Autonomous Surveillance Robot Using Convolutional Neural Network

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Abstract- *Video surveillance is the way toward observing the circumstance of a region or an individual. This generally occurs during a military scenario where surveillance of borderlines and enemy territory is vital to a country's safety. This problem can overcome by designing the Convolutional Neural Network-based surveillance robot, which involves a live camera to detect objects and monitor rivals. In this current work, a Raspbian OS-based surveillance robot with remote monitoring is designed. During the war, this robot can collect information from the enemy terrain, gather information at a far secure area, and safely devise a plan for the counter-attack. The robot is fully autonomous, can detect and avoid obstacles using the ultrasonic sensor. CNN is used for detecting objects, and this program is implemented using python.*

Keywords- Border Surveillance, Raspberry pi 3, Open CV, Obstacle detection,Autonomous Robot, Convolutional Neural Network.

I. INTRODUCTION

Border surveillance systems have recently achieved interest to address the concerns about national security. The major problem in protecting long stretches of borders is the need for sizeable human involvement in monitoring the premises. This major problem can be overcome by Robotic technology. Automated innovation is obtaining one amongst the many advances in the world.

The utilization of automated innovation quickly affects the world severally. As innovative advances proceed, research plans and building new robots fill different practical needs, regardless of domestic, business, or military. Numerous robots even do risky positions to individuals, like defusing bombs, mining, and investigating wrecks. Autonomous surveillance robots have begun assisting security personals in surveillance operations. While aerial and ground robots help in most of these activities, ground robots are heavily used to do surveillance activities because of their easy implementation and cheaper cost than aerial robots.

Real-time object detection is required because safety and security are essential in remote monitoring and control systems such as intelligent home environments, consumer monitoring systems, etc. Real-time human body detection is necessary for various fields like home security systems, surveillance systems, communication systems, and more. In general, the surveillance systems are built up with multiple cameras placed at various angles of view to track human objects. Especially the tracking task is needed on cameras for dynamic objects, which increases the number of cameras used in the system. An intelligent surveillance system with cameras is complicated and costly. In the proposed method, a single camera is installed on a robot, and the robot can move all directions to capture the live feed. With raspberry pi 3 minicomputer, open cv, and MobileNet architecture, the live feed is classified in real-time and directly sent to the authorities in the base station. The robot is outfitted with an ultrasonic sensor and sound sensor. The ultrasonic sensor is used to avoid obstacles in the path during motion, and when there is any sound detected, the robot stops and monitors the area. DC motors equipped with an L293D motor driver helps in the movement of the robot. This surveillance robot also has the option to control manually.

II. SYSTEM OVERVIEW

In the existing system, human has to monitor and make decisions on the border. Later manual robots are used to monitor the border, requiring human assistance in implementing the system. This paper design can be divided into two sections hardware implementation and software implementation.

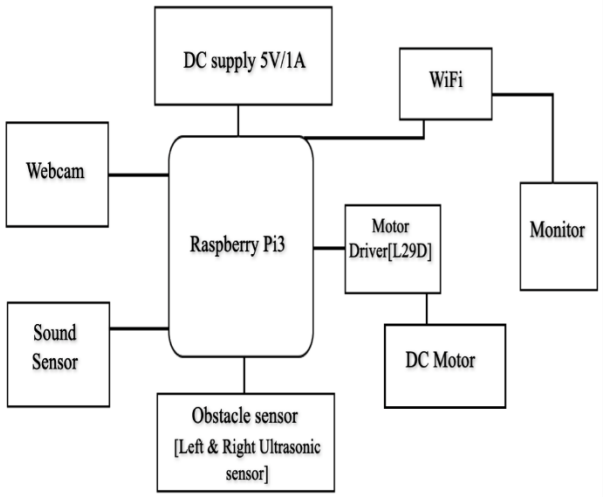

Figure 1: Block diagram of the proposed model.

