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Object Sensing and Identification using IoT

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Abstract **– Object sensing and Identification using IoT (Internet of Things) is a project based on Computer Vision and Image processing. ESP-32 cam module is used to take an input video feed and this video feed is then sent to an IoT device (in our case laptop) where this image is compared to a pre-existing image library (Open CV) and the output is then displayed to the laptop monitor. Simultaneously Ultrasonic sensor sends the sound wav which is used to calculate the distance from the system to the object which is to be identified. The camera Module and Ultrasonic sensor are mounted on top of a Pan-Tilt servo motor which is used to widen the viewpoint of the camera and ultrasonic module and thus increasing the field of view. These elements combine to create a module that can sense and identify unknown objects.**

Keywords **– Object Sensing, Object Identification, Object Recognition, Open CV, ESP 32 CAM Module, Ultrasonic Sensor, Pan-Tilt Servo.**

I. INTRODUCTION

A. *Introduction to the Project*

In this ever-expanding world, security has been one of the prime concerns. To identify an object and distinguish it from one another has been part of this process, with the advancement in the field of computer vision and image processing has enabled us to better distinguish the objects digitally and identify/ recognize them.

Computer vision and Image processing along with the growing GPU & CPU power of modern-day computers has decreased the time consumption on this and thus made it possible to apply this concept in every day-to-day scenario [1].

Robotics along with efficient semiconductor designing and manufacturing has enabled us to touch into whole another level of untapped potential of computer vision.

Nowadays Computer Vision and Image processing can be applied to live video feeds and thus helping in the monitoring system and replacing the conventional approaches.

Here in this work, we have developed a system that takes a live image feed using a camera module and then broadcasts it to the IoT device where it gets processed and after comparing it with the pre-existing image models it identifies the object.

This camera module along with an ultra-sonic sensor is mounted on top of a Pan-Tilt servo motor, the pan-tilt servo facilitates the movement of the camera module and thus helping the system to cover a broader range of area. The pan servo helps in horizontal motion while the tilt servo helps in vertical motion. And with the help of a pan-tilt servo, we are calculating the angle at which the camera module is pointing towards.

The ultra-sonic sensor present in the pan-tilt servo is used to calculate the distance between the system and th-

-e object which is to be identified.

B. *Purpose of this Project*

The key purpose of this project is to recognize and identify different objects in the live feed along with calculating an approx. distance and angle of the object which is to be identified from the system.

C. *Problem Identification*

In the conventional method of object identification, it faces a huge drawback of limited datasets which has been overcome in this project with the use of a pre-existing library named Open CV which is a pre-stored collection of multiple objects.

While some of the previously proposed models have taken our approach none of them have implemented it together with an ultrasonic sensor which has enabled us to also determine the distance of the objects.

Most of the proposed models by the authors can only identify a single object at a time not only that but also the camera module has a limited field of view these are overcome in this project using the Pan-Tilt servo.

II. Object Identification

Although there are different kinds of algorithms available, we have used Single Shot Detection (SSD) algorithm here, specifically a Mobile Net architecture pre-trained with Caffe Model, for predictions. The SSD algorithm is employed to make those predictions. The input is queued, and the associated bounding boxes are provided as outputs. The real-time video stream is processed to generate predictions and bounding boxes across it.

The Single Shot Detector (SSD) detects objects using a deep neural network. The approach divides the bounding box output space into default boxes with different aspect ratios. This method scales the feature outline according to the object size and location. The Single Shot Detector network combines predictions from feature outlines of different resolutions to naturally handle objects of different sizes [2].

The SSD model has proven to be more effective than some other detection algorithms, such as YOLO and Faster R-CNN.

The performance of the SSD which is compared by the authors with different systems of algorithms shows the better performance of SSD [3].

III. Methodology

A. *System Design*

Here the block diagram and connection diagram of the implemented system is described.

(a) Block Diagram

In this project, we developed a system that can detect and identify an object. To identify the object, it compares the live feed of the object to the pre-recorded images from the library known as Open-CV.

