

IOV-ENABLED REAL-TIME ACCIDENT DETECTION AND LOCALIZATION SYSTEM FOR ENHANCED EMERGENCY RESPONSE

Hamayoun Shahwani^{*1}, Muhammad Imran Ghafoor², Saeed Ahmed Magsi³, Saeed Zaman⁴,
Mudassir Khan⁵, Mehmood Baryalai⁶

^{1,3,5}Department of Electrical Engineering, Balochistan University of Information Technology, Engineering, and Management Sciences (BUITEMS), Quetta, Pakistan

²Faculty of Engineering and Technology Superior University, Lahore, Pakistan

⁴Department of Transportation Lmkr, Islamabad, Pakistan

⁶Department of Information Technology, Balochistan University of Information Technology, Engineering and Management Science Sciences (BUITEMS), Quetta, Pakistan

¹hamayoun.yousaf@buitms.edu.pk, ²engr.imranbhatti09@ieee.org, ³saeed.ahmed@buitms.edu.pk,
⁴engr.saeedzaman88@gmail.com, ⁵mudassirkhan43.mk@gmail.com, ⁶mehmood.baryalai@buitms.edu.pk

DOI: <https://doi.org/10.5281/zenodo.17720623>

Keywords

Accident detection system, Internet of Vehicles (IoV). Real-time alerts, Traffic management, Rescue coordination, Post-crash delays

Article History

Received: 04 October 2025

Accepted: 12 November 2025

Published: 26 November 2025

Copyright @Author

Corresponding Author: *

Hamayoun Shahwani

Abstract

In Pakistan, road accidents continue to be a common source of deadly incidents, and survival rates are largely reliant on how long it takes for first responders to arrive at the scene. In order to improve traffic management and emergency response, this paper describes an accident detection and reporting system that makes use of the Internet of Vehicles (IoV). In order to automatically detect collisions and send out real-time alerts, the suggested system combines in-car sensors with Global Positioning System (GPS) and Global System for Mobile Communication (GSM) modules. The system enables quick assistance by sending an SMS with the exact location of the accident to pre-designated emergency contacts or responders upon detection. Our method guarantees precise localisation and minimises response times, in contrast to traditional GSM only systems that deliver alerts without position information. Additionally, the technology facilitates situational awareness by providing first responders with vital information, which enhances coordination and reduces rescue time. The work emphasizes the importance of automated accident reporting as a means of reducing post-crash delays and highlights potential improvements for future IoV-based emergency management frameworks

INTRODUCTION

The rate of traffic accidents nowadays is increasing rapidly. Due to work demands, the utilization of vehicles has expanded, and as a result, accidents occur mainly because of oversteering. Individuals are at risk due to their excessive speed, and because of the inaccessible advanced techniques, the accidents rate cannot be reduced effectively. To

minimize the accident rate in the country, this system presents an optimal solution.

Whenever a collision occurs in a city, a message is sent to the indicated mobile number via the Global System for Mobile Communication (GSM) module in a short time. Arduino is the core of the system, which helps in transmitting the message to various devices in the framework. A vibration sensor is

activated when the collision occurs, and the data is sent to the registered number via the GSM module. The Global Positioning System (GPS) will help to identify the exact location of the accident spot. The proposed system checks the occurrence of an accident and notifies the nearest medical centres and registered mobile numbers about the location of the accident. The location can be transmitted through the GPS to provide the geographical coordinates of the area. The accident is detected by a vibration sensor, which serves as a significant module in the system Lee et al.,

2016. Vehicular networks are widely used in the mobile and automotive industries. However, in the 5G era, the Internet of Things has evolved into the integrated future internet. This has led to new research areas such as smart transportation and smart communication. From this advancement, the concept of the Internet of Vehicles (IoV) emerged. The main aim of IoV is to enable communication between vehicles, facilitate the exchange of information, and reduce the accident rate Ji et al., 2020. The major goal of our research is to provide a safer driving experience in foggy conditions, where visibility is significantly limited. As a result, the probability of accidents increases considerably. By utilizing vehicle-to-vehicle communication, the system aims to reduce the number of accidents occurring under such conditions Thakur and Malekian, 2019. Detection of road obstacles, Lane change assistance, and congestion reduction Shahwani et al., 2017, can also make use of such a warning message to promptly distribute it to the appropriate cars.

A. Significance of Accident Detection

The importance of accident detection and warning systems is highly significant for society. Imagine a situation where an accident occurs and the emergency services are immediately notified. Given the Internet of Things' (IoT) explosive rise, it now has the capability to connect these two scenarios Ahmed et al., 2025; Tareen et al., 2022; Jahangeer et al., 2023; Muhammad et al., 2024; Priyan and Devi, 2019.

For the Internet of Vehicles (IoV) paradigm to be effective, it must be able to track the location of objects (such as vehicles in this case), which can prove valuable in enabling ambulances to reach the accident site on time Shahwani et al., 2021.

SAINT+ Shen et al., 2017 suggests an effective navigation strategy that reroutes other vehicles from the emergency vehicles' navigation Bazai et al., 2025; Sulaman et al., 2022 routes in order to enable emergency vehicles to reach the accident scene. In order to prevent traffic jams near the accident scene, SAINT+ also permits other cars to take an early diversion.

B. research outcomes

- Cost-effective and highly efficient
- Contributes to saving lives
- Enhances overall safety
- Ensures low power consumption
- Minimizes the likelihood of human error
- Improves time efficiency

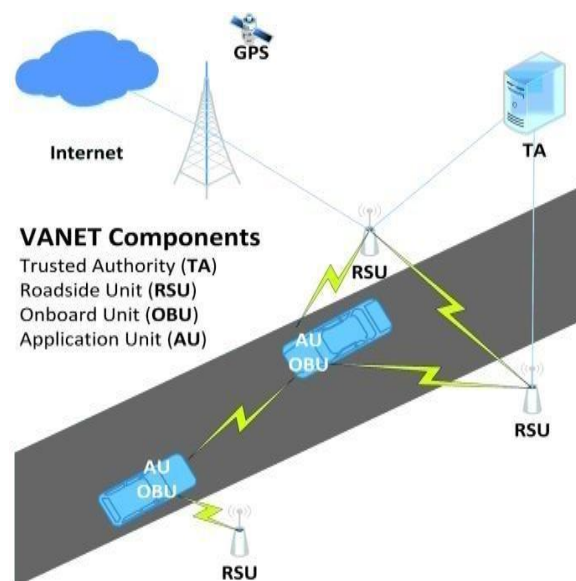


Fig. 1. VANET Components

C. VANET Description

The vehicular network is a well-organized wireless network designed to ensure passenger safety and improve driving performance. Vehicles in such networks are fully equipped with systems that enhance safety, including sensors, GPS, and communication modules. In a Vehicular Ad Hoc Network (VANET), data is primarily used to improve safety by reducing message delivery delays. To guarantee passenger safety and offer more comfortable riding, a number of message delivery methods are available.

