IoT Sensor and Deep Neural Network based Wildfire Prediction System

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Abstract—**Forests, one of the most valuable and necessary resources and protect earth's ecological balance, are a natural habitat to animals and forest products are vital in our lives in many direct and indirect ways. But wildfires can cause critical damage to grounds and many other resources like properties, human life, wildlife in superabundant amounts. Wildfires burn acres of land and destroy everything in their paths in mere minutes. Wildfire destroys homes, animals, trees and plants, wildlife as well as vegetation. The effects of wildfires are numerous and wide-ranging. it causes a hugely significant impact on the economy, environment, heritage and social fabric of rural areas. Naturally caused wildfires can be predicted using factors[3] like temperature, humidity, soil moisture, pressure and many more. In this paper, the prediction of forest fires by machine learning using some operational monitoring over a region and encountering changes in climate using different sensors are advocated. The Wildfire Prediction System (WiPreSy) monitors and records changes in climatic parameters and predicts the intensity of forest fire based on real-time data, thus avoiding the massive loss due to forest fires.**

Keywords—Forest fire prediction, Temperature and humidity sensor DHT11, Soil moisture sensor YL-69, Pressure and Altitude Sensor BMP-280, GPS sensor, Wildfire prediction, Complete system for forest fire prediction, Bolt IoT and cloud

I. INTRODUCTION

A forest is entirely a biological community for biotic as well as abiotic factors like animals, birds, trees, etc. and water, rocks, and climate in that forest area, respectively. Wildfires are one of the worst types of natural disasters to hit any part of the world. Every year there is a fire season during the Australian summer. Such wildfires are caused due to climate change. In July 2019, a massive forest fire began in Australia. In this season, at least 27 million acres of Australia have been burnt, 29 people were killed and 2,500 homes were destroyed. It is estimated that 1.25 billion animals have been lost in Australian wildfires. [7] Research shows lightning and climate change are the causes of Australian wildfires. Another devastating wildfire in the Amazon rainforest broke out in January 2019. The forest fire continued till October 2019. 906,000 hectares of land was burned in the 2019 Amazon rainforest wildfires [8]. According to the study of the National Interagency Fire Center(NIFC), there were an average of 67,000 wildfires annually and an average of 7.0 million acres burned annually over the past 10 years [9]. Lightning, volcanic eruptions, earthquakes, increased temperature, dry vegetation are the few of the major causes of wildfires. Fires destroy diversity and have long-term impacts on the environment. Loss of life, agriculture, and vegetation, soil erosion, soil infertility, air pollution, water pollution and release of harmful gasses are few effects of wildfires. Global warming is the major effect of forest fires. The wildfires, when reached to danger, can be punishing, extraordinary and very difficult and to handle. Therefore predicting the occurrence of such a drastic event can be beneficial and informative and enacts an important role in taking precautionary measures to handle such event and be prepared and also avoid wildfires for future and consequently preventing its deleterious effects on the environment.

Therefore the aim is to develop a machine learning model which will :

1. Evaluate the historic forest fire data.
2. Predict the possibility of forest fires using real-time data fed into the system via IoT devices and sensors.

3. Identify a trend based on useful and distinct parameters such as location, altitude and temperature to be able to predict the possibility of the forest fires when real-time data is fed as input.

II. PROPOSED SYSTEM

One of the existing systems is the KNIME model which predicts the burnt area by forest fires. It allows users to visually pipeline, executes the analysis steps, and finally, inspects the results, models[10]. However, it doesn't suggest any preventive measures. The prediction model seems to be a better alternative so that the necessary measures can be taken to prevent forest fires and the associated losses. Another method used for detection of wildfire is by using camera surveillance systems which provide only the line of sight images and hence are ineffective in contrast to the prediction system proposed in this paper, which uses the real-time data from various sensors that record the changes in the environmental parameters. Lastly, the prediction systems which make use of satellite images are ineffective because these images get updated once every two days. Since two days is a long period and can affect the results of a prediction system negatively, prediction using the real-time data is a better alternative.

