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Internet of Things and AI Computer-vision Robot for Forest Surveillance and Monitoring

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Abstract-— **Main goal of this paper is to provide surveillance and monitor the forest conditions. For this we have used both Internet of Things and AI Computer-vision technologies. Sensors have been placed on robot which is movable in all direction and OV2640 camera along with esp32 cam has been placed to get video feed. Further this video feed is proceed to detect intruders using python IDE and OpenCV. Sensor data is sent to IoT server, which can be monitored. Main purpose of monitoring sensor data is to detect fire. Robot is controlled using RF transceivers, which has very good range and has stepper motor for accurate movement. Since RF transceivers are used we can also send sensor data to the user for emergency situation.**

Index Terms - AI Computer-vision, Internet of Things, OpenCV, OV2640 camera

I. INTRODUCTION

Forest fire in the year 2019- 2020 at Australia was the wakeup call for whole humanity to understand the importance of forest monitoring and surveillance [1]-[4].

Fig: 1 Australian forest fire.

Forest fire causes huge amount of loss, millions of wildlife die, many trees and bushes are destroyed which results in global warming. It takes too much of efforts to extinguish forest fire, so it’s always better to detect it in early stage and prevent it.

Apart from forest fire forest is subjected to many illegal actives like hunting, smuggling etc

Considering all these aspects forest surveillance and monitoring becomes mandatory. It’s the motivation for our project.

Now to brief about the technology used, both Internet of things and AI Computer-vision have application in every field. With the help of them proving surveillance will be more accurate and easier.

For example Internet of Things will help us to monitor every sensor data continuously; if we get any value more than threshold we can get alerts or command systems to do certain action.

Using AI we can detect various objects, animal, fire, or humans based on necessity and alert the user when desired event happens. Like this these technology can be used to monitor and provide surveillance to the forest.

literature survey

Existing work:

There are many papers written and projects made to provide surveillance or to monitor, but not in specific to forest and considering the practical challenges which we face in forest.

Among the available devices or proposed papers they are camera based or only sensor data based methods, which are not accurate. All those methods are fixed to only one place, so the area they cover will be less and very expensive to implement. So if we use cameras or sensors which are on moving unit will be much more helpful and solve the issue of cost and efforts to install.

In existing camera based approach only video feed is displayed, it should be monitored constantly. It’s impossible for forest like vast area. AI Computer-vision added to camera feed has great advantage over previous fixed camera and only video stream.

In ref [5] they have proposed a CNN model for fire recognition in previously captured videos, which are captured randomly. Their approach is basic image

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processing with minimal trained data sets but it isn't capturing live video feed.
Authors mainly focus on software part. They try to process the video stream no information about how the video is captured. In this paper they process the video stream using CNN algorithm and try to detect fire disaster.

It has many drawbacks like:
It can detect only large fire disaster as algorithm can't identify small fire. This delay may cause difficulties to extinguish fire.
It's not reliable as sometimes it detects sun set as fire.
It's not suitable for real-time application.
In ref [6] Authors uses aerial footages to detect smoke and through which they try to detect forest fire.
For this model to detect fire it should be big and only then it can detect and due to density of trees it takes time to detect. So this approach is not practical.
In ref [7] Authors take sensor based approach. They use smoke sensor with zigbee module to transmit data of forest fire. As mentioned earlier, there can be certain false trigger sometimes when we go only with sensor approach. Since its stagnant we need more and more modules to cover large area.
Only sensor based projects monitor data but they are not moveable, it is a major drawback [10-11].
Due to this number of devices increase and it's difficult to maintain the data we get and power them.

objective of the project

Considering all existing methods and their disadvantages we have proposed following objectives for our project.

- To use Internet of Things and AI Computer-vision to provide surveillance and observe forest.
- To implement project on movable robot which has precise movement and capable of distant control.
- To use OV2640 along with esp32 cam board to capture the video and send it over Wi-Fi to local server.
- To process the video on server to provide surveillance by detecting for desired object or humans, animals and many more.
- Place sensors to detect fire and to get other necessity data to monitor forest.
- Send that data continuously to an Internet of Things platform and do certain actions when the value rise above threshold value.
- Use RF communication has backup communication to send data over it if Wi-Fi fails.

These are the objectives of project to fulfill our motto to provide surveillance and observe forest to protect it.