The block diagram of the system is described below -

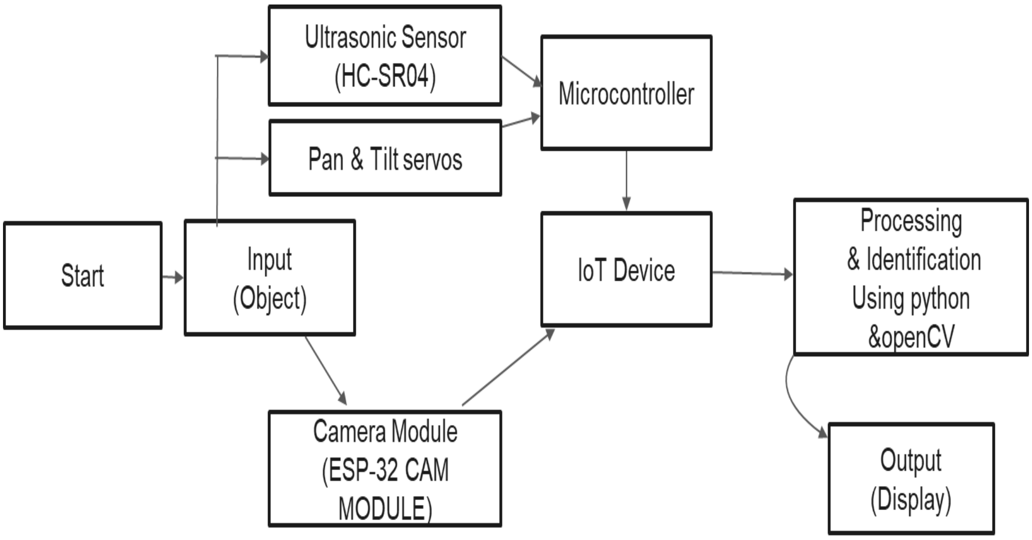

Fig. 1. Block Diagram of Object Sensing and Identification.

Description of elements of the block diagram is -

- Input - The object to be identified is taken as the input when the system is turned on.
- Camera Module - The camera module is used to take a live video feed of the object to be identified and then transmit this data via an inbuilt Wi-Fi module to the IoT device.
- Ultrasonic Sensor - This Ultrasonic Sensor transmits a sound signal as simultaneously as the camera module takes the input, this data is used to calculate the distance of the object from the system.
- Pan-Tilt Servo motor - This module has a mounted Camera & Ultrasonic sensor on top of it is used to change the viewing point of the camera module and ultrasonic sensor, it is controlled using keyboard keys in the IoT device.
- Microcontroller - The microcontroller Atmega 328P is used as a microcontroller that stores the code of operation for the pan-tilt servo and ultrasonic sensor.
- IoT device - IoT stands for Internet of things, in this case, we are a using laptop as an IoT device to bridge the gap between the raw data from the camera, ultra-sonic module, and control the Pan tilt servo, and to produce the required result.
- Processing & Identification - PyCharm is used to code the program for sensing and identification and to connect to the Open-CV library.
- Output - The output is displayed on the computer monitor where the image identification, distance, and angle of the object to the system are displayed.

