SECTION A:

INNOVATIVE SCIENCE AND TECHNOLOGY

DESIGN AND IMPLEMENTATION OF AN INTELLIGENT MOTORCYCLE SECURITY SYSTEM

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Abstract

A Motorcycle is a two wheeled automotive means of transport, powered by a two stroke piston engine.

In Uganda motor cycle is a widely used means of transport due to its portability, less fuel consumption and affordability. Motorcycle like the bajaj cost approximately six millions in Uganda and there investors who even import them and sell them on a loan basis. Motor cycles can easily access even feeder roads due to their size. The Bajaj motor cycle is the most common type bought in Uganda due to its speed in transport, and the ease to repair, its spares are more affordable than many other motorcycles however due to all these advantages , it has lead to promotion of theft as it can be easily sold either as a whole or in spares and many individuals have lost there finances when they loose there motorcycles . for those who acquire them on loan deals, end up selling there assets to secure the loans. Others even loose there lives as they tend to protect the motorcycles in case of robbery.

Their traditional security measures that have been put to secure motorcycles like using locks, chains , and integrating car security devices on motorcycles however these have proven inadequate and expensive.

The primary goal of this study is to develop a cost-effective, efficient, and easily deployable security solution tailored to the local environment.

This project focuses on on the design and implementation of an intelligent motorcycle security system using integrated sensors like an accelerometer, tilt sensor, the GSM, and GPS modules , and a buzzer to

provide a smart solution against theft of motorcycles. The Arduino UNO acts as the system's central processing unit and is in charge of gathering information from the sensors and initiating the safety measures

In-case a cyclist parks his motorcycle to attend to a shop, ease him self, he will need to activate the security system before he lives. Once someone comes and tries to move the motorcycle, it will create an alarm and send a notification message to the the cyclist phone that includes the location of the motorcycle. This will alert the cyclist to go and attend to the motorcycle and also the alarm will create a discomfort to the thief as its alerts the surrounding about an illegal action that might be taking place

There is a module where a cyclist can register the security device with two contacts in that someone else can always be notified of the insecurity case and fall up. This will help to track records of the last seen positions of motorcycles in cases where the cyclist might have got a problem when ridding like in case of highway robbery. The cyclist will just need to press the remote button and the message will also be sent to the secondary contact that might be a close friend or wife the same time trigger an alarm. The findings indicate that the system can successfully prevent theft attempts up to 80% of the tested scenarios, with an average response time of less than 10 seconds. The study concludes that intelligent motorcycle security systems, integrated with modern communication technologies, can significantly reduce motorcycle theft

KEYWORDS: Arduino UNO, security device, accelerometer, tilt sensor, GSM,GPS modules, buzzer

Introduction

In 2020 as I was sent to a super market on a family motorcycle, on entering I left the motorcycle along the road. On coming back our motorcycle was no where to be seen , I felt out of words as I had less to explain to Dad. In Uganda such coincidences of motorcycle theft are rise up day by day. Yet even the increased use of motorcycles is increasing day by day due to its portability , flexibility, low fuel consumption , speed, ability to go through feeder roads. Motorcycle transport business is joined by a bigger number of youths and it has largely contributed to the countries employment sector and economic transformation due to the ease of transport.

The nature of the roads in Uganda are small which causes jam on streets, motorcycles are less affected by jam making it a highly dependent means of transport. However on the press released