METHODOLOGY

AI Computer-vision:

Artificial Intelligence Computer-vision is a technology which imitates the human action of vision. Initially we need to specify certain information about things which we want it to recognize and then it store the information in memory and recognize it next time, just like how humans learn [12]. Illustration of this is shown in fig 2.

Working:

Computer can't store data like humans it stores in form of binary ones and zeros. The image or data which we give to computer it stores each pixel values of the image and recognize it in same manner.
That is it capture the frame in video feed convert it into pixel value compare it with stored data and if it matches it recognize or else it will move to next frame. The more we train more accurate the results are.

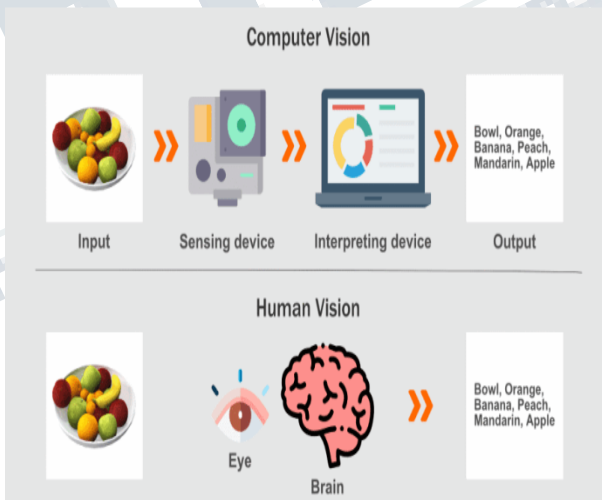

Fig 2: working of AI Computer-vision.

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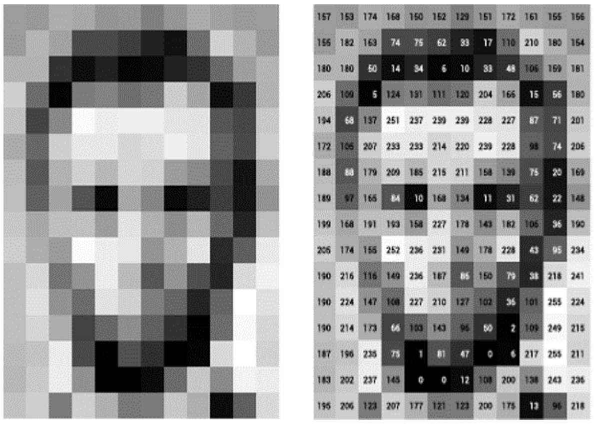

Fig 3: Getting pixel value

Using this technology we can train our model guide the system to recognize any object, fire or intruder and other things.

I will be very help full for surveillance and to observe the forest conditions.

We can keep track of the hunters or any intruders in the forest or we can track activity of any animals and we can also detect the fire in early stages and prevent it too.

Internet of Things:

Internet of Things is a trending technology that makes things smarter. It makes everything interactive. For example a simple device AC becomes more smart and interactive with help of Internet of things; that is it can constantly measure room temperature and update it to user. Based on user behavior it can set pattern for itself, it enables distant control to user and it can automatically update its status to its manufacturer, so that it can be serviced before it is damaged. These are very few possibilities mentioned; with help of Internet of things we can do much more application [13].

Architecture of Internet of Things is shown in the diagram given below.

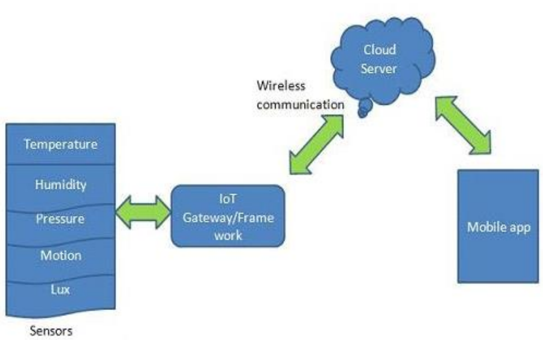

Fig 4: Internet of Things architecture

As shown in architecture the entire sensor data is collected and processed using microcontroller and then it is sent to Internet of Things platform or server from where user can access data and monitor anytime. Not only monitoring data user can also have control over particular device.

