Patrolling Robot Using Deep Learning And Raspberry Pi

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Abstract- *The Patrolling Robot with Weapon Detection project aims to improve security and surveillance capabilities by employing an autonomous robot equipped with advanced technologies. This robot is designed to patrol an area autonomously while constantly monitoring its surroundings through a camera module. It utilizes weapon detection algorithms to identify potential threats. The project described involves creating a patrolling robot using a Raspberry Pi and various modules such as GPS, GSM, and a Camera. The primary goal of the project is to enhance security by deploying a robot that can patrol an area, detect potential threats (weapons), and send alerts to a specified mobile number with location information obtained from GPS.*

Keywords- Artificial Intelligence (AI), Deep Learning, Surveillance, Weapon Detection, Convolutional Neural Network (CNN), Threat Detector, Internet of Things (IoT)

I. INTRODUCTION

Security and surveillance have become top concerns in today's rapidly evolving world. The need for innovative and proactive solutions to keep people and property safe is more important than ever. In response to this demand, the Patrol Robot with Violence and Weapon Detection project introduces an advanced security system that combines autonomous robotics and cutting-edge technology to address these concerns.

Traditionally, surveillance and patrols have been performed by human security personnel, which can be labor-intensive and subject to personnel limitations. The Patrol Robot with Violence and Weapons Detection project leverages the power of automation and artificial intelligence to significantly improve security and surveillance capabilities. The focus of this project is to develop autonomous robots that can effectively patrol specific areas while continuously monitoring their surroundings. This robot is equipped with a series of advanced technologies such as Raspberry Pi, GPS, GSM, and camera modules. These components work together to provide real-time monitoring, threat detection, and rapid response capabilities.

The main feature of patrol robots is their ability to detect potential threats, especially violence and weapons. It uses advanced algorithms and image processing techniques to analyze visual data captured by vehicle cameras. When a potential threat is detected, the robot is programmed to respond quickly and send an alert to a specific mobile phone number. These alerts include important information such as: B. Location determined by a GPS module to allow security personnel or authorities to respond quickly and effectively.

The fusion of robotics, artificial intelligence, andsurveillance technology in this project not only enhances security, but also brings several benefits:

Continuous monitoring: The robot operates her 24/7, reducing monitoring gaps that human operators can create due to fatigue and other factors.

Instant threat detection: By integrating force and weapon detection algorithms, robots can quickly identify potential threats and prevent security breaches before they escalate.

Rapid Alert System: With the ability to send alerts in real time, robots enable rapid response and intervention, minimizing risk. Cost-effective: Over time, autonomous patrolling robots could become more cost-effective than maintaining a large human security force.

Expanding coverage: Robots can navigate difficult terrain and reach areas difficult for human patrols, providing comprehensive security.

In summary, the "Patrol Robot with Violence and Weapons Detection" project represents a significant advance in security and surveillance solutions, and by combining robotics, artificial intelligence and cutting-edge technology, this project will help our country Address and provide the foundation for your evolving security needs. Modern society demands more effective and proactive security systems. In the next section of this project, we will take a closer look at the components, features, and ways the system accomplishes its goals.

II. EXISTING SYSTEM

In the existing system, security patrols in certain areas are typically conducted manually by security personnel. Surveillance cameras may be in place, but they are typically monitored passively, and incidents are reported after the fact. Limited data is collected during patrols, and there may not be a centralized system for tracking incidents and their locations. Data collection during patrols is typically limited to written reports, which may lack precision or consistency. Incident reports may be manually compiled and may not include precise location data.

III. LITERATURE SURVEY

Ahmed Abdelmoamen Ahmed and Mathias Echi, [1] The camera side used a Raspberry Pi 3 device, Intel Neural Compute Stick 2 (NCS 2), and Logitech C920 webcam. At the camera side, they built a CNN model that can consume a stream of images directly from an on-site webcam, classify them, and displays the results to the user via a GUI-friendly interface. A motion detection module is developed to capture images automatically from the video when a new motion is detected. Finally, they evaluated the system using various performance metrics such as classification time and accuracy. their experimental results showed an average overall prediction accuracy of 94% on the dataset.

Abnormal Human Activity Detection By Convolutional Recurrent Neural Network Using Fuzzy Logic, [2] A Fuzzy logic system was used to successfully extract the appropriate frame in the shortest amount of time. In addition, a pre-train convolutional network and LSTM have been introduced, allowing the model to capture both local and long-term dependencies in sequential data. The suggested architecture employs the Inception of pre-train convolutional neural network to improve feature extraction by capturing numerous local dependencies, and the LSTM is used to accurately recognize deviant behaviors such as Abuse, Arrest, Fighting, Arson, and Assault.

