Problem Solving with Intelligent Intrusion Detection Using Deep Learning and Iot: A Review

Jay Ashokkumar Soliya[1], Amarsinh Bhimrao Varpe[2], Anil Patel[3]
Faculty of Engineering & Technology Parul University, Vadodara, Gujarat, India.

Abstract— **This study aims to develop an intelligent intrusion detection and alert system by utilising machine learning and internet of things components. The setup uses a PIR sensor and an Arduino Uno to detect motion. Motion events are recorded after data has been collected and preprocessed. Machine learning techniques that recognise motion patterns, such as Random Forest and Decision Tree, are used to distinguish between humans and animals. When the system senses a human presence, it notifies the SIM900A module. Using a camera module in conjunction with a cloud-based server for Deep Learning analysis is an add-on that may be utilised to increase detection accuracy. This approach uses real-time data processing and machine learning to provide a robust intrusion detection solution.**

*Keywords—***Intrusion Detection, IoT, Machine Learning, PIR Sensor, Notification Setup, SIM900A Module, Ultrasonic Sensor, IR Sensor, Arduino Uno, OV7670 Camera.**

I. INTRODUCTION

Strong surveillance systems are essential for timely intrusion detection and reaction, as border security is a major concern. In order to improve monitoring, the "Advanced IoT-Based Border Surveillance and Intrusion Detection System" combines hardware elements like the Arduino Uno and Arducam with IR, PIR, Lidar, seismic, and acoustic sensors. The system attempts to quickly warn a control room, identify intrusions, and record photographs by using the Thing Speak web server and the MQTT protocol for real-time data transfer and notifications. Among its main benefits are the ability to integrate several sensors for increased precision, real-time monitoring, fast reaction times, affordability, and scalability. However, to properly confirm its efficacy and usability, comprehensive documentation on the user interface and performance data is required, as well as intensive real-world testing [1].

Embedded systems are more compact and effective than traditional computers because they are specialized electronic devices with integrated microprocessors made to carry out particular functions. Embedded systems, as opposed to general-purpose computers, are designed with speed and efficiency in mind, frequently utilizing specialized programming languages and development tools. Microprocessors allow for greater customization and device enhancement, although embedded systems are usually less flexible and need physical circuitry alterations. These systems are widely used in consumer goods, and new chips are regularly incorporated into a wide range of gadgets. Smaller organizations could use consulting services to assess the benefits of embedded systems, since they contain significant value in industries that require optimized performance despite their potential high cost due to lengthy development cycles [2].

Modern solutions to guard against invasions are becoming more and more necessary as concerns about home security grow. The paper "I0T-Based Smart Intruder Detection System for Smart Homes" presents a state-of-the-art system that combines node MCU hardware, ultrasonic sensors, and the Blynk application for real-time alerts and notifications. By quickly alerting homeowners to intrusions through an in-home alarm and Blynk smartphone notifications, this technology seeks to improve home security. With its scalable design that allows it to cover more areas or different access points, as well as its real-time alert feature, this inexpensive and user-friendly device is ideal for a wide number of households. Though mainly designed for home security applications, its efficacy and dependability are highly dependent on the stability of the cloud-based Blynk program [3].

Despite the lack of exact accuracy metrics or performance evaluations for the dataset or models utilized, the study investigates a sophisticated security system intended to improve home security through a holistic approach. The system places a strong emphasis on the application of complex algorithms in an effort to lower false alarms and

increase dependability. Having a dependable wireless connection, a flexible architecture, and an automated, user-friendly, and affordable solution are important goals. The research aims to determine prevalent security flaws, assess deep learning models' efficacy, and investigate less expensive substitutes for conventional home security systems. In the end, the suggested method aims to provide a useful, affordable, and effective way to protect households from various dangers [4].

The security system described in the paper "I0T Based Intruder Detection System Using GSM" is powered by an AVR At mega 8A microcontroller and employs GSM technology for dependable communication. It uses sensors such as the MC-38 magnetic switch and the SW-420 vibration sensor to identify breaches, and when an incursion is found, the GSM Module (SIM800L) sends out SMS notifications. The system is an affordable and low-maintenance solution due to its modular and flexible architecture. Although the study lacks exact accuracy assessments and datasets, using GSM lowers the dangers associated with internet-based systems and facilitates rapid growth. Additionally, relying solely on SMS may provide challenges in places with spotty cellular coverage. Not with standing these shortcomings, the system appears to be a dependable and reasonably priced security choice [5].