The hardware implementation consists of developing the intelligent robot, while the software implementation focuses on programming raspberry pi using the python program. In the proposed system, a camera is used to capture the live feed of the environment and transmits it directly to the authorities in the base station. The convolutional neural network is used simultaneously to identify and classify the objects present in the surrounding easily. The robot is fitted out with an ultrasonic sensor and sound sensor. The ultrasonic sensor is used to avoid obstacles in the path during motion, and when there is any sound detected, the robot stops and monitors the area in 360 degrees. DC motors equipped with an L293D motor driver helps in the movement of the robot. There may arise situations when security personals need to take over the control of the surveillance robot under certain circumstances. Therefore this surveillance robot also has the option to control manually. Raspberry-pi has been widely used to do projects in various fields like medical, defence, agriculture, and industries. This surveillance robot is designed with raspberry pi 3 using the python program.

III. HARDWARE COMPONENTS

The Raspberry Pi-3 Model B is a powerful, low cost and small-sized single-board computer that can be used for many major and minor applications. Raspberry pi 3 has the most powerful processor, and it is ten times faster than the previous generation. This third-generation pi has additional wireless LAN and Bluetooth connectivity, making it the ideal solution for the powerful application. The Raspberry pi 3 contains many ports like a camera connector, Ethernet port, GPIO pins mainly used for interfacing sensors and switches, USB port for external I/O devices, HDMI ports for monitor and audio jack port. A single board connects it. It does not have any internal storage or pre-installed OS, but we can insert an SD card with Linux-based OS.

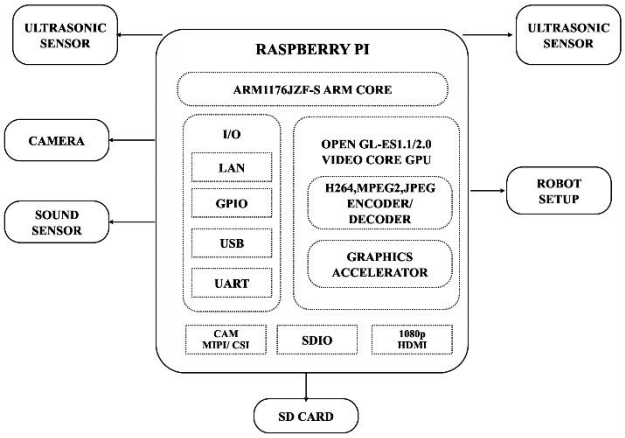

Figure 2: Hardware layout of the proposed model.

A. LM393 Sound Sensor

Sound is sensed through a microphone and fed into an LM393 op-amp in the sound detection sensor module. A microphone provides feedback to the buffer, peak detector, and amplifier in this sensor. This sensor notices a sound and processes an output voltage signal to a microcontroller. After that, it executes the required processing. It comprises an onboard potentiometer to adjust the set-point for sound level.

B. Ultrasonic Sensor

An ultrasonic sensor is an electronic device that emits ultrasonic sound waves and transforms the reflected sound into an electrical signal to calculate the distance between the sensor and the target object. Ultrasonic waves propagate at a higher rate than detectable sound waves. This sensor is widely used in a variety of applications that include measuring distance or sense objects. The Ultrasonic transmitter and receiver are formed by two eyes-like sensors on the front of the module. The sound is emitted by the transmitter using piezoelectric crystals, and the receiver receives sound after it has traveled to and from the target. The sensor calculates the time between the transmitter's emission and its interaction with the receiver to assess the sensor's distance from the object. D = 1/2 T x C (where D is the distance, T is the time, and C is the sound speed of 343 meters per second) is the formula for this measurement.

C. L293D Motor Driver

A Direct Current motor is a device that transforms DC electrical energy into mechanical energy. The operation of a DC motor is based on the idea that a current-carrying conductor encounters a mechanical force when it is placed in a magnetic field. A DC engine drives the robot. The L293D Motor Driver Module is a medium-power motor driver that works well with

DC and stepper motors. It makes use of the well-known L293 motor driver IC. It can turn on and off four DC motors or control the speed and direction of two DC motors. It has a total DC of up to 600mA and can drive motors up to 12V.