Work Flow of Project:

Woking flow and methodology of the project has been explained in the block diagrams given below.

Lets begin with getting video feed from Ov2640 camera to local server. Fig 5 shows how it is impemented.

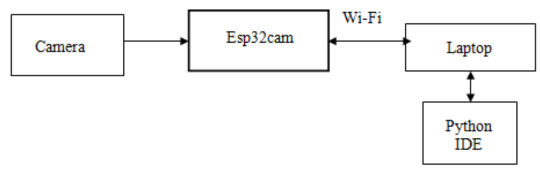

Fig 5: Block diagram of importing the video feed

Locomotion of the project involes two ends. One which control the robot or the transmission end and other the receiver end which is robot itself.

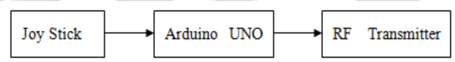

Fig 6: Transmitter for Locomotion

This contain joystick and microcontroller to to make movement of the robot. Data is transmitted over RF trans-recieiver.

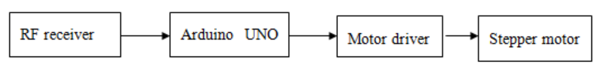

Fig 7: Receiver for Locomotion.

In receiver end data received by transreciver is decoded and based on the data requireec input is given to motor driver ands it drives the stepper motor.

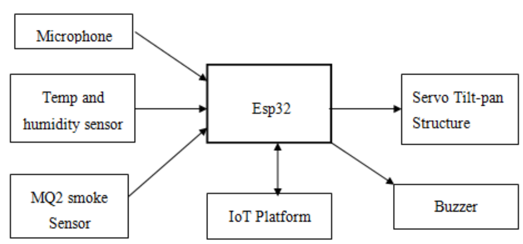

Fig 8: Sensor data monitoring block diagram.

As shown in fig 8 it's the block diagram of sensors availble on board. All the sensor data is fed in to esp32 dev board and then sent to Internt of Things Server. Not only sensor data but there are actuators which we can contol from the Internet of Things server platform.

Basic workflow is explained in this section, proper working and technical details is given in next section.

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IMPLEMENTATION

Hardware description:

To achieve the objective of our project we require certain hardware components. Each of them has been described in this section:

1. Stepper Motor:

Stepper motor has been used because it has best precession. If DC motor is used there are chances of robot going offset as we have no control over DC motor rotation. But in stepper motor we can control it as per our requirement, because it runs based on the number of steps we give. Internal structure of stepper motor is given in Fig 9.

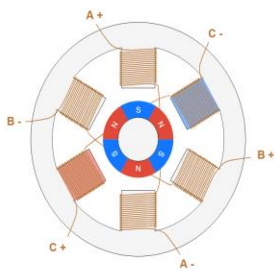

Fig 9: Structure of Stepper Motor

2. RF Transceiver:

Fig 10: NRF24L01 RF Transceiver

As mentioned earlier due to long range RF Transceivers are used as backup communication and also to control robot. NRF24L01 is a transceiver with an antenna which is used majorly for project purpose. It has range of about 800m, but it can vary based on the obstacles present in line of sight between Transmitter and Receiver.

3. ESP32 board:

Fig 11: Esp32 development board.

Esp32 board is used to collect sensor data and sent it to Internet of Things platform or server via Wi-Fi. It has built in Wi-Fi support and has sufficient pins to connect all sensors and actuators. It is advanced 32 bit microcontroller all protocol support.

4. ESP 32 Cam board:

Fig 12: Esp32 Cam Board

Camera which we are using in this project is OV2640. Esp32 cam board comes with built in support for this particular camera. It also has memory card slot to record the camera captures.

Since is the lowest price board which supports camera and send data to local server via Wi-Fi, this board is used in this project. It is the best low cost solution which serves our purpose.

5. MQ2 Smoke sensor:

Fig 13: MQ2 Smoke Sensor Module

Smoke sensor is use to sense fire without sensor being in contact with fire. MQ2 sensor has capability to sense gas, smoke and other few chemicals. It sends the analog signal, which is converted to digital by micro controllers.

6. DHT 11 Humidity and Temperature Sensor:

DHT 11 sensor is used in this project to measure the temperature and Humidity of the forest environment which will help us to know if there is fire break out. DHT 11 measures the temperature and humidity present in air so it can detect fire from distance itself.

