A Comprehensive IoT-Based Bike Crash Detection and Emergency Response System for Enhanced Road Safety.

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ABSTRACT ***Motorcycle travel, deemed one of the riskiest modes of transportation, faces a staggering fatality rate, with 212.7 deaths for every million miles travelled. Unlike enclosed vehicles, motorcycles expose riders to their surroundings, heightening the need for proactive safety measures. This paper explores the development and implementation of a Motorcycle Crash Detection and Alert System (MCDAS) utilizing the Multi-axes accelerometer. The system is designed to detect when a motorcycle falls and promptly alert emergency services and contacts via Firebase cloud. The study delves into the challenges posed by two-wheeled vehicle dynamics and outlines a novel collision detection algorithm tailored for motorcycles. This algorithm is validated against experimental evidence, providing a robust foundation for crash detection systems in this unique context. Additionally, the paper introduces a novel method for vehicle detection and tracking, employing thresholding, mathematical morphology treatment, and original labelling to enhance accuracy and reduce artifacts. In the context of road accidents, especially prevalent among two-wheelers, the paper presents a system that combines accelerometer data and a user's heartbeat sensor to assess the severity of accidents. This timely information triggers alerts to nearby medical centers and contacts through GSM and GPS modules, facilitating immediate medical aid. The Android application associated with the system not only sends text messages to medical centers and friends but also shares the precise accident location, significantly reducing response time. important contributions and heralds a new departure for the vehicle safety paradigm.***

1.INTRODUCTION

Bike crashes, often resulting in severe injuries or fatalities, can be particularly perilous in remote or nocturnal riding conditions where immediate assistance may be scarce. This project introduces an innovative Bike Crash Detection system leveraging Internet of Things (IoT) technology to promptly identify accidents and alert the necessary emergency services. The system employs sensors, including gyroscopes and vibration sensors, to accurately detect crash events by monitoring the bike's tilt angle and vibration impact during travel[1]. To enhance accuracy, additional sensors and time delays are incorporated into the system, preventing false positives. The confirmation of a crash and prevention of erroneous detections are facilitated by side stand and temperature sensors. In the event of a crash, the system utilizes a GPS module to pinpoint the exact location and transmits victim data to a centralized command center through a GSM module[1]. The centralized command center, equipped with a web application developed for optimized rescue operations, swiftly identifies the crash location and communicates with nearby ambulances via a dedicated mobile application for drivers. For user reassurance and false alarm prevention, the system includes an "I am ok" switch, allowing the withdrawal of the SOS signal if the victim is unharmed. Additionally, an "emergency" switch enables manual activation of the SOS signal, accompanied by audible alarms and emergency lighting to attract local assistance[1]. Beyond enhancing response times, the system proves valuable in locating victims within challenging terrains such as bushes or mountain slopes. The integration of IoT technologies, along with the development of dedicated web and mobile applications, marks a significant advancement in bike crash detection and emergency response, promising to mitigate the severity of accidents and save lives.

The Integrated Automotive Safety system aims to level the safety playing field for all vehicles, irrespective of their age, by addressing prevalent on-road risks. Focusing on challenges like rollovers, collisions, and unresponsive drivers post-accidents, the project becomes crucial for older vehicles lacking contemporary safeguards. As an innovative approach, it utilizes IoT technology to enhance bike crash detection, extending safety measures to a broader spectrum of drivers, including those operating older vehicles vulnerable to current road risks[2]. India grapples with the alarming reality of being a global leader in road accident fatalities, necessitating urgent measures to address the escalating road safety crisis. With a specific focus on the pervasive issue of drunk driving, a critical public health concern, this project endeavors to curb the rising trend of road accidents attributable to alcohol impairment. The system incorporates cutting-edge Internet of Things (IoT) technology to identify the presence of alcohol in a vehicle, promptly activating an automatic engine lock as a proactive measure. By tackling the fundamental issue of drunk driving, this technology aims to play a crucial role in diminishing road accidents and elevating overall road safety in India.

2. LITERATURE SURVEY

In the current era of pervasive mobile phone usage and ubiquitous internet access, road safety has emerged as a critical concern, particularly in the context of accidents involving two-wheeled vehicles. The prevalence of accidents, often attributed to factors like driver intoxication, drowsiness, and unforeseeable behaviour of neighbouring vehicles, necessitates innovative solutions. While existing accident prevention systems exist, their efficacy in mitigating various accident scenarios remains a challenge. A distinctive approach to enhancing road safety is explored through the integration of wireless detector networks and Bluetooth protocols.