There are many factors such as temperature, pressure, soil moisture affecting forest fires. According to the study, there are many systems used for the detection of fire in a forest. These systems use various factors such as temperature, perception values, slopes, wind speed, wind direction, images and many more. But there are very few systems for prediction of wildfire. The prediction model will be based on the historic data as well as real-time data about the factors affecting wildfire fed by the sensors and a pattern will be observed. While the existence of all the factors at once is not necessary for the fires, a combination of some factors among these will determine the likelihood of the fire. And this likelihood will be categorised into low, medium, high and very high. The more the data, the better will be the accuracy. If the wildfires are accurately predicted, the safety measures, as well as precautions, can be undertaken to avoid the huge losses incurred by the wildfires. The proposed system uses machine learning, cloud storage and IoT sensor configuration.

A. *Machine Learning:*

A simple logistic regression may very well be applied for the problem, however, this approach uses a Dense Neural Network created using Keras API with input dimensions corresponding to the fields collected by the IoT Sensors and a binary output. The non-binary output is further obtained using the Keras Functional approach and taking in a parallel input of date and location as features and occurrence of wildfire as output label.

B. *IoT Sensor Configuration:*

The environmental parameters like temperature, humidity, soil moisture, altitude and pressure are monitored and recorded using various sensors. This sensor data serves as real-time input for the prediction model. The values are updated every five minutes and are sent to the BOLT Cloud for remote access and collaborative storage. The data on the cloud can be accessed from any place using either the BOLT mobile application or website.

C. *Cloud Storage:*

The data from the sensors gets updated on the BOLT cloud every five minutes. A graph is plotted in order to visualise the changes in parameters and the pattern. A CSV file can be downloaded to keep a record of all these parameter values for the corresponding time stamps. The Bolt API is used to return all the data collected by the device. To retrieve the data, this API uses the device name and API key. The Bolt device must be active and must have valid hardware configuration in order to update the real time data. The data is further pushed into the Google firebase database.

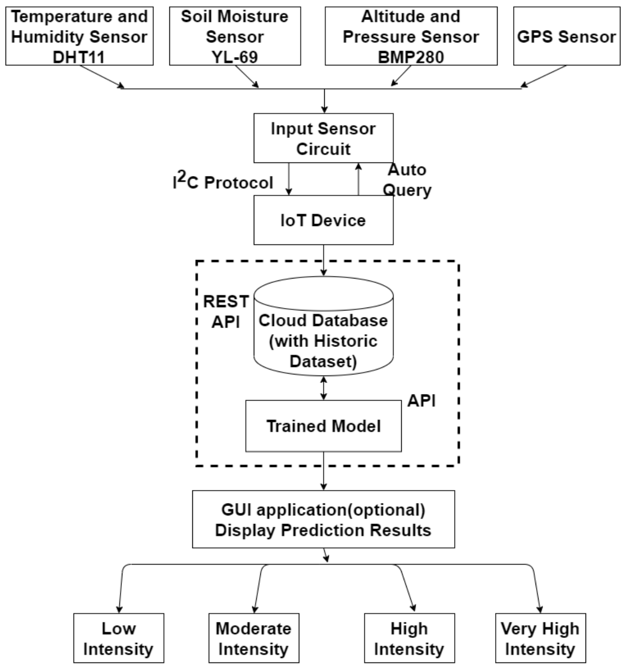

Fig.1 Flow diagram for the proposed system-WiPreSy

III. METHODOLOGY

In order to build an effective system, the parameters considered for prediction of forest fires are temperature, humidity, soil moisture, pressure and altitude. Sudden changes in these parameters can result in forest fires. The sensors are used to collect the real-time data. To record the real-time temperature and humidity, a DHT11 sensor is used. To measure the real-time soil moisture, the Yl-69 sensor is used. Yl-69 sensor has two pieces; the electronic probe and the probe with two pads. To acquire pressure and altitude the BMP280 sensors are used. The Bolt Iot platform is used for cloud storage, which can be accessed from any location. The Bolt device is connected to all the sensors to measure the real-time data. The fluctuations in the values of parameters are represented by a graph and a csv file. The data can be monitored with the help of timestamps and further pushed into Google Firebase database.

