

IoT-Enabled Embedded System for Rash Driving Detection and Automatic Speed Control Using GPS and GSM

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Abstract. The loss of human life is the most significant loss that cannot be regained, in contrast to other property losses. Every year, a lot of people die in car accidents. Many different things have been tried to stop these road accidents. There are now better roads, and many road safety programs have been put in place. Many different technologies and methods have been developed to teach people to drive safely, but most haven't helped prevent accidents. The proposed system for this project monitors several vehicle parameters, including speed, engine speed, brake pedal status, and steering angle. An embedded microcontroller board measures all of these things. The goal is to learn about a driver's driving style by looking at how they use the gas and brake pedals. If the way a person drives meets the criteria for reckless driving, the system notifies the driver and, if the behavior continues, limits the vehicle's speed and sends a text message to the nearest police control room via a GSM module. The system also controls how fast cars can go in areas with a lot of people, such as cities and villages along the route. The GPS module system keeps track of the vehicle's location at all times. If it enters a city, the speed limit is set to a safe level.

Keywords: GSM Module; Good Road Infrastructures; GPS Module; Brake Pedal Status; Steering Angle; Pre-Defined Rash; Vehicle Speed.

Introduction

These days, the number of cars on the road is growing very quickly [45]. This is making the number of road accidents go up a lot, and people are dying because of them [55]. The World Health Organization says that about 1.2 million people die every year. India has only 1% of the world's cars, yet it accounts for 16% of all road accident deaths [33]. In 2018, the number of people killed in road accidents in India reached an all-time high of more than 1.51 lakh, which is 3,500 more than in 2017 [53]. Uttar Pradesh had the most road deaths, followed by Maharashtra and Tamil Nadu. We see a lot of people die on the road these days because of accidents that go unnoticed [41]. This happens a lot at night, when the only way to talk is by phone. More cars are on the road, but the roads aren't getting any better at handling them, which is causing more accidents [48]. We might

not be able to stop people from getting hurt, but we can still help them. In these cases, vehicle collision detection is helpful [38]. Researchers have proposed a range of systems for detecting accidents, including smartphone apps, GSM and GPS software, vehicular ad hoc networks, and mobile apps [60].

Every second counts when someone's life is at stake [47]. More and more people are using cars. Because of the heavy traffic, accidents are happening more and more every day. This leads to people dying because the ambulance takes too long to get to the accident scene or from the accident scene to the hospital [43]. So, it is important to get the person who was hurt in the accident to the hospital as soon as possible. It is important to report any accidents to the investigation unit [52]. So, it's also helpful if the notice reaches the inquiry section, as this will shorten the time required for the investigation. More and more people are using cars [37]. Because of the heavy traffic, accidents are happening more and more every day [57]. This causes people to die because the ambulance takes too long to get to the scene of the accident or from the scene of the accident to the hospital [50]. So, you need to get the person who was hurt in the accident to the hospital right away. If an accident occurs, the investigation unit must be notified immediately [34]. So, it's also helpful if the notice reaches the inquiry section so the investigation can be completed more quickly.

The goal of this project is to create and deploy embedded computing devices that can be uniquely identified within the current internet infrastructure. These devices will help night drivers find their way and avoid drowsiness-related accidents. The project is about the Internet of Things [35]. "The Internet of Things (IoT) is a network of connected computers, mechanical and digital machines, objects, animals, or people that have unique identifiers and can send and receive data without needing to interact with each other or with computers." When something is connected to the internet, it can send and get information, or both [49]. Things are smart when they can send and/or receive information, and the smarter they are, the better. A thing doesn't need a supercomputer or a lot of storage to be smart [42]. To work, all a thing needs to do is connect to super storage or a supercomputer. Being connected is great [54]. This system could be further improved in the future with new technologies to make the vehicle system even safer and more secure [39]. An alcohol sensor can also be added to the hardware, since most accidents happen when people are drunk [59]. One way to do this is to put an alcohol sensor in place that can tell when the alcohol level goes above a certain limit. This project could also include a sensor that prevents the person from blinking [44]. Who has an accident because they are sleepy? Putting an eye blink sensor where the person needs it can help. Can make graphical software to keep track of the car [56].