P.Anbumani , K.Feloomi , B.Dharshana And S.Divya, [3] They proposed robot is designed to autonomously patrol a designated area and capture images and videos of the area using the camera module. The ultrasonic sensor is used to detect obstacles and prevent collisions, while the sound sensor is used to detect unusual sounds and alert the user. The buzzer is included to provide an audible alarm in case of any significant disturbance in the patrolling area. The robot is designed to move around and change directions using the motor driver and motors, which are operated by an Arduino Uno.

Richard Lincoln Paulraj; Punith M; Shalini M, [4] This paper demonstrates a patrolling Robot to enhance security. The sensor-based crime detection relies on Raspberry Pi, L2939D motor driver Module, Pi Camera, Sound Sensor, Dc - Motor and Neo-6 AGPS Receiver. The patrolling robot monitors and secures the premise at a lower cost; it uses a sound sensor to detect the unusual sound occurring and migrates to the place to send live footage and location under the sky view to alert the user to stay conscious.

Annu Kumari, [5] In this paper, they proposed a self-automated Robot chassis car along with an obstacle detection technique. The main idea behind this paper is to reduce collision that occurs from accidents on roads. To achieve this, several methods are performed such as lane, stop sign, and object detection. It contains various terminology based on deep learning to perform image processing and machine learning. To determine we had used a pi camera attached to the raspberry pi board to collect input images to steam data over a server.

IV. PROPOSED SYSTEMDESIGN

The proposed system introduces an autonomous patrolling robot equipped with advanced technology. The robot is equipped with a camera and weapon detection algorithms, allowing it to actively monitor its surroundings. Weapon detection algorithms provide real-time identification of potential threats, significantly reducing response time. The robot uses GPS to provide precise location data, which is sent via GSM to a designated mobile number or server when threats are detected.

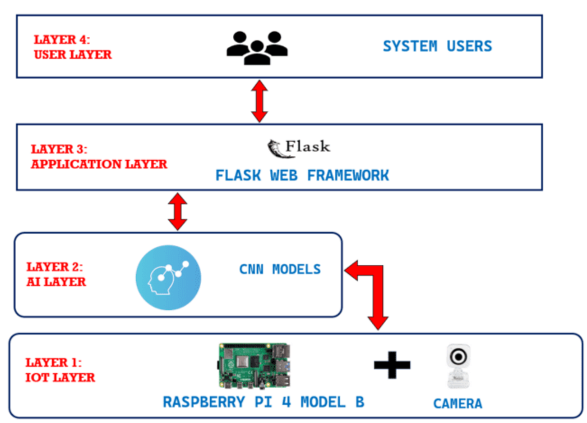


Fig 1:SYSTEM ARCHITECTURE

As illustrated in Figure 1, the distributed run-time system for Patrolling Robot is organized with parts executing on IoT devices at the camera side. The hardware components of the camera side are shown in Layer 1, which contains a Raspberry Pi 4 Model B, and webcam. Layer 2 describes the deep learning models used in Patrolling Robot, which includes the CNN model.Layer 3 illustrates the web-based interface of Patrolling robot running on the System. We used Python Flask Framework to develop a user-friendly web application that enables users (shown in layer 4) to interact with the system.

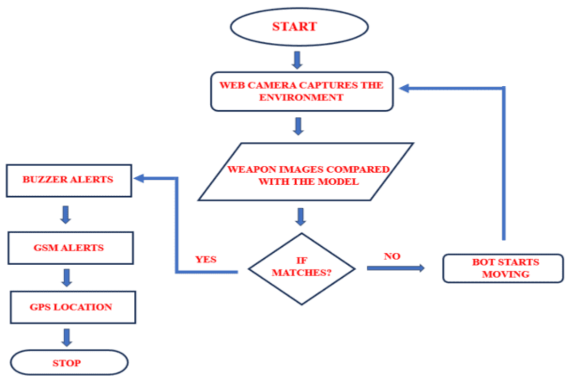


Fig2: SYSTEM FLOW DIAGRAM

At the camera side, we trained a CNN model with 2 convolutional layers, one input layer and one output layer. When the webcam captures an image from real time environment, the image is preprocessed to prepare it for input into the CNN model. The preprocessed image is then fed into the CNN model. The CNN model extracts feature from the image and uses these features to classify the image.