Every vehicle that takes part in a VANET serves as a wireless router or node, facilitating communication over a distance of roughly 300 meters to one kilometre, resulting in the creation of a large-scale dynamic network. As shown in figure 1, VANET facilitates communication between cars and roadside units (RSUs), greatly increasing the effectiveness of transport networks. Because roads limit the movement of vehicles, traffic laws offer a reliable basis for

communication in particular geographic areas Hussain et al., 2020.

By exchanging crucial information including location coordinates, vehicle speed, and infrastructural configurations, VANET's main goal is to guarantee road safety. In addition to safety precautions, VANET improves user enjoyment and security by providing value-added services like email, multimedia sharing (audio/video), and other infotainment apps Shahwani et al., 2021, Tabassum et al., 2024.

D. Vision of the IoV

As seen in figure 2, IoV has a distributed network design that makes use of data produced by connected cars and VANETs. Enabling real-time communication between automobiles, human drivers, pedestrians, roadside infrastructure, and fleet management systems is one of its main goals Dandala et al., 2017. In order to improve road safety, lessen traffic congestion, and enable intelligent transport services,

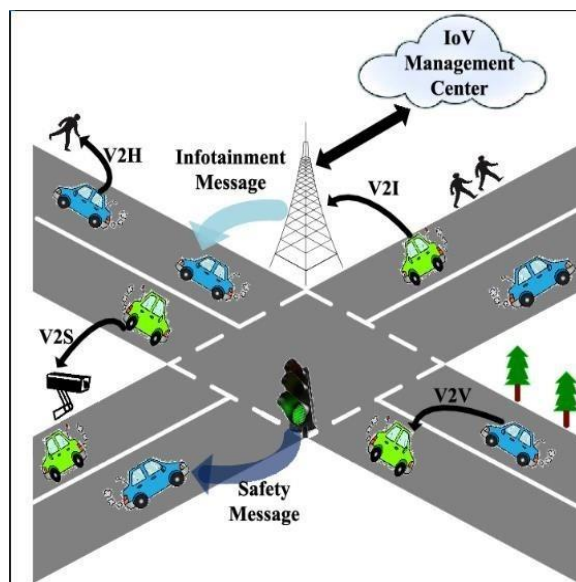


Fig. 2. Internet of Vehicle Components

such seamless communication is essential. IoV lays the groundwork for cutting-edge applications like autonomous driving assistance, accident prevention, and effective traffic management by enabling fast information interchange. IoV supports five types of network communication Ali2023:

- Intra-Vehicle Communication (IVC): Uses OBUs to track the vehicle's internal functioning..
- Vehicle-to-Vehicle (V2V): Enables the wireless exchange of information such as speed and position between surrounding vehicles.
- Vehicle-to-Infrastructure (V2I): Facilitates wireless communication between a vehicle and Roadside Units (RSUs).
- Vehicle-to-Cloud (V2C): Provides vehicles with access to additional information and services from the internet via Application Programming Interfaces (APIs).
- Vehicle-to-Pedestrian (V2P): Enhances safety and awareness for Vulnerable Road Users (VRUs), including pedestrians and cyclists.

II. JUSTIFICATION OF THE RESEARCH

In Pakistan, GSM access now extends to nearly every region, making communication widely available, affordable, and reliable. In this research,

a combination of GPS and GSM technologies is utilized. According to available statistics, a total of 104,105 road accidents occurred in Pakistan between 2008 and 2019, resulting in 44,959 fatalities and 59,146 non-fatal cases. Overall, 55,141 people lost their lives, while 126,144 sustained injuries during this period. The annual road accident fatality rate for the years 2008–2019 is illustrated in the figure 3.

In developed countries, several accidents avoidance technologies have already been deployed; for example, the eCall system in Europe provides automatic accident notification.

However, Pakistan, being a developing country with limited technological infrastructure, faces challenges in adopting such advanced solutions due to the high costs and implementation barriers. The proposed system aims to improve the efficiency of the emergency response by reducing the response time by approximately 40% in urban areas and 50% in rural areas Sharif et al., 2018.

III. PROBLEM STATEMENT

Rapid growth in urban populations and an increasing number of vehicles have led to road congestion and accidents. One of the main causes of fatality in traffic accidents is the failure to provide prompt medical attention. In such situations, automatic accident detection Hameed,

Yang, Bazai, Ghafoor, Alshehri, Khan, Baryalai, et al., 2022; Hameed, Yang, Bazai, Ghafoor, Alshehri, Khan, Ullah, et al., 2022; Haq et al., 2023; Mercan et al., 2021 can play a vital role in saving lives. In this paper, a model for automatic accident detection is proposed using VANET and IoV. With the aid of in-car sensors, the program can identify collisions and gauge the seriousness of the situation. In the event of an accident, the detected information is transmitted to a hospital through the ThingSpeak platform, where the central server can identify the accident location and the nearest medical center. The system then forwards the necessary details to an ambulance to ensure a prompt emergency response.

IV. OBJECTIVES

The main objectives of this research are outlined below:

A. General Objective

In order to reduce the number of fatalities resulting from traffic accidents, the main objective is to minimize the accident reaction time by shortening the period between a road collision and the arrival of emergency responders.

B. Specific Objectives

- Employ on-board units (OBUs) for vehicle-to-vehicle communication.
- Enhance passenger safety by promptly delivering accident information.
- Transmit accident details to the nearest emergency response center.
- Utilize the capabilities of the vehicular environment to reroute vehicles in case of emergencies.

V. INTRODUCTION TO COMPONENTS

A. Global System for Mobile Communication(GSM)

The prototype has a GSM module that sends the vehicle's position in the form of latitude and longitude coordinates via SMS to emergency responders. In this study, the most recent GSM technology is used, specifically the GSM SIM900A module, which supports a dual-band network. At

present, GSM is widely adopted by numerous service providers around the world. The SIM900A is characterized by its slim and compact design, robustness in operation, and ease of use. Additionally, it offers ultra-low power consumption in idle mode, as illustrated in the figure 4.

B. Operation/Specifications of GSM

- In the event of an accident, the GSM module automatically sends a message to a pre-programmed mobile number stored in the Arduino. It supports data, SMS, and call functionalities.
- The GSM SIM900A module operates at a standard baud rate of 9600 bps and supports dual-band frequencies of 900/1800 MHz.
- Supply voltage range: 5V.
- Low power consumption: 1.5 mA in sleep mode.

C. Global Positioning System (GPS)

- A GPS module shown in figure 5 provides reliable positioning, navigation, and timing (PNT) services to users worldwide.
- Satellites transmit microwave signals which are received and processed by GPS receivers.
- Determines the precise location of any object on Earth and is widely used in both military and civilian applications, as illustrated in the figure below.