Beginning with the growing significance of security in homes and offices due to rising risks like theft and housebreaking, Arinde Victor Adeshina and Idowu Liberty Abraham's report "Multi-Sensor Intrusion Detector System" highlights this point. Setting the stage for their research on improving property security through the integration of several sensors and communication technologies, it emphasizes the necessity of an advanced, automated intrusion detection system that makes use of contemporary technologies to offer real-time alerts [6].

In response to the surge in small time crimes including theft and robbery, Olagundoye John Abiodun and Okwori Anthony Okpe's study "Smart Home Security using Arduino-based Internet of Things (I0Ts) Intrusion Detection System" highlights the growing need for sophisticated home security systems. It describes how conventional security measures gave way to contemporary electronic systems and emphasises the value of Internet of Things-based solutions for alerts and real-time monitoring. The main goal of the article is to create a smart home security system that uses Arduino and Internet of Things (I0T) technologies to improve security in real time by sending out SMS messages [7].

II.LITERATURE REVIEW

In this research in latest paper review, we discuss about the numbers of components are used to detect the intrusion by their behavior and give alert to the respective owner.
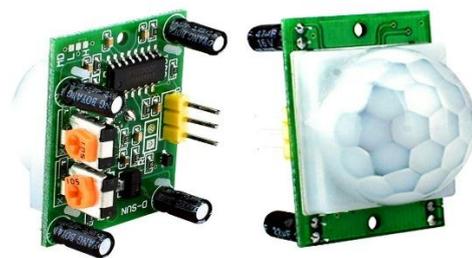
A. PIR Sensor (Passive Infrared Sensor)

Fig.1. PIR Sensor

Ishan Thakral1., et.al. (2023)., has worked on "The Advanced IoT-Based Border Surveillance and Intrusion Detection System", paper describes a hardware-rich surveillance system that uses an Arduino Uno and Arducam among other hardware components to provide high resolution monitoring. The Passive Infrared (PIR) sensor is one of the many sensors used, and it is very important. By monitoring variations in infrared radiation levels, which are generally emitted by human bodies, PIR sensors are used to identify motion. The main purpose of the PIR sensor in this setup is to identify the movement of potential intruders. The ability to detect motion is crucial for timely replies, since it prompts the camera module to take pictures of the intruder and transmits real-time notifications to the control room through the Thing Speak web server and MQTT protocol [8].

K. Vijayaprabakaran*., (2021)., in its specified setup, the publication "I0T Based Smart Intruder Detection System for Smart Homes" does not specifically address using a Passive Infrared (PIR) sensor. Rather, the system uses NodeMCU and ultrasonic sensors to identify intruders and deliver notifications in real time through the Blynk app. By timing the time, it takes for sound waves to return from an item, ultrasonic sensors can identify intruders by detecting motion or presence. As the control unit, the NodeMCU processes sensor data and

communicates with the Blynk app to alert homeowners to any incursion that is detected. When these elements are combined, a user-friendly, cost-effective home security system is produced. Although the system's primary application is with ultrasonic sensors [9].

Kanaujia, V. K., (2024)., was the Passive Infrared (PIR) sensor is an essential part of the study on building an intelligent home security system using Arduino technology and Internet of Things (I0T) sensors for detecting movements and possible intruders. The way PIR sensors work is that they pick up on infrared radiation that is released by living things, mostly human bodies. This allows the system to detect unauthorized movements inside the residence. The Arduino Uno R3 microcontroller receives a signal from the PIR sensor when it senses motion. The microcontroller interprets the data and initiates the proper response. This may include setting off an alarm, sending the homeowner a notification through a mobile app, or employing infrared cameras to take pictures or movies. The PIR sensor's integration improves the system's capacity to offer automatic intrusion detection and alerts, guaranteeing [10].

Golder, A., et.al., (2023)., was presented by using infrared light from objects in its area of vision to detect motion, the Passive Infra-Red (PIR) sensor is a vital component of the system. This sensor, which operates between 3 and 5 volts and requires just 100 to 150 uA of current, is prized for its affordability, simplicity, and low power consumption. It works well in harsh temperatures between -20°C and 70°C and can detect movement within a range of 0.1 to 6 meters. The wavelength range in which the PIR sensor functions is 7μm to 14μm, which is equivalent to the infrared light generated by both humans and animals. It also has a 120° wide field of view, which guarantees thorough coverage for motion detection in the monitored area [11].