In this case, the CNN model would classify the image as either a weapon or not a weapon. If the CNN model classifies the image as a weapon, then the system triggers an alarm. This may involve sounding a buzzer, sending a GSM alert, or recording the GPS location of the camera.

V. SOFTWARE DESCRIPTION

We collected more than labeled 10k weapon images for training the CNN model from different sources such as Kaggle. Many images in our dataset are in their natural environments because object detection is highly dependent on contextual information. Our dataset is divided into three parts: training, validation, and testing. Table 1 shows the number of images used in the three phases across the nine weapon classes.

The number of images in each phase is determined based on the fine-tuned hyperparameters and structure of the CNN model. CNN model is implemented using Keras development environment.

The training images must have the same size before feeding them as input to the model. Our model was trained with colored (RGB) images with resized dimensions of 256 × 256 pixels. We set the batch size and number of epochs to be 150 images and 5 epochs, respectively. The model training was carried out using a Google colaboratory.

Given our weapon detector model is considered a multi-class classification problem, where it classifies the input image as belonging to one or more of the weapon classes, we used the Relu activation function at the Convolution layer.

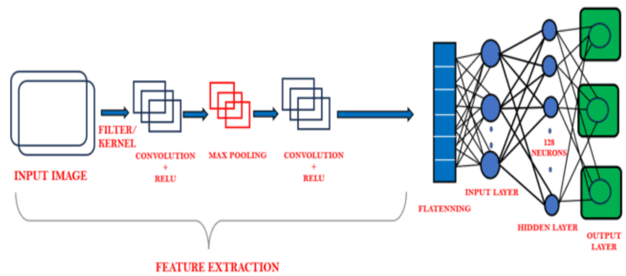


Fig3:THE STRUCTURE OF CNN MODEL

VI. HARDWARE DESCRIPTION

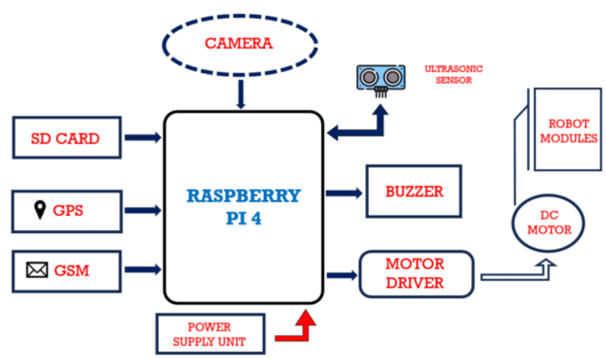


Fig. 4 HARDWARE ARCHITECTURE

A. Raspberry pi 4

The Raspberry Pi 4 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B and Raspberry Pi 4 Model B. Whilst maintaining the popular board format the Raspberry Pi 4 Model B brings you a more powerful processer, 10x faster than the first-generation Raspberry Pi. Additionally, it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

FIG5:RASPBERRY PI 4 MODEL B

B. Ultrasonic Sensor

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object Ultrasonic sensor emit ultrasonic pulses, and by measuring the time of ultrasonic pulse reaches the object and back to the transducer. The sonic waves emitted by the transducer are reflected by an object and received back in the transducer. After having emitted the sound waves, theultrasonic sensor will switch to receive mode. The time elapsed between emitting and receiving is proportional to the distance of the object from the sensor.

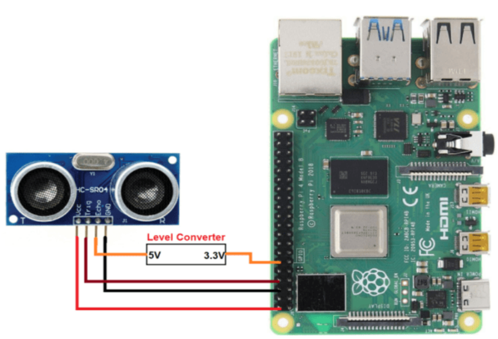


FIG 6: ULTRASONIC SENSOR INTERFACE WITH RASPBERRY PI

C. Global Positioning System (GPS)

The Global Positioning System (GPS), originally Navistar GPS, is a space-based radio navigation system owned by the United States government and operated by the United States Air Force. It is a global navigation satellite system that provides geo location and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The GPS system does not require the user to transmit any data, and it operates independently of any telephonic or internet reception, though these technologies can enhance the usefulness of the GPS positioning information. The GPS system provides critical positioning capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver.

