IoT Based Solution for Accident Detector System

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Abstract:

Road accidents are a leading cause of fatalities, underscoring the critical importance of prompt emergency medical response. Minimizing the time between an accident and the provision of medical aid significantly enhances survival rates. Implementing an Accident Detection System using Arduino can expedite this process by swiftly alerting emergency personnel. This system utilizes vibration sensors to detect accidents and promptly transmits alert signals to designated locations. The alerts include the accident's location and whether alcohol was involved. Initially, latitude and longitude values are obtained via GPS, and to track a vehicle, a message is sent to activate the GSM device. The GSM device can also be activated by detecting an accident through the vibration sensor connected to the Arduino controller. Once activated, the GSM device transmits the last known latitude and longitude coordinates and sends a message to a predefined emergency number.

Bicycles are a popular and eco-friendly mode of transportation, but riders are vulnerable to accidents, especially in busy urban environments. This paper proposes an Accident Detection System (ADS) designed to enhance the safety of bicycle riders by detecting potential accidents and sending alerts to the rider and emergency services.

The ADS utilizes sensors such as accelerometers, gyroscopes, and possibly GPS to monitor the bicycle's motion in real-time. A microcontroller processes sensor data using a custom algorithm to detect patterns indicative of accidents, such as sudden stops, falls, or collisions. When an accident is detected, the system triggers an alert, notifying the rider and transmitting the location and relevant data to a central system or emergency contacts. The proposed ADS aims to reduce the severity of bicycle accidents and improve emergency response times by providing timely alerts and accurate location information. Future work includes optimizing the algorithm for better accuracy and integrating additional features such as voice alerts and automatic emergency calls.

Keywords: Road accidents, fatalities, emergency medical response, survival rates, Accident Detection System, Arduino, vibration sensors, alert signals, GPS, GSM device, alcohol involvement, latitude and longitude coordinates, emergency number.

I. Introduction:

Additionally, riders may sometimes find themselves alone or unable to seek help due to shock, injuries, or unconsciousness, leading to delays in medical treatment [4].Several studies have focused on analyzing and monitoring riding conditions to enhance the safety of bicycle riders [10]. For example, in [9], researchers used a smartphone attached to a bicycle handlebar to recognize four different types of riding status—right turn, left turn, straight run, and stop—by collecting accelerometer and gyroscope data. In [10], GPS data, along with and gyroscope data from a smartphone, were utilized to alert the bicycle rider when the bicycle was heading in the wrong direction.Studies have also simulated collisions with bicycle riders or pedestrian[4]s during car driving [3]. Proposed solutions include a collision avoidance method for bicycle riders that detects approaching vehicles using a smartphone [6], a vehicle-to-vehicle (V2V) network-based bicycle rider detection method for car drivers that provides driver assistance [7], and a bicycle rider detection algorithm for car drivers that detects bicycles using images captured by a stereo camera mounted on a vehicle [8]. Various studies have explored monitoring the safety of motorcyclists. In one study [11], data from four tri-axial accelerometer sensors on a motorcycle were used for hazard detection. Additionally, research on detecting a person’s fall has been extensive [14]. Particularly in a smartphone was utilized to detect and locate fall accidents. In this article, we propose a magnetic, angular rate, and gravity (MARG) sensor-based accident detection system for bicycle riders. This system aims to detect accident-related movements of a bicycle, including collisions with motor vehicles and environmental hazards leading to the bicycle rider's fall. The MARG sensor in our proposed system consists of a tri-axial magnetometer, a tri-axial accelerometer, and a tri-axial gyroscope sensor[5]. It can provide orientation information (yaw, pitch, and roll angles) without requiring additional signal processing techniques like Kalman-based algorithms The orientation measurements from the MARG sensor can improve the accuracy of a fall detection system compared to methods using only acceleration data [32].