Arinde, V., et.al., (2024)., has used the Multi-Sensor Intrusion Detection System relies heavily on the PIR (Passive Infrared) sensor to identify unwanted movement within its detection range. It detects infrared radiation from objects in its field of view, concentrating on the heat that human bodies release. The PIR sensor produces an electrical signal when it picks up this kind of infrared radiation, which suggests that an intruder is present. The

microcontroller in the device then processes this signal and sounds an alert. The PIR sensor is a crucial part of recognizing intruders in real-time and improving the overall security of the premises because of its capacity to detect motion through changes in infrared levels [12].

Abiodun, O. J., (2024)., had worked on the Passive Infrared (PIR) sensor is an essential component of smart home security systems because it uses human body radiation to detect infrared radiation to determine the presence of intruders. The PIR sensor senses a change in infrared radiation levels when an intruder enters the monitored area. It then sets off an alarm system, frequently alerting the homeowner via SMS. Because it allows for real-time monitoring and quick reaction to unwanted incursions, the PIR sensor is therefore a crucial part of intrusion detection systems. The sensor's precise motion detection greatly increases the efficacy of the system, resulting in dependable home security [13].

Singh, P., Chaudhary., (2024)., worked on in their worked an essential part of motion detection systems is the PIR (Passive Infrared) sensor, an electrical gadget that senses infrared radiation generated by objects in its field of vision. When an object, like a person or animal, moves over its sensor area, the device detects the change in infrared radiation levels inside its field of view. This movement modifies the infrared radiation that the sensor detects, which in turn modifies the electrical signal that is generated. PIR sensors are quite good at spotting motion, but they are unable to pinpoint the precise attributes of the thing they are detecting. As such, they find widespread application in security systems, including automated lighting controls and burglar alarms, where their capacity to detect motion is leveraged to enhance security and convenience [14].

B. GSM Module:

Fig.2. GSM900A Module

Iyer, S., Gaonkar., (2020)., has presented I0T Based Intruder Detection System Using GSM discusses

how important it is for the intruder detection system to have dependable communication. An AVR Atmega 8A microcontroller powers the system, processing data from sensors like the MC-38 magnetic switch and SW-420 vibration sensor to find breaches. The microcontroller uses the GSM Module (SIM800L) to send SMS notifications to the user's mobile application immediately upon detecting an incursion. One of the system's main benefits is its utilisation of GSM technology, which reduces the hazards involved with internet-based communication systems and provides users with a more dependable way to get alerts. The GSM-based strategy guarantees [15].

Golder, A., Gupta.,(2023)., has worked GSM technology is essential to the home security system under discussion since it guarantees dependable and prompt communication for real-time alerts. To communicate with the user's mobile phone, the system makes use of a GSM module, more precisely the SIMCOM SIM900 GSM modem. The system may send out instant notifications through mobile phone calls when motion is detected when the GSM module is combined with an Arduino Uno microcontroller and PIR sensors. This strategy responds to the growing demand for trustworthy security measures due to an increase in criminal activity. The GSM module is essential to the operation of the system since it gives homeowners a direct line of contact to report any incursions that are detected, hence improving overall security. Because the system makes use of GSM technology, it can provide an economical and effective way to [16].

Arinde, V., (2024)., has worked the GSM module is a key component of the automatic intrusion detection system in the study paper. In the case of an intrusion, it is in charge of phoning property owners to provide them real-time alerts. The microprocessor of the system initiates the dialling of a pre-registered phone number when it detects unauthorised motion, sound, or entrance through the use of sensors such as the PIR sensor, sound sensor, or magnetic switches. Property owners may react quickly to possible security breaches thanks to this instant phone call notice, which guarantees that action is taken quickly to stop more intrusion. The technique is both efficient and cost-effective because phone calls are preferred over SMS because they guarantee timely alert delivery and help cut expenses [17].

Abiodun, O. J., (2024)., worked on the research paper's description of the smart home security system heavily relies on the GSM module. When an incursion is detected, the homeowner receives an SMS alert from the system. An ultrasonic sensor built into the device can identify motion or the presence of an intruder. The Arduino Uno microcontroller receives a signal from the ultrasonic sensor when an intruder is detected. After processing this signal, the Arduino instructs the GSM module to send an SMS alert to a designated emergency number. This enables the homeowner to take rapid action by notifying them of any security breaches immediately [18].