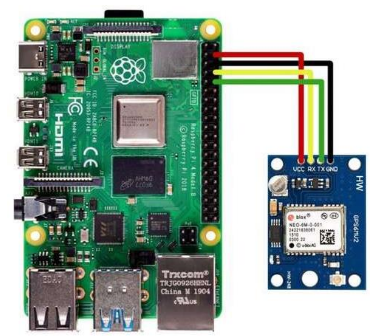


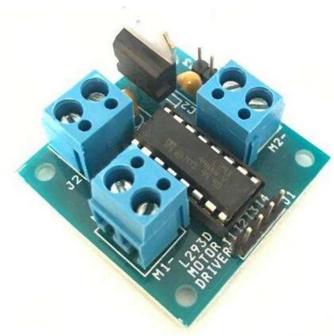
FIG 7: GPS MODULE INTERFACE WITH RASPBERRY PI

D. Global System for Mobile Communications (GSM)

A Global System for Mobile Communications (GSM) modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. This tutorial will explain how to interface a GSM modem with Toradexmodules. This GSM Modem can accept any GSM network act as SIM card and just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. The SIM900A is a complete Dual-band GSM/GPRS solution in a SMT module featuring an industry-standard interface; the SIM800 delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM800 can fit almost all the space requirements in your applications, especially for slim and compact demand of design.

E. Motor Driver

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a singleL293D IC. Dual H-bridge Motor Driver integrated circuit (IC).L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.



L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 will stop the corresponding motor. Logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively. Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

F. GPIO PINS

General-purpose input/output (GPIO) is a generic pin on an integrated circuit or computer board whose behavior including whether it is an input or output pin is controllable by the user at run time. GPIO pins have no predefined purpose and go unused by default. The Raspberry Pi 4 features the same 40-pin general-purpose input-output (GPIO) header as all the Pi going back to the Model B+ and Model A+. Any existing GPIO hardware will work without modification; the only change is a switch to which UART is exposed on the GPIO's pins, but that's handled internally by the operating system. Serial Peripheral Interface (SPI) is an interface bus commonly used to send data between microcontrollers and small peripherals such as shift registers, sensors, and SD cards. It uses separate clock and data lines, along with a select line to choose the device you wish to talk to.

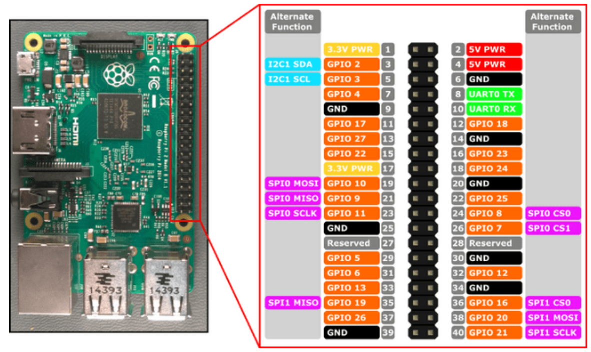


FIG 8: GPIO PINS

VI. PHYSICAL IMPLEMENTATION

Raspberry Pi 4 Model B is used as an IoT edge processing unit on the camera side. The Raspberry Pi is equipped with a 64-bit quad-core processor running at 1.4GHz, dual-band 2.4GHz, and 5GHz wireless LAN. We installed bullseye OS on the Raspberry Pi, which can host and run the Keras development environment. We connected a webcam to the Raspberry Pi via the General Purpose I/O (GPIO) pins.

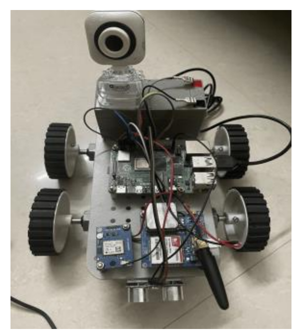


FIG9: PHYSICAL IMPLEMENTATION OF PATROLLING ROBOT

Quantum Hi-tech webcam is used to simulate the surveillance camera at the edge. We selected this webcam because it has several surveillance features such as high-resolution live streaming with USB capability, high-dynamic-range capability, digital zoom, and autofocus, and as well as working smoothly with bullseye OS.

Figure 9 shows the physical prototype implementation of patrolling robot.