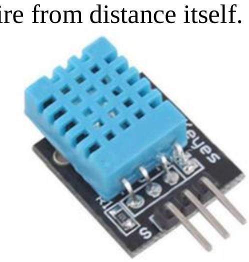

Fig 14: DHT11 Humidity and Temperature Sensor

7. Micro phone module:

Fig 15: Sound Detection Microphone Module

Micro phone module is used to measure the change in surrounding sound. If sound above threshold is detected it alerts the user and user can pay attention to video feed to see what has happened.

8. Ultrasonic Sensor:

Fig 16: Ultrasonic Sensor

Ultrasonic sensor measure the distance constantly and if there is any obstacle it alert the user and also stop the robot. It helps to avoid collision of robot and prevent damage.

9. Tilt pan setup:

This servo setup is used for movement of the camera to increase the angle of vision. Servo can move till 180 degree and have the precise movement as it has encoder inside it. We need to give PWM signals to control it. Due this movement camera can be tiled 180 degree vertical and pan 180 degree horizontal.

10. Buzzer:

Buzzer is the on board device which is controlled by user when necessary. It is also triggered by microcontroller on its own to alert the surrounding when sensor value reaches above threshold.

These were the required hardware for the project.

Software Requirement:

In this project we have used Arduino IDE to program the microcontrollers and Arduino C programming language. This is for sensor part of the project.

For AI Computer-vision application we have used Python IDE and Python Programming language. In Python IDE we have few libraries which were of great help to achieve AI Computer-vision. Few of them were:

Open CV: it is the major open source library for any kind of video processing. Its built in datasets were very helpful to detect humans or objects.

There are other supportive libraries too, which were numpy, Matplotlib etc.

Server:

There are various Internet of things platform, but we have Blynk as Internet of things Server because it was user friendly and fulfilled all our necessity of the project.

Implementation:

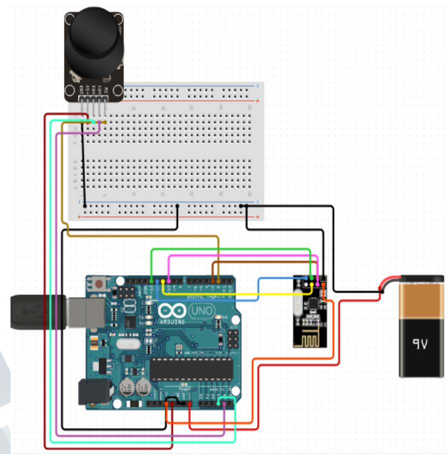

Fig 17: Transmitter Circuit for Locomotion

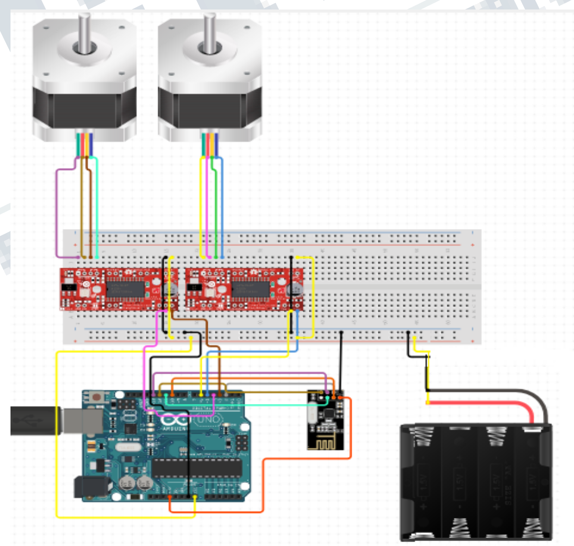

Fig 18: Receiver Circuit for Locomotion

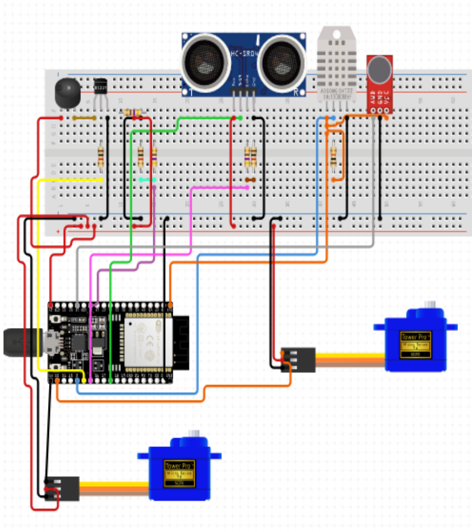

Fig 19: Sensor Monitoring Circuit Diagram

RESULTS

This project has been implemented successfully and objects if the project were met. Results of the project are shown below.

