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IOT Based Video Surveillance System

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ABSTRACT- In present scenario, the security concerns have grown tremendously. The security of restricted areas such as borders, is of utmost importance, in particular with the worldwide increase of military conflicts, illegal immigrants, and terrorism over the past decade. Monitoring such areas rely currently on technology and manpower, however automatic monitoring has been advancing in order to avoid potential human errors that can be caused by different reasons. The purpose of this work is to design a surveillance system which would detect motion in a live video feed and record the video feed only now where the motion was detected, also to track moving objects based on background subtraction using video surveillance. The moving object is identified using the image subtraction method through machine learning based Algorithms (i.e., like keras and OpenCV). This work is based on AIOT (Artificial Intelligence of Things which is a combination of Artificial Intelligence and Internet of Things). In addition, face detection and Intruder Alert through notification is proposed in this work.

KEYWORDS- Surveillance, AIOT, Motion Detection, YOLO, Au

I. INTRODUCTION

Now- a-days the advancement in wireless communication technology in robots there can be an autonomous robot car which will be controlled manually.

II. FIXED SURVEILLANCE

Surveillance is the continuous monitoring process of the territory which is compulsory for military security. In the era of small embedded systems and the Internet-of- Things (IoT), we must cope with a continuously increasing number of data streams coming from cameras, microphones, and other sensors [1]. For the unmanned security CCTV (Closed-Circuit Television) was the conventional solution due to the easy installation and less cost . Although, the fixed CCTV can get the continuous image of the observation area, but the camera focus is concentrated to the center of the observing area [2]. Objects belonging outside the observing area cannot be observed clearly due to the blind spot and the image quality is not high in the out-focused objects. In order to solve the disadvantage of the fixed CCTV, the moving systems with HD (High Definition)-camera are much interested in the security and surveillance system such as line-tracking robot, rail-tracking robot and self-driving robot [3].

III. EMBEDDED SYSTEMS

An embedded system has three components. It has hardware, application software and a Real Time Operating system (RTOS) as shown 1.1. RTOS supervises the application software and provides a mechanism to let the processor run a process as per scheduling by following a plan to control the latencies. RTOS defines the way the system works. It set the rules in the execution of the application. So, we can define an embedded system as a Microcontroller based, software driven, and reliable, real-time control system designed to perform a specific task.

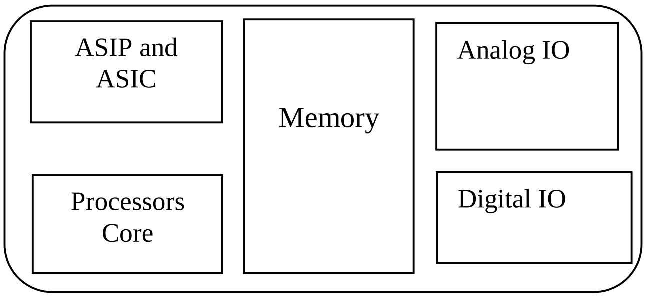

Figure 1: Basic block diagram of embedded systems

IV. OBJECT DETECTION

In Surveillance system Object recognition shown in figure 1.2, play an important role based on computer vision and pattern recognition [4]. It is still a challenging problem because large variations of shapes, illumination, viewpoints, resolution, and occlusion usually occur in images of objects in real world applications, especially when they are captured in wild conditions. Most existing object recognition and detection methods, match images of objects and persons with visual appearance features [5].

In many computer vision tasks, instead of a single image, an image set is used to depict an object more effectively. As more satisfactory performance can be achieved by utilizing set information, learning with image sets has attracted more and more attention in recent years [6-8].