C. Ultrasonic Sensor

Fig.3. Ultrasonic Sensor

Arinde, V., (2024)., The primary function of the ultrasonic sensor in the research paper's description of the intrusion detection system is that of a proximity sensor. By sending out ultrasonic waves and timing how long it takes for the waves to bounce back after striking an object, ultrasonic sensors can determine whether or not there are any nearby objects. Because of their ability to detect objects and calculate distance accurately, ultrasonic sensors are perfect for applications like intrusion detection. The ultrasonic sensor is included into the system to monitor any movement within a specified range, so improving the overall ability to detect intrusions. The sensor sends out an alarm when it notices motion or an object, and the GSM module then starts notifying the property owner via phone call [19].

Singh, P., (2024)., in the article on Utilising the concepts of ultrasound transducers transmitters, receivers, and transceivers ultrasonic sensors are essential in a wide range of applications. Through the use of transmitters that transform electrical impulses into ultrasonic waves and receivers that transform the reflected ultrasound waves back into electrical signals, these sensors work. Transceivers possess the ability to send and receive these waves simultaneously. Ultrasonic sensors are very

important for distance measurement in sonar radar systems. They measure an object's distance by measuring the time lag between the ultrasound wave's emission and the echo it receives. Because these sensors are condition-sensitive, they are invaluable in situations where accurate remote acoustic detection is needed [20].

III.PROPOSED METHODOLOGY
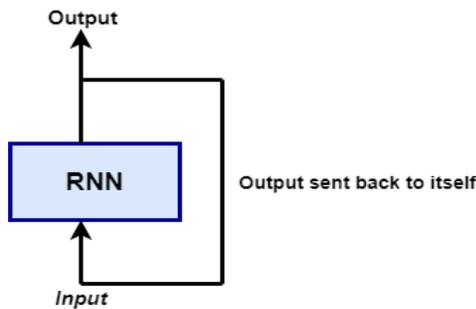
A. Recurrent Neural Network (RNN)

Fig.4. Recurrent Neural Network (RNN)

One type of artificial neural network that is mostly utilized in speech recognition and natural language processing (NLP) is the recurrent neural network (RNN). Deep learning and the creation of models that mimic the behavior of neurons in the human brain both employ RNN.

Recurrent networks are used to identify patterns in data sequences, including spoken language, text, genomes, handwriting, and numerical time series data from government agencies, stock markets, and sensors.

With the addition of a memory state to each neurone, a recurrent neural network resembles a conventional neural network in appearance. A basic memory will be included in the computation.

Recurrent neural networks are a particular kind of sequential deep learning-oriented algorithm. We always assume that every input and output in a neural network is reliant on every other layer. Because these neural networks carry out mathematical operations in a sequential manner, they are known as recurrent neural networks.

B. Application of RNN

When it comes to forecasting the future, RNN is useful in many situations. RNN is used in the financial sector for predicting stock prices and the direction (positive or negative) of the stock market. RNN is utilized in autonomous vehicles since it can predict a vehicle's path and prevent collisions.

RNN is extensively utilized in sentiment analysis, machine translation, text analysis, and picture captioning. For instance, a movie review can be used to determine the viewer's emotional response to the film. When the film studio doesn't have enough time to read, compile, categories, and evaluate the evaluations, automating this process is incredibly helpful. The task can be completed by the machine more accurately.

IV.CONCLUSION

This review paper describes a methodical way to use an Arduino Uno, machine learning techniques, and a PIR sensor to create an intelligent intrusion detection system. Using Random Forest or Decision Tree models, the system efficiently distinguishes between human and animal motion. The SIM900A module is used to transmit notifications, which improves the responsiveness of the system. Future improvements will greatly increase detection accuracy and system robustness by utilizing cloud-based deep learning algorithms and adding a camera module. A more complex and dependable intrusion detection system can be achieved by utilizing the cloud server's advanced picture analysis and model refining capabilities.

ACKNOWLEDGEMENTS

REFERENCES

[1] Sahoo, K. C., & Pati, U. C., (2017)., IoT based intrusion detection system using PIR sensor. In 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), pp. 1641-1645.