1) GPS hardware connection: According to the GPS datasheet shown in the table I, the module operates with a supply voltage range of 3.3V to 5V. Using a wired connection, the module transmits satellite information to devices that request it, which in this case is the Arduino.

- One wire connected to 5V supply.
- One wire connected to ground (GND).
- Repeated observations at regular intervals are made possible by the GPS signal. In order to provide exact timing information and three-dimensional location (latitude, longitude, and altitude), GPS satellites send signals from space that are picked up by GPS modules.

TABLE I GPS PIN CONFIGURATION WITH ARDUINO

S.No	Name	Type	Description
1	Vcc	P	Power to be input
2	Rx	I	Data for Input
3	Tx	O	Data for output
4	GND	P	Ground
5	GND	P	Ground

D. Power Supply

In this research, power is supplied from the vehicle battery (12V) or from a separate external battery if required. A voltage regulator is used to step down and stabilize the voltage for different modules. This conversion is essential because the GSM module requires 4.2V, while the LCD and GPS modules operate at 5V. The voltage regulator

ensures that each module receives the appropriate operating voltage for reliable performance.

E. Liquid Crystal Display (LCD)

An LCD is used in this research as an output display module. It can be mounted near the dashboard, allowing the



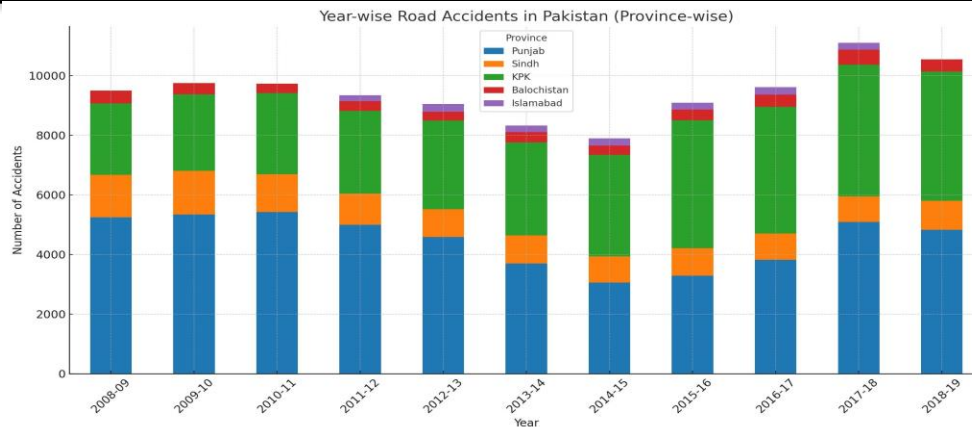


Fig. 3. Road deaths statistics of Pakistan (2008-2019)



Fig. 4. GSM SIM 900A



Fig. 5. GPS module

system's status to be monitored conveniently. LCDs are composed of multiple layers, including two polarized panels and electrodes, and function based on the principle of blocking light rather than emitting it. Since they require backlighting, LCDs consume significantly less power compared to cathode ray tubes (CRTs) or LEDs.

In this work, a 16×2 LCD with 14 pins is used as shown in figure 6. The choice of a 16×2 module provides sufficient space to display system information clearly, including messages and results. Its ease of programming and ability to display numbers, characters, and simple graphics make it

highly efficient and widely applicable in embedded systems.

F. ADXL335 Accelerometer Sensor

In this prototype, the ADXL335 accelerometer sensor given in figure 7 is used due to its wide range of applications. Accelerations brought on by motion, shock, or vibration can be measured by the sensor. It operates on the principle that 1g corresponds to an acceleration of 9.8 m/s².

Working Mechanism and Specifications: A compact, thin, low-power, three-axis accelerometer with signal conditioned voltage outputs is the ADXL335. It uses a

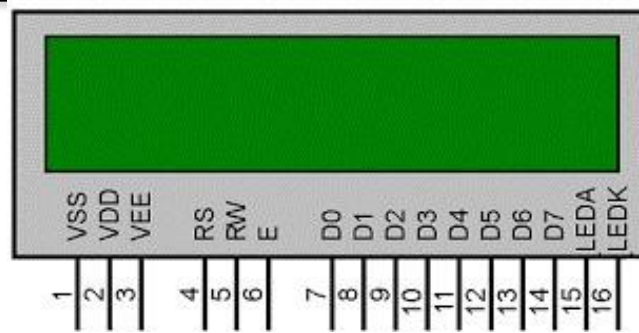


Fig. 6. Liquid Crystal Display

minimum full-scale range of $\pm 3g$ to measure acceleration. This sensor is suitable for applications such as tilt sensing, motion detection, and vibration monitoring.

- The ADXL335 provides complete 3-axis acceleration measurement.

- It measures acceleration within a range of $\pm 3g$ along the X, Y, and Z axes.
- The output signals of this module are analog voltages corresponding to the acceleration detected.

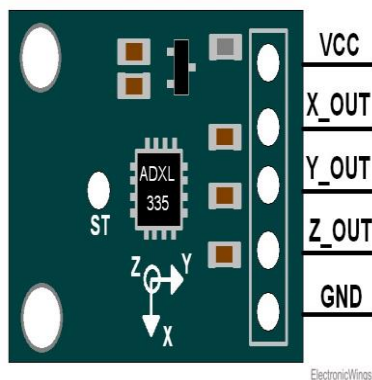


Fig. 7. ADXL 335 Accelerometer

- Vcc: Connect this to 5V.
- X-out: X switch to A0.
- Y-out: Y switch to A1.
- Z-out: Z switch to A2.
- GND: Connect this to ground here.

The ADXL335 accelerometer provides a straightforward voltage at the yield X, Y, and Z pins, which corresponds to the rising speed in distinct ways, such as X, Y, and Z as shown in figure 8

1) Angles using ADXL: The ADXL335 can determine the angle of inclination by utilizing the X, Y, and Z axis values. It is also capable of calculating roll, pitch, and yaw angles with respect to the X, Y, and Z axes. According to the ADXL335 datasheet, the maximum voltage level at 0g is 1.65V, with a sensitivity scale factor of 330 mV/g. The three-axis values are measured in degrees, typically within a range of -90° to $+90^\circ$, and -180° to $+180^\circ$, as illustrated in the figure below.

