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AI BASED FOREST FIRE SYSTEM

A Report for the Project 2

Submitted by

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BONAFIDE CERTIFICATE

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ABSTRACT

Forest fire has a severe effect on wildlife animals, humans and ecological system. According to the survey conducted by forest authorities, every year huge loss is caused due to forest fire accidents. The idea of this project is to build an early detection and prevention system for forest fire to preserve the nature. Throughout this planned work it is primarily used to prevent the forest fire by monitoring the threshold value of each sensor and take an immediate action to achieve high reliability prevention using this technology. IoT played a vital role for detection which also help in building a real time application by Arduino programming. As soon as it detects a fire condition the system will inform the concerned authority and they can take an immediate action by deploying the firefighters. Using ML, the system will be able to calculate the percentage of damage caused, if any. This project primarily works into two phases, first phase is early detection & prevention and second phase is after an incident analyses of the areas near the forest. Nevertheless, the issue of forest fire control provides a worthy space and exciting area for future research.

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LIST OF SYMBOLS & ABBREVIATIONS

IoT: Internet of Things

ML: Machine Learning

AI: Artificial Intelligence

SRS: Software requirement specifications

PIR: Passive infrared sensor

WSN: Wireless sensor network

SN: Sensor node

CN: Central node

IR: Infrared rays

1. INTRODUCTION

1.1. OVERALL DESCRIPTION

Forests are the savior of earth’s ecological balance. Forest fires usually occur in areas remote from populated places, in order to that their detection at an early stage and timely reports to the competent services are of utmost importance. Forest fires are one among the foremost important and prevalent sort of disasters and that they can create great environmental problems for Nature. it's known that they're detectable and simply preventable. One and possibly the foremost important method for shielding forests from wildfires is their early detection. The earliest possible detection enables a rapid response to attenuate the spread. Moreover, information regarding the seat of the hearth is invaluable for the rapid deployment of fire-fighters. Therefore, early detection, containment at the primary stages and extinguishment of a fireplace before it spreads are crucial for wildfire management.

To reduce the risk and prevent the forest fire they are big offerings to fight it like planes, fire brigade trucks, also extinguishers to small areas which depends upon the severity of the fire and leads to large investment by concerned agencies. The best way out is early detection of forest fire and prevention.

Forest fires are highly destructive and are uncontrollable when it starts spreading over the area. Fire causes respiratory problems for living beings even they are living several kilometers away. The 2019, Australia wildfires almost 15 million acres have been burned and the fire also killed about one billion animals. The 2019, Amazon forest fire was burning at a rate which was not seen in almost a decade. It destroyed the ecosystem and caused destructive climate pollution to the atmosphere.

IoT has several sensors to detect multiple factors, so we have used some sensors for forest fire detection. Using the latest technology, it makes the

system more reliable and efficient. In this project, we developed an IoT and Web infrastructure for monitoring the forest situation, if there is any issue the system will inform the admin immediately and action can be taken instantly. Several types of sensors used in this developed system are Smoke sensor, temperature sensor, PIR sensor. Also, if any damage occurs, we can also calculate it using ML algorithm, we have trained a model for the same using the embedded algorithm available on the platform.

1.2. PURPOSE

Forest fires as of late have been annihilating both for normal biological system, biodiversity and woodland economy. With expanding populace weight and change in worldwide atmosphere situation, there is an expansion in level of fires that are a significant reason for declining Indian woodlands. As indicated by woodland study report of India, 50 % of backwoods regions in nation are fire inclined (going from 50 to 90 % in certain conditions of nation). Around 6 % of the woods are inclined to extreme fire harms. The reason for this planned framework is to manufacture a dependable fire location framework so as to know dynamic status of backwoods temperature in specific conditions. It is about the sensors and dynamic checking framework to dodge a significant fire and genuine harm to woods.