The loss of human life is the most significant loss that cannot be recovered, unlike other property losses. Every year, a lot of people die in car accidents [36]. Many different things have been tried to stop these road accidents. There are now better roads, and many road safety programs have been put in place [58]. Many different technologies and methods have been developed to teach people to drive safely, but most haven't helped prevent accidents [51]. The proposed system for this project monitors several vehicle parameters, including speed, engine speed, brake pedal status, and steering angle. An embedded microcontroller board measures all of these parameters [40]. The goal of this is to figure out how the driver drives by looking at how they use the accelerator and brake pedals. If the driver's behavior meets the predefined criteria for reckless driving, the system alerts the driver and, if the behavior continues, limits the vehicle's speed [32]. At the same time, a text message is sent to the nearest police control room using a GSM module. The system also controls the car's speed in areas with a lot of people, such as cities and villages along the way [46]. The GPS module system tracks the vehicle's location and limits its speed to a safe level when it enters a city area.

Methodology

Literature review

Night-vision cameras and automated control systems written in Python have improved accident-prevention systems. These systems are meant to make drivers more aware of their surroundings when visibility is low and to prevent crashes by detecting obstacles and sending alerts [18]. But there are still problems distinguishing real accidents from low-speed events, leading to false reporting. These systems might struggle to determine whether the user is in the car when they are detected, making them less reliable [25]. Even though new technologies have made it easier to monitor and respond, performance is still affected by challenges in understanding context and by changes in the environment [9]. The current literature underscores the need for enhanced validation algorithms and multi-sensor integration to improve accuracy and reduce false positives in intelligent accident prevention frameworks [2]. Accidental medical help systems mostly deal with delays in getting help in an emergency, which is a big reason why people die in car accidents. These systems often use GPS, GSM, accelerometers, and Arduino-based microcontrollers to detect collisions and automatically send location information to emergency responders [23].

They work well in serious accidents, but they often miss minor or rare accidents that don't cause any immediate injuries [21]. This can lead to either underreporting or unnecessary emergency mobilization. This imbalance could cause resources to be used inefficiently and delay important cases [11]. Previous research underscores the need to enhance sensitivity calibration and adaptive threshold mechanisms to distinguish between significant and minor impacts. Adding health-monitoring sensors and improving how contextual data is processed could make automated medical alert systems even more responsive and reliable [29]. Emergency medical service support systems for car accidents focus on quick communication and coordinated rescue efforts [17]. These frameworks recognize that car accidents are a leading cause of death and aim to reduce response time by sending automated alerts. But most systems don't connect the victim's medical history and real-time health data, which are very important for making smart treatment choices. Not having this information could make it harder to get the right help during the golden hour [5]. To improve pre-hospital care, the literature suggests using wearable health sensors, cloud-based medical records, and secure data-sharing platforms.

Ensuring that emergency networks and healthcare facilities can work together remains a significant research challenge in building complete accident response ecosystems [13]. Mobile-centric safety solutions have emerged thanks to smart accident-prevention systems, such as Android-based apps that support multimodal alert dissemination. Apps like HDY Copilot use smartphone sensors to detect unusual motion patterns and automatically notify emergency contacts [1]. These systems are easy to use and don't cost much, but they rely heavily on the integrity of smartphones and network connections [24]. If the device is damaged in an accident or loses signal, the system won't work. Studies show that combining smartphone-based detection with embedded modules in cars can make the system more reliable [7]. Also, to avoid connectivity issues and ensure emergency response capabilities are always available, it is recommended that cloud backup communication and additional alert channels be used.