FIG 10: A SNAPSHOT OF THE INFERENCE RESULT OF CNN MODEL AT CAMERA SIDE

VII. EVALUATION

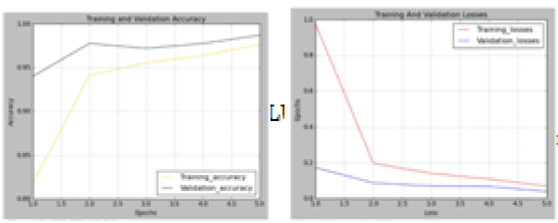


FIG 11: THE TRAINING ACCURACY AND LOSS OF THE CNN MODEL

Figure 11 illustrates the calculated training error and loss graphically. As shown in the figure, the mean squared error loss is decreasing over the 5 training epochs, while the accuracy increases consistently.

Evaluation is reviewing performance (accuracy) of models and deciding a best model. This is the process where the models are improved based a goal performance. Success criteria can be based on speed of algorithm, memory usage, or prediction accuracy. The sum of correct classification divided by the total number of classifications, can be used.The idea of building machine learning models works on a constructive feedback principle. You build a model, get feedback from metrics, make improvements, and continue until you achieve a desirable accuracy. Evaluation metrics explain the performance of a model. An important aspect of evaluation metrics is their capability to discriminate among model results. Since our project uses classification, some criteria for classification are introduced

TABLE 1: THE AVERAGE CLASSIFICATION ACCURACY AND PREDICTION TIME OF CNN

CLASS	CLASSIFICATION ACCURACY	PREDICTION TIME
Weapon	94.0%	10ms
Person	96.0%	7ms
Background	100%	5ms

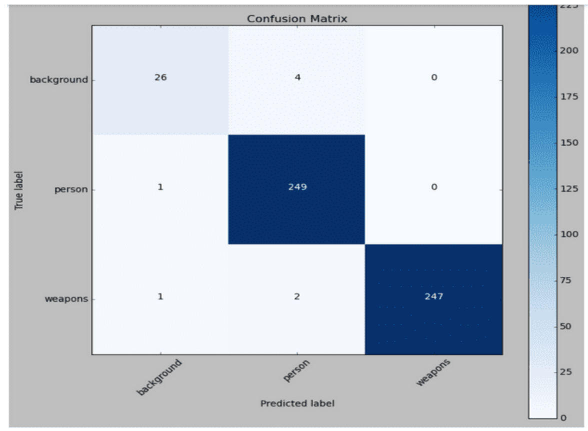


FIG 12: THE CONFUSION MATRIX FOR THE CNN MODEL

VIII. CONCLUSION

To summaries, the "Patrolling Robot Using Deep Learning and Raspberry Pi" initiative represents a significant development in the realm of autonomous security and surveillance. This project was successful in developing a proactive and responsive patrolling robot by utilizing the capabilities of the Raspberry Pi, cutting-edge sensor technology, and advanced picture processing. With its autonomous navigation, real-time danger identification, and efficient communication networks, this robot provides a viable solution to our modern world's developing security issues.Looking ahead, the prospective uses of this technology range from industrial facilities to public venues and even cooperation with law enforcement organizations. The project's success demonstrates the revolutionary potential of technology in improving security measures, as well as its role in constructing a better and more secure world.

Technical Expertise: The development and maintenance of the system require technical expertise. The integration of various components and programming the system requires expertise in robotics, IoT, and software development.

Environmental Limitations: The system may not be suitable for all environments. The system's efficiency may be affected by extreme weather conditions such as heavy rain or snow, which may hinder the robot's movement and performance.

Limited Autonomy: The system's autonomy is limited by the robot's battery life. The robot may require recharging or replacement of batteries, which may affect the system's efficiency.

Privacy Concerns: The use of cameras in the system may raise privacy concerns. The system should be designed and used in compliance with privacy regulations and guidelines to ensure the protection of individuals' privacy.

IX. FUTURE DIRECTIONS

I) ADVANCED DEEP LEARNING MODEL:

Integration of more sophisticated deep learning models for improved object recognition and scene understanding.

Continuous training of models to adapt to new environments and scenarios.

II) LOCALIZATION AND MAPPING:

Implement slam (simultaneous localization and mapping) techniques for better mapping of the environment and accurate localization of the robot.

III) AUTONOMOUS NAVIGATION:

Enhance the navigation algorithms to support more complex scenarios, dynamic obstacle avoidance, and efficient path planning.

Implement machine learning-based navigation policies to adapt to changing environments.

IV) MULTI-SENSOR FUSION:

Integration of additional sensors such as lidar, radar, or stereo cameras for better perception and depth sensing.
Implement sensor fusion techniques to combine information from different sensors for more robust decision-making.

V) ENERGY EFFICIENCY:

Explore ways to optimize power consumption to extend the robot's operational time. This could involve more efficient hardware design and power management strategies.

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