Deployment of IoT and AI based Forest Fire Prediction and Animal Poaching Detection System

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***Abstract*—Technological improvements in the areas such as Internet of Things (IoT), Artificial Intelligence, applications have become smarter and connected devices give rise to their exploitation if environment throughout the world. Increase in generation of data by these systems, Machine Learning techniques can be applied to further enhance the intelligence and the capabilities. The field of sustainable environment and renewable energy has attracted many researchers and we have come up with a new approach in saving energy as well as predicting wild fires with this approach that uses IoT in getting data and handling data, further prediction using Machine Learning. In this review, Forest fires is considered to be an umbrella term that covers prediction of happening, real-time monitoring and prevention/detection of forest fires. These are rare but very significant events. This paper describes the development of Machine Learning and IOT system that enables real-time data visualization of the factors that help in increase in risk of forest fire that is generated by the forests. Additionally, there systems also give the prediction of forest fire and if happens, the best of way of preventing or stopping it for growing.**

I. Introduction

Wildfires are of the major causes of degradation of India's forests and wildlife. According to a paper written by NRSA, it is estimated that the proportion of forest areas prone to forest fires annually ranges from 33% in some states to over a staggering 90% in others. Forest fires in India are not only caused due to natural processes or natural forces but also as a result of human error. India has recently witnessed a 125% spike (from 15,937 to 35,888) in fires that are associated with human error in just two years (2015-2017). These cases rather than prediction of fires, need quick ways to suppress it or stop it from spreading. Vast areas have been torched due to improper maintenance of forests. There are no traditional methods other than remote sensing followed to prevent or to manage forest fires in India and in many parts of the world.

Most of the detection methods include satellite imagery and estimation of forest fire through it. But there are significantly certain limitations with it.

1. They focus more estimation after wild fire occurrence.
2. No smarter way to prevent as quick as possible.
3. Ariel sensitivity is very less.
4. Need heavy resource for real-time monitoring.

To overcome these limitations, we have built a smart IOT device powered by Artificial Intelligence that additionally also has other functionalities such as prediction of forest fires and quick way to stop them from spreading.

Several research works have reputed in very similar aspects. Most common approaches are using satellite imaging technology to observe which part of the area is on fire and which part is not. This method on the other hand requires heavy processing of images that are given by satellite which is not very sensitive and moreover this techniques can only be applied when there is occurrence of wildfires. Our approach uses network of sensors connected over Wi-Fi protocol and was implemented for real-time sensor data affiliation where all the processing has been done in the online cloud server for environment monitoring just like a WSN model using IOT architecture. The proposed architecture is server-client architecture, Server side of the device consists of a processor device such as raspberry pi, which is additionally connected to the external sensors such as anemometer, temperature, humidity/moisture and a fire detection sensor. Server side apart from getting the sensor data, also does the ML predictions on the incoming data from other nodes continuously. In every node, we just have a wireless module which is again connected to all these sensors. Here, instead of processing these incoming sensor data it sends the data directly into server where it is all stored. Original data is again

filtered to serve as a input to the ML algorithm which is ensemble learning.

In this paper, we presented a system for real-time wildfire prediction and detection of it which is done by by both Machine learning artificially as well as the results obtained by calculating the Haines Index where data is taken from the sensors. Both of these results are then compared to give the accurate information about the occurrence of the forest fire. This novel method increases the accuracy of the prediction which is shown below.

II. Previous Work

There is lot of work done in past for handling the forest fires as well as analyzing the damage caused with the help of Machine Learning. But none of the past methods include usage of Haines Index as a part of them. We are adding up the IOT technology and Artificial Intelligence in order to improve the traditional methods and fetching the best outcome.

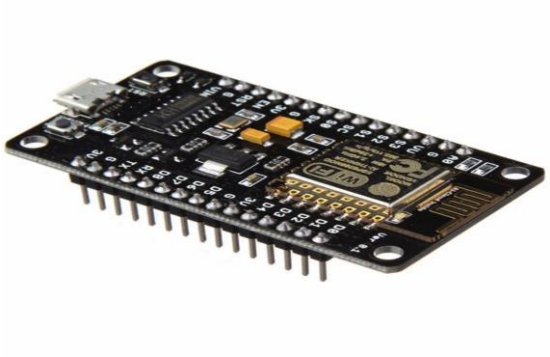
III. Hardware

The device uses the Server-client architecture. The hardware used in this prototype consists of few modules namely -- a Wifi module (ESP8266) in every node that acts as a client, additionally every node has a DHT11 sensor which acts as Temperature and Humidity data extractor that is essential for calculating the Haines Index, IR fire sensor which acts as a flame detector, A anemometer which gets the data of the wind pattern. Looking at the server side, we have a Raspberry pi which acts as a local machine learning inference machine and also as a local data storage device.

The whole prototype is extremely affordable and cost efficient in contrast to its epic features. This makes it possible to scale high and also upgrading or maintaining it. This on situation also helps in incorporating the additional sensors when needed or to fight extreme situations. These devices also help in assisting firefighting with developed strategy. The reason for the proposed system to use IoT infrastructure is that there is no need of human interaction, they are completely automated and can be debugged not only onsite but also from base station or even from home. They are interrelated computing devices having ability to transfer data over network without human-machine interaction. Section IV explains the overview of the proposed system.
Going on the detailed description of the devices:

A. NodeMCU

NodeMCU consists of ESP8266 chip that has capability of Wi-Fi and have TCP/IP protocol enabled. It has microcontroller Tensilica Xtensa 32-bit LX106 RISC microprocessor which operates at 80 to 160 MHz adjustable clock frequency and supports RTOS. NodeMCU operates at 3V to 3.6V and has a building voltage regulator. NodeMCU also has a built in ADC channel which is limited to 10bit. NodeMCU has SPI and I2C interface to enable the sensor communication and connection with it.