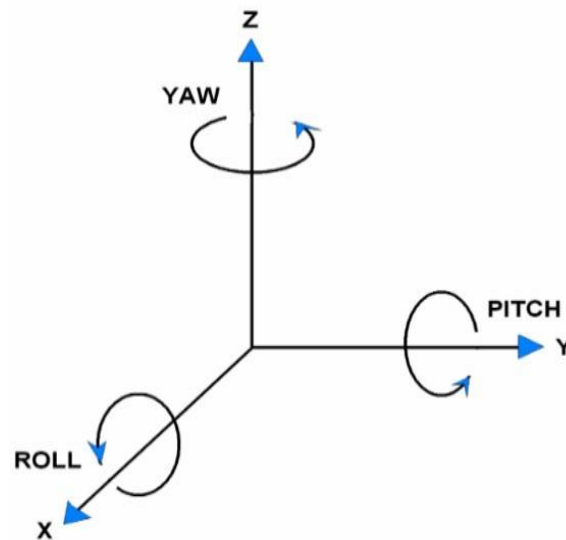


Fig. 8. Angle rotations of ADXL335

G. Arduino UNO

The Arduino UNO used in this system provides several important functions. It features 20 digital input/output pins and a reset button, and operates at 5V, the image is given in 9. Pulse Width Modulation (PWM) is employed as a technique for signal control. The Arduino Uno can be connected to a PC via a serial port using a USB cable, and it can also be powered by an external adapter.

The Arduino Uno integrates the sensors and other components connected to it in order to automatically transmit messages that notify emergency service providers about the occurrence and location of an accident. This significantly reduces the response time to reach the accident site. Arduino is an open-hardware platform that offers straightforward input/output interfaces for reading a wide range of analogue sensors and monitoring voltages.

1) Analog to Digital Converter (ADC): An on-chip multichannel analog-to-digital converter (ADC) is a feature of the Arduino Uno. It also uses Pulse Width Modulation (PWM) techniques by

toggling its digital I/O pins to generate modulated signals. The duty cycle of these PWM signals yields an output frequency of approximately 490 Hz.

2) Input pins: The Arduino Uno consists of both analog and digital pins. The analog pins (A0–A5) are used for reading sensor inputs, while the digital pins (3–11) provide output signals. Input from the analog pins is processed through the Analog-to-Digital Converter (ADC), and output is generated through the digital pins.

To read values from the analog pins, the reference type is defined in the code, followed by the command `analogRead(pin)`. For generating PWM output, the command `pinMode(pin, mode)` is used to configure the digital pins, followed by `analogWrite(pin, value)` for signal output. These functions allow proper utilization of the analog and digital capabilities of the Arduino Uno.

The input pins can support a drive current of up to 40 mA, making them suitable for direct interfacing with a wide range of sensors, as illustrated in the figure below.



Fig. 9. Arduino UNO

H. Field Work Description

Data collection techniques are as follows:

1) Data collection Techniques and Methods: After reviewing the survey, the following data collection methods were utilized: online journals, published reports, data analysis reports, physical evidence, knowledge tests, and personal experience gained during four years at university. The choice of these methods was guided by the need to balance resource availability, reliability, analytical requirements, and research skills.

During the data collection process, different research papers were studied. Consultations were held with hospital doctors, as they have extensive knowledge of road accident cases. Meetings were also conducted with Road Traffic Authorities (RTAs) and traffic police to obtain statistical data on accident occurrences. In addition, interactions were made with families of accident victims through surveys to gather first-hand information.

To add to the information gathered, a variety of academic publications and internet resources on traffic accidents were examined. Following the collection of this data, it was methodically examined and cross-checked with the intended audience to confirm conclusions. Based on the investigation, a thorough summary of the used data collection methods was subsequently created.

2) Ethical Dilemmas and Limitations during research : During the fieldwork, flexibility and precise data collecting were crucial factors. The construction of the suggested system was fraught with difficulties and moral conundrums. First, because research publications and hospital surveys did not offer a thorough summary of the necessary data, there were constraints in the data collection process. Second, many of the hardware components required for research implementation were either hard to get locally in Pakistan or unavailable. To address this, detailed specifications of the required components were researched online. Thirdly, challenges were encountered in managing the overall cost of implementation and maintenance of the research. These constraints significantly influenced the fieldwork, hardware implementation, and the accurate collection of sensor data.

I. Think-Speak Server

A cloud-based IoT analytics platform service called ThingSpeak makes it possible to aggregate, visualise, and analyse real-time data streams Asghar et al., 2021. Data can be transmitted to ThingSpeak from connected devices, where it can be processed and visualized in real time. The platform also supports generating instant graphical representations of live data and sending alerts or

notifications based on predefined conditions, as illustrated in the figure 10.

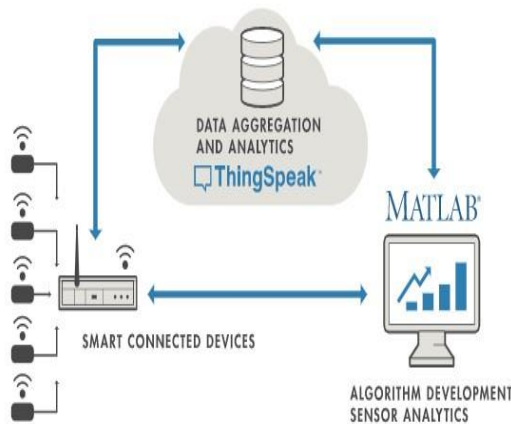


Fig. 10. Think-speak server

1) Connect the Hardware to ThingSpeak: ThingSpeak can be used with a wide range of Internet-enabled devices as given in flow diagram 11. When transmitting data from such devices or equipment, developers can utilize native libraries

available for popular embedded prototyping platforms such as Arduino, ESP8266, Particle, and Raspberry Pi. These libraries simplify integration and allow seamless communication with the ThingSpeak cloud for real-time data collection and analysis.

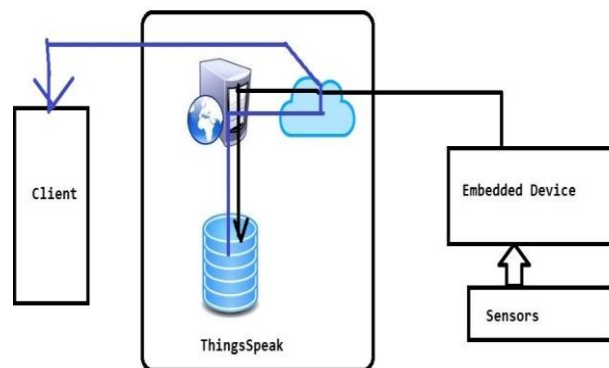


Fig. 11. Flow chart of Think-speak

2) Access the information both on the web and disconnected: ThingSpeak stores all transmitted information in a centralized cloud repository, allowing users to easily access the data for both online and offline analysis. Private data is protected through an API key that remains under the user’s control Bazai and Jang-Jaccard, 2019, 2020; Bazai, Jang-Jaccard, and Wang, 2017; Bazai, Jang-Jaccard, and Zhang, 2017; Bazai et al., 2019, 2021 . Once logged into a ThingSpeak account,

data stored in the cloud can be securely downloaded via the web. Furthermore, the platform supports automatic data retrieval in CSV format using REST API calls with the appropriate API key. A cloud-based IoT analytics platform service called ThingSpeak makes it possible to aggregate, visualise, and analyse real-time data streams.