This innovative perspective envisions vehicles forming a mobile ad-hoc network, facilitating the exchange of crucial information perceived by onboard sensors. This concept introduces a dynamic and adaptive framework, potentially offering real-time insights into the surrounding environment to prevent accidents. This emphasizes the role of a robot platform within an operating system and software development environment as an optimal solution for public safety in the event of accidents. This research delves into the intricate balance between hardware and software components, showcasing the potential for a comprehensive system to address the multifaceted challenges associated with road safety.

Furthermore, presents an insightful survey, exploring the integration of personal mobile devices, Microcontrollers, Bluetooth, and JAVA technology. This survey highlights the versatility and adaptability of utilizing a range of technologies to enhance road safety, providing a foundation for the integration of Internet of Things (IoT) in the realm of bike crash detection. In synthesizing these diverse perspectives, this literature review lays the groundwork for an advanced bike crash detection system using IoT. The exploration of wireless networks, robot platforms, and the integration of diverse technologies offers valuable insights, setting the stage for a comprehensive and effective solution to mitigate the occurrence and severity of bike-related accidents.

In recent years, the integration of Internet of Things (IoT) technologies into road safety, particularly in the domain of bike crash detection systems, has witnessed significant advancements. Noteworthy among these is a two-phase system proposed in which adeptly distinguishes between low and high-speed bike accidents. Employing a sophisticated set of sensors, including a three-axis accelerometer, location encoder, bumper sensor, and a false alarm button, this system accurately identifies the crash state and promptly notifies emergency responders with specific information for swift accident recovery. Furthermore, introduces a comprehensive solution focused on real-time monitoring and communication. Leveraging GPS, GSM, and Android phones, this system not only locates accident sites promptly but also provides emergency updates to the nearest hospital's Intensive Care Unit and the victim's relatives. The integration of advanced sensors in the Embedded App Crash Detector emphasizes the critical link between swift detection, communication, and emergency response. Moreover, brings a unique dimension by utilizing smartphones for real-time identification and monitoring of vehicle accidents, showcasing the potential for widespread accessibility. While these systems demonstrate significant progress, challenges such as power consumption and sensor placement persist, prompting the need for further research to enhance accuracy and reliability. In conclusion, the literature underscores the promising trajectory of IoT technologies in revolutionizing bike crash detection systems, with continued research aimed at overcoming existing challenges and exploring new avenues for improvement.

3. PROPOSED METHOD

3.1 Problem Statement

In the realm of road safety, despite notable advancements in vehicular safety technologies, the persistent menace of bike accidents looms large, representing a critical challenge to the well-being of road users. These incidents often result in severe injuries and, tragically, fatalities, highlighting the urgency for comprehensive solutions that transcend the limitations of current bike crash detection systems. The existing landscape of such systems is marred by a lack of holistic features and real-time capabilities, curtailing their efficacy in ensuring a swift and effective emergency response.

A notable gap in the current state-of-the-art solutions lies in the absence of an integrated system that seamlessly harnesses the potential of Internet of Things (IoT) technologies. This deficiency restricts the development of a comprehensive solution capable of both accurate crash detection and immediate communication with emergency responders. The lack of a holistic approach impedes the maximization of the potential to

minimize the impact of bike accidents and initiate timely emergency responses.
Furthermore, the inadequacies of current systems extend to the rapid identification of accident locations and effective communication with critical healthcare facilities. Delays in providing timely medical assistance to accident victims persist due to the limitations of existing systems. The need for an innovative IoT-based bike crash detection system becomes increasingly evident, emphasizing the importance of enhancing the accuracy of crash identification and facilitating seamless communication with emergency services. By addressing these critical shortcomings, a cutting-edge system can be developed to ensure a rapid and effective emergency response, ultimately contributing to the preservation of lives and properties on the road.

The bike crash discovery and alert whole employs a well-planned fittings arrangement, intelligent operating system algorithms, and a orderly experiment procedure to guarantee allure influence. The integration of the Arduino Nano, ADXL-335 accelerometer, GSM SIM800L piece, GPS Neo-6M piece, LM2596 step preacher, and zero PCB forms the foundation concerning this creative system. Additionally, the Blynk app serves as a program that controls display, aiding program execution and physical-opportunity listening.