1.3. SCOPE AND MOTIVATION

As of now, several forest fire detection and prevention system have been made and successfully applied but the issue of forest fire risk has lot more things to research and improve the system so it works more effectively and efficiently.

Forest fire management requires high reliability system, so in any incident the system will inform them before any fire accident. Due to the lack of emergency plan and the need of efficient system is much higher. The

installation of early detection system in a better way by identifying the sites is also a major challenge. With the complete information and warning of incident the smart system can help to reduce the risk and prevent the forest fire which can save the biodiversity and lives of millions.

2. LITERATURE REVIEW

The idea of this research is to fabricate a system through IoT sensors, which is arbitrarily spread in the forest and to make a self-sorted out powerful system between the sensors to cover all the enormous territories in the forest that will used to maintain a strategic distance from the fire harm whenever. The capacity of the sensor is to identify fire in the inclusion region between the time intermission of each 5-10 minutes. At the point when the fire is recognized the entirety of the sensor in the region will be dynamic and order to stop the normal assignment.

The concept is to build early fire detector using Arduino which is connected with different IoT sensors. Putting all efforts to develop a smarter system by connecting it to a webpage and monitoring the developed system statistics controlled by the Arduino programming. The use of latest technology can help to prevent the catastrophic accidents in forests.

The aim is to early detect the fireplace in forest by considering the several factor like smoke, temperature, humidity, flame and based on the data we get from this programming, the forest department will be able to take an appropriate decision and the rescue team will be able to arrive on time at exact location. Consider, if it is a large region and it produces more carbon monoxide than the ordinary vehicle traffic. Surveillance of the danger areas and an early detection of fireplace can appreciably shorten the response time and additionally decrease the practicable injury as nicely as the fee of firefighting. Known rule applies here: 1 minute – 1 cup of water, 2 minutes - 100 liters of water, 10 minutes - 1000 liters of water. The goal is to notice the fireplace as quicker as possible, its actual localization and early notification to the fire devices.

When fire starts then the flammable texture may likewise issues fuel to the hearth focal spot. The spot at that point will expand and more extensive. The first phase of start is alluded as "surface fire‟ stage. This may feed on abutting bushes and the fire will turn into higher and transforming into "crown fire‟. Generally, at this stage the

hearth transforms into wild and injury which end up being extreme that could stay for quite long time while depending on atmosphere conditions and the territory.

Forest fire detection using optimized solar–powered ZigBee wireless sensor networks- In this paper, they have developed system for Forest Fire Detection which overcomes the demerits of the Existing technologies of Forest Fire Detection. It can be ensured that the system developed can be implemented on a large scale with its promising results. The system is provided with low-power elements, higher versions of Zigbee, Maximum power point tracking Algorithm is used in order to make the system run for longer periods efficiently.

Forest fires are a very serious problem in many countries, and global warming may contribute to make this problem worse. Experts agree that, in order to prevent these tragedies from happening, it is necessary to invest in new technologies and equipment that enable a multifaceted approach.

This paper describes a WSN for early detection of forest fires. This network can be easily deployed at areas of special interest or risk. There are two types of nodes from the physical structure point of view: SNs, to collect data from the environment, and CNs, to gather data from the SNs and transmit the information to a Control Centre.

The nodes also can be in different functioning modes. This enables a proper and seamless configuration of the network, provides redundancy, and ensures there will be full temporal and geographical coverage in the deployment zone. The information gathered is related not only to early detection purposes but also to environment monitoring to maximize the WSN usage. This environmental data can also be employed to firefighting preventive tasks such as vegetation modelling, microclimate studies, and propagation model parametrization.