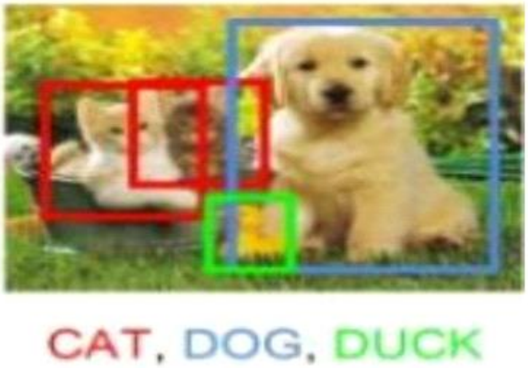

Figure 2: Object Recognition

IV.YOLO

YOLO stands for you only look once which was developed in 2015 by Joseph Redmon, Santosh Divvala, Ross Girshick, and Ali Farhadi. This algorithm requires only one forward propagation pass through the network to make the predictions. This algorithm divides the image into grids. YOLO is an object detection algorithm much different from the region-based algorithms [9]. In YOLO a single convolutional network predicts the bounding boxes and the class probabilities for these boxes. In YOLO the image split into an SxS grid, within each of the grid we take m bounding boxes. For each of the bounding boxes, the network gives an output a class probability and offset values for the bounding box. The bounding boxes have the class probability above which a threshold value is selected and used to locate the object within the image.

In the image each grid cell, the target variable is defined as:

$$Y_{i,j} = [p_c\ b_x\ b_y\ b_h\ b_w\ c_1\ c_2\ c_3\ c_4]^T \quad (6)$$

The limitation of the YOLO algorithm shown in figure 1.3 is that it struggles with the small objects within the image, for example, it might have difficulties in identifying a flock of birds. This is due to the spatial constraints of the algorithm [10].

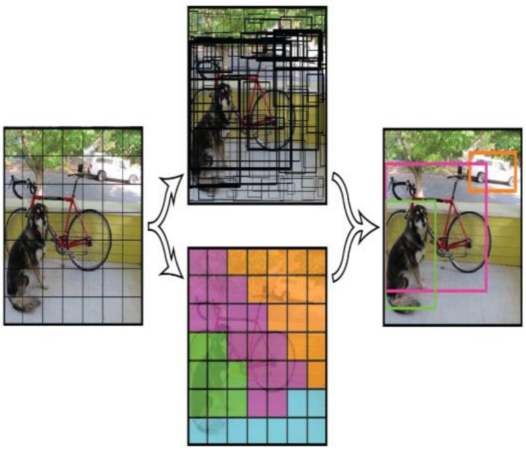

Figure 3: YOLO Algorithm

V. Literature Survey

Here the robot is controlled by using internet in PC from webpage or Android mobile phone through special designed APK. And the camera present to the robot captures the data and sends the data to the controller through internet. A computerized surveillance robot is used for safety-conscious which includes at airports, government installations etc. The wise software should reveal security cameras and detects if any difficulty [11-13].

The way this system was able to react to events was rather limited: basically, it was a system with only sensors. All it could do was to detect an object and monitor through our portable device. In order to make up for the missing actuator, we decided to integrate a robot into the framework. In addition to sensing dangerous situations, it would also be able to immediately act, trying to counter the threat.

In summary, we make the following contributions:

- Enhance the quality of the recorded surveillance video by providing a mobile platform in the form of a robot, allowing the camera to change positions, rotate, and zoom in and out to investigate a potentially dangerous event further.
- The system also to act when detecting such an event by performing a specific activity with the robot.

The design is simple and robust. The robot can be applied to remote areas, where the build is different and preserved.

VI. Methodology

In this work, the embedded system design shown in figure 4 is made using some electronic components and ESP-32 CAM Module. ESP-32 CAM is a low power consumption and low latency video streaming module. It provides serial communications and GPIOs. In the other hand, the Smartphone hardware development has a rocket improvement recently; it lets the Smartphone cheaper but has more power in computing. Therefore, it is decided to make the embedded system a combination of both Smartphone and an ESP-32 module. The ESP-32 module controls the robot and the Android for the computer vision processing such as object processing, detection, etc. The embedded system design for the following is shown:

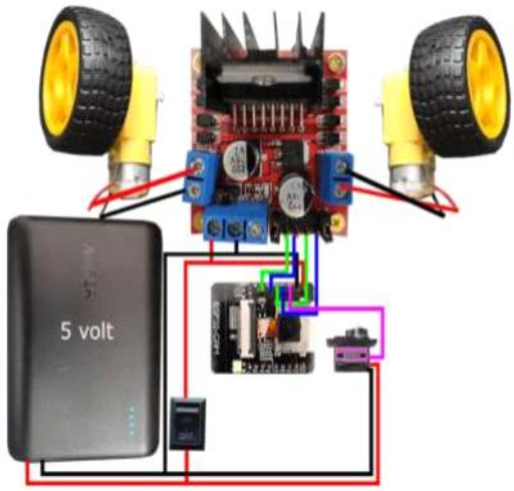

Figure 4: Circuit Connection of Embedded System Design

The flow chart of the communication is shown in figure 5:

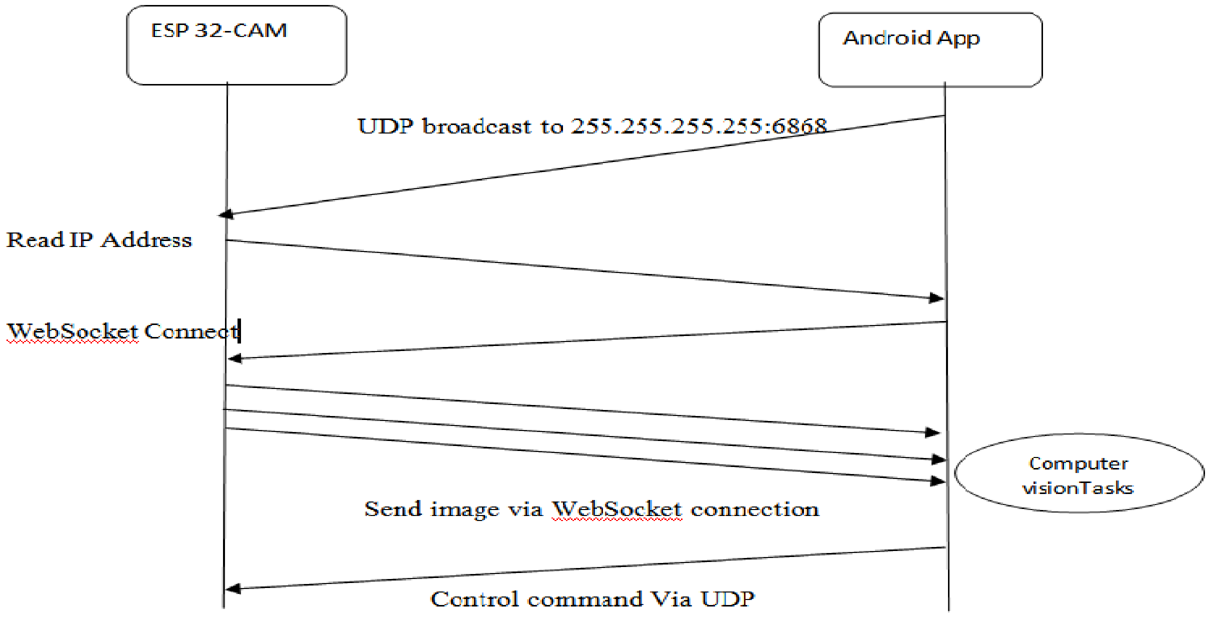

Figure 5: Flow Chart for the communication protocol

VII. OBJECT TRACKING

In Object tracking program takes an initial set of object detections and develops a unique identification for each of the initial detections and then tracks the detected objects as they move around frames in a video.

There is simplest algorithm for object tracking is based on the centroid of the objects between the time frames. Since we use bb boxes for detection, the centroid will be the centre point of this bounding box. For instance, let's take a 30-seconds video of rabbits in the mp4 format.