IV. WORKING METHODOLOGY

The autonomous surveillance robot is designed with Raspberry pi 3 model B, and It is a third-generation Raspberry pi. Raspberry pi 3 has the most powerful processor, and it is ten times faster than the previous generation. This third-generation pi has additional wireless LAN and Bluetooth connectivity, making it the ideal solution for the powerful application. The surveillance bot is sent on a mission; it monitors the surrounding area with the help of an installed camera, captures the live feed, and transmits it directly to the base station. The spy bot is moved with the help of a DC motor and L293D motor driver. It drives autonomously without the use of manual human control. There may arise situations when security personals need to take over the control of the surveillance robot under certain circumstances. Therefore this surveillance robot also has the option to control manually. The manual control is possible with the help of the onboard Bluetooth module present in the raspberry pi 3. The robot is equipped with an LM393 sound detection sensor; when noise is detected in the surrounding, the robot stops the movement and monitors the area in 360-degree rotation. During the autonomous movement, the surveillance robot sense and eliminate obstacle in the path with the help of ultrasonic sensors. The robot is fitted out with two ultrasonic sensors on both sides of the robot path. It will move in a specific direction. When the obstacle is coming in its course, it will turn to the opposite direction, i.e., when the left ultrasonic sensor detects the barrier, the robot changes direction to the right and vice versa. The convolutional neural network is used to process the image, classify, and segment the live feed.A CNN is a feed-forward neural network that is generally used to analyze visual images by processing data with grid-like topology. It is also known as ConvNet.A CNN is used to detect and classify objects in an image. It has multiple hidden layers that help in extracting information from an image.

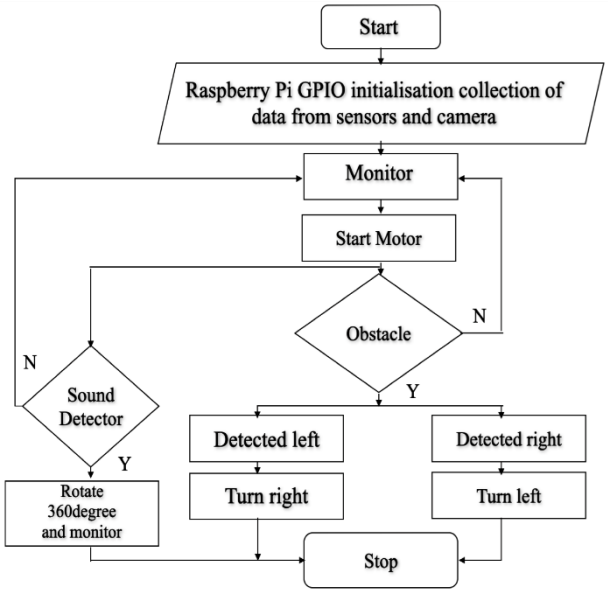

Figure 3: Flow diagram of proposed model.

The four essential layers in CNN are the Convolution layer, ReLU(Rectified Linear Unit) layer, Pooling layer and Fully connected layer.

A. Convolution Layer

It is the first step in the process of extracting essential details from a picture. Several filters perform the convolution operation in a convolution layer. Every image is viewed as a pixel value matrix.

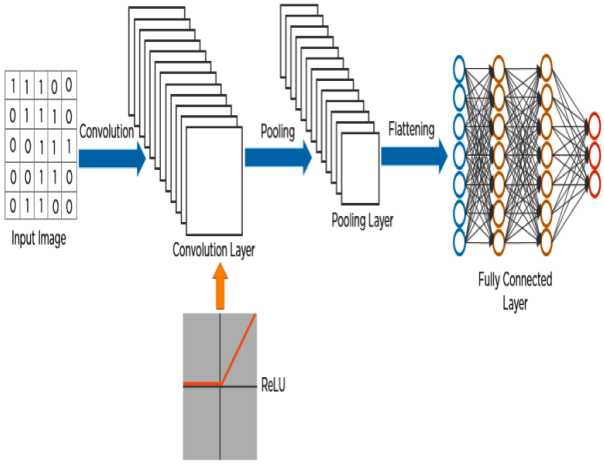

Figure 4: Architecture of CNN.

B. ReLU layer

The rectified linear unit is abbreviated as ReLU. After the function maps have been removed, they must be moved to a ReLU layer. ReLU performs an element-by-element process, setting all negative pixels to zero. It causes the network to

become non-linear, and the result is a rectified function map. For feature detection, the original image is scanned with multiple convolutions and ReLU layers.

C. Pooling Layer

The function map's dimensionality is reduced by pooling, which is a down-sampling process. To build a pooled feature map, the rectified feature map is now passed through a pooling layer. The pooling layer employs various filters to identify multiple aspects of the image, such as edges, corners, the body, and the eyes. Flattening is the next step in the process. Flattening is a technique for converting all of the 2-D arrays generated by pooled feature maps into a single, continuous linear vector. To classify the image, the flattened matrix is fed as an input to the fully connected layer.