3.2 Hardware Setup:

The fittings arrangement starts with the Arduino Nano, strategically established on the bike to be a part of the main part of computer. The ADXL-335 accelerometer is fixedly attached to the bike frame, permissive it to measure palpable-opportunity stimulation dossier. The GSM SIM800L module and GPS Neo-6M piece are joined, each accompanying allure antenna for adept signal acceptance. The LM2596 step-unhappy preacher guarantees a stable capacity supply to all elements, lowering the risk of wandering behaviour all the while unexpected accelerations or decelerations. The nothing PCB is ritual-planned to accommodate and arrange these elements in a compact and sturdy class, optimizing space and guaranteeing dependability.

Arduino Nano: The Arduino Nano serves as the main part of computer of bureaucracy. It is a computer to state dossier from the accelerometer (ADXL-335), process this dossier to discover hurried changes exhibitive of a crash, and spark the alert scheme respectively. The Arduino Nano too controls the ideas 'tween various parts.

ADXL-335 Accelerometer: The ADXL-335 accelerometer is working to measure the bike's spurring in absolute-opportunity. In the event of a crash, the major change in stimulation prompts the accelerometer to transmit matching dossier to the Arduino Nano. This dossier is important for deciding either a crash has happen.

GSM SIM800L Module: The GSM SIM800L piece authorizes the bike crash discovery method to please instant alerts in the form of SMS ideas. When the Arduino Nano detects a crash, it uses the GSM piece to please predefined ideas to particularized crisis contacts, providing facts about the crash and the current GPS position.

GPS Neo-6M Module: The GPS Neo-6M piece supports correct location news. It steadily revises the bike's current GPS matches, admitting bureaucracy to include district dossier in the alert ideas shipped all along a crash. This guarantees that emergency responders or contacts are cognizant of the exact crash point.

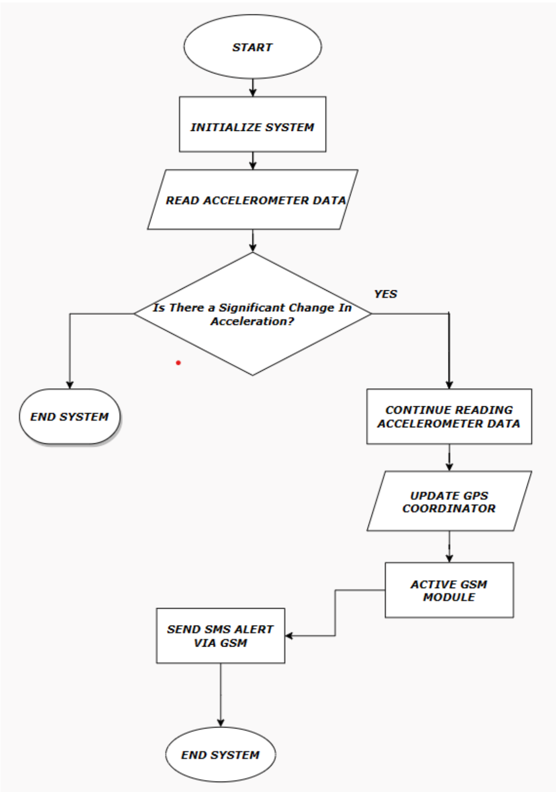

Fig 3.2.1 Flowchart

LM2596 Step-Down Converter: The LM2596 step-below preacher organizes the power supply for the elements. It guarantees a resistant and constant heat, barring potential issues caused by vacillations in the energy-producing station. This is critical for the dependability of bureaucracy, particularly during surprising occurrences to a degree a crash.

Zero PCB: The rule-devised nothing PCB acts as the circuit board that links and arranges the differing elements of bureaucracy. It optimizes the blueprint and arrangement of

the elements, lowering the overall breadth and improving bureaucracy's efficiency. The nothing PCB further donates to the persistence and strength of the crash discovery and alert system.
The active of bureaucracy includes the Arduino Nano uniformly listening data from the ADXL-335 accelerometer. When a important change in hurrying exhibitive of a crash is discovered, the Arduino Nano sparks the GSM SIM800L piece to transmit SMS alerts holding the crash details and GPS matches. The GPS Neo-6M piece guarantees the veracity of the district dossier, while the LM2596 step-unhappy preacher supports a stable capacity supply. The nothing PCB aids the unification of these parts, constructing a compact and productive bike crash discovery and alert system.