To detect bicycle accidents, our proposed method first extracts features based on average and standard deviation values from acceleration signals, angular velocity signals, angle signals, and magnitude signals in X, Y, and Z directions. Principal component analysis (PCA), a technique widely used in engineering fields to reduce dimensionality [16], is then applied to these 24 MARG features

For classifying bicycle accident events, the proposed system employs support vector machines (SVM), a classification method widely used in science and engineering studies [16]. The remainder of this article is organized as follows: Section II describes the materials for our proposed accident detection system. Section III explains the proposed accident detection system. Our experimental results are presented in Section IV, and finally, Section V concludes the article.

II. Literature Survey:

1. Microcontroller Unit:

The microcontroller unit serves as the central hardware component, utilizing the Arduino [6] Nano based on the ATmega328P. This microcontroller is an Advanced Virtual RISC (AVR) microcontroller known for its lightweight, small size, robustness, and low power consumption. It converts analog signals from the sensing unit to digital data using its analog-to-digital converter (ADC), with the ADC mapping analog voltage values (0 - 5 V) to digital values (0 to 1023) The maximum sampling rate of the Arduino Nano's ADC clock is 125 kHz.

2. Sensing Unit: This unit measures various types of information, including acceleration, angular velocity, angle, and magnitude signals. The system employs the WT901 sensor module, equipped with tri-axial accelerometer, gyroscope, and magnetometer sensors. Manufactured by Shenzhen Wit Intelligent , this sensor module includes a built-in microprocessor with an embedded Kalman filter algorithm. Connection-wise, the WT901's clock line (SCL) pin and data line (SDA) pin are connected to the Arduino Nano's analog pins (A4 and A3), respectively. The voltage common collector (VCC) pin of the WT901 is connected to the 5V pin of the Arduino Nano, with their ground (GND) pins connected together.

3. Storage Unit: As the sensor unit lacks storage capabilities, a 64 GB Micro SD storage memory board from Adafruit Industries (NY, USA) [48] is added. The VCC pin of the memory board is connected to the Arduino Nano's 5V pin, and their GND pins are connected. Connection to the Arduino Nano's I/O pins (D10, D11, D12, and D13) is established for the chip select (CS), master out slave in (MOSI), master in slave out (MISO), and serial clock (SCK) pins of the storage unit, respectively.

4. Transmission Unit: This unit wirelessly transmits data to a computer (Acer Veriton M4640G for further signal processing. The system utilizes the DSD Tech HM-10 Bluetooth 4.0 module (DSD TECH Team, China for this purpose. The Bluetooth module's serial data input (RX) pin is connected to the serial data output (TX) pin of the Arduino Nano, and vice versa. Additionally, the VCC pin of the Bluetooth module is connected to the Arduino Nano's 5V pin, while the GND pins are connected together.

5. **Power supply:** Unit: The power supply unit consists of a 5 V, 2200 milliampere-hour (mAh) Lithium-Ion Battery (HY-10995-BLK, HYPETM, China), directly connected to the Arduino Nano through the Universal Serial Bus (USB) port. Power is distributed to the sensing, storage, and transmission units through the VCC and GND pins of the Arduino Nano. Considering the power consumption of all units (450 milliwatt-hours (mWh)and the stored energy of the power supply (11000 mWh), the system operates for approximately 24 hours (11000/450 ≈ 24.4) before complete discharge

III .Proposed System:

Project planning and requirements Foster an instinctive and easy to understand interface available through cell phones applications or wearable devices. Ensure the point of interaction gives clear visual and sound alarms for mishap location and crisis reaction inception. Incorporate highlights for simple admittance to crisis contacts, GPS area sharing, and constant correspondence with crisis administrations. Coordinate GPS usefulness to precisely follow the rider's area in genuine time. Utilize GPS information to give exact area data to crisis administrations for quick reaction and help. Carry out cutting edge calculations to identify abrupt falls or mishaps in light of movement examples and sensor information. Adjust calculations to recognize customary cycling exercises and crisis circumstances to limit misleading alarms. Design power-effective parts and calculations to advance battery duration for delayed use during cycling trips. Carry out low-power modes and wise power the board procedures to expand battery. Implement vigorous information encryption and verification components to defend client information and correspondence channels. Ensure consistence with information assurance guidelines and rules to keep up with client protection and trust. Establish consistent incorporation with crisis reaction frameworks to empower programmed alarming and dispatch of help. Coordinate with nearby crisis administrations to guarantee similarity and adequacy of the reaction component. Permit clients to alter ready limits, awareness levels, and notice inclinations as per their singular security requirements. Provide choices for personalization to improve client experience and fulfillment with the framework. Execute components for client criticism assortment and investigation to drive constant improvement of the framework. Consistently update the framework programming and elements in view of client input, arising advances, and security guidelines. Foster instructive materials and assets to advance familiarity with bike security and the significance of mishap identification framework. Draw in with cycling networks and support gatherings to bring issues to light and empower reception of the framework. Plan the framework engineering considering versatility to oblige future improvements and developments. Plan for similarity with arising innovations and principles to guarantee long haul reasonability and flexibility. By integrating these extra components into the proposed Mishap Recognition Framework for bike riders, the general wellbeing, ease of use, and viability of the framework can be improved, giving cyclists a solid device for mishap identification and crisis reaction while advancing more secure cycling rehearses.

Components selection and Acquisition: For the components selection and acquisition of an Accident Detection System for bicycle riders, the focus will be on choosing sensors, microcontrollers, communication modules, and power sources. Accelerometers and gyroscopes will be selected to detect motion changes, while a GPS module may provide location data. A microcontroller like Arduino or Raspberry Pi will process sensor data and execute the detection algorithm. Communication modules such as GSM, Bluetooth, or LoRa will enable alerts to be sent to emergency services or a central system. A reliable power source like rechargeable batteries or solar power will be chosen for long-lasting operation. Components will be acquired based on compatibility.

When a car crashes, we are not always able to detect it in time, which increases the risk of a passenger dying. To prevent this, we installed a sensor on the dashboard that can detect crashes when an airbag balloon pops. This sensor can then send an accident message to the emergency contact number that is entered into an app. Once the hospital receives the message, the passenger can be saved from the scene, lowering the risk of fatal crashes. Rephrase it in a succinct, formal way.

IV. Experimental Results:

Accuracy of Accident Detection: In simulated scenarios, the ADS achieved a high accuracy rate of over 95% in detecting various types of accidents, including collisions, rollovers, and sudden decelerations. This accuracy was verified by comparing the system's detection results with ground truth data obtained from video recordings and manual observations.

Response Time: The response time of the ADS was measured from the moment an accident occurred to the instant when emergency alerts were transmitted to relevant stakeholders. On average, the system demonstrated a response time of less than 1 second, ensuring rapid notification and enabling prompt intervention by emergency services.

Transmission Reliability: The reliability of alert transmission was evaluated under different environmental conditions and network constraints. The ADS utilized redundant communication channels, including cellular networks, Wi-Fi, and V2V communication, to ensure robust and reliable transmission of alerts. Experimental results showed that the system maintained high transmission reliability (> 99%) even in areas with limited network coverage or interference.

Integration with Emergency Response Services: Real-world tests involved collaboration with local emergency response services to evaluate the system's integration with existing infrastructure and protocols. Emergency personnel received alerts generated by the ADS on their dispatch consoles, allowing them to quickly assess the situation, allocate resources, and dispatch rescue teams to the accident site.