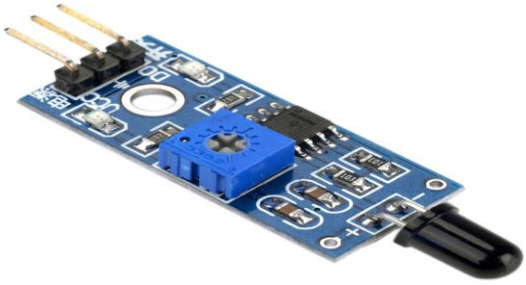


B. DTH11

DTH11 is a sensor module that consists of a dedicated NTC temperature sensor and a humidity sensor. This module also has a filtering capacitor to have an external usage. This gives the 8-bit output that consists of both temperature and humidity.

C. Flame Detector

This sensor can detect the presence of flame or fire at an wavelength of 760nm to 1100 nm range of light source. This works on 3.3V input and has a built in voltage comparator. This sensor is also having adjustable trigger level for precise detection.



D. Anemometer

This anemometer is custom made using a encoder motor that gives the direction of wind and how fast it is.

E. Raspberry Pi

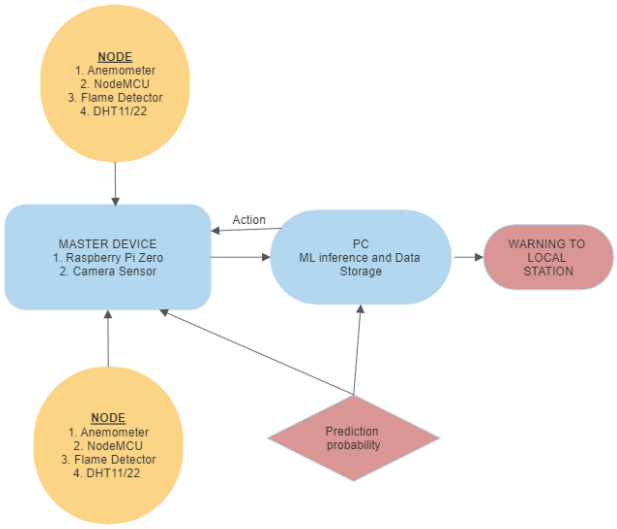
Raspberry Pi acts as the local Machine Learning model inference computer and also as a storage device. Rpi has got 2GB of RAM and additionally we are using intel compute stick for faster processing of Machine Learning Predictions.

F. Camera

Server node (raspberry pi) consists of a camera device that monitors the environment at every particular time stamp when the prediction values get hiked. Here there will be a local image classification done looking for forest fuel or biomass.

IV. System working

Here, the below figure shows the block diagram of the system and the hardware architecture and explains the flow of data and the predictions.



Theoretical working of the device would be in a way where every segment of the working is decentralized and distributed. The whole model of data is distributed in 2 separate segments. One segment does the prediction by using Haines Index and the other is with the help of neural networks. In the master computer, continuous inference on the incoming data is taking place where all of data from the sensors are preprocessed and dimensionally reduced and given as input. The output is having a SoftMax activation function for estimating the probability distribution of having the occurrence of forest fire.

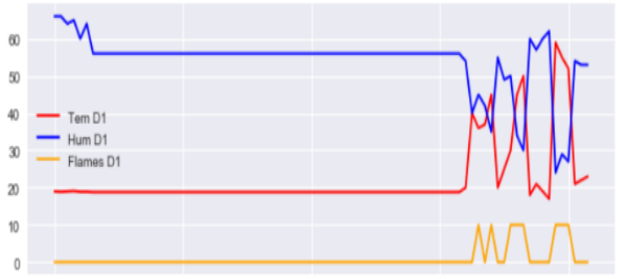
$$\sigma(\mathbf{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}} \text{ for } i = 1, \ldots, K \text{ and } \mathbf{z} = (z_1, \ldots, z_K) \in \mathbb{R}^K$$

This function omits the estimated probablity of the results

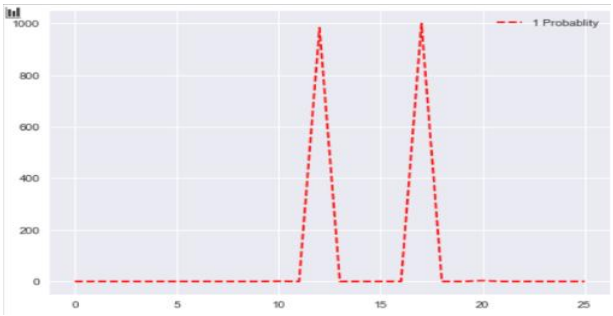
Based on the threshold setting we can use it for locational update of the master node which is a raspberry pi consisting of a camera. This update consists of image classification which is looking for biomass. Once it is locally classified, an alert will be made according to the situation. Below are the tested graphical results on a small local area. In the second case, forest fire conditions are being simulated and the accuracy of the device is being tested. The same architecture when trained with images of animals being poached will work as a animal poaching detection system.

V. Results and Conclusion

With this project we have built a software and hardware where you can deploy in forests which can be used to detect and predict the occurrence of forest fire as well a animal poaching detection system. The current hardware setup has a low range, this can be reinforced with new technologies like LoRa. Threshold function is updated on the future work of the project where the prediction function is automated. Here is the generated graph from the data taken from 3 nodes to a master device.



All of the sensor data is preprocessed into a single channel and the graph shows that data. When fames are simulated are in the environmnet at few particular instants, the(yellow) levels hike. At the same particular point there is huge change observed in the tempereture as well as in the humidity levels in the environment.



These are prediction probablity instants for the same data shown in the above picture.

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