J. Program and software

The software and programs used in the research are described as follows:

- 1) Proteus: A proprietary software program for electronic design automation (EDA) is called Proteus. Electronic design engineers and experts frequently use it to produce electronic layouts and schematics for printed circuit boards (PCBs). The suite includes the ISIS software, which is used for schematic design and real-time circuit simulation. In this research, Proteus was utilized to simulate the Arduino-based implementation, as illustrated in the figure 12.
- 2) Arduino Software : Arduino is a cross-platform application developed using functions from C and C++. Its main purpose is to write and upload programs to Arduino compatible boards, but it may also be used with development boards

from other vendors with the aid of third-party cores. The GNU General Public License (GPL) governs the distribution of the Arduino IDE’s source code. Both C and C++ are supported by Arduino, along with particular code organisation guidelines. It offers a standard software library with a variety of frequently used input and output functions that is generated from the Wiring research.

User-defined code requires only two essential functions: one to initialize the sketch and another to define the main program loop. The GNU toolchain, which comes with the distribution, is used to compile these routines and link them with a program stub into an executable cyclic executive program. The process is illustrated in the figure 13.

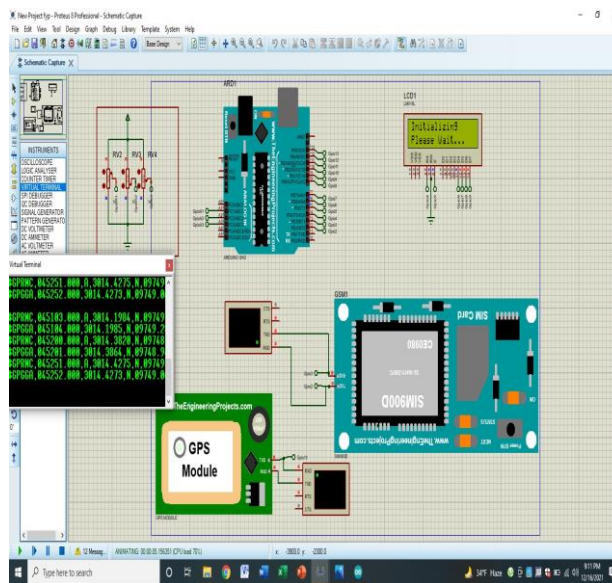


Fig. 12. Circuit diagram of Think-speak

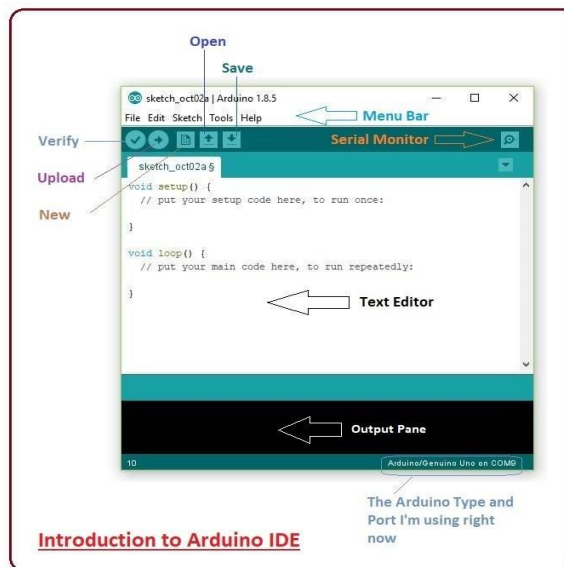


Fig. 13. Arduino platform

K. Hardware interfacing of research Circuit diagram is depicted in Figure below: This system integrates multiple components, including Arduino, GSM, GPS, and an accelerometer, given in circuit diagram in figure 14. A 12V power supply is provided to the system. The digital pins 2 and 3 of the Arduino are connected to the GSM module,

while digital pins 10 and 11 are assigned to the GPS module. Both the GSM and GPS modules operate on 4.2V supplied through a voltage regulator. The LCD module uses the Serial Clock Line (SCL) and Serial Data Line (SDA), which are connected to Arduino digital pins 4 and 5.

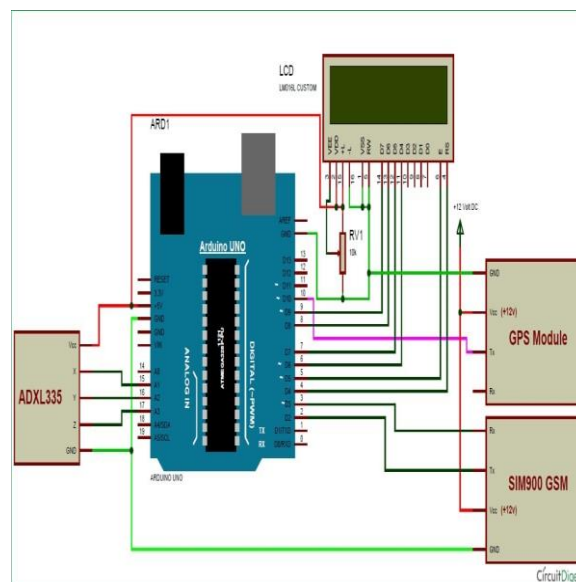


Fig. 14. circuit diagram

For the accelerometer, one wire is connected to the 5V supply, while the X, Y, and Z output pins are connected to the Arduino analog pins A1, A2, and A3, respectively. The ground pin of the accelerometer is connected to the Arduino ground. A control switch is also connected to the 12V supply; this switch allows the driver to prevent the system from sending a false emergency message in case of a non-critical event.

Since the Arduino's default serial pins (0 and 1) are reserved, software-defined serial pins (10 and 11) are configured for GPS communication. Various libraries for GPS, GSM, and the accelerometer were included in the Arduino code, which was

written according to the pin configuration defined in the hardware.

1) Placing and Location of objects in Vehicles: The research sensing units and items are put in the dashboard of the vehicle and detecting units will be put in the safety belt. Different areas are portrayed in the figure 15

VI. LITERATURE REVIEW

A. Theoretical Framework

The domain of accident detection has been extensively studied, with various researchers employing different techniques to identify accident events. The majority of methods rely on mechanical sensors to identify collisions, and they



Fig. 15. Location of sensors

interface with these sensors using smartphones or Android based apps to connect to medical facilities via mobile data networks. While many of these solutions are reliable, they often depend on specific instruments, hardware requirements, and continuous mobile data services, which are constrained by the limited battery capacity of smartphones. A few of the proposed solutions from the literature are discussed in the following sections.