Convert the entire video into multiple image frames. Each frame has to be passed onto any object detection algorithm (YOLO). The output will be a set of bounding boxes corresponding to every object in the frame.

Computation of centroid for the bounding boxes: As we know, bounding boxes are represented by 4 values that correspond to (x-centre, y-centre, width, and height). In this case, we can directly use the centre values to figure out the central point. The other format for the bounding box is (xmin, ymin, xmax and ymax). In this scenario we find the centroid using (xmin + xmax) / 2 and (ymin + ymax)/2. By using these two coordinate values, we can locate the bb box mid-point.

Compare the Euclidean distance between all the centroids from the previous frame with all the centroids in the current frame. To assign the same id, the two objects (in the consecutive frames) should have minimal Euclidean distance when compared to the rest of the objects in the frame. In the scenario where a greater number of objects detected when compared to the previous timeframe, a new id gets allocated to the newly added ones. In the event of objects getting dropped in between the frames, the allocated id will be removed from passing on to the successive frames. We can also have control over when the id must be dropped exactly. To cite an example, if an object does not appear in 4 consecutive frames, then it could be deregistered.

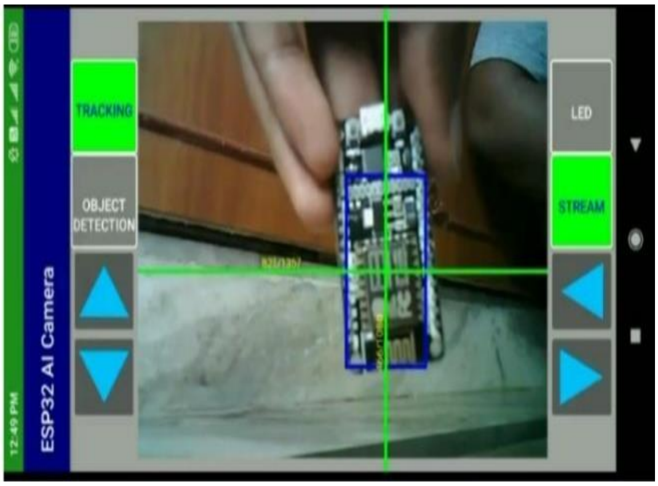

Figure 6: Object tracking with centroid

VIII. LANE TRACKING

Traffic safety is becoming more and more popular these days due to increase in urban traffic [14]. Automating driving may help reduce this urban traffic. Lane detection and tracking is important to lateral vehicle guidance and lane departure warning which can eliminate many avoidable accidents [15]. Autonomous navigation on roads requires information of lanes, which is also an open problem for autonomous intelligent vehicles and driverless vehicles.

While existing lane recognition algorithms demonstrated over 90% detection rate, the validation test was usually conducted on limited scenarios. The aim of this work was to identify these gaps and to suggest research directions that can bridge them. The straight lane detection algorithm based on HT was used in this study as an example to evaluate the possible perception issues under challenging scenarios, including various road types, weather conditions, changed lighting etc. The study found that the HT-based algorithm presented an acceptable detection rate in simple backgrounds. However, it failed to identify road dividing lines under varied lighting conditions. The binarization process failing to extract lane features before detections[16-19]. In addition, the existing HT-based algorithm would be interfered by lane-like interferences, such as guardrails, railways, bikeways, utility poles, pedestrian sidewalks, buildings so we need for further improvements of present road lane detection models to be robust against interference.

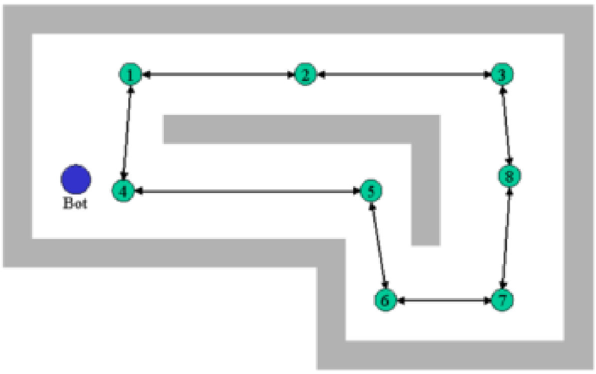

Figure 7: setup for basic lane tracking algorithm

IX. RESULTS

The AI based surveillance Bot is assembled with the hardware component. The Surveillance Bot is viewed from different work ions are shown in figure 4.1.