To address the complexity of healthcare emergency responses in accident situations, people have suggested using agent-based decision-support frameworks. These systems use mobile agents that can move between network nodes on their own, carrying data needed to make decisions across the network [22]. The method makes it easier to adapt and respond to changing emergencies. But concerns about data security, interoperability, and agent reliability remain very important. Literature reviews emphasize the necessity for secure communication protocols and standardized data exchange formats to facilitate mobile agent functionality [4]. Even though they hold promise

for coordinating complex healthcare, more testing is needed to ensure that real-world accident management systems are stable and safe from cyberattacks [26]. Using microcontroller chips, GPS-based accident-prevention safety systems continuously monitor vehicle speed and compare it to historical data. These systems try to predict potential collisions and send alerts by detecting sudden changes in speed [19]. The theoretical basis links the severity of an accident to the conversion of kinetic energy into destructive forces when two objects collide. Speed monitoring helps identify risks early, but it doesn't account for all environmental factors, driver behavior, or road conditions [30]. Research indicates that incorporating supplementary sensors, including gyroscopes and proximity detectors, can improve predictive accuracy [14]. More and more, experts are recommending multi-parameter analysis to go beyond simple speed-based tests and perform a full, real-time risk assessment.

Theories of accident causation provide ways to think about the factors that cause road accidents. These theories classify causes such as person-based factors, system-based failures, interactions between people and systems, and sequential dynamics between people and systems [15]. The person-as-cause viewpoint focuses on individual carelessness, tiredness, or risk-taking behavior, while system-based theories focus on problems with infrastructure or organizations. Recent research increasingly endorses integrated models that acknowledge the interaction between human and systemic components [20]. Even though these models have been extensively studied in theory, they are still not widely used in predictive systems. Safety engineering research is still focused on closing the gap between theoretical causation analysis and practical technological solutions. The literature on accident control emphasizes the importance of managing energy transfer in controlled environments to prevent injuries [6]. Accidents happen when safety measures break down, and energy is released that people can't handle. To prevent serious incidents, effective prevention systems need people to find and report near misses before they escalate [28]. Organizational safety culture is an important part of this process. This is because when managers pay more attention to reporting and taking corrective action, the number of accidents goes down [12]. Research consistently shows that fostering accountability, openness, and a culture of continuous improvement leads to better accident control results. Adding near-miss analysis to technological safety frameworks improves their ability to prevent problems.

Research on predicting accidents examines how to use data and analytical models to forecast when they might occur. Scenario analysis, regression techniques, and hybrid statistical approaches are some of the most common methods. The goal is to make it possible to take steps to prevent injuries before they happen [10]. But no single predictive model can be 100% accurate, because data quality and the complexity of the situation can change. Researchers say that using multiple analytical methods can make predictions more reliable. Researchers are increasingly using machine learning models to uncover nonlinear relationships between variables [16]. Even though methods have improved, problems with data completeness, real-time processing, and interpretability continue to affect how well accident prediction systems perform in practice [27]. Accident investigation offers essential insights into causation and remedial measures. Thorough investigations show that an organization is open, has a strong safety culture, and is committed to finding and fixing the root causes of problems [3]. Even companies with good safety records can have accidents happen again and again if they don't apply what they've learned from past incidents. For investigations to work, people need to feel safe reporting facts without fear of punishment [31]. The literature emphasizes that effective accident analysis depends on clear procedures, evaluations based on evidence, and a commitment to ongoing improvement [8]. Using digital documentation tools and data analytics in investigations improves learning and helps prevent long-term accidents.

Project Description

Every year, more and more people are driving cars, and the number of car accidents is slowly increasing. The 2020 survey found that almost 1,214 road crashes occur every day in India [62]. Drivers under 24 are the most likely to be in deadly crashes; by 2020, this age group will have grown by 19%. When accidents happen, one or more people may be badly hurt, and sometimes immediate first aid isn't available [64]. Some reasons could be running a red light, driving too fast, accidentally pressing the gas pedal, breaking traffic rules, and so on. This proposed system quickly connects the police and hospitals nearby. The proposed SADPS also serves as a video surveillance and monitoring system. New methods enable automatic background subtraction and object tracking [65]. This paper proposes a new device to prevent cars from crashing into each other. The LCD screen next to the steering wheel shows the driver how far away the other cars are from the car every second. The device can see the car from all sides [63]. This system tells the driver to use the automatic brake [61]. When two cars get closer together, the car's alarm goes off, and the LCD screen shows how far apart they are. An alarm wakes the driver, and figuring out the distance helps them estimate how likely they are to crash.