(b) Explanation of the connection

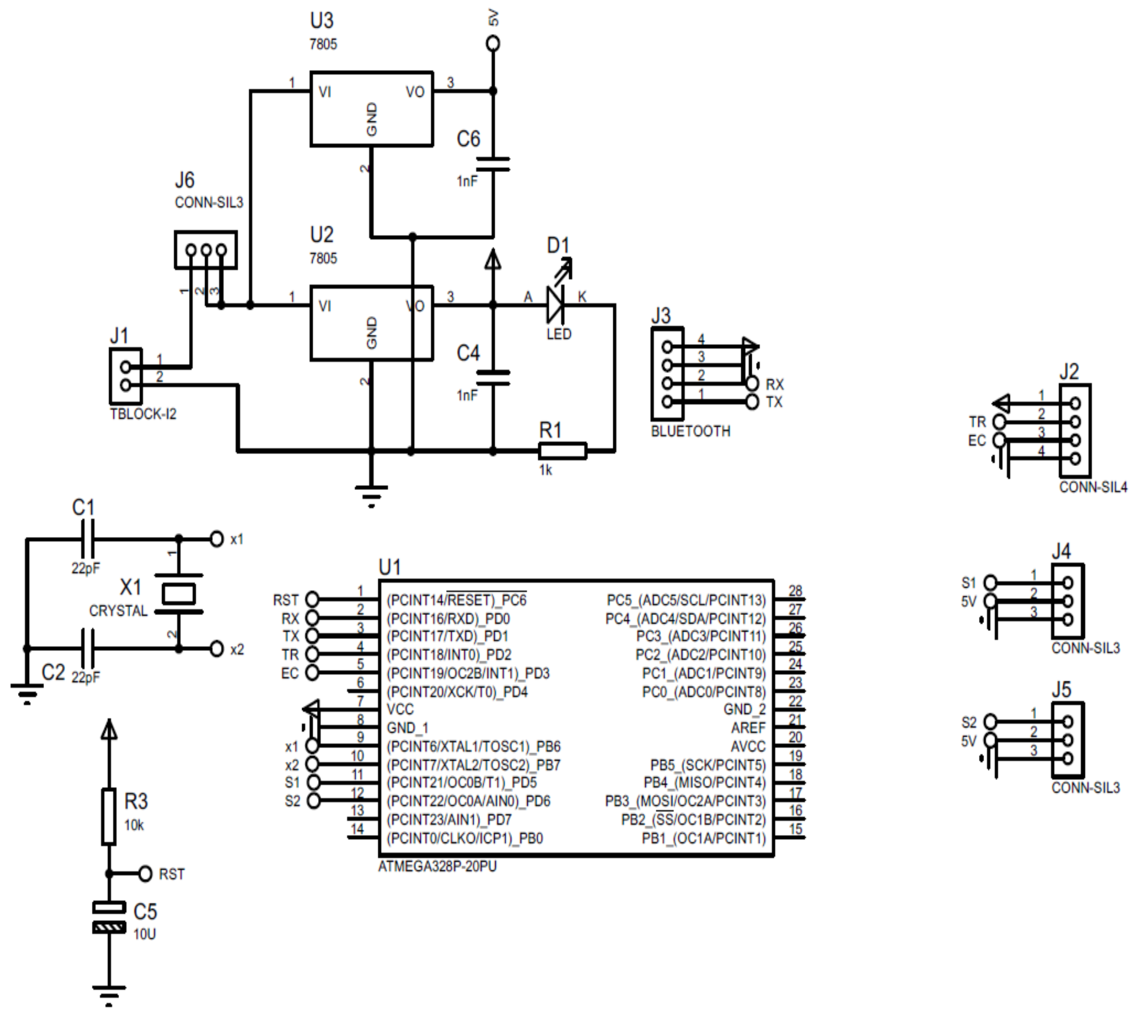

Fig. 2. Proteus Block Diagram of the system.

- To create a web server and to generate an IP address we have given the 5V, GND, TX, and RX to the ESP32 cam using Arduino Uno and shorted the GND to GPIO 0 of the ESP32 cam module (only for the uploading of the code) GPIO 0 determines whether the ESP32 is in flashing mode or not. This GPIO is internally connected to a pull-up 10k Ohm resistor. When GPIO 0 is connected to GND, the ESP32 goes into flashing mode and we can upload code to the board.
- Then we connected the data pin of the two servos for the pan and the tilt to digital 9 & 10 of the Arduino Uno board and provided the power supply from the battery.
- Then we connected the trigger and echo pin of the Ultrasonic sensor to digital pins 7 & 8 respectively.
- After completion of the code upload, we have taken out the IC of the Arduino and placed it in the external PCB and have done the connections.

B. *Process*

The process is about the steps involved in the working of the system i.e., how it is turned on and the various steps that are involved.

- Firstly, we have made sure that we have all the necessary parts, and components required for this project.

- Then to get a live feed from the ESP-32 CAM module we retrieved the IP address of the CAM module by interfacing it with the Arduino-UNO board and ATmega328P microcontroller.
- Using this generated IP address, we are capturing the live video feed which is to be used for image processing and in turn used for object recognition.
- To broaden the field of view of the CAM module and Ultrasonic sensor a PAN TILT servo is interfaced with the microcontroller and a serial monitor in the PyCharm is used to Control the PAN TILT servo motor.
- Ultrasonic sensor is used for distance calculation, it exchanges the data with the microcontroller to provide the distance of the object while the horizontal and the vertical angle are calculated by PAN TILT Servo.
- All the necessary coding work for the project is done in python IDE (i.e., PyCharm).
- Python code is used to generate the raw data of ultrasonic sensor and CAM module into meaningful data and to achieve this OpenCV is used as a library for object identification.
- Previously recorded camera IP addresses are put in Python code; also, specific characters of laptop keyboard are mapped to control the PAN TILT servos movement.
- Exchange of data between Atmega328P and IoT device (Laptop) is achieved using USB to TTL converter.
- To enable the successful running of the hardware/software the ESP32 CAM and IoT device are connected in a LAN network after which python code is executed in PyCharm.
- After successful execution of code, a command window popup displays the output of the CAM module along with identity.
- By providing the input from the keyboard PANTILT servo direction can be controlled, these input keywords are predefined in this case 'W', 'S', 'A' & 'D' words from the keyboard will move UP, DOWN, LEFT & RIGHT respectively.
- To get the input from the ultrasonic sensor (distance) along with horizontal and vertical angles “R” keyword is pressed on the keyboard.

