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Yolo-Based Technique for Stubble Burning Detection System Using Web App

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Abstract: Stubble burning is the process of clearing rice crop remnants from the field in preparation for the next crop, wheat. Combine harvesters, as we all know, leave behind crop residue. Hence, stubble burning becomes crucial in areas where the "combine harvesting" technique is used since it has a negative environmental impact (it is a large source of air pollution and causes the soil to lose nutrients, which increases the need for fertilizer). Therefore, it is very important to put a stop to this practice. To keep a check on these burning, we are devising a stubble burning detection system. The burning or smoke will be detected using an imaging system to capture the data and report the appropriate information by backtracking the datasets. The machine learning model will be trained using an accurate dataset of wildfires, forest fires, and existing datasets on stubble burning. The problem would be solved using a highly efficient automated system that uses neural networks which would be built using and testing different ML models. The GPS location of the affected area will be provided to the concerned department, i.e., gram panchayat and local police station, through an app for further action.

Keywords: *CNN, YOLOv5, Stubble Burning, Supervised Learning, Deep Learning, Image Data, Artificial Intelligence and Survival Analysis.*

1. Introduction

One of the major reasons for air pollution in Northern India during winter is the practice of stubble burning. It has increased over the past few years because of the excessive use of combine harvesters, which do not offer a solution to remove long stalks remaining from the harvested crops, and due to a lack of alternatives, farmers must burn these stalks. However, owing to the increasing worries about the impact on the environment because of these burnings, the government has made it completely illegal to burn stubble [21]. Many pollutants (RSPM, Nitrogen oxides, Sulphur oxides) [8] are produced by stubble burning in a very short period, which results in a sudden and severe environmental impact. Moreover, since the burnings take place during the winter season, the smoke that is created because of these burnings does not disperse or dilute, and rather gets confined close to the ground, due to a weather condition also known as the inversion condition. This further lowers the already low air quality, and this becomes very harmful to human health. It is due to these facts that it becomes essential for a check to be regularly performed on these burnings so that a dataset of defaulters (and their location) can be created. However, since this practice is so widespread across several states of North India [13], it is often very difficult to properly account for all the burnings taking place and keep a record of them. To reduce the effort to be put into detecting these fires, with the help of a capstone project, we are fabricating a fire and smoke detection model specifically designed for detecting stubble burnings. We plan to create an app that will provide information about fires over large areas using an imaging system and a machine learning-based complex model will be used for accurate identification of the burnings [14]. The system will use a neural network which, in turn, would have been obtained by building and testing different machine learning models. Whenever the burnings are detected, the app will send alerts to the concerned officials which will contain the location coordinates. We will be implementing our model using YOLOv5. The technique called YOLO, which stands for "You look only once," divides photos into a grid system based on object detection. The grid is in charge of identifying what are known as cells—objects that are contained inside it. Its precision and quickness make it one of the most well-known object detection methods. We are creating a web application to receive notifications of stubble burning. This application is created using Gradio, an open-source web application development kit. The software will notify the relevant authorities via the web application as soon as stubble burning is detected, including the GPS coordinates of the fire and a picture of it [22].

2. Motivation

Since 2002, the burning of stubble in Punjab and Haryana has been identified as the primary source of air pollution in Delhi.

In addition to creating a cloud of particles that can be seen from space, this burning has caused what is known as a "toxic cloud" in New Delhi, leading to the declaration of an emergency due to air pollution [15]. We thought it was an

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absolute necessity to deal with this problem by developing and designing a system that could detect the stubble-burning activity in the fields. The most parsimonious way to tackle the problem of stubble burning is by detecting the smoke and fire using a machine learning-based convoluted model using an imaging system and reporting this to the concerned authorities so that appropriate action is taken.[13][10] The scope of the project is to develop an automatic system consisting of multiple sensors and the minute machine learning algorithm that offers accurate real-time data and is the most economical way to keep an eye on stubble burning and report it to the relevant authorities, such as the local police and gram panchayat in that specific village[23].

3. Contribution

An Automatic Invigilation system to keep checks on the stubble fires over a particular area.

So, we have devised a solution that can keep a check on all the burnings over the surrounding perimeter. The app will send the location of distress and the data after it computes the area with the trained ML model. The imaging system, i.e., cameras that will be installed on pillars will map the perimeter of the surrounding fields and using an image processing model, of the type and colour of the fire will take appropriate steps. The large number of locations in which the cameras will be installed will make the process easier and will be very efficient.The project will deliver automatic signals to the officials which will also be accompanied by its location, in a low-cost and efficient way with a minimum number of false positives [24]. There will be a database embedded into the system as well for recording important data. The final delivery will be directly associated with the reduction in pollution in the surrounding areas, which can be avoided when steps are taken responsibly and on time.