by Uganda police on 19th/ December / 2024 on its website as of [15], many cyclists have experienced robbery of motorcycles where even some loose there lives [15], On the 12.3.2024, at around 4pm, an unknown bodaboda rider, on motorcycle registration, number UGB 267L, approached Nalwadda Ritah at Rutete zone in Zirobwe sub county and bought fuel of Ug 6000sh. The suspect handed her a Ugx 50.000 shilling note, but as the victim was sorting out his change, the suspect pounced on her, and grabbed the bundle of money from her and sped off. She raised an alarm, which attracted other bodaboda rider. They gave the suspect a chase up to Lufula zone, where he jumped off the motorcycle and tried to escape. He was pursued, arrested and lynched to death by an angry mob. His motorcycle and several exhibits of sticks and bricks were recovered. Two suspects were arrested. [15], On the 13.3.2024, a one SSekasamba Kasim, a 24 year old, bodaboda rider was attacked by two suspects, one of whom was later identified as Ssebulime Yasin. He was arrested at the scene, after his associate, escaped with the robbed motorcycle, Bajaja Boxer, registration number UFQ829V. The second suspect was intercepted by an angry mob, and lynched to death at Kigoma village. A killer weapon of a panga was recovered on Ssebulime Yasin of Masitowa in Nansana.

The two suspects attacked the victim as he transported them from Nansana Masitowa to Kawoko. They used a hammer to hit him on the head and the panga for hacking him. In many urban areas, motorcycle theft rates are alarmingly high, causing financial and emotional distress for owners. Existing security solutions such as locks or traditional alarms are either too basic or too expensive. This project introduces a smart, integrated security system that can be installed on any motorcycle, providing better protection by using modern technologies like GSM and GPS for remote control and real-time alerts. It will help to overcome the limitations of conventional systems, which are often either too basic or too costly. Secondly there many instances where cyclists face highway robbery and even loose their lives, I'm looking forwards to incorporating a mechanism that in case a cyclist falls a convict of such a scenario, he places a button on a remote that sends a notification to the stage security so as he can instantl

Problem Statement

Motorcycles are particularly vulnerable to theft due to their portability and lack of effective security systems. Many conventional security systems like locks, chains, alarms are easily bypassed. Thus,

there is a need for an intelligent security system that allows real-time monitoring and control, providing better protection and response mechanisms for motorcycle owners.

Main Objective

To reduce motorcycle theft by designing an intelligent security system using an accelerometer sensor, a PIR - sensor incorporated with a GSM and a GPS for real-time monitoring to detect motorcycle security bleaches.

Specific objective

To design a fast, intelligent and cost effective motorcycles Security system

Literature Review

The use of anti-theft control systems has been very popular lately among automobiles but more so in motor vehicles. Most recent systems utilize GSM and GPS modules to provide vehicle location information to the owner. Significant advancements have been made in anti-theft systems for vehicle alarm and tracking. Some of the related works are as follows: GSM is a cellular digital system standard phones which are widely used in advanced technology [8]

In [2], Motorcycle Security System using GSM and RFID (Radio frequency identification) by W. W. I. Wan Jusoh, K. A. Mohd Annuar* , S. H. Joharia , I. M. Saadonb , and M. H. Harunc was dEsigned.

In [3], a vehicle theft alarm and location tracking system was implemented using GPS and RFID technologies. The system introduced mobile communications into the embedded system to track vehicles. A buzzer alarmed when an incorrect password was entered, and an alert notification was sent to the owner via a GSM module. The system tracked and communicated the location in terms of latitude and longitude to the vehicle's owner.

In [4] proposed a multi-tracking system for multiple vehicles using GPS and GSM. A GPS navigation device calculated the coordinates as the vehicle moved and transmitted the data to a

tracking server through GSM. The data was stored in a database and enabled live tracking with the ability to turn the vehicle ignition on via short messages.