Results and Discussion

Module Description

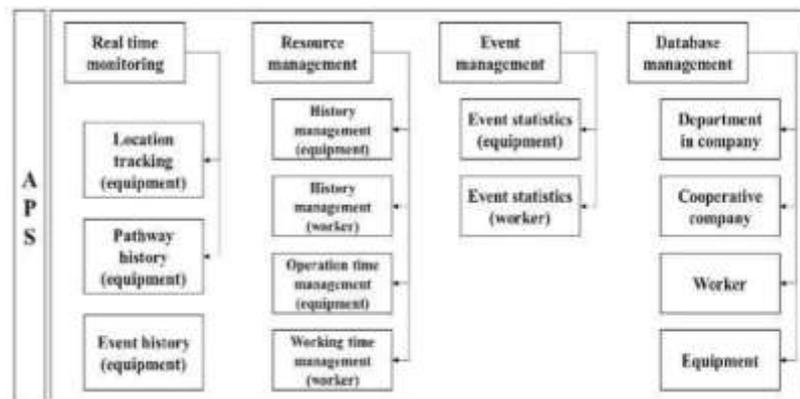


Figure 1. Architecture Diagram

Figure 1 shows the project's architecture diagram. As the number of commercial and non-commercial vehicles on the road rises quickly, along with improved transportation infrastructure and in-vehicle technology, traffic accidents are likely to occur, often resulting in many deaths [69]. More than half of these deaths happen because medical professionals and rescue workers take too long to respond. If an accident victim gets medical help right away at the scene, their chances of survival could go up a lot [104]. This work proposes a low-cost accident detection and notification system that uses a multi-tier IoT-based vehicular environment. It mainly uses V2X Communication, edge, and cloud computing [92]. In this study, vehicles are outfitted with an On-Board Unit (OBU) and mechanical sensors (accelerometer, gyroscope) for dependable accident detection, as well as a Global Positioning System (GPS) module to pinpoint the accident's location. Also, a camera module is built into the car to record the moment of the accident [82]. To make it easier for vehicles to communicate with each other (IVC), each vehicle's OBU has a wireless networking interface. When an accident happens, a car senses it and sends out an alert message.

It then sends the message and the accident location to an intermediate device at the edge of the vehicular network, which is therefore called an edge device [98]. When this edge device receives the alert, it locates the closest hospital and requests that an ambulance be sent right away. It also

preprocesses data and serves as a link between the sensors inside the car and the server in the cloud, which is far away [75]. Traffic authorities are currently dealing with a major problem: accessing data from these environments in real time. Wireless interfaces can usually send real-time sensor data, but this feature isn't available for sale yet in the vehicle's OBU [102]. Instead, the Internet of Things (IoT) connects the vehicles, the edge node, and the central server. By analyzing the right data on road accidents, we can develop plans of action to reduce deaths [87]. To help the right people perform a thorough analysis of refined, reliable data, we suggest a dynamic, cloud-hosted front-end visualization. The charts and graphs that are made help the people who work at the right organizations make the right decisions based on a thorough analysis of the data that has been processed and stored [103].

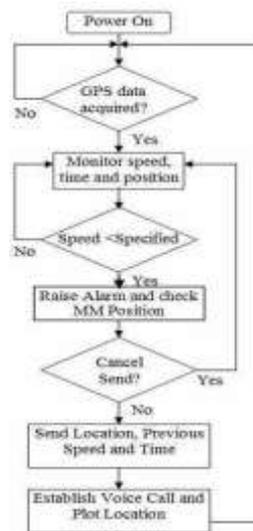


Figure 2. Data flow diagram

The project data flow diagram is shown in Figure 2. The high demand for cars has also made roads more dangerous and increased accidents [86]. People's lives are in great danger. This is because our country doesn't have the best emergency services. This paper presents an automatic alarm system for vehicular accidents [97]. This design is a system that can find accidents much faster and send basic information to the first aid center in a few seconds [70]. This information includes the accident's geographical coordinates, time, and angle. In a short amount of time, this alert message is sent to the rescue team, which will help save lives [93]. A Switch is also there to prevent a message from being sent in rare cases when there is no casualty. This can save the medical rescue team a lot of time.