Comparison	Human based observation	Satellite system	Optical cameras	Wireless sensor networks
Cost	Low	Very high	High	Medium
Efficiency and practicality	Low	Low	Medium	High
Faulty alarms repetition	Low	Low	Medium	Medium
Fire localising accuracy	Low	Medium	Medium	High
Detection delay	Long	Very long	Long	Small
Fire behaviour information	—	Yes	—	Yes
Can be used for other purposes	No	Yes	No	Yes

Table 1. Comparison of different techniques

In this paper, a forest fire detection algorithm is proposed. The algorithm uses YCbCr color space since it effectively separates luminance from chrominance and is able to separate high temperature fire center pixels because the fire at the high temperature center region is white. The final results show that the proposed system has good detection rates and fewer false alarms, which are the main crucial problems of the most existing algorithms.

The presences of fire in video streams are indicated by semantic events. Most of the existing systems can only be used for the videos obtained from stationary cameras and videos obtained from the controlled lightening conditions. These existing automatic fire detection systems cannot be used for video streams obtained from mobile phones or any hand held devices.

Figure 1. Amazon rainforest wildfire,2019

The Amazon, the world's most biodiverse rainforest, was burning at a rate not seen in almost a decade. It was decried as a global tragedy. Lit by farmers, the fires raged through villages, destroyed ecosystems and pumped climate-warming pollution into the atmosphere. We need to take care of forest and ensure a high reliability system and destructive accidents like this never happen again.

3. PROBLEM STATEMENT

Forest fires lead to destruction of forest wealth and not only that it also destroys the flora and fauna which causes harm to biodiversity. Forest are great resources and to preserve them is a major challenge. As, they are irreparable damage to the ecosystem, so forest fire detection and prevention is utmost important and best way to tackle this problem.

But the forest fire early detection and prevention is another major challenge faced all over the world. Several methods for controlling and monitoring of fires have been proposed. In earlier days, manned observation towers were used but this technique was inefficient and failed. After that satellite and camera imaging technologies were tried but this also proved inefficient and ineffective. For example, cameras were installed at different sites in forest but these provide only line of sight pictures. For a very large areas alert system is required as it is really tedious task to monitor all the images.

4. SOFTWARE REQUIREMENTS

4.1. PRODUCT DESCRIPTION

4.1.1. Product Perspective

This system covers the following information.

a. Review summary reports
b. Sensors reports and real time data.
c. Blogs/Articles etc.

4.1.2. Product features

The main features of this approach are as follows:

a. Machine Learning approach
b. Real Time Data
c. Simple to handle
d. Understanding system
e. Customer environment

4.1.3. Operating environment

a. Client - Server system (Based on Watson Studio)
b. Any PC or Mobile OS that have supported browser

4.1.4. Design & implementation constraints

The server-side application will reside on Watson Studio Cloud. The thin client will be able to operate on any machine running supported Browser e.g. Google Chrome, Safari, Mozilla Firefox, Microsoft Edge.

4.1.5. Documentation

Two sets of documentation will be provided to the client:

- Instructions for installing the product on the server and maintain server.
- A tutorial for Web Site, tools using Watson Studio, along with a listing of difficulties we faced during the process.

4.2. SYSTEM FEATURES

The prediction of the development of the fire front and fire parameters, as well a of fire characteristics (intensity, flame length), aims to improve fire forecasting and fire suppression:

- Use for certain spatial evaluation methods of the risk
- Installation of fire suppression support infrastructures (roads, fuel breaks, water points)
- Support of persons in charge of the fire suppression, in real time, for strategic choices. The estimation of the fire size at the time of attack and the prediction of the evolution of the fire front are important information for the deployment of suppression forces.

The operational objective of the fi re models, i.e., the use in real time, within tactical framework, is not reached yet. Indeed, taking into account the complexity of the forest fi re phenomenon, due to interactions between various factors of the natural environment and between the fire and these factors, and taking into account the current calculation power of computers, the calculating times are much too slow today.

4.3. EXTERNAL INTERFACE REQUIREMENTS

4.3.1. User Interfaces

It’s a windows Arduino Based User Interface that can tell you the threshold value of current temperature and environment around the sensor. End user can get the chart to check the data and to manipulate the data. End user can Interact with IoT device and sensors and a PC having Arduino IDE installed.