Harshadbhai Krishna Patel [5], From the Designs of GPS and a GSM Based Vehicle Location and Tracking System, he illustrated that the GSM modem is a specialized type of modem that accepts a SIM card, and operates a subscription to mobile operators, such as mobile phones. GSM uses a communication process known as circuit switching which allows two devices to communicate to each other. When both devices are connected, a constant stream of digital data will be transmitted. The GSM network consists of the main system, Switching System (SS), Base Station (BSS) and Mobile Station (MS). GSM module is used to transfer data from wide distance. It also can identify the data being transmitted. It usually supports AT commands. SIM300 can be integrated with a variety of applications

A system in [6] combined GPS and GSM frameworks with Google Earth for vehicle tracking. GPS enabled the system to identify a vehicle's location, and GSM transmitted the data via SMS. The received coordinates were filtered using a Kalman filter to improve precision. Google Earth was used to view the location; however, this system lacked the ability to immobilize vehicles remotely with advancement, we target to include a module that can deactivate the relay of the starter system of the motorcycle. On ignition , this relay is connected in a normally open position. Once there is a security blench , it switches the relay to an open position in that there will be no flow of current once the device detect a security bleach.

In [7], a low-cost car anti-theft system was designed using a micro-controller with wireless communication protocols. The system utilized an RF transmitter-receiver set operating at 434 MHz, allowing remote data transmission over short distances. The main limitation was its inability to function effectively over long distances due to obstacles or range constraints. [8] proposed a vehicle theft detection, locking, and tracking system using GSM and GPS. The system tracked stolen vehicles and allowed the owner to turn off the engine remotely by immobilizing the engine via SMS. However, the absence of an authentication unit limited its security as it could not differentiate between the owner and intruders.
In [9], a GSM-GPS-based vehicle theft detection system was designed to send location updates to the owner's mobile device. The system relied on SMS for communication and provided latitude

and longitude coordinates of the vehicle's location. However, it did not include an authentication unit to prevent unauthorized access.

A low-cost vehicle theft control system using micro-controllers, GPS, and GSM technologies was developed in [10]. The system included accident detection, sending emergency alerts with exact location coordinates to authorities. While the system featured password-based security, it did not incorporate advanced real-time sensors for theft detection.

According to E. Ergen et al, [11], Tracking Components and Maintenance History within a Facility Utilizing Radio Frequency Identification Technology, RFID reader is a device used to perform the interrogation of RFID. The tag reader has an antenna that works for radio waves Journal of Advanced Research in Applied Mechanics ISSN (online): 2289-7895 | Vol. 16, No. 1. Pages 1-9, 2015 2 Penerbit Akademia Baru emitting and the tag will respond by sending back data. There are some factors that can affect the distance at which a tag can be read. The factors are as follows: the frequency used for identification, antenna gain, orientation and polarization of the reader antenna and transponder antenna, also the placement of the tag on the object that is to be recognized. All these factors mentioned will have an impact on a variety of reading RFID system

Proposed System

The proposed system integrates an accelerometer sensor for motion detection and an authentication mechanism to enhance security. The accelerometer sensor detects unauthorized movements, such as tilting or vibration, which can signal a theft attempt. Additionally, GPS technology tracks the motor cycles location on safety bleach, while GSM enables remote communication and control.

The system allows the motor cycle to be immobilized remotely by deactivating the starter relay, provides real-time data transmission to the owner's mobile device. The prototype will be tested on a Bajaj motor cycle as it’s the most used in Ugandan cities double-layer smart car chassis to simulate real-world vehicle mobility.

The accelerometer sensor enhances theft detection by providing immediate alerts based on unexpected vehicle motion. Combined with GPS and GSM functionalities, the system ensures

robust security, remote access, and real-time monitoring, offering a cost-effective and reliable solution to motor cycle theft prevention.

Components needed

GPS Trackers:

Some advanced systems use GPS to track the motorcycle's location, but these tend to be expensive and usually do not provide real-time alerts when theft occurs. They also do not integrate other forms of detection, such as motion or tilt sensors.

Buck

Figure 1 buck

GSM module

Figure 2 GSM module

Locks and Alarms:

Conventional systems like locks or simple alarms are popular but have limited effectiveness against determined thieves. They are often easy to bypass and do not offer real-time feedback to the owner.