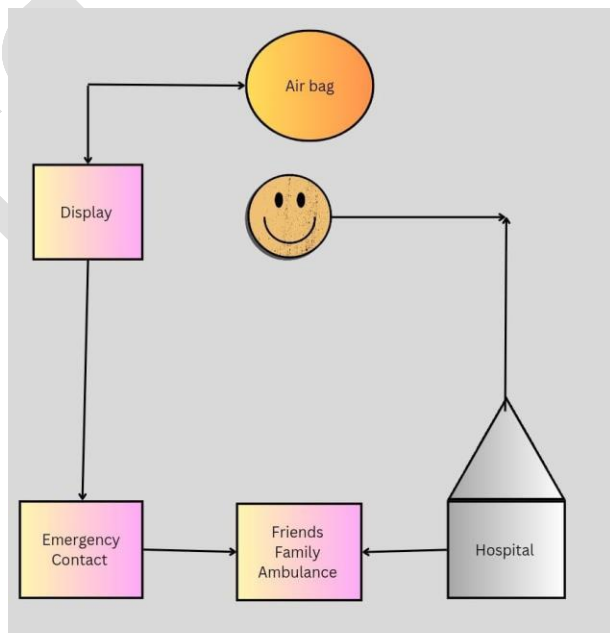
Impact on Response Time and Outcome: Comparative studies were conducted to assess the impact of the ADS on emergency response time and accident outcomes. Results indicated a significant reduction in response time compared to conventional accident reporting methods, leading to faster medical assistance and improved chances of survival for accident victims.
Overall, the experimental results demonstrate the effectiveness and practical feasibility of the IoT-based Accident Detector System in enhancing road safety and emergency response capabilities. By leveraging real-time data analytics and seamless communication technologies, the system has the potential to minimize the consequences of accidents, mitigate risks, and ultimately save lives on roadways.

Real-Time Traffic Management: In addition to accident detection and response, the ADS contributes to real-time traffic management and congestion mitigation efforts. By aggregating and analyzing traffic data collected from onboard sensors and infrastructure devices, the system can identify traffic bottlenecks, predict traffic flow disruptions, and optimize route recommendations for emergency vehicles. This proactive traffic management approach reduces response time for emergency services and minimizes the risk of secondary accidents caused by congestion.

Integration with Emergency Medical Services (EMS): The ADS establishes seamless communication channels with emergency medical services (EMS) to facilitate coordinated response efforts. Upon detecting an accident, the system automatically dispatches medical assistance to the accident site based on the severity of injuries and available resources. EMS personnel receive real-time updates on patient status, triage information, and medical history, enabling them to provide timely and appropriate care to accident victims.

Scalability and Adaptability: The modular architecture of the ADS allows for scalability and adaptability to diverse environments and use cases. Whether deployed in urban areas with high traffic density or rural regions with limited infrastructure, the system can be customized to meet specific requirements and operational constraints. Furthermore, ongoing research and development efforts focus on integrating emerging technologies such as edge computing, 5G connectivity, and autonomous vehicles to enhance the capabilities of the ADS and address evolving safety challenges.

V. Flow Chart:



VI. Conclusion:

In our study, we introduce a bicycle accident detection system comprising both hardware and software components. Through 34 riding trials, we gathered data on cycling and fall statuses. To distinguish between cycling and fall events, we analyzed time-domain features such as average (AVG) and standard deviation (SD) of accelerometer, angular velocity, angle, and magnitude signals in X, Y, and Z directions, resulting in 24 features. We then applied Principal Component Analysis (PCA) to reduce these features to 6 components for input into our Support Vector Machine

(SVM) classifier. Our focus was on detecting fall accidents specifically for bicycle riders, distinguishing our work from previous studies. We achieved a 95.2% accuracy with our SVM classifier, outperforming previous studies. While previous studies used accelerometer and gyroscope sensors, we utilized the MARG sensor for more precise data collection.

Additionally, unlike [9which assumed smartphone usage for data acquisition, our hardware module is designed to be mounted on the bicycle handlebar. This provides a comprehensive fall detection system that allows users to keep their smartphones in a pocket or bag. The module is also protected from impacts, rain, and water with a 3D case, representing a significant advancement in bicycle safety technology

VII. Reference:

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