3.3 Objectives:

The primary objectives of the proposed bike crash detection system are to enhance road safety and expedite emergency response mechanisms. The system aims to accurately identify and differentiate between low and high-speed bike accidents through the integration of advanced sensors, including a three-axis accelerometer, location encoder, and bumper sensor. Real-time communication capabilities, facilitated by GPS and GSM modules, are intended to ensure swift relay of critical accident information to emergency responders, hospitals, and the victim's relatives. The user-friendly Android Control Panel empowers users to actively engage with the system, providing updates and triggering emergency signals. Overall, the system seeks to minimize response times, improve the accuracy of crash identification, and actively involve users in the emergency response process for effective accident mitigation.

3.4 Architecture:

The operational structure of the proposed IoT-based bike crash detection system involves a series of pivotal phases, each meticulously designed to deliver a comprehensive and streamlined approach towards identifying and responding to bike accidents. These distinct phases harmoniously interact to fortify the overall efficiency of the system.
Initialization Phase: Every time the system is powered on, it embarks on an initialization phase where embedded sensors, encompassing the three-axis accelerometer, location encoder, and bumper sensor, undergo meticulous calibration to ensure the precision and reliability of data acquisition. Additionally, communication modules, such as GPS and GSM, establish connections, laying the foundation for real-time communication with external entities.

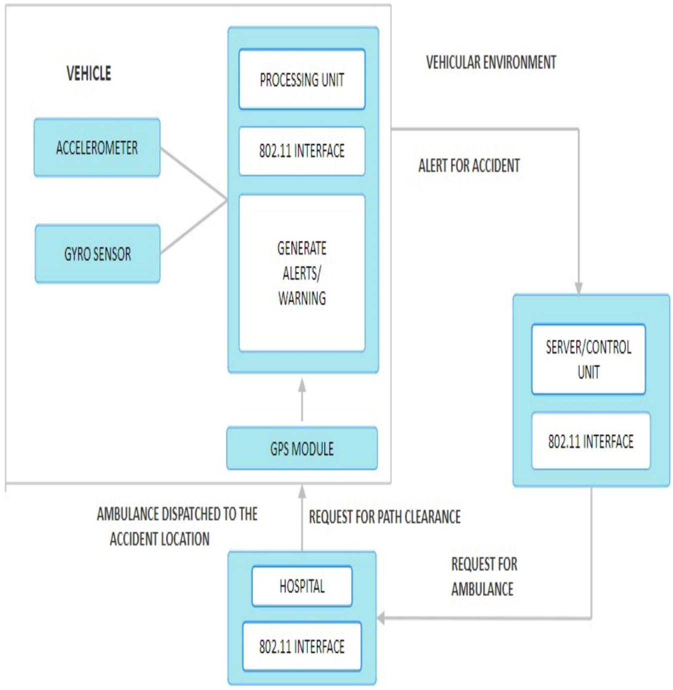

Figure 3.4.1 Architecture

Sensing and Detection Phase: Following the initialization, the system seamlessly transitions into the sensing and detection phase. The three-axis accelerometer continuously monitors the bike's motion, detecting anomalies in acceleration patterns that signify a potential crash. The location encoder and bumper sensor play integral roles in corroborating the occurrence of a crash event, minimizing the likelihood of false alarms. This phase is paramount in guaranteeing the accuracy of crash identification.

Communication Phase: Upon the detection of a crash, the system enters the communication phase. The GPS module precisely captures the accident location, while the GSM module initiates communication with the centralized command center. Simultaneously, the Android Control Panel facilitates seamless interaction between the user and the system, allowing for the provision of critical information and updates. The communication phase is essential for ensuring the swift and accurate relay of information to emergency responders, hospitals, and the victim's relatives.

Emergency Response Phase: Concurrently with the communication phase, the centralized command center, empowered by a web application, processes the received data, pinpoints the crash location, and identifies nearby emergency services. Ambulances are promptly alerted through a dedicated mobile application, streamlining the emergency response process and ensuring the swift dispatch of medical aid to the accident site.

User Interaction Phase: Running in parallel with the emergency response phase, the system offers a dedicated user interaction phase through the Android Control Panel. This phase empowers users to actively engage with the system by providing updates, withdrawing false alarms through a dedicated button, and manually triggering emergency signals. The user interaction phase adds a vital layer of engagement, enabling users to play an active role in the overall emergency response process.

In summation, the architecture of the IoT-based bike crash detection system unfolds through a well-defined sequence of phases, starting from initialization to user interaction. This systematic approach guarantees accurate accident detection, expeditious communication with emergency services, and active user participation in the comprehensive emergency response process.