Reporting the GPS location of the fire through the app will help the authorities to keep a check on the air quality index and a rapid solution to solve the problem. This will be possible with geo coordinates we will be able to obtain from the pictures taken by the imaging system.

4. Related Work

A. Thermal Remote Sensing:

The research paper mentioned that they used three different data sets from three different sensors to monitor and map the real-time fire events in three states: the Advanced Very High-Resolution Radiometer (AVHRR) on NOAA 18/19 & MetOp 1/2, which is available from IARI Satellite Ground Station, at 1,100 meters; the Visible Infrared Imaging Radiometer Suite (VIIRS) at 375 meters aboard Sumo NPP; and the Moderate-Resolution Imaging Spectroradiometer (MODIS) at 1000 meters aboard Terra & Aqua. Using MODIS and VIIRS sensors, they were able to identify the fire during the day and at night. To effectively apply mitigation plans, stubble burning must be continuously monitored in close to real-time. Sensing-based remote sensing of active fire events is accomplished with satellite remotes.

B. Temporal Remote Sensing:

This study used a modified possibilistic fuzzy classification strategy to identify burnt paddy fields utilizing temporal multispectral Sentinel-2A/B data and a temporal Class-Based Sensor-Independent Indices Database. It is possible to use stubble-burnt paddy field areas to estimate pollution input to the atmosphere. The availability of 5-day temporal resolution temporal remote sensing data makes it feasible to monitor burnt stubble rice fields in the Patiala district of Punjab state. The process of extracting burnt paddy field sites has been carried out in several locations at 5-day intervals, including October 20, October 25, October 30, November 9, and November 19, 2018 [3]. In a supervised manner, the temporal multispectral Sentinel 2A/2B image (3002 × 3002 pixels) has been subjected to the use of CBSII with MPCM technology. In general, green vegetation is indicated by a high NBR value, whereas recently burned regions and bare ground are indicated by a low value[5].

C. Satellite Remote Sensing:

[4] Information from a variety of earth observation satellites was used in this study to monitor and evaluate biomass-burning activities using the stubble-burning detection method. The quantitative assessment of burned regions in the Punjab region was derived from remote sensing data gathered from many sensors (LISS-3, LISS-4, MODIS, and AVHRR). The statistical threshold known as the multi-temporal image was employed to extract the burned areas using the difference technique with three different indices (ND6, NBR, and GEM13) [17]. Using spectral separability analysis, the indices' performances were assessed, and it was discovered that GEM13 performed the best in terms of spectral discrimination between burned and unburned surfaces [16].

D. Digital Analyzing of Satellite Images:

[7] This work presents an effective method for identifying stubble-burned areas using remotely sensed photos in different locations of Punjab, which might be used to stop extensive environmental deterioration. Satellites are used to obtain remote views at different times. Images are single mosaics made up of several bands concatenated together. As is well known, remote images consist of several pixels and are relatively huge [11]. The acquired data is displayed on maps of the region to pinpoint the precise position of the fires after the photos have been processed and analyzed.