Modern communication technologies integrated into vehicles provide new opportunities to improve assistance for individuals injured in traffic accidents Eze et al., 2016. Recent research shows how artificial intelligence (AI) systems that can automate many of the decisions needed by

emergency services might support communication capabilities Tabassum et al., 2022, Akram et al., 2023, Noor et al., 2023, Hamza et al., 2023. This enables a more efficient allocation of rescue resources according to the severity of the accident, thereby reducing response times Washington et al., 2020.

To further improve the overall rescue process, rapid and accurate estimation of accident severity is a key factor in helping emergency services assess the necessary resources. The proposed system offers a novel intelligent framework that can automatically detect traffic accidents, notify responders via vehicle networks, and evaluate the accident's severity using contextual data and inferred information. The method improves the

promptness and efficiency of emergency response by taking into account the most important variables that define accident severity.

B. Conceptual Framework

Additionally, on-board technologies are used to monitor impact forces, especially in frontal collisions, in order to detect accidents. Following the confirmation of an accident, these systems provide details about the occurrence via email or SMS to a designated recipient. This is followed by a prearranged call to emergency management agencies. Although these programs have appealing features, their functionality depends on whether internet access is available at the scene of the accident. Depending on a number of factors, like the unavailability of the mobile network, device malfunctions, or battery depletion from running numerous apps on the same device at once, this dependency may lead to failure.

Additionally, some academics have suggested utilising contextual information in conjunction with smartphones' built-in sensors to identify accidents Dhanasekar and Subramanian, 2016. Vehicles with integrated sensors are able to detect abrupt acceleration or deceleration and use web based communication to send notifications to the emergency assistance centre. Despite being a promising strategy, this approach has the same drawbacks as previously mentioned methods, especially with regard to its need on mobile devices and constant internet access.

C. Empirical Framework

Creating a framework that can satisfy application needs while lowering hardware, deployment, and service costs is the main driving force behind this design concept. Adopting Vehicular Ad Hoc Networks (VANETs) is a workable solution to this major problem since more and more modern cars are outfitted with wireless interfaces. A subtype of

ad hoc networks called VANETs was created especially to function in automotive settings with low setup costs. When it is required to broadcast alerts to neighbouring nodes—for instance, to inform of an accident, recommend a different route, or make room for a rescue vehicle in an emergency—this technology can be used to distribute messages throughout the network. Even when running on low-power devices, such connectivity is effectively supported by small sensor devices and other On-Board Units (OBUs) under the Internet of Vehicles (IoV) framework.

VII. METHODOLOGY

Important books and journals were examined based on the stated viewpoint, especially those that addressed accident detection employing GPS and GSM technology for vehicle tracking. This strategy is in line with the goals of the current project, which uses Arduino to process sensor data and then send an alert message over GSM to an authorised mobile number and the ThingSpeak server. Additionally, there is an override option that enables the driver to press a switch in the event of a non-emergency or false alarm. Therefore, if there hasn't been an emergency, the hardware features a reset mechanism that needs to be turned on.

For short-range communication, an RF module is also incorporated. As seen in the illustration, the RF module warns oncoming cars of an impending collision, causing them to slow down and move cautiously. 16.

- The system is powered on and begins operation.
- The accelerometer sensor (ADXL335) continuously monitors readings, and any unusual acceleration is analyzed.
- The Arduino processes the detected parameters and executes the decision logic.
-

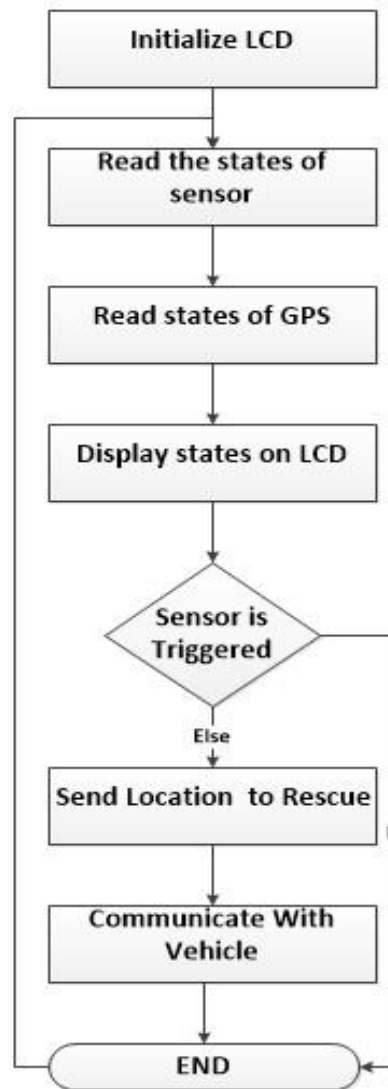


Fig. 16. flow chart

- If an accident is detected, the Arduino activates the GPS receiver, retrieves the vehicle's location, and forwards it to the GSM module. If no accident is detected, the process cycle repeats.
- The GSM module, controlled by the Arduino, transmits the location coordinates along with vehicle identification details to emergency responders.
- If there is no emergency, the driver can press the reset button to cancel the alert, preventing any data from being sent to responders.

- In case of an accident, the RF module is activated to alert approaching vehicles, warning them to reduce speed and proceed cautiously.

VIII. RESULTS AND DISCUSSIONS

A. Overall working operation of research

After collecting the information and analyzing the research statistics, the system was implemented and a complete prototype was developed. The programming and interfacing of the Arduino were carried out during implementation, integrating the GPS, GSM, and accelerometer modules. For

system output, a 16×2 LCD was used to display status updates.

The accelerometer sensor (ADXL335) was positioned at a specific location in the vehicle. When an accident occurs, the sensor detects the collision and generates a signal, which is indicated by an LED on the device. After receiving this signal, the Arduino carries out the preprogrammed commands. The Arduino reads data across the second axis if the accelerometer's base output of 3V is greater than the specified reference voltage. Location coordinates obtained from the ADXL sensor and GPS module are then processed by the Arduino. The GSM module subsequently sends the accident location and an accident notification message to the program-stored predetermined number. Although personal cell numbers were utilised during testing, the predetermined number might be associated with an emergency response service. Additionally, the data is sent to the ThingSpeak server. Messages were transmitted with an average delay of about six seconds. Coordinates of the accident site and its time of occurrence are included in the Minimum Set of Data (MSD). This greatly lowers the number of fatalities by allowing emergency personnel to swiftly reach patients. Family members of the victims can view client information stored on the ThingSpeak server, including channel credentials. If there is no emergency, the driver can cancel the alarm by

pressing the reset button within 30 seconds. The GPS value can thus be a little off from the real position. Furthermore, the device may be triggered by needless shocks or vibrations; nevertheless, the application calibrates the accelerometer using roll, pitch, and yaw characteristics to filter out false triggers. Thus, the system reliably collects and processes data across the vehicle.