4. IMPLEMENTATION

Our design for the bike crash detection system represents a careful integration of advanced components, featuring the Arduino Nano microcontroller, ADXL-335 accelerometer, GSM SIM800L module, GPS Neo-6M module, LM2596 Step-Down Converter, and Zero PCB. The pivotal role of the ADXL-335 accelerometer entails continuous monitoring of the bike's acceleration, diligently analyzing for abrupt and irregular changes that might indicate a possible crash event. In the unfortunate scenario of a crash, the Arduino Nano processes the accelerometer data, triggering a swift response that activates the GSM SIM800L module. Subsequently, this module initiates the transmission of an alert message to preconfigured emergency contacts, relaying crucial details about the incident's precise location, obtained through the GPS Neo-6M module.

The LM2596 Step-Down Converter plays a crucial function in ensuring a steady and dependable power supply to the various components, optimizing their performance even in challenging conditions. The Zero PCB acts as a facilitator for seamless integration and organization of the circuitry, serving as a foundational platform for efficient functionality. This all-encompassing system not only serves as a crash detection mechanism but also operates as a holistic solution, enhancing rider safety by delivering real-time crash information, complete with accurate GPS coordinates. This amalgamation of state-of-the-art technology not only identifies potential hazards but also orchestrates a prompt and well-informed emergency response, contributing significantly to the overall road safety for bikers.

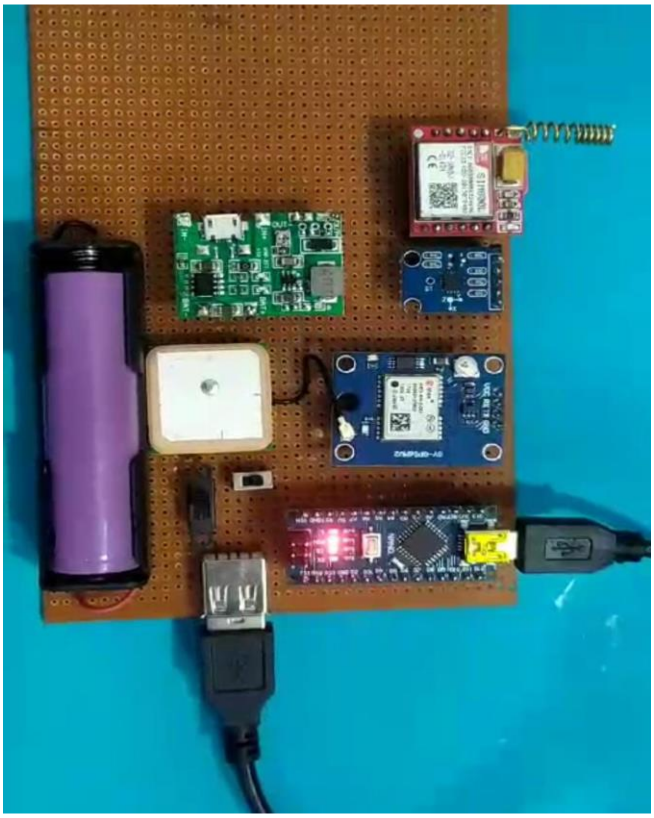

Fig 4.1 Hardware implementation

In conclusion, our bike crash detection system represents a pinnacle of innovation and integration in the realm of road safety technology. With a robust foundation for real-time incident reporting and a focus on enhancing emergency response, the system emerges as a holistic solution to improve overall road safety for bikers. By seamlessly integrating cutting-edge technology, our initiative aspires to make a significant impact, contributing to the broader goal of reducing accidents and ensuring a safer journey for all.

5. RESULTS AND DISCUSSIONS

The experimental results for bike crash detection were obtained through the Arduino IDE's Serial Plotter feature, providing insightful data on the accelerometer readings in terms of gravitational force (g's) across three axes plotted against time in seconds. Four distinct scenarios were simulated and plotted on the graph to assess the system's performance under various conditions.

In the first scenario, representing the upright position while traveling on the road, the accelerometer readings demonstrated stability and consistency, affirming the system's ability to accurately capture the normal operational state of the bike.

The second scenario simulated a forward crash maneuver, where the accelerometer readings exhibited a rapid and significant deviation from the baseline. This notable spike in readings indicates the system's capability to promptly detect and respond to a forward crash, aligning with the intended objective of timely accident identification.