5. Proposed Work

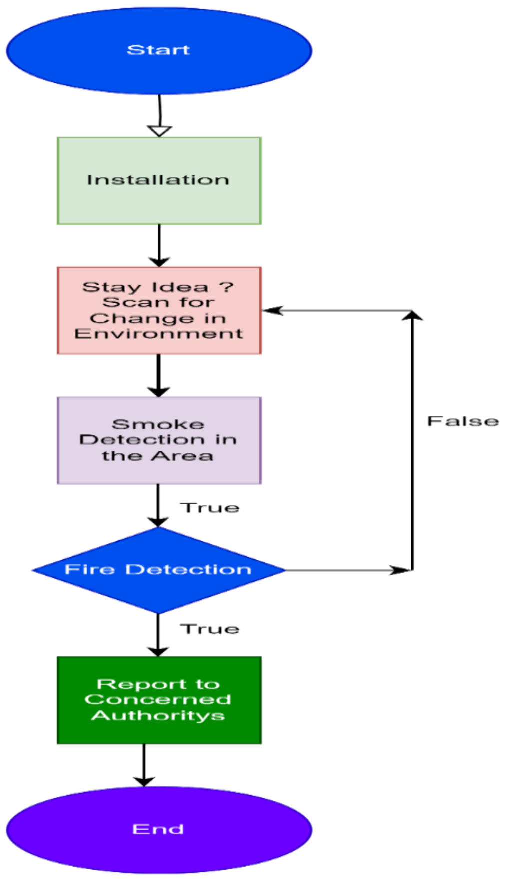

Fig.1. System Architecture

We use an imaging system equipped with a high-resolution camera, a processor, and an application that provides the results. The application that is integrated with the Machine Learning model processes the data from the high-resolution camera. The app sends data for online and real-time access to the web server. From the previously available data, prediction of the region and time, whenever stubble burning occurs [2]. We embed the YOLOv5 model in our application [18]. As soon as the image is captured it is processed and checked for fire and smoke. And if detected more than a confidence level it will send a notification to the concerned authorities. A thorough study of various datasets will be done with the help of suitable sources like Kaggle. Python, Machine Learning, and other front-end techniques will be used to achieve the outcome. The data will be stored in a cloud-based service called Google Firebase. And notifications will be provided to the authorities if the actual fire is predicted with the help of the model.

The model will be calibrated according to the imaging system it uses. The project can be deployed with a UAV, on a street camera, or even with the help of a mobile phone camera automatically A traditional Deep CNN design is made up of three well-knots:

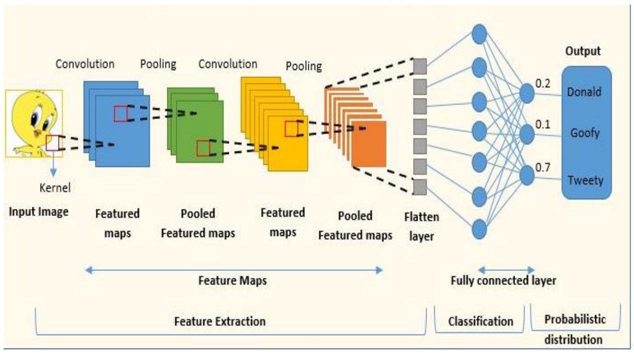

Fig.2. Structure of CNN

A. Convolutional Neural Network

1) Computer vision-related issues and applications, including object identification and localization, image segmentation, super-resolution, labelling, indexing and retrieval, and Deep CNN, have demonstrated encouraging outcomes. Their enduring appeal is ascribed to their hierarchical design, which extracts extremely potent components from raw data. The YOLO algorithm is based on a convolutional layer, where feature maps are generated when applied to particular kernels to the input data.

2) To pick the best activation, a max pooling layer uses a constrained neighbourhood of feature maps acquired from the preceding convolutional layer. This layer aims to provide translation invariance and, to some extent, a dimensionality reduction [18].

3) High-level data knowledge is fed into the model's completely connected architecture, which creates its global representation. This layer fits several layers of max pooling and convolutional structures, which eventually yields a high-level representation of the input data. These layers are built hierarchically, so the result of one layer becomes the input data for the layer below it [19]. All of the neurons in convolutional kernels and fully connected layers have their weights balanced and learned during the training phase. These weights in the model can both identify the objectives and reflect features of the input training data. Figure 2 shows CNN's core organizational structure.

B. Working

The working plan to detect stubble burning using cameras embedded in poles/UAVs using machine learning-based algorithms involves four steps. First, the system is mounted on top of street poles in areas where it is suspected to have frequent stubble-burning activities. This significantly reduces the need for human effort to monitor such areas. The system will directly report all suspicious activities to the concerned authorities, who can act according to their discretion. Second, constant monitoring of the area where the system has been installed will take place, and the images and videos will be sent to the authorities at regular intervals to make their work easier. Smoke detectors/sensors are also to be installed to make the system more robust [9]. Third, the system will separate the images of interest from other images using the machine learning model trained on thousands of images. Fourth, the images of interest will be flagged and sent to the authorities as priority data through a distinct notification [2]. This data can also be used for future predictions to formulate plans, or to use it as evidence if needed in matters of legal stature. YOLO is a very efficient and reliable algorithm, which uses a single neural network to divide images into bounding boxes and assign probabilities to each box. It is called YOLO because the image is processed after one look only, i.e., there is no need to feed the image repetitively to obtain results. The algorithm produces results after having only one look at the image.

6. Experimental Analysis

I. Test Configuration

A. Measures of Performance

The performance of the suggested framework is evaluated using three parameters.

Sensitivity: Sensitivity can be defined as the fraction of actual positive cases that are predicted to be positive, also known as true positives.

TP/TP+FP equals sensitivity.

Specificity: The percentage of real negatives that have been predicted as negative (or true negative) is known as specificity.

Particularity = (TP + TN/TN = FP)

Accuracy: The proportion of observations for which our analysis was accurate is known as accuracy. Formally speaking, accuracy is understood to mean:

(TP+TN/TP+TN+ FP + FN) = Accuracy

B. Outcomes

To forecast fire, we trained our algorithm on over 10,000 photos. Testing yielded an accuracy of 78.67%, and the system could identify the majority of burns in a variety of weather and daylight situations. We have examined and thoroughly examined over twenty research papers to identify the shortcomings in the prediction technique. With the current technology, we can use Short Message Service to inform the authorities. Using our social media videos, we tested our model.