4.3.2. Hardware Interfaces

On the hardware side, you get a very simple and interactive implementation of IoT device. In order to implement it you need:
Arduino Uno R3, PIR sensor, smoke sensor, TMP36 sensor.

4.3.3. Software Interfaces

Software side, you need:

PC: Windows (7 or later, Windows 10 recommended), Mac (10.12 and later), Linux

IDE: Arduino IDE (Open source Project, you will get on Microsoft store)

The software interfaces will include either the Apache Tomcat or Glassfish Server and Watson Studio to manage and manipulate the data.

4.3.4. Communications Interfaces

The thin client and server-side application will communicate via the Internet and Java Web Services. Specifically, the method of transportation will be XML.

4.4. OTHER REQUIREMENTS

Sensor performance is depending upon the implementation you got and how well your circuit is designed will primarily be dependent on network speed and server performance. However, the we are concerned about performance and real time data

processing and generating and to manipulate the data on the cloud side. So, we need a fast and stable connection to send the data accurately. One more important factor

is to notice that threshold value must set according to area you put the sensor. And the threshold value must be change during season and in order get correct value of threshold we need to manipulate the data correctly and apply some Machine Learning algorithm to Predict the environment.

5. METHODOLOGY ADOPTED

The purpose of this designed system is to build a reliable forest fire detection system in order to know active status of forest temperature in certain conditions. It is all about the sensors and active monitoring system to avoid a major fire and serious damage to forest. One & possibly the most important method for protecting forests from wildfires is their early detection. A particular measure is set on the device and if the ground temperature or the environment temperature reach to that threshold, a signal is being send to the admin team.

In our proposed system we are interfacing Arduino Uno R3 with different IoT sensors such as smoke sensor, PIR Sensor, temperature sensor, which is capable of detecting the fire conditions and sends the information to the concerned authority on detecting fire conditions. Webpage display the graph of each sensor and shows the real time information. Through the ML algorithm, we can also calculate percentage of damage caused, if any by analyzing the images of surface fire area captured by drone. The trained model has capability to visualize burned and intact home, which also helps in understanding how much time will it require to recover and how critical situation is in the site of fire. This system covers all the aspects and risk factors that are involved in forest fire.

Stages of Design

The entire system depends upon the Internet of Things and the framework has been divided into 4 parts:

- Interfacing and programming of sensors with Arduino.
- Interfacing sensor data with real time analysis.
- Interfacing Arduino with respective software.
- Analyzing drone images with the help of machine learning.

Working Principle

The overall working of the model depends upon the threshold value of each sensor, if any sensor detects any unusual activity it will generate an alert and sends a information to concerned authority so immediate action can be taken by deploying the firefighters. If there is any damage, it can also be estimated through ML algorithm and appropriate decision can be taken to resolve the issue. First aim is to reduce the risk and prevent the forest fire, if in any case system is unable to inform, we have another option of capturing drone image of affected site to estimate areas with higher damage percentage based upon that emergency services can be prioritized.

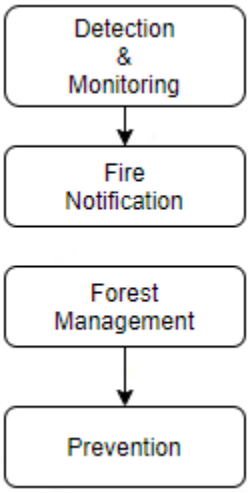

Figure 2. Flow of Control

Sensor	Threshold Value
PIR	High
Smoke	200
TMP 36	60
LED	High

Table 2. Threshold value

6. IMPLEMENTATION

System Design

The model is quite simple which has Arduino Uno R3 interfaced with smoke sensor, PIR sensor, temperature sensor, buzzer, Led Light.