Figure 3 U shaped Lock Anti-theft

U shaped Lock Anti-theft 4 digit Pass MTB Road Bike Security Steel cable Lofor electric scooter motorcycle

Advanced Solutions:

Recent technologies have begun integrating tracking systems with alarms and immobilization options. However, these systems are usually costly and may not offer all the features needed for comprehensive theft detection.

Research Gap

Most systems either focus on GPS tracking or alarm systems but fail to integrate multiple detection methods so this project aims to incorporate both. There is a lack of affordable solutions that provide real-time alerts . This project addresses this gap by combining an accelerometer, GPS tracking, and remote immobilization at a cost-effective price.

Theoretical Framework

As in [12] Smith, J. (2020), provided an understanding of modern motorcycle security systems and how they are implemented.

In [11] , Jones & Taylor (2019), discussed the integration of alarms and GPS tracking, influencing the decision to integrate GSM and GPS modules into the system for real-time monitoring. These theoretical frameworks guided the decision-making process when selecting components and integrating them into the system.

Methodology

Hardware Components

PIR Sensor (Passive Infrared Sensor): Detects motion around the motorcycle, acting as a primary trigger for alarms and notifications.

Figure 4 pir sensor

Accelerometer sensor: Detects any unauthorized tilting or movement of the motorcycle, indicating potential tampering and hence triggering the alarm and asking the micro-controller to send an Sm's with the location of the motorcycle.

Vero board : for providing a medium of fastening the components that make up the security device

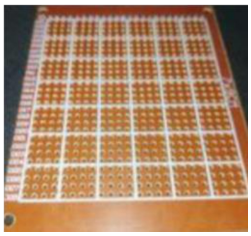

Figure 5 Vero board

Terminal block 2pin 5.08mm pitch

The terminal block provides a point for input voltage . wires from the battery will arrive at this point .

Figure 6 terminal block

Arduino UNO: Acts as the micro-controller that processes sensor inputs and manages outputs like alarms, GPS data, and GSM communication.

Figure 7 arduino uno

GSM Module (SIM800L): Sends SMS alerts to the owner's phone when suspicious activity is detected.

Figure 8 gsm module

GPS Module: Provides real-time tracking of the motorcycle's location.

Buzzer and LED: Provide audible and visual indications of a security breach.

Figure 9 buzzer

Power Supply (12V battery): Uses the motorcycle's battery to power the system, with voltage regulation to support the Arduino and components.

Figure 10 voltage regulator

Backup Battery (PACK): Ensures continuous operation even if the motorcycle's main battery is disconnected.

Relay for Immobilization: Allows the motorcycle's engine to be remotely disabled in the event of theft.

Figure 11 lithium cells

Figure 8

Software

Arduino IDE: The coding environment used to program the micro-controller, enabling sensor inputs to trigger actions such as SMS notifications and GPS tracking.

Proteus Simulation: A simulation environment used to virtually test the design and functionality of the system before implementing the hardware.

System Architecture

The system architecture integrates multiple components, each performing a critical role in detecting theft, alerting the owner, and preventing the theft from progressing. The flow of information from sensors to the Arduino, and then to the GSM and GPS modules, ensures that every part of the system operates cohesively.

The development of the Intelligent Motorcycle Security System will follow a systematic methodology encompassing several key phases: requirements analysis, system design, prototype development, testing, and deployment. This approach ensures a comprehensive and effective solution that meets user needs.

1. **Requirements Analysis**

Stakeholder Engagement: Identify and involve stakeholders, including motorcycle owners, manufacturers, and law enforcement agencies, to gather insights and requirements.
Market Research: Analyze existing security systems to identify gaps, weaknesses, and user preferences.

Feature Specification: Define essential features (e.g., GPS tracking, biometric authentication, mobile alerts) based on stakeholder feedback.

2. **System Design**

Architecture Design: Develop a system architecture that integrates hardware (sensors, GPS module) and software (mobile app, server-side logic).

Component Selection: Choose appropriate technologies and components, including:

GPS Module: For real-time location tracking.