[2] Thakral, I., Kumari, S., Singh, K. K., & Aggarwal, N., (2023)., An Advanced IoT Based Border Surveillance and Intrusion Detection System. In 3rd International Conference on Technological Advancements in Computational Sciences (ICTACS),IEEE, pp. 1193-1198.

[3] Elimarteena, M., & Nagaraju, V. S., (2021)., IOT based home security system with pir and ultrasonic detection using Arduino. In *5th*

International Conference on Electronics, Communication and Aerospace Technology (ICECA), IEEE, p. 497-502.

[4] Vijayaprabakaran, K., Kodidela, P., & Gurram, P. (2021)., I0T based smart intruder detection system for smart homes. *International Journal of Scientific Research in Science and Technology*, *8*(4), p.48-53.

[5] Kanaujia, V. K., Srivastava, D., Vats, S., & Vishwakarma, P., (2024)., Intelligent Home Security System Using Arduino & IOT Sensors (No. 12366).

[6] Iyer, S., Gaonkar, P., Wadekar, S., Kohmaria, N., & Upadhyay, P. (2020)., I0T based Intruder Detection System Using GSM. In Proceedings of the 3rd International Conference on Advances in Science & Technology (ICAST).

[7] Ananthanarayanan, A., Sivasai, T., Gowda, D. D., Ganya, H. T., & Shreyas, K. S. (2021)., Smart Mirror Using Rasberry Pi for Human Monitoring and Intrusion Detection. In International Conference on Design Innovations for 3Cs Compute Communicate Control (ICDI3C), IEEE, p.207-210.

[8] Golder, A., Gupta, D., Roy, S., Al Ahasan, M. A., & Haque, M. A. (2023)., GSM Based Home Security Alarm System Using Arduino Using Mobile Call. In 14th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON), IEEE, p. 0268-0274.

[9] Kodali, R. K., Rajanarayanan, S. C., Koganti, A., & Boppana, L. (2019). I0T based security system. In TENCON IEEE Region 10 Conference, p. 1253-1257.

[10] Sahoo, K. C., & Pati, U. C., (2017)., IoT based intrusion detection system using PIR sensor. In 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT),p. 1641-1645.

[11] Arinde, V., & Idowu, L. (2024)., Multi-sensor Intrusion Detection System. arXiv preprint arXiv:2406.05137.

[12] Abiodun, O. J., & Okpe, O. A., (2024)., Smart Home Security using Arduino-based Internet of Things (IoTs) Intrusion Detection System. World Journal of Advanced Research and Reviews, 22(3), p.857-864.

[13] Abiodun, O. J., & Okpe, O. A., (2024)., Smart Home Security using Arduino-based Internet of Things (IoTs) Intrusion Detection System. World Journal of Advanced Research and Reviews, 22(3), p.857-864.

[14] Singh, P., Chaudhary, M., Saini, N., & Bhatt, R., (2024)., WSN application for crop protection to divert animal intrusions in the agricultural land.

[15] Dr.A.Arun Kumar, Dr.Nookala Venu.,(2023)., "Intelligent Intrusion Detection System For IOT Networks Using Deep Learning", ISSN No.1006-6748, Volume 29, Issue 11.

[16] Shweta Bhardwaj, Praveen Kumar, Hima Bindu Maringanti.,(2021)., "Intrusion Detection in Internet of Things Using Machine Learning Classiffiers", International Conference on Technological Advancements and Innovations, DOI.10.1109ICTAI53825.

[17] Marwa Baich, Touria Hamim, Nawal Sael, Yman Chemlal.,(2022)., " Machine Learning For IOT Based Networks Intrusion Detection A Comparative Study", Vol.215,P.742-751, Elsevier.

[18] Yogita Shewale, Shailesh Kumar, Satish Banait., (2023)., "Machine Learning Based Intrusion Detection In IOT Networking Using MLP and LSTM"., International Journal of Intelligent Systems and Applications in Engineering,Vol.11, No.75.

[19] Liloga, Dr.P.Ranjana.,(2023)., "An Intrusion Detection System Using A Machine Learning Approach In IOT Based Smart Cities", Journal of Internet and Information Security, Vol.13,p.11-21.

[20] Mubasher H.Malik, Hamid Ghous, Mutahira Mubeen, Ansar Munir Shah, Nazeer Ahmad., (2021)., "Intelligent Intrusion Detection System For Internet of Things Using Machine Learning Techniques", International Journal of Information Systems and Computer Technologies, Vol.3, No.1.