The system is powered straight from the vehicle's supply and fitted inside the car. The mechanism immediately engages and functions as intended once the engine begins. When the engine is switched off, it deactivates. Vehicular Ad Hoc Networks (VANETs) can be used to expand the system's capability to a smart vehicle environment. Through roadside devices and vehicle-to-vehicle communication, VANETs provide traffic management, which lowers the risk of accidents by increasing traffic flow and decreasing delays.

Additionally, the RF module is activated by the ADXL335 when it senses an accident, alerting oncoming cars to slow down and drive carefully.

The ADXL 335 sensor detects the accident, the Arduino will collect the GPS location and combine it with google map link and send it through GSM at register number given in figure 17. The RF module will start communication with the upcoming vehicle that accident happened. After clicking on the link we receive it in the inbox. The google map will open

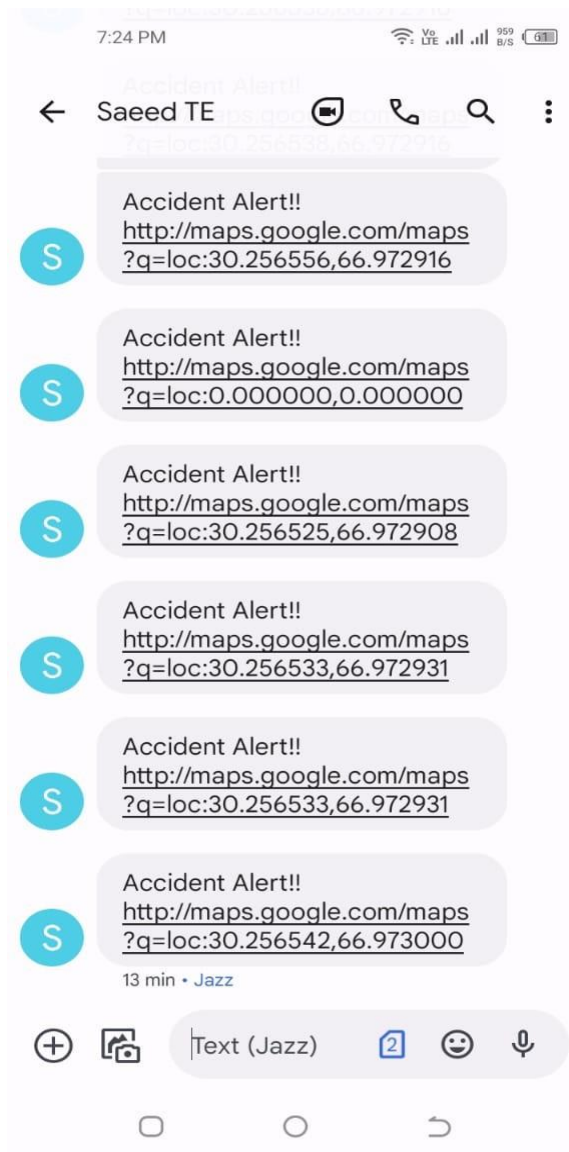


Fig. 17. Received SMS from GSM and show the exit location of accident spot as given in figure 18.



Fig. 18. Google Map Location

IX. CONCLUSION AND FUTURE WORK

An efficient, dependable, and economical approach to accident detection and reaction is provided by this study. To reduce reaction times and precisely locate accidents, the suggested architecture combines Arduino with GPS, GSM, and an accelerometer sensor. The system improves road safety, lessens the severity of accidents, and creates safer driving conditions by utilising current technologies. It is tailored to the social, political, and economic contexts of emerging nations and has demonstrated efficacy.

Additionally, the technology reduces the time between an accident and the arrival of emergency responders by addressing the lack of automated methods for location tracking and accident detection. This increases the likelihood that victims will receive treatment in a timely manner and may eventually save many lives.

Because of its adaptability, the accident detection framework can be used for a wide range of embedded system integrations.

The following improvements are suggested for the proposed prototype:

- A remote webcam can be integrated to capture images of the accident site, providing additional information for emergency responders.
- The system can be interfaced with the airbag mechanism for enhanced driver safety.

- Braking systems can be automatically locked to help prevent further vehicle movement after an incident.
- A warning light or loud horn can be added to alert nearby people in case of an accident.
- A proximity sensor can be included as a buzzer to generate a beep sound before a potential collision, serving as an early safety alert for the driver.

REFERENCES

- Ahmed, M., Ghafoor, M. I., Bazai, S. U., Sardor, S., Bhatti, U. A., & Eshchanov, T. (2025). Hybrid ml approach for robust intrusion detection in iot networks. 2025 IEEE 2nd International Conference on Deep Learning and Computer Vision (DLCV), 1-6.
- Akram, S., Bazai, S. U., Ghafoor, M. I., Marjan, S., Hamza, M., & Shah, S. A. A. (2023, March). Systematic literature review: Evaluating effects of adversarial attacks and attack generation methods. In 2023 International Conference on Energy, Power, Environment, Control, and Computing (ICEPECC) (pp. 1-6). IEEE.