IV. Result and Discussion

A. *Result*

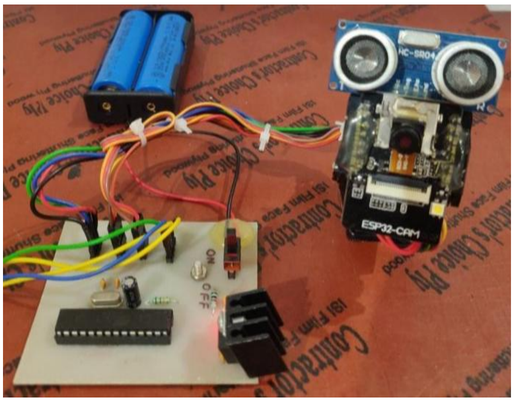

Fig. 3. Shows the final Product (Final Product).

- The keyboard of the IoT device (Laptop) is used to control the Pan-Tilt Servo Motor as shown in Fig 4. The following button press will result in the following actions in the Pan-Tilt servo,

  W = Up;

  S = Down;

  A = Left;

  D = Right;

  R = Angle at which Ultrasonic sensor is pointing towards.

Every press result in 10 degrees of shift.

Fig. 4. Keys of IoT to control Pan-Tilt Servo motor.

- Movement in Pan results in a change in Horizontal Angle, while the change in Tilt servo results in a change in vertical angle.
- Fig.5 shows a Pan-Tilt servo motor with a mounted ultrasonic sensor and ESP cam module.
- For working on the final system, the switch in the PCB must be turned ON.
- USB to TTL must be connected to the IoT device (laptop).

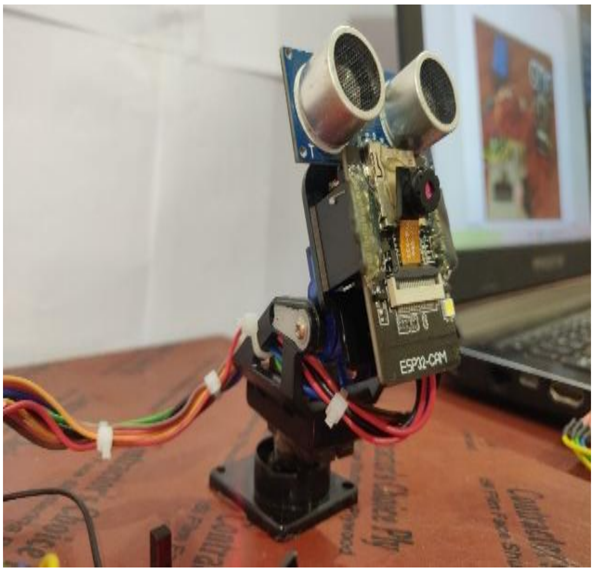

Fig. 5. Pan-Tilt servo motor.

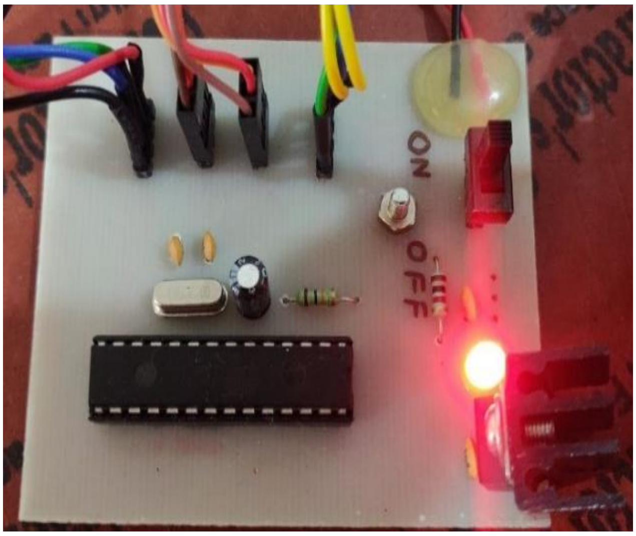

Fig. 6. Layout of the system.

- For getting the angle and distance reading “R” key must be pressed in the console of PyCharm.
- Fig. 7 represents the console output of the ultrasonic sensor for objects at different distances.