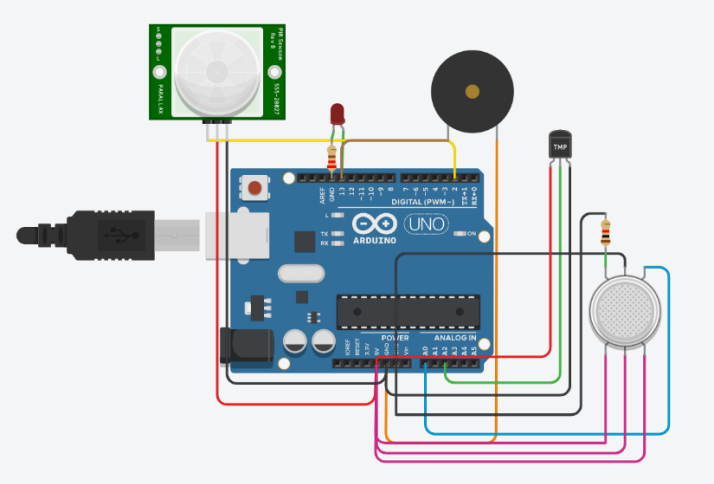

Figure 3. System Architecture

Hardware Used

1. Arduino Uno R3: The Arduino Uno R3 is a microcontroller board which has 14 digital I/O pins, a power jack, reset button, USB connection. Connection is simple, connect it to a computer with the help of USB cable. It is best board to get started. For connection of sensors we need jumper wires. It has output voltage of 5V and input voltage varies from 6V-20V. It has flash memory in which the program can be uploaded.

Figure 4. Arduino Uno R3

2. Smoke Sensor: It senses smoke, act as fire indicator. It detects the amount of gas in ppm and gives output in analog value which is converted to digital using Arduino board.

Figure 5. Smoke Sensor

3. PIR Sensor: PIR modules consist of passive infrared sensor that detects motion through radiate IR light. Heating objects also generate infrared rays.

Figure 6. PIR Sensor

4. TMP 36 Sensor: TMP 36 contains temperature detector. It outputs the voltage which can be converted into Celsius with mathematical calculation.

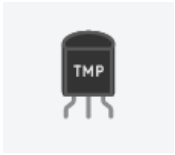

Figure 7. TMP 36 Sensor

Circuit Explanation

We require connecting wires for connection of sensor with Arduino board. Pin configuration as follows- PIR sensor has three pins signal pin with D2, power pin with 5V and ground pin with GND. Same with TMP 36 it also has three pins power pin with 5V, V_{out} with A2 and ground pin with GND. Smoke sensor has six pins in this three pins are connected with 5V, two pins with GND in which one pin is connected to GND with help of resistor and the last pin is connected with A0. LED light and speaker are connected to GND and D13.

Working Code for Arduino:

```
int sensorState = 0;
char degree = 176;
const int gas = 0;
int MQ2pin = A0;
void setup()
{
  pinMode(2, INPUT);
  pinMode(13, OUTPUT);
  Serial.begin(9600);
}
void loop()
{sensorState =digitalRead(2);
  int tmp = analogRead(A2);
  float voltage = (tmp * 5.0)/1024;
  float milliVolt = voltage * 1000;
  float tempCel =  (milliVolt-500)/10;
  float sensorValue,MQ2pin;
  sensorValue = analogRead(MQ2pin);
  if(sensorState == HIGH) {
    digitalWrite(13, HIGH);
    Serial.println("IR detected, Sensor activated!");
  } else {
    digitalWrite(13, LOW);
  }
```

```
    if(tempCel>60){
    digitalWrite(13,60);
    Serial.print("Abnormal Temperature, Celsius: ");
    Serial.print(tempCel);
    Serial.println(degree);
    }
    else{
    Serial.print("Celsius:");
    Serial.print(tempCel);
    Serial.print(degree);
    }
    if(sensorValue>=200){
      digitalWrite(13,200);
      Serial.print("\nSMOKE DETECTED");
      Serial.print(" Sensor Value: ");
      Serial.println(sensorValue);
    }
    else{
      Serial.print(" Sensor Value: ");
      Serial.println(sensorValue);  }
    delay(3000);
  }
  float getsensorValue(int pin){
        return (analogRead(pin));
}
```

Working of sensors

Each sensor has fixed threshold value based upon that system gives warning. For example, smoke sensor has threshold value of 200, PIR sensor detects high and low value signal. Different conditions are set to detect the fire as early as possible. Suppose if there is any abnormal temperature, TMP36 sensor will sense it and sends the warning.