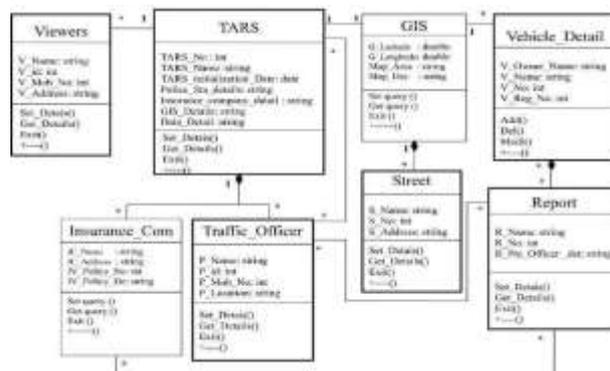


Figure 3. Class Diagram

The Class Diagram of the project is shown in Figure 3. The Traffic Accident Reporting System (TARS) was developed using UML concepts, as shown in Fig. 1. UML class diagrams depict the system's structure, including classes, attributes, and relationships [81]. The full Traffic Accident Reporting System TARS has been built with features and functions. The UML class model shows how the different properties, such as association, aggregation, and inheritance, are used in the form of subclasses [96]. In a UML class diagram, the Viewers class has several connections to TARS, and TARS has only one connection to the Viewers class [66]. The TARS class has one link to the GIS class and several links to the Insurance_Com and Traffic_Officer classes, just as the GIS class does. The GIS class is only linked to the TARS class, but it is linked to the Vehicle_detail class in many ways [83]. The GIS class is also linked to the Street class in many ways, and the Street class is only linked to the GIS class. The Vehicle_detail class has many connections to both the GIS class and the Report class [76]. The Report class is linked to the Vehicle_Detail, Traffic_Officer, and Insurance_Com classes in multiple ways. The Traffic_Officer and Insurance_Com classes are also linked to the Report class in multiple ways.

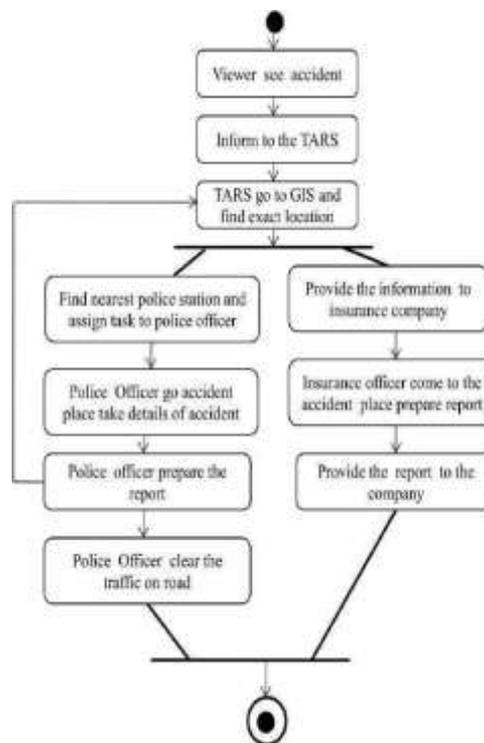


Figure 4. Activity Diagram

The project's Activity diagram is shown in Figure 4. An activity diagram is a type of flowchart that shows how control moves from one step to the next [90]. The activity diagram displays individual activities sequentially, illustrating both controlled and uncontrolled movements. Figure 2 shows the UML activity diagram for the model above. The activity diagram shows how the whole Traffic Accident Reporting System works [71]. The activity diagram shows that people who witness the accident can report it to TARS by email or phone. They can also go directly to the traffic police and report the accident. When the TARS learn of an accident, the system will use the internet to connect to the GIS system and find the exact location where it occurred [80]. After determining where the accident happened, the TARS locates the closest police station and notifies the appropriate person. At the same time, they send the information to the insurance company.