Similarly, the third and fourth scenarios simulated left and right-side fall maneuvers, respectively. In both cases, the accelerometer readings depicted distinctive patterns indicative of lateral falls. These results suggest the system's effectiveness in discerning different crash orientations, crucial for providing accurate alerts and facilitating an appropriate emergency response.

The successful simulation and plotting of these scenarios validate the reliability and accuracy of the bike crash detection system. The system's responsiveness to various crash scenarios underscores its potential in real-world applications, where diverse accident conditions may occur. The results affirm that the integration of the Arduino IDE's Serial Plotter feature effectively captures and visualizes the accelerometer data, enabling a comprehensive assessment of the system's performance under different crash conditions.

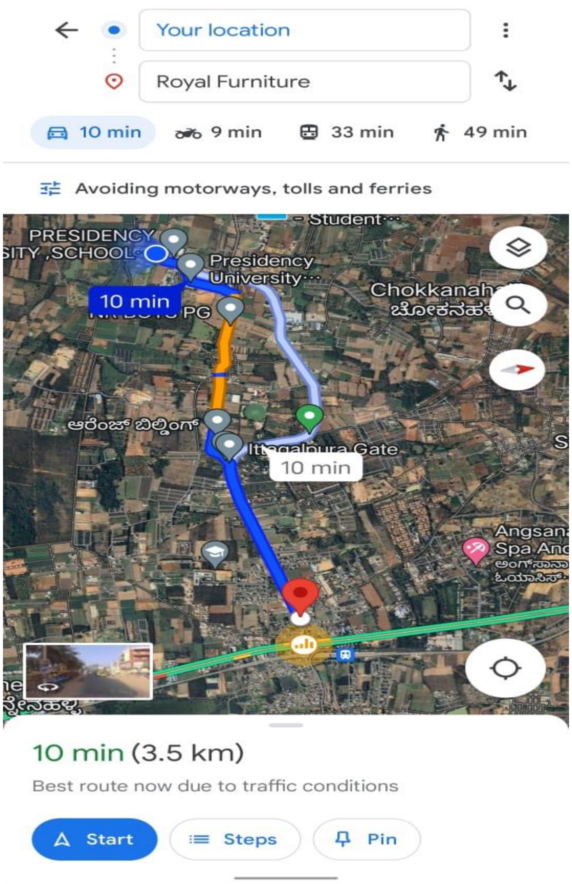

Fig 5.2 Location Tracking

6. CONCLUSION

In the dynamic landscape of Internet of Things (IoT) systems, the integration of intelligent devices equipped with embedded systems, processors, and sensors has revolutionized data collection and processing from the environment. These devices, orchestrated through IoT gateways, facilitate seamless communication, sending data to the cloud for analysis or conducting localized assessments. While human interaction with these devices is possible, the crux of their functionality lies in autonomous processes, reducing reliance on human intervention.

Motorcycle accidents, often resulting in fatalities due to delayed responses rather than immediate fatalities at the scene, underscore the critical need for efficient and prompt emergency interventions. The aftermath of a motorcycle crash leaves drivers susceptible to shock, impairing their ability to call for help independently. Exposure to the elements further exacerbates this vulnerability. In crowded or deserted areas, the likelihood of bystanders taking initiative to seek assistance or call emergency services remains uncertain, contributing to delayed response times. This dilemma necessitates a proactive approach, ensuring crucial notification to designated individuals for the affected driver.

This paper addresses this imperative by introducing a system designed to detect motorcycle accidents, validate the authenticity of alarms, and promptly alert emergency contacts with comprehensive details about the accident's location and time. The envisioned outcome is to equip recipients with adequate information for immediate communication with relevant authorities and the provision of essential assistance. This proactive notification mechanism not only expedites emergency response but also facilitates a clearer understanding of the situation for those rushing to the scene.

Furthermore, the potential expansion of this system is explored, proposing additional features such as an extended list of emergency contacts. This enhancement envisions sending crash details to multiple contacts, increasing the likelihood of obtaining timely assistance. Moreover, incorporating location addresses for each contact enables a refined approach, selectively notifying the three nearest contacts to the crash site. Such advancements amplify the system's efficacy in garnering prompt and tailored support during critical moments following a motorcycle crash.

In essence, this paper advocates for a paradigm shift in emergency response to motorcycle accidents, leveraging IoT technologies to bridge the gap between the occurrence of an accident and the crucial assistance that follows. The envisioned system not only addresses the immediate challenges but also opens avenues for further refinement and expansion, embodying a progressive step towards enhancing overall road safety and emergency response mechanisms.

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