycle theft. The engine immobilizer or kill switch feature and alarm system are very much useful to prevent thief

from stealing motorcycles. In cases of motorcycles that are completely taken, this study helps in the recovery through the use of Global Positioning System (GPS) technology that locates the location of the vehicle.

This study was able to interface the hardware modules of the system producing an interfaced hardware that corresponds with the proposed hardware design of the study. The hardware module is in small size that allows the installation under the seat of the vehicle safe and easy. The engine immobilizer or kill switch is easy to install without the need of physical change of the motorcycle.

This study found some weak points in the system. The accuracy and the response of GPS depend on a wide variety of factors. Under excellent conditions with lots of satellites visible, it indicated accurate coordinates within 2-3 meters of the correct coordinates. At other times, locations and conditions, position errors range from 15-50 meters, to no position fix at all. This was proven when the system was conducted in a place surrounded by tall buildings.

The communication of the user and the motorcycle were made possible through the use of the Global System for Mobile (GSM). The medium of communication depends on the cellular network coverage. Under some circumstances, there are delays on delivering and receiving of text SMS.

Over all, the output results of the system meet the proposed output and functionality of the study.

Recommendations

After a very careful, thorough research and analysis process, here are some recommendations from the researchers in order to enhance future works/study of this application.

1. Make use of the other functional parts of the motorcycle such as its horn and lights as an alarm or buzzer;
2. Create a web application for the mobile application to sync alert logs and location logs and to back-up all the information in the mobile application; and
3. Create a mobile application for alternative online monitoring and control of the system.

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