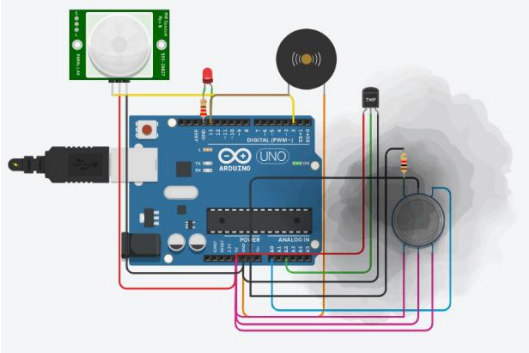

Figure 8. Demonstration of smoke sensor

When smoke is detected, the buzzer and LED light get activated. Smoke can be seen in above picture.

Trained ML model

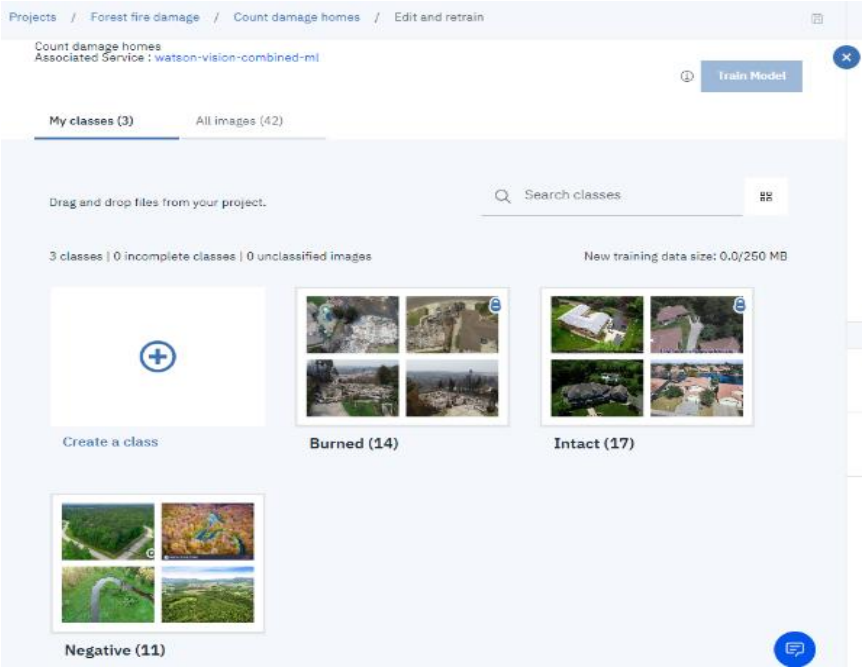

Figure 9. Development of ML model

In this ML model, three classes are defined i.e. Burned, Intact, Negative. We need to classify the intact and burned homes. For accurate result negative class is also defined, it will not identify inappropriate objects.