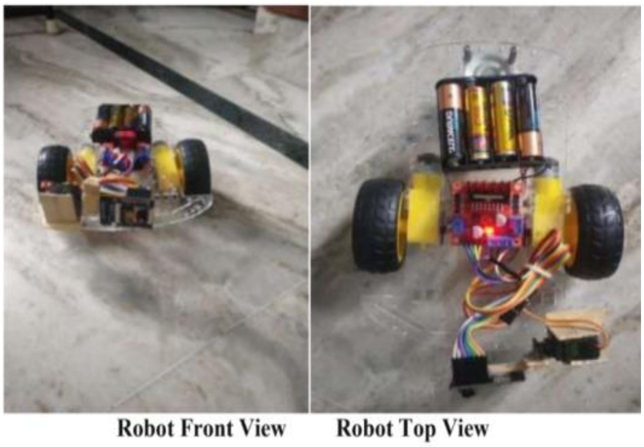

Figure 8: Front view and top view of Robot

The length of the surveillance bot is about 20 Cm long and is light weight bot and is perfect for maneuvering small areas with remote access. The prototype of Bot is designed to cover the ground level monitoring where ESPCAM is attached with the servo motor, so that it can cover certain altitude from the ground level to detect the objects.

The App User Interface is shown in figure 9 presents itself on the mobile screen with options for video streaming, Object Detection, Tracking and LED button to light up the built-in LED in the ESP-32 cam module.

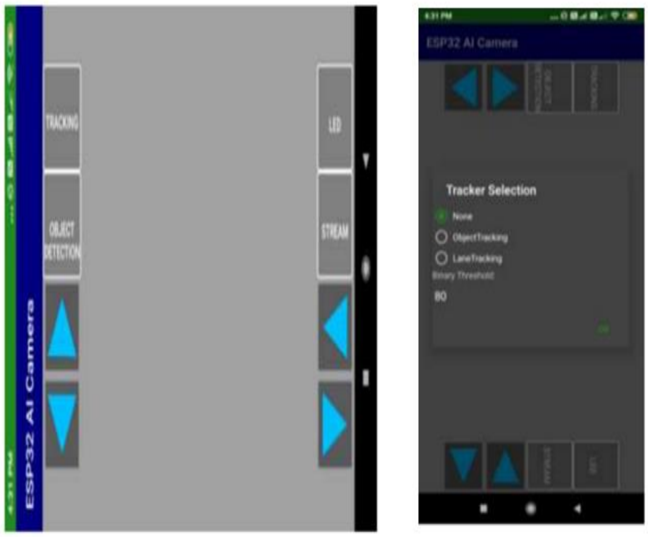

Figure 9: App GUI Tracking Options

The process of Object Detection is shown in figure 10; the ESP-32 cam module starts to detect any object in front of it when the user presses the Object detection option in the App. With the help of bounding box, the cam module can detect the object.