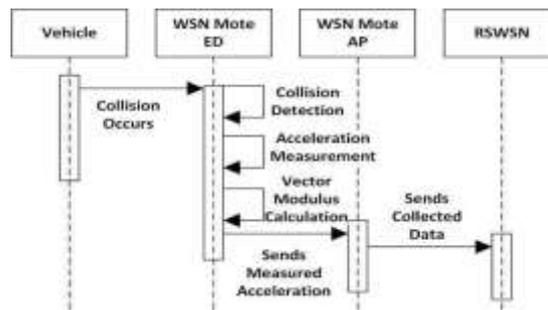


Figure 5. Sequence diagram

The sequence diagram is shown in Figure 5. The sequence diagram shows how objects interact [101]. The sequence diagram sends the message from the top to the bottom. Figure 3 shows the sequence diagram for the TARS UML model above. There are five important objects in this TARS sequence diagram [74]. They are shown at the top of the diagram as rectangles with their class names. The five main parties are the Accident-affected party, TARS, GIS, Officer, and Insurance Company. An arrow and its message show how two objects talk to each other [94]. The sequence diagram is shown in Fig. 3. The party involved in the accident must report it to the Traffic Accident Reporting System (TARS) by mail or phone [99]. The TARS connect to the GIS system to find the exact spot where the accident happened. After finding the exact spot, the system locates the nearest traffic police station, informs the officer, and assigns the job [67]. At the same time, let the insurance company know as well. The police officer and the insurance company officer arrive at the accident scene and begin writing the report [84]. The insurance company's representative sends the report to the company. The traffic cop writes up the report and sends it to TARS. Then, the cop clears the traffic and moves on to the next task.

4.3. Module Description

4.3.1. Module 1: Data Collection and Training Data

Using the Internet of Things algorithms to collect data and train.

4.3.2. Step 1: Data Collection

1. The first step in building the accident detection model is to gather the datasets [77].
2. The training data set is important for understanding how to prevent road accidents, as records from past accidents help predict what will happen, how much damage will be done, and what will happen next (Figure 6).
- 3.



Figure 6. Test Image

4.3.3. Step 2: Processing of data

1. The pre-processing step could come before the coaching and testing of the information.
2. To set up a good system to prevent car accidents, records of past accidents are very important for figuring out how to avoid them, how severe they will be, and what will happen [85].
3. Road accidents cause significant damage and deaths, both to individuals and to society [68]. Smart safety systems are designed to provide everyone who uses the road with a safe way to get around [79]. This method recognizes that people can be severely injured in car accidents and that the system needs to improve.
4. The phishing dataset's numbers were changed to 0, 1, and -1 . The data said that 1 was real, 0 was suspicious, and -1 was phishing [89]. It was important to preprocess the data so we could select the right features and distinguish between bad behavior (Figure 7).

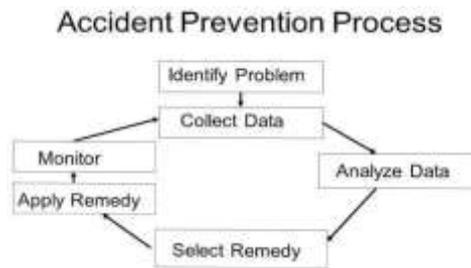


Figure 7. Preprocessing of data

4.3.4. Step 3: Split the Data

After preprocessing, the data is split into two groups: training and test [78]. The training data accounts for 70% of the total, and the testing data accounts for 30%.