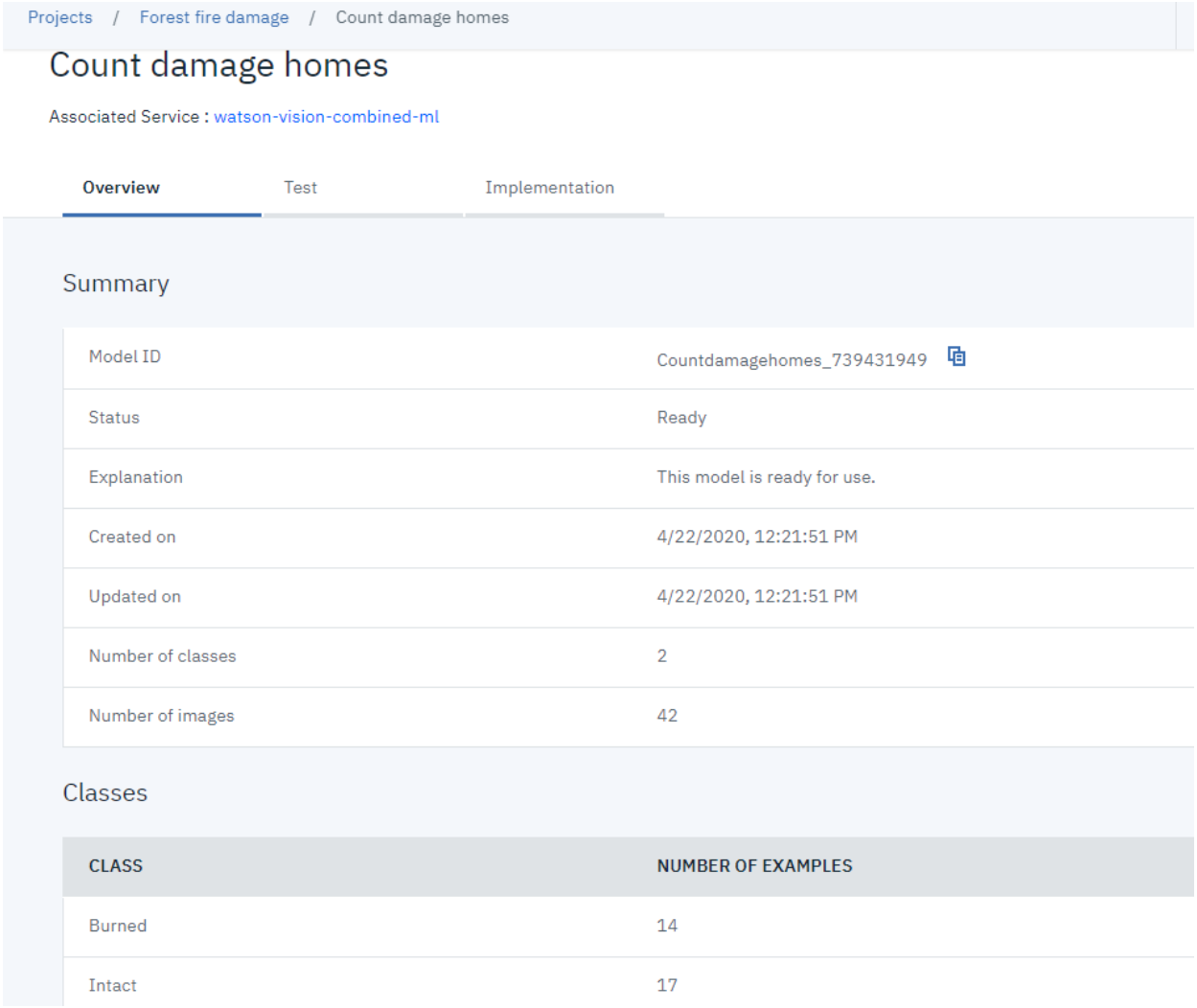

Figure 10. Model trained successfully

7. OUTPUT/RESULT

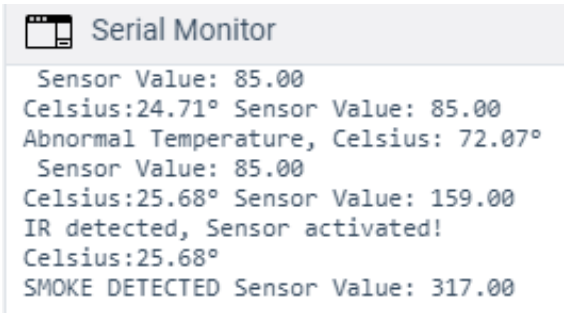

Figure 11. Values obtained from IoT sensors

Value obtained from three sensor, if any Infrared ray detected, it gives output as IR detected, Sensor activated! Similarly, if there is any temperature change it will show Abnormal temperature and its intensity. For any smoke detection it output as Smoke detected and sensor value.