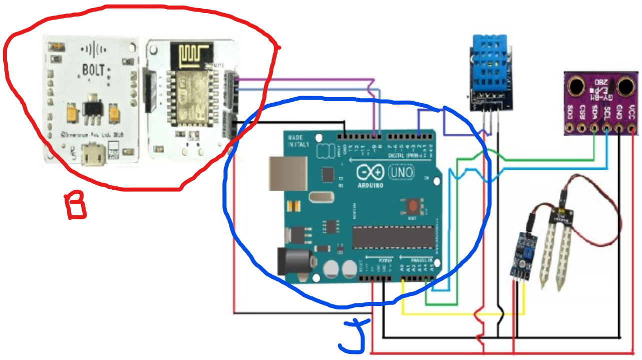

Fig.2 Sensor Circuit

time_stamp	d_id	Temperature(celcius)	Humidity	Soil moisture	Altitude	Pressure
14-02-2020 17:52	6095192	26	18	1000	1335.59	96529.2
14-02-2020 17:57	6095192	26	18	1003	1326.64	96560.75
14-02-2020 18:02	6095192	26	18	1013	1323.65	96571.27
14-02-2020 18:07	6095192	26	18	1016	1331.86	96550.24
14-02-2020 18:12	6095192	25	18	1016	1335.59	96537.09
14-02-2020 18:17	6095192	26	18	1005	1338.58	96518.69
14-02-2020 18:22	6095192	26	18	1013	1340.82	96510.8
14-02-2020 18:27	6095192	25	18	1000	1343.07	96502.91
14-02-2020 18:32	6095192	26	18	1017	1343.07	96502.91

Fig.3 CSV File

Once the data is gathered, it is then One Hot Encoded into the desired labels. A Sequential model is a good choice for implementation of a densely connected network but the given problem statement works on inputs provided by a variety of sensors as well as historical data of occurrences of wildfires over several years.

Therefore, to accommodate these complex requirements, an alternate Functional model may be used. This model takes in its input in two separate, parallel layers with the number of nodes corresponding to the number of associated parameters. For the input layer associated with the climate factors collected over the circuit, dense layers are used to first derive the necessary value from each factor over the training period. The challenge associated with such a model is splitting the data into training and testing sets with two separate sets of features. Fig.4 shows an accurate representation of such Functional model.