1. The goal of feature extraction is to identify the most common features of a website that can help determine whether it is a phishing site or a legitimate one.
2. The feature selection wrapper approach uses a variety of search algorithms to identify the best set of features to improve classification performance [72]. This set of features is called the objective function in the wrapper approach.
3. A frequency-based feature evaluation has been conducted to identify the prevalent website characteristics associated with phishing sites.
4. There are steps in testing the model to ensure it can make accurate predictions [88]. Making predictions on the test set is the first step.
5. The model has two data sets: a training set and a test set [95].
6. The algorithm is run on the test data set, and then the training data set is used to evaluate its accuracy.
7. The model is put into action after testing.

In today's world of science and technology, transportation is an important part of life. When we have this with us, we feel like the most civilized beings on Earth [91]. Cars are an important part of our daily lives, but like everything else, they have good and bad points. The biggest danger to human life is car accidents [100]. The main cause of many of the accidents is speed. This paper

suggests a very effective system for detecting and notifying of accidents using smartphones [73]. It will track the accident using impact sensors, process the data with a microcontroller, and send notifications to the nearest emergency services and the victim's family via GPS and GSM.

5. Implementation and testing

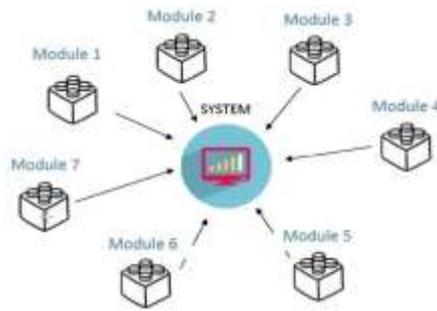


Figure 8. Centralized System Architecture Showing Interconnected Modules (Module 1–Module 7)

Unit testing means checking each small part of the code that works independently (Figure 8). Integration testing goes a step further by looking for errors that occur when units start working together [106]. Just because units have passed the tests at earlier stages doesn't mean they will work well together.

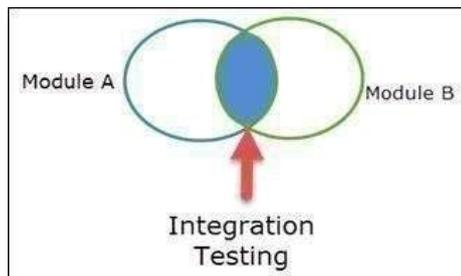


Figure 9. Integration Testing Between Module A and Module B

They don't need to know how code works or think about how the parts work on the back end (Figure 9). Integration testing goes a step further: we look for bugs that occur when units start working together [105]. The black box method is used for integration testing. This method means that a testing team uses the app's user interface to interact with its components. For example, they can click on buttons and links, scroll, swipe, and so on.

Just as the transportation system has advanced, the world has made rapid technological progress. Vehicles are modernized and efficient, but they also cause a lot of street accidents that kill people. Unidentified crashes and late rescues make things even more tense, especially in remote areas [108]. A low-cost programmed accident discovery system is suggested to lower this unintentional death rate. This system would automatically locate the accident and send an SMS to the concerned relative with the exact GPS location of the accident. The suggested system has both hardware and software. The equipment module consists of an Arduino board with a push button and a GPS module that is already in the car. The software part is an Android app that users download to their phones [109]. The experimental results show that the system works well as planned. The

proposed system's overall functionality is divided into two sub-tasks. The first part improves the module so it can record information such as the number of people in the vehicle and their condition after the accident [107]. The second part looks at stored data, such as where accidents occurred, why they occurred, and how many people were hurt or killed in accidents in a given area, to try to figure out what caused them. An app was developed and tested to automatically detect accidents and quickly get help to people who were hurt.

Conclusion

As science and technology continue to improve in the 21st century, vehicle safety becomes increasingly important. As the number of cars goes up, so does the number. There are more and more road accidents every day, so we need to address them. Most of the time, accidents happen because people are drunk, tired, or their engines are too hot and catch fire. This project will help lower the number of accidents caused by the reasons listed above. Because the system is automatic, cheap, and uses little power, it is easy to install in a car. Sadly, if an accident does occur, the system will detect it and send the exact location to the emergency unit via a GSM module and GPS. This helps save many lives by letting the rescue agent know in time. This system is cheap, easy to use in any car, and aimed at regular people.

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