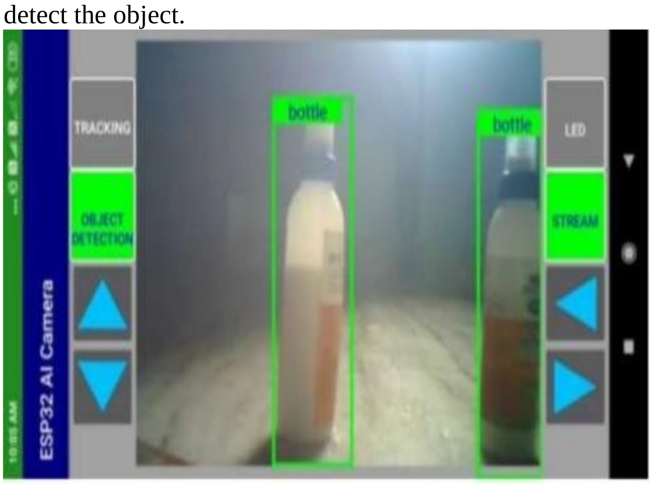

Figure 10: Object Detection of multiple Objects

Object Tracking can be done by selecting the Tracking option present in the App and the by selecting object tracking the module start to track the objects in front of it.

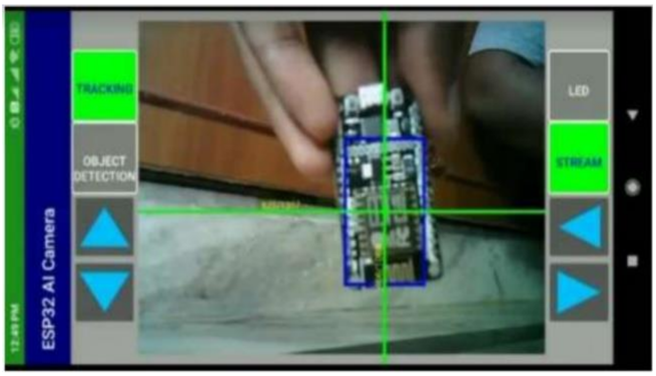

Figure 11: Object tracking by locking the centroid of the Bounding box

Lane Tracking can be done by selecting the Tracking option present in the App and the by selecting lane tracking the module start to follow a predetermined path.

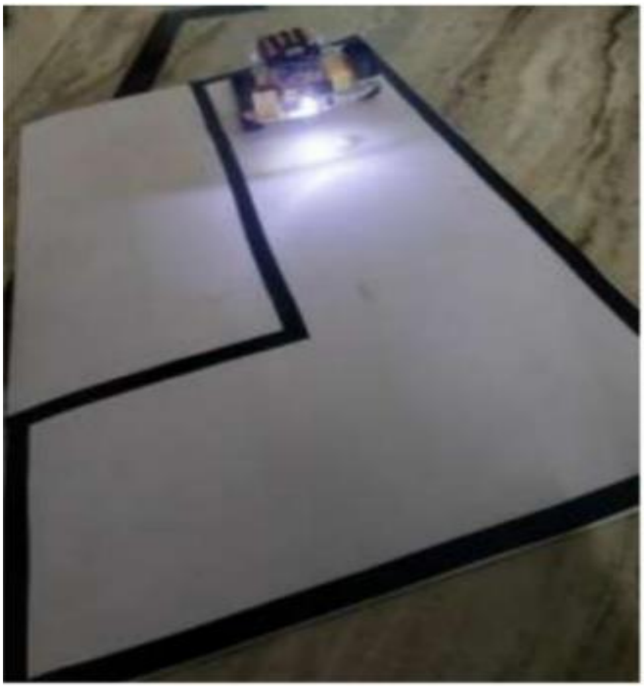

Figure 12: Lane Detection

X. CONCLUSION

In this work, the framework for making a robot for surveillance purpose is proposed. It overcomes the problem of limited range surveillance by using the concept of IOT. The prototype is used for: Surveillance of remote areas, Recording and sending video output of the required environment, Factory or floor surveillance, Activity Analysis, Road Traffic monitoring and Security purpose. The AIOT based smart surveillance system has been aimed to design in such a way that it fulfils the needs of the user for surveillance area. When the motion is detected in the surveillance area the video is recorded. Email alert and SMS notification are sent to the user informing about the motion detection. Future scope of the work includes live video streaming in addition to digital processing techniques, zoom in and zoom out options can be added in updating the position of the camera. Providing door access to the persons based on the digital processing techniques. A specific app can be developed for the purpose of transmitting video to an authorized person.

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