Following is the procedure for recognizing images in a video stream. A corrected feature map is generated by applying the convolved map to a rectified linear unit function. Multiple convolutions and rectified linear unit layers are applied to the image to locate the features. To identify specific sections of an image, different pooling layers with various filters are used. The final output is generated by flattening the pooled feature map and feeding it to a fully connected layer.

In the proposed surveillance robot MobileNet SSD model is used for the deep learning convolutional neural network. The MobileNet-SSD model is a Single- Shot multi-box Detection network proposed to perform object detection. This model is executed using the Caffe framework. The Mobile-Net model is based on depthwise separable convolutions, a form of factorized convolutions that factorize a standard convolution into a depth-wise convolution. A 1 × 1 convolution is called a point-wise convolution. For MobileNet, the depth-wise convolution applies a single filter to each input channel. The point-wise convolution then uses a 1 × 1 convolution to combine the outputs of the depth-wise convolution. A standard convolution filters and combines inputs into a new set of outcomes in one step. This is split into two layers by the depth-wise separable convolution, one for filtering and the other for combining. This factorization reduces computation time and model size dramatically. Images are given as input and trained for the accurate classification of an object[for example, human, animals, and inanimate objects]. In each category, fifty images are trained to get maximum accuracy. During the model's training, less regularisation and data augmentation techniques are used because small models have less trouble with overfitting. After a series of computational work on the raspberry pi, the image classification is displayed. The live feed is seen as a rectangular box of classified output whose width and height are measured by the pixels' number from those dimensions.

V. RESULT AND DISCUSSION

Self-governing reconnaissance robots have started helping security personals in observation tasks. While both elevated and ground robots aid the more significant part of these exercises, ground robots are vigorously used to do reconnaissance exercises due to their simple execution and less expensive expense contrasted with elevated robots.

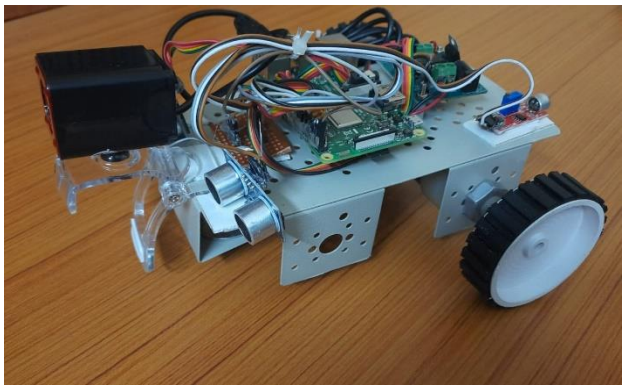

Figure 5: Proposed Surveillance Robot.

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Last login: Thu Mar 18 11:15:58 on ttys000
. /Users/prakash/opt/anaconda3/bin/activate && conda activate /Users/prakash/opt
/anaconda3/envs/Project_CNN;
(base) prakash@Prakash ~ % . /Users/prakash/opt/anaconda3/bin/activate && conda
activate /Users/prakash/opt/anaconda3/envs/Project_CNN;
(Project_CNN) prakash@Prakash ~ % cd Desktop
(Project_CNN) prakash@Prakash MobileNet % python real_time_object_detection.py -
-prototxt MobileNetSSD_deploy.prototxt.txt --model MobileNetSSD_deploy.caffemode
l
[INFO] loading model...
[INFO] starting video stream...
62 357
66 359
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67 367
69 358
70 362
72 354
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Figure 6: Output feed of the model.

This robot can help security personals remotely monitor from far away distance and eliminate human casualties during the abrupt assault on the territory. This surveillance robot can be used for search and rescue-type operations and bomb defusing. It can likewise review the disaster-affected zone where the reach of humans is beyond the realm of imagination.

VI. CONCLUSION

The proposed robot used for the secure reconnaissance purpose can operate effectively to collect various information required by the user. For instance, the presence or absence of unwanted people in the border area can be monitored and notified to the control room for further actions. The brain of the surveillance robot is the Raspberry Pi minicomputer. The robot is operated in different modes by leaving the robot to navigate its own with the sensor status or by controlling the movement manually.

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