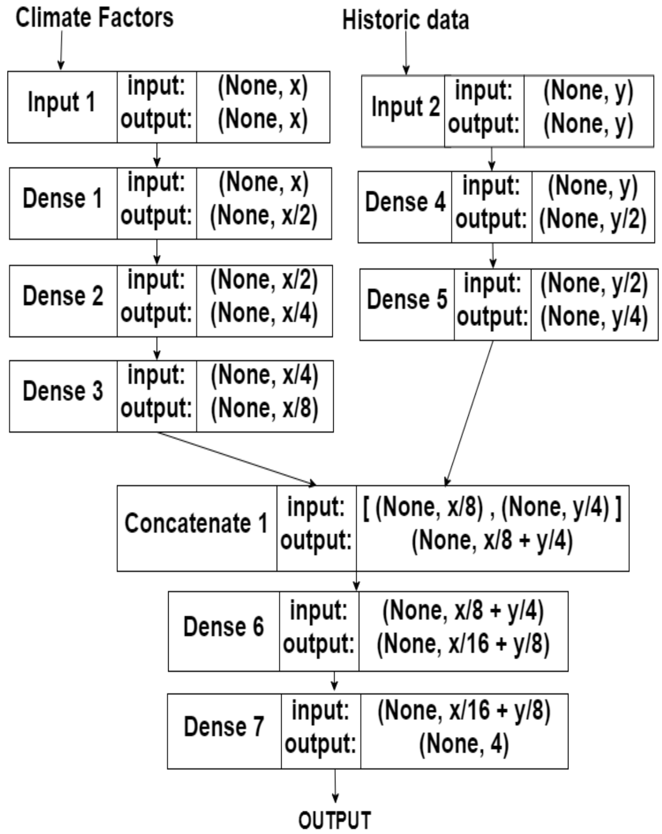

Fig.4 Functional Neural Network Architecture

The concerned user of the system can monitor the system and the changes in the values of parameters with the help of an android application. From the Google firebase database, each time the sensor output gets updated, the changes will be reflected in the application. The application indicates the intensity of the predicted forest fire, and if the intensity is high, notification is sent by the application to the user on the smartphone. The user is also able to view the past alerts and hence maintain a history of the past predicted forest fires for future references.

IV. RESULTS

The data sent from IoT sensors to the Bolt cloud is represented in the form of a graph and a CSV file. This data can be accessed from anywhere through a website or a smartphone via the Bolt app, thus facilitating remote access and collaborative storage. The trained model predicts the probability of fires when the real-time data is fed from the cloud to the model. The probability is determined using a confidence measure as a metric. Validation accuracy of our Deep Neural Network is 91% whereas the loss generated using binary cross-entropy is 1.12. The intensities are represented using the range: low, medium, high and very high. Accordingly, the users are alerted via a notification. Through an android application, the users can log in, keep a track of the values of parameters and alerts.

```
Epoch 30/30
594812/594812 [==============================]
<keras.callbacks.History at 0x7fc5d3c18f60>

 - 28s 48us/step - loss: 1.1463 - acc: 0.9062

 - val_loss: 1.1243 - val_acc: 0.9100
```

Fig.5 Metrics of 30th epoch

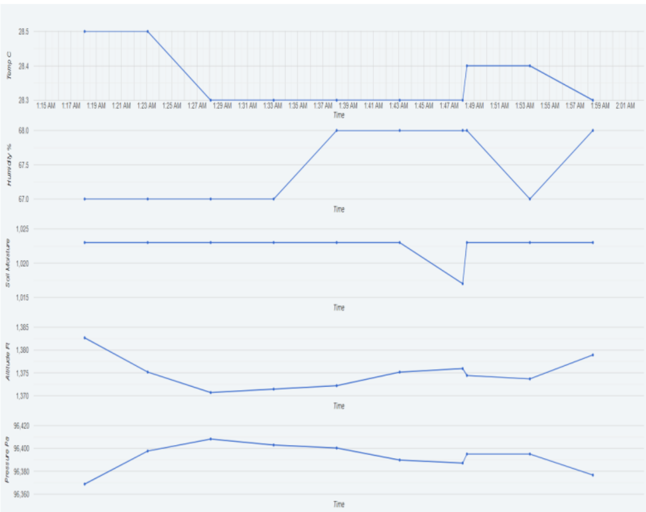

Fig.6 Graphs to visualise sensor data on BOLT cloud

V. FUTURE SCOPE

The system developed requires an active internet connection to get real-time data from the forests. Since it is quite difficult to get an internet connection in forest areas, the system can be further enhanced to an offline device. The sensors used for this system are less powerful. However, more powerful sensors can be used to increase the efficiency of the model.

VI. CONCLUSION

The increase in forest fires has affected the environment as well as business adversely. Wildfires can be manmade or can occur naturally. Estimating the naturally caused wildfires will help in the prevention of forest fires Various relations between the affecting factors (such as temperature, humidity, soil moisture, etc) can be used for predicting the wildfires. Thus the solution to the stated problem aims to predict the occurrence of wildfire using machine learning with the help of historic data as well as recording the environmental changes using various sensors which will feed the real-time data. Predicting the wildfire based on real-time data, therefore, will be a great step towards the preservation of forests and thus the environment.

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