Fig 3. Sample Output

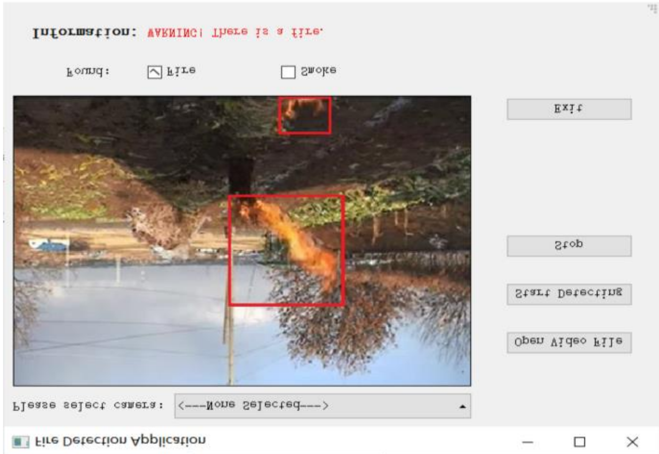

Fig 4. Auto Stuble Detection Yolov5

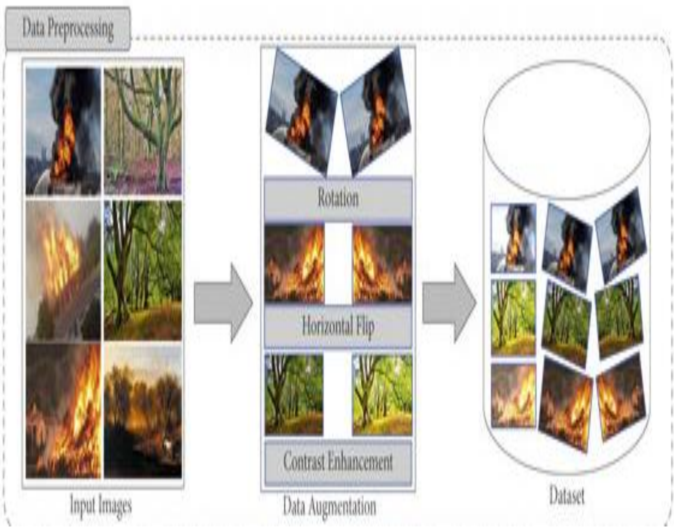

Fig 5. Data Processing

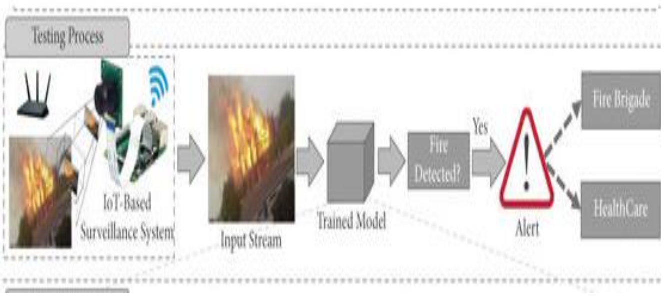

Fig 6. Testing Process

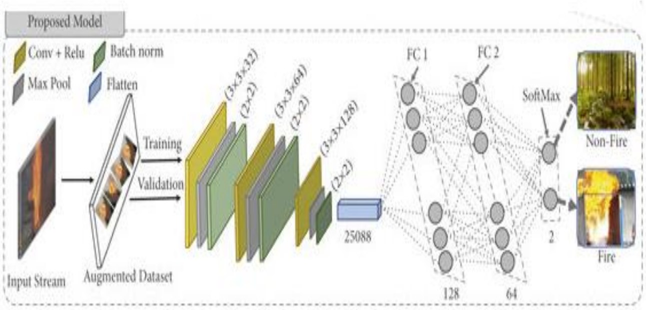

Fig 7. Proposed Model.

7. Conclusion

Our method is based on the YOLO algorithm and the idea of deep learning to find Stubble Burnings. To assist in the identification of burns, this deep learning model is installed on a Raspberry Pi with a neural stick on a street module. We were able to test the code in our immediate environment and were able to get accurate results. After taking this initial step into account, our goal is to create an online, mobile, and iOS application that will utilize the same technology as the automated stubble-burning detection system. Overall, this program will facilitate the work of law enforcement agencies who constantly monitor stubble burnings and assist local police and law departments in several states where the practice is widely practiced.

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