Biometric Sensors: For user authentication.

Microcontroller: To process inputs and control outputs.

User Interface Design: Create intuitive interfaces for the mobile app, focusing on user experience and functionality.

3. **Prototype Development**

Hardware Assembly: Build the physical components of the system, integrating sensors, GPS, and the microcontroller.

Software Development:

Develop the mobile application for both Android and iOS platforms.

Implement server-side functionalities to manage data and facilitate communication between the motorcycle and the user's device.

Integration: Ensure seamless communication between hardware and software components.

4. **Testing**

Unit Testing: Test individual components (e.g., GPS, biometric sensors) for functionality and reliability.

Integration Testing: Assess the interaction between hardware and software, ensuring they work cohesively.

User Acceptance Testing (UAT): Involve a group of end-users to test the system in real-world scenarios, gathering feedback on usability and performance.

Security Testing: Evaluate the system against potential security threats (e.g., hacking attempts) to ensure data protection and integrity.

5. **Deployment**

Pilot Launch: Introduce the system to a limited user group to monitor performance and gather initial feedback.

Iterative Improvements: Based on pilot feedback, make necessary adjustments and enhancements to the system.

Full-Scale Launch: Roll out the system to the broader market, accompanied by marketing efforts and user education.

Post-Deployment Support: Provide ongoing technical support and updates to users, ensuring system reliability and satisfaction.

6. **Evaluation and Maintenance**

Performance Monitoring: Continuously monitor system performance and user feedback to identify areas for improvement.

Regular Updates: Implement software updates to improve security, functionality, and user experience.

User Feedback Loop: Establish channels for users to report issues or suggest features, fostering ongoing engagement and enhancement of the system.

Conclusion

By following this structured methodology, the Intelligent Motorcycle Security System will be designed and implemented effectively, addressing the critical security needs of motorcycle owners while leveraging advanced technology to enhance user experience and safety.

SYSTEM DESIGN AND IMPLEMENTATION

Block diagram

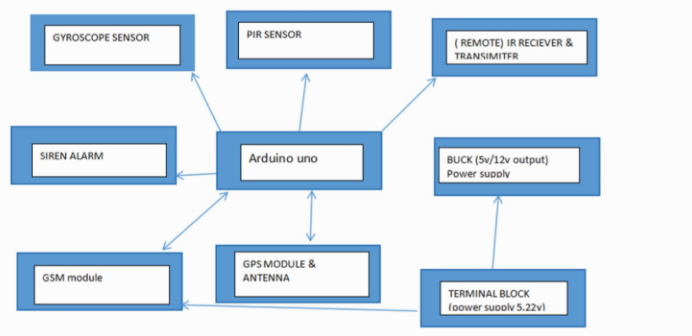

Figure 12 block diagram

Circuit diagram

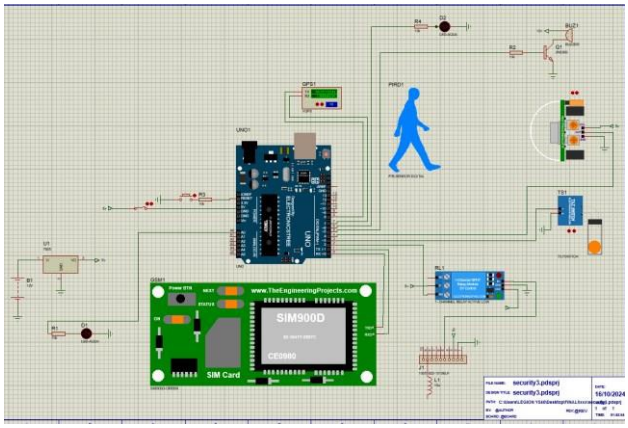

Figure 13 circuit diagram

Circuit diagram description

Sensor Module

PIR Sensor: Detects motion around the motorcycle. If motion is detected, it triggers the alarm and sends data to the control unit (Arduino).