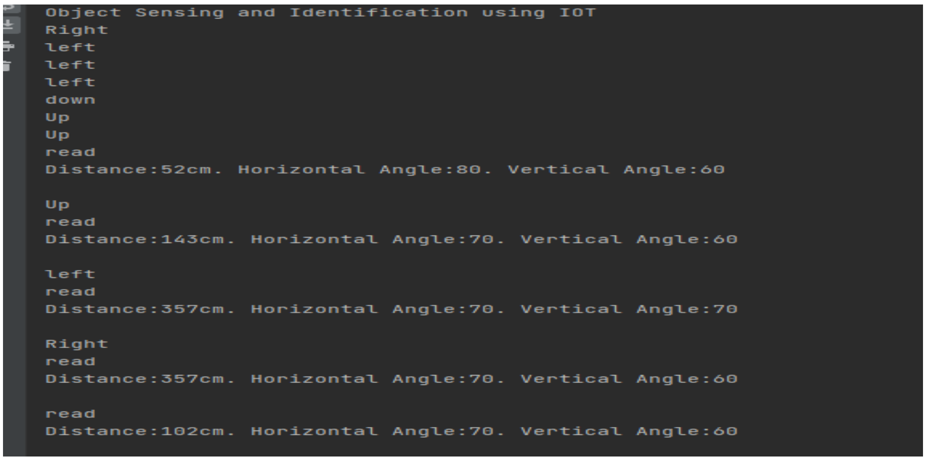

Fig. 7. Distance by Ultrasonic sensor on a console for multiple distance objects.

Fig. 8. Multiple Subject Identification of Same Classes.

- Output of ESP 32 cam is shown after object identification using OpenCV is shown on the output panel in PyCharm as shown in Fig. 12 and 13.
- Fig. 8 shows multiple object identification of the same class while Fig. 9 shows multiple object identification of different classes.

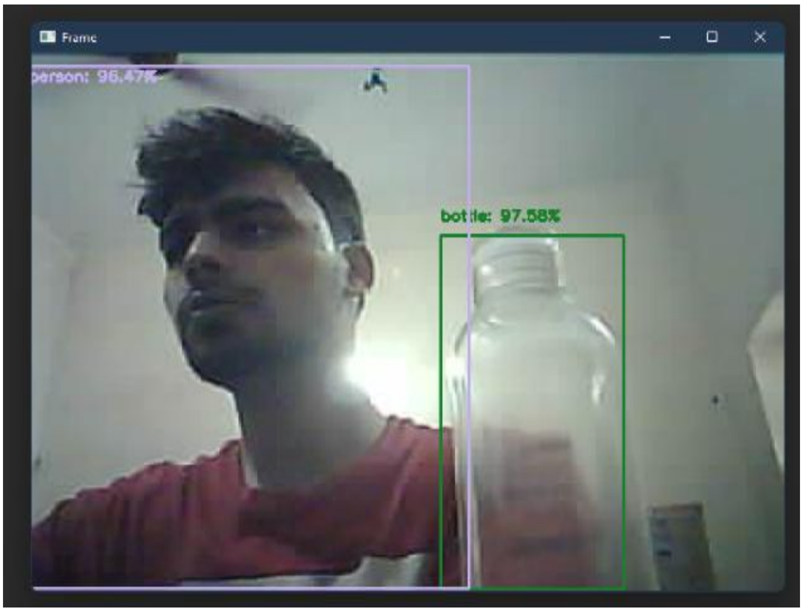

Fig. 9. Multiple object identification of different classes.

- Initially when the power is turned on the Pan-Tilt servo Calibrates itself to 90 degrees both vertically and horizontally.
- In the console of PyCharm the Input command to shift down for Tilt servo and output of Ultrasonic sensor is given in Fig. 10.