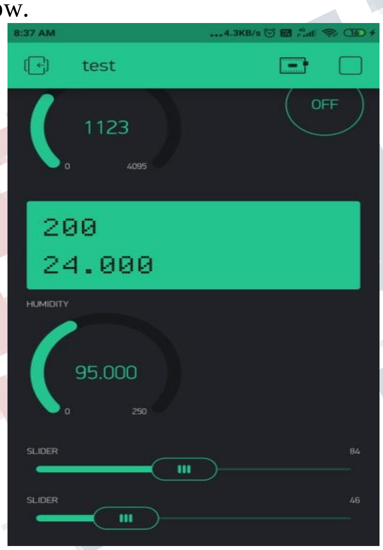

Fig 20: Sensor data Monitor and Control

As shown in fig 20, all live data will be displayed continuously and when data cross the threshold user will be notified.

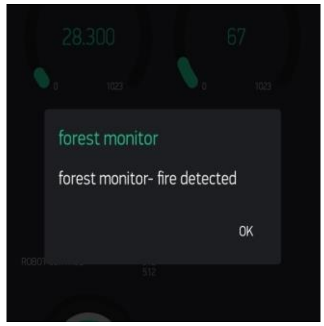

Fig 21: Notification in Blynk App

In fig 21 we got notification when temperature and smoke level is above threshold, now user can look into the video feed to confirm and take required action.

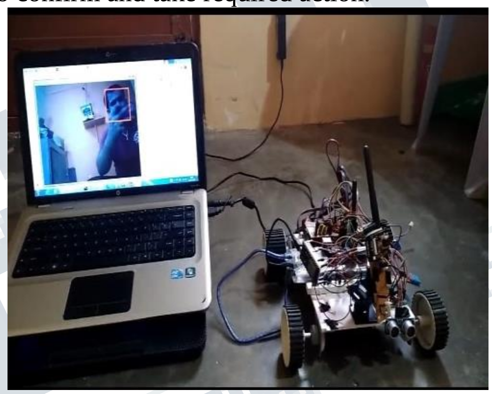

Fig 22: Live video feed and Intruder detection

As shown in fig 22, via Wi-Fi video feed is sent to local server then it is taken to python IDE and processed to detect intruder. Demo of intruder has been shown similarly with proper data set we can process to identify desired object or fire and many other things.

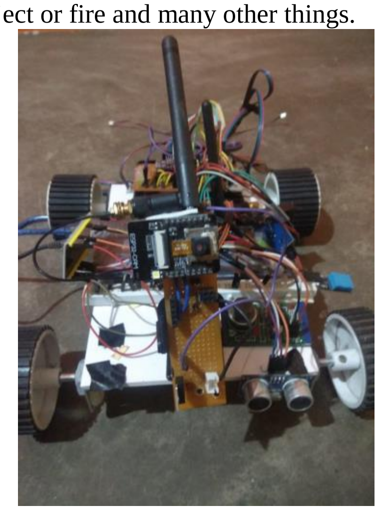

Fig 23: Final Result of the Project

CONCLUSION

To conclude with we would like to mention that it's the prototype of the objectives mentioned, during practical implementation it faces various challenges like:

It can transmit the image within single Wi-Fi range. But this issue can be solved using repeaters or making area Wi-Fi enabled area. If internet is available we can send data to global server which will nullify the range issue.

Necessity of availability of internet to send data to Internet of Things platform is a setback. This will be resolved with upcoming Satellite internet which enables internet to every nook and corner of the globe.

To mention about the future scope, presented prototype make efficient use of the available technology and achieved all the objectives defined. It is the best low cost and advanced solution for surveillance and monitoring of forest area.

Further as advancement multiple robots can be implemented and Interconnection of robot can be in-planted.

Implementation of solar power along with robot will solve the power issue and make more self reliable.

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