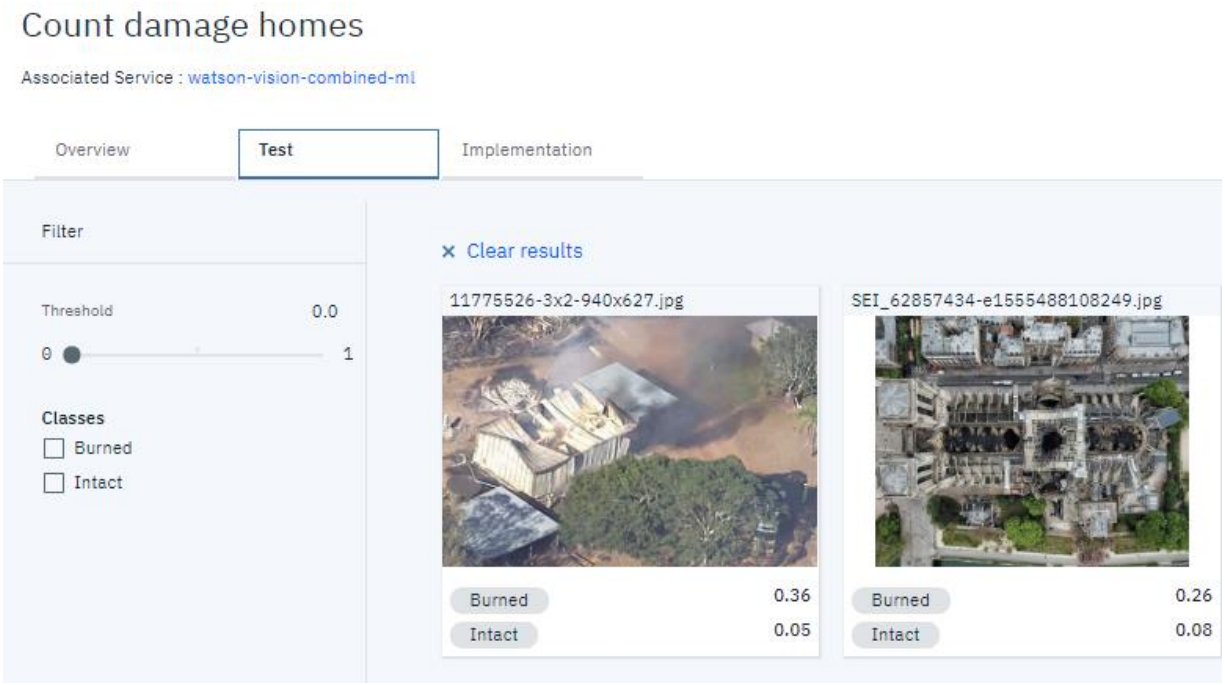

Figure 12. ML model output

Above image is result obtained from the trained ML model, showing count for damaged and intact homes.

8. CONCLUSION/FUTURE SCOPE

Conclusion

This project will help in early detection of forest fire and the prevention. It also involves the risk factor of analyzing the drone images of affected areas using machine learning algorithm which overcomes the existing project. This system detects the fire conditions in a short time before any fire accidents spreads over the forest area.

Future Scope

In future, we are planning to install smart water tank system in dense forest where reachability of resources and firefighters is difficult. In addition to that we will be updating the system with more features and reliability. We will also include a high pitch sound system that will keep away the animals from the site of fire.

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