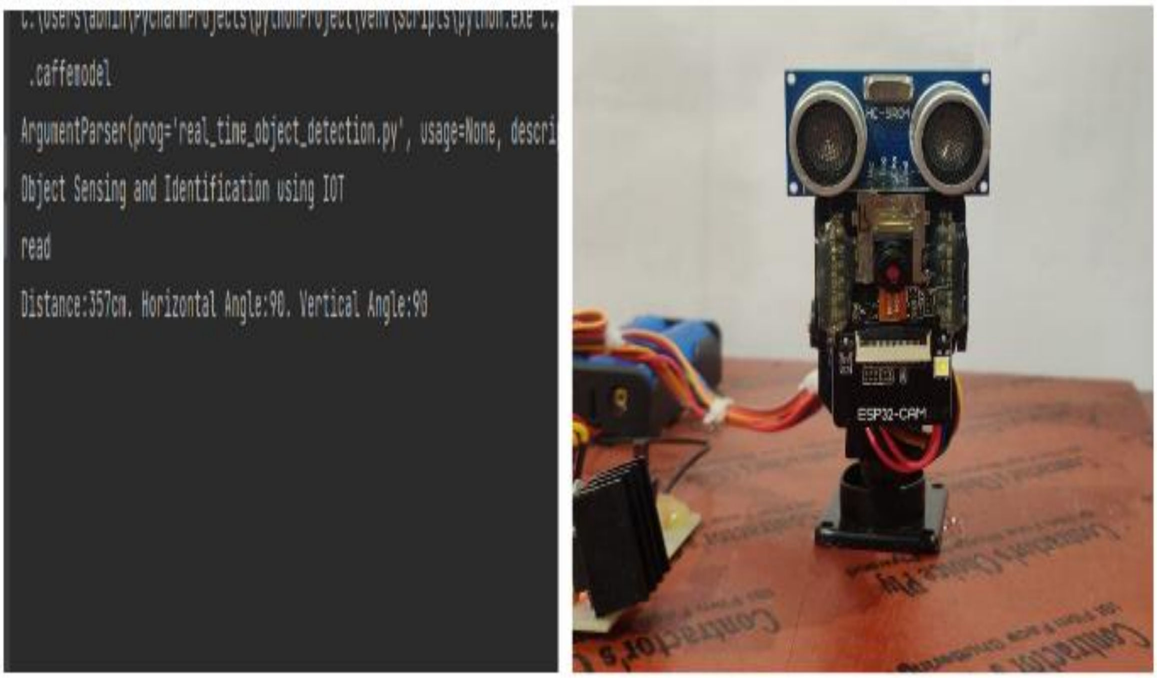

Fig. 10. Output of initial command prompt of PyCharm and hardware orientation.

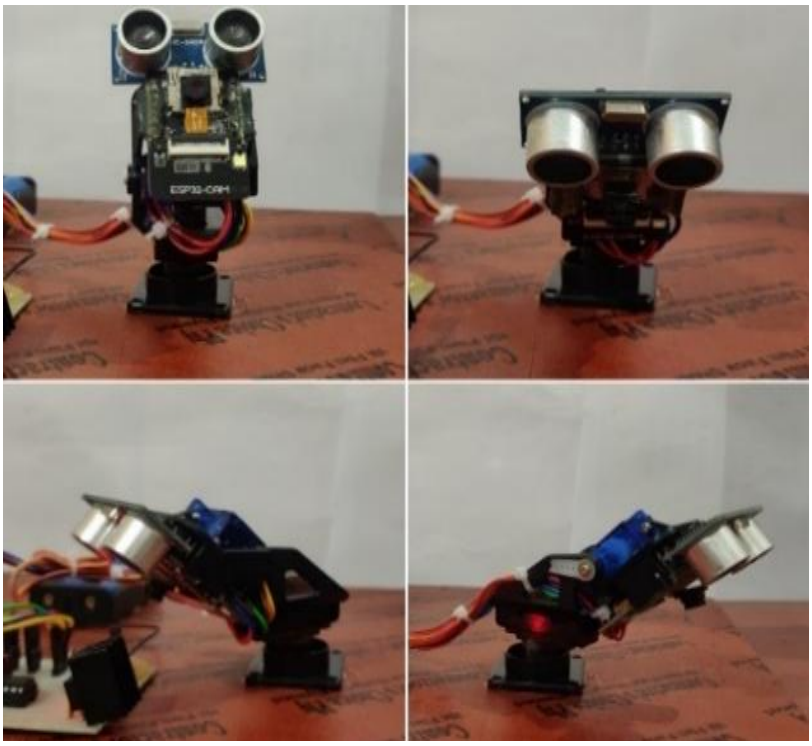

Fig. 11. Different orientations of pan-tilt servo.

V. Conclusion and Future Scope

A. *Conclusion*

- This project provides a module that helps identify the object and calculate its distance from the system.
- The camera module and ultra-sonic sensor are mounted on top of the pan-tilt servo motor which can be adjusted (both horizontally and vertically) according to the requirement.

B. *Future Scope*

- Use in autonomous driving-

A radar/lidar System can be added for wide object sensing and identification in autonomous driving.

- Security Alert system-

The system can be programmed to alert the user when a specific object is detected.

- Military application-

The system can be implemented for sensing ground & aerial objects and help to identify them.

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