- Asgar, M. N., Saleemi, F. J., Iqbal, S., Chaudhry, M. U., Yasir, M., Bazai, S. U., & Khan, M. Q. (2021). A novel parts of speech (pos) tagset for morphological, syntactic and lexical annotations of saraiki language. *Journal of Applied and Emerging Sciences*, 11(1), pp-77.
- Bazai, S. U., & Jang-Jaccard, J. (2019). Sparkda: Rdd-based high-performance data anonymization technique for spark platform. *International conference on network and system security*, 646-662.
- Bazai, S. U., & Jang-Jaccard, J. (2020). In-memory data anonymization using scalable and high performance rdd design. *Electronics*, 9(10), 1732.
- Bazai, S. U., Jang-Jaccard, J., & Alavizadeh, H. (2021). A novel hybrid approach for multi-dimensional data anonymization for apache spark. *ACM Transactions on Privacy and Security*, 25(1), 1-25.
- Bazai, S. U., Jang-Jaccard, J., & Wang, R. (2017). Anonymizing k-nn classification on mapreduce. *International conference on mobile networks and management*, 364-377.
- Bazai, S. U., Jang-Jaccard, J., & Zhang, X. (2017). A privacy preserving platform for mapreduce. *International conference on applications and techniques in information security*, 88-99.
- Bazai, S. U., Jang-Jaccard, J., & Zhang, X. (2019). Scalable big data privacy with mapreduce. In *Encyclopedia of big data technologies* (pp. 1454-1462). Springer.
- Bazai, S. U., Naushad, A., Bhatti, U. A., Ashirova, A. I., Nurmatovich, H. A., et al. (2025). Proximal policy optimization based autonomous navigation in dynamic environment using lidar-camera fusion technique. *2025 IEEE 2nd International Conference on Deep Learning and Computer Vision (DLCV)*, 1-6. Dandala, T. T., Krishnamurthy, V., & Alwan, R. (2017). Internet of vehicles (ioV) for traffic management. *2017 International conference on computer, communication and signal processing (ICCCSP)*, 1-4.
- Dhanasekar, N., & Subramanian, G. G. (2016). Accidental navigation and rescue system using gsm and gps technology. *Asian Journal of Research in Social Sciences and Humanities*, 6(11), 158-166.
- Eze, E. C., Zhang, S.-J., Liu, E.-J., & Eze, J. C. (2016). Advances in vehicular ad-hoc networks (vanets): Challenges and road-map for future development. *International Journal of Automation and Computing*, 13(1), 1-18.
- Hameed, M., Yang, F., Bazai, S. U., Ghafoor, M. I., Alshehri, A., Khan, I., Baryalai, M., Andualem, M., & Jaskani, F. H. (2022). Urbanization detection using lidar-based remote sensing images of azad kashmir using novel 3d cnns. *Journal of Sensors*, 2022(1), 6430120.
- Hameed, M., Yang, F., Bazai, S. U., Ghafoor, M. I., Alshehri, A., Khan, I., Ullah, S., Baryalai, M., Jaskani, F. H., & Andualem, M. (2022). Convolutional autoencoder-based deep learning approach for aerosol emission detection using lidar dataset. *Journal of Sensors*, 2022(1), 3690312.
- Haq, S. U., Bazai, S. U., Fatima, A., Marjan, S., Yang, J., Por, L. Y., Anjum, M., Shahab, S., & Ku, C. S. (2023). Reseek-arrhythmia: Empirical evaluation of resnet architecture for detection of arrhythmia. *Diagnostics*, 13(18), 2867.
- Hussain, R., Lee, J., & Zeadally, S. (2020). Trust in vanet: A survey of current solutions and future research opportunities. *IEEE transactions on intelligent transportation systems*, 22(5), 2553-2571.
- Hamza, M., Bazai, S. U., Ghafoor, M. I., Ullah, S., Akram, S., & Khan, M. S. (2023, March). Generative adversarial networks (gans) video framework: A systematic literature review. In *2023 International Conference on Energy, Power, Environment, Control, and Computing (ICEPECC)* (pp. 1-5). IEEE.
- Jahangeer, A., Bazai, S. U., Aslam, S., Marjan, S., Anas, M., & Hashemi, S. H. (2023). A review on the security of iot networks: From network layer's perspective. *IEEE Access*, 11, 71073-71087.

- Ji, B., Zhang, X., Mumtaz, S., Han, C., Li, C., Wen, H., & Wang, D. (2020). Survey on the internet of vehicles: Network architectures and applications. *IEEE Communications Standards Magazine*, 4(1), 34-41.
- Lee, E.-K., Gerla, M., Pau, G., Lee, U., & Lim, J.-H. (2016). Internet of vehicles: From intelligent grid to autonomous cars and vehicular fogs. *International Journal of Distributed Sensor Networks*, 12(9), 1550147716665500.
- Mercan, V., Jamil, A., Hameed, A. A., Magsi, I. A., Bazai, S., & Shah, S. A. (2021). Hate speech and offensive language detection from social media. *2021 International Conference on Computing, Electronic and Electrical Engineering (ICE Cube)*, 1-5.
- Muhammad, M., Bazai, S. U., Ullah, S., Shah, S. A. A., Aslam, S., Amphawan, A., & Neo, T.-K. (2024). A systematic literature review on the role of big data in iot security. *Journal of Telecommunications and the Digital Economy*, 12(1), 39-64.
- Noor, S., Bazai, S. U., Ghafoor, M. I., Marjan, S., Akram, S., & Ali, F. (2023, March). Generative adversarial networks for anomaly detection: a systematic literature review. In *2023 4th International Conference on Computing, Mathematics and Engineering Technologies (iCoMET)* (pp. 1-6). IEEE.
- Priyan, M., & Devi, G. U. (2019). A survey on internet of vehicles: Applications, technologies, challenges and opportunities. *International Journal of Advanced Intelligence Paradigms*, 12(1-2), 98-119.
- Shahwani, H., Bui, T. D., Jeong, J. P., & Shin, J. (2017). A stable clustering algorithm based on affinity propagation for vanets. *2017 19th International Conference on Advanced Communication Technology (ICACT)*, 501-504.
- Shahwani, H., Shah, S. A., Ashraf, M., Akram, M., Jeong, J. P., & Shin, J. (2021). A comprehensive survey on data dissemination in vehicular ad hoc networks. *Vehicular Communications*, 100420.
- Sharif, A., Li, J. P., & Saleem, M. A. (2018). Internet of things enabled vehicular and ad hoc networks for smart city traffic monitoring and controlling: A review. *International Journal of Advanced Networking and Applications*, 10(3), 3833-3842.
- Shen, Y., Lee, J., Jeong, H., Jeong, J., Lee, E., & Du, D. H. (2017). Saint+: Self-adaptive interactive navigation tool+ for emergency service delivery optimization. *IEEE Transactions on Intelligent Transportation Systems*, 19(4), 1038-1053.
- Sulaman, M., ullah Bazai, S., AKram, M., & Khan, M. A. (2022). The deep learning based smart navigational stick for blind people. *UMT Artificial Intelligence Review*, 2(2).
- Tabassum, I., & Bazai, S. U. (2024). Augmenting Multimedia Analysis. *Deep Learning for Multimedia Processing Applications: Volume One: Image Security and Intelligent Systems for Multimedia Processing*, 194.
- Tabassum, I., Bazai, S. U., Zaland, Z., Marjan, S., Khan, M. Z., & Ghafoor, M. I. (2022). Cyber Security's Silver Bullet-A Systematic Literature Review of AI-Powered Security. *2022 3rd International Informatics and Software Engineering Conference (IISEC)*, 1-7. IEEE.
- Tareen, S., Bazai, S. U., Ullah, S., Ullah, R., Marjan, S., & Ghafoor, M. I. (2022). Phishing and intrusion attacks: an overview of classification mechanisms. *2022 3rd International Informatics and Software Engineering Conference (IISEC)*, 1-5. IEEE.
- Thakur, A., & Malekian, R. (2019). Fog computing for detecting vehicular congestion, an internet of vehicles based approach: A review. *IEEE Intelligent Transportation Systems Magazine*, 11(2), 8-16.
- Washington, S., Karlaftis, M., Mannering, F., & Anastasopoulos, P. (2020). *Statistical and econometric methods for transportation data analysis*. Chapman; Hall/CRC.