Tilt Sensor: Detects any unauthorized tilting or movement of the motorcycle.

Control Module (Arduino UNO)

Processes inputs from the sensors and determines whether to activate the alarm or send notifications through the GSM module.

Manages outputs like sending SMS alerts .

Alarm and Notification Module; alerts the surrounding of a security bleach and sends notification to the motorcycle owner.

Buzzer : This is activated when the system detects unauthorized activity, alerting nearby people and providing a deterrent to thieves.

GSM Module: Sends an SMS alert to the owner's phone, including the real-time GPS location of the motorcycle.

GSM, a cellular digital system standard phones which are widely used in advanced technology industries. First named after the frequency band around 900 MHz, GSM -900 provide the basis for several other networks using GSM technology, usually GSM networks operating at frequencies band around 1800 MHz and 1900 MHz GSM network technology it has become a largest source of industrial technology for and the communication protocol that allows the transmission of text messages between phone devices and sending short message

Power Module

12V motorcycle battery supplies power to the entire system.

Voltage regulators step down the voltage to 5V for the Arduino and other components. But due to voltage drop , its recommended to use 5.26 voltage supply to be able to activate the GSM th at sends SMS.

Backup battery ensures the system remains operational if the main power is cut off.

Security Features

Real time monitoring: the motor cyclist parks his motor cycle in a free space and activates the security device with a remote. once there is a security bleach like some one accessing the motor cycle, the cyclist receives a message with a link of the current location of the motorcycle, the micro

controller triggers a buzzer to notify the neighbors of a security bleach. The cyclist makes a fall up to recover his motor cycle. Once he is at it, he presses a remote to deactivate the alarm.

Flowchart

Power on system.

Initialize sensors and communication modules (GSM, GPS).

Monitor sensor data (motion or tilt).

If motion or tilt is detected:

Activate buzzer.

Send real-time GPS location via SMS using the GSM module.

If no movement is detected, the system remains on standby.

The owner disables alarm with a remote.

Figure 14 flow chart

Simulation and Testing Proteus

Simulation

Objective: To simulate the system's functionality virtually before implementing it on hardware.

Procedure:

no

Create a simulation environment using Proteus.

Add and connect components, including sensors, GSM, GPS, and relays.

Run the simulation to verify that the system behaves as expected, including sensor triggers, alarm activation, and SMS notifications.

Arduino Coding and Testing

Write Arduino Code: The code will control sensor inputs and trigger outputs like alarms, GPS tracking, and GSM communication.

Upload Code to Arduino: Test the system by simulating motion and tilt to ensure accurate sensor readings and responses.

Test GSM and GPS: Verify that SMS alerts are sent promptly and that the GPS provides accurate real-time location data.

Results and Discussion

System Performance

The system performed well under simulated conditions, accurately detecting motion and tilt and triggering appropriate alarms and notifications. The GPS module provided real-time location data, and the GSM module successfully sent SMS alerts. The relay successfully immobilized the motorcycle when commanded via SMS.

Conclusion

The intelligent motorcycle security system could effectively addresses the problem of motorcycle theft by incorporating an accelerometer sensors, buzzer, gps and gsm, real-time alerts received on a security bleach and an alarm tuned to notify the surrounding. However the system was limited to one notification on alarm that could only send the current geographical location. Due to resource constraints and time, the module for immobilization by deactivating the relay hasn't been incorporated and these are the things I look at in future advancements.

The PIR-SENSOR hasn't been activated as it could trigger an alarm on even a by-passer which could raise complaints to the neighbors and discomfort.

Further tests still need to be carried out on a motorcycle at distance in motion once the remote is activated to truck the rate at which the backup security could intervene so as to fully certify that it also provides a security measure to those driving in-case there endangered.

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ELECTRONIC-FUNDS TRANSFER AND THE FINANCIAL PERFORMANCE OF POST BANK UGANDA LIMITED.

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ABSTRACT