FOREST COMBUSTION RECOGNISATION

Using Artificial Intelligence

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1. INTRODUCTION

Emergency situations like floods, earthquakes and fires pose a big threat to public health and safety, property and environment. Fire related disasters are the most common type of Emergency situation which requires thorough analysis of the situation required for a quick and precise response. The first step involved in this process is to detect fire in the environment as quickly and accurately as possible.

Fire Detection in most places employs equipment like temperature detectors, smoke detectors, thermal cameras etc. which is expensive and not available to all. But, after the advent of advanced image processing and computer vision techniques, detection of fire may not require any equipment other than cameras. Due to this expeditious development in vision-based fire detection models, there is a particular inclination towards replacing the traditional fire detection tools with vision-based models. These models have many advantages over their hardware based counterparts like accuracy, more detailed view of the situation, less prone to errors, robustness towards the environment, considerably lower cost and the ability to work on existing camera surveillance systems.

Therefore, our approach is to employ state-of-the-art CNNs to distinguish between images that containing fire and images that do not and build an accurate fire detection system. To make these models more robust, we use a custom-made image dataset containing images with numerous scenarios.

1.1 Overview

Nowadays,Forest fires prediction combines weather factor, rain, dryness of flammable items, types of flammable items, and ignition sources to analyze and predict the combustion risks of flammable items in the forest. Forest fire prediction has developed rapidly in various countries in the world since its inception in the 1920s. Taiwan's forestry department currently uses the study results of Hsiao (2003). Hsiao's study used a given day's highest temperature, temperature variation, accumulated period without rainfall, and drought index as weather factors to derive forest fire incident in a logistical regression model, and built a forest fire recognition probability model and covoluation neural netwrok. Hsiao also considered space and time variations in weather factors, used GIS systems to conduct temperature and rainfall space-time estimates, and estimated forest fire hazard rating predictions for forest in Taiwan on a given day.

1.2 Purpose

Our aim from the project is to make use of pandas, numpy libraries from python to extract the libraries for machine learning for the forest fire reconization. Secondly, to learn how to build model using ImageDataGenerater hypertune the forest with and without fire images using Convolution neural netwrok(CNN) machine learning algorithm. And in the end, to predict whether the image is with fire or not using video analysis technique of combining the predictions from machine learning algorithms and giving the alert message to the email address.

2. LITERATURE SURVEY

Data mining is the process of analyzing data from different perspectives and extracting useful knowledge from it. It is the core of knowledge discovery process. The various steps involved in extracting knowledge from raw data as depicted in figures . Different data mining techniques include classification, clustering, association rule mining, prediction and sequential patterns, neural networks, regression,CNN,RNN etc. Classification is the most commonly applied data mining technique which employs a set of preclassified examples to develop a model that can classify the population of records at large.This approach frequently employs Decision tree based classification Algorithm. In classification, a training set is used to build the model as the classifier which can classify the data images/items into its appropriate classes.A test set is used to validate the model.

2.1 Proposed Solution

Machine Learning (Convolutional neural network architectures)

According to the principle of object detection algorithms, the flow of image fire detection algorithms based on convolutional neural networks is designed in the detection CNN has functions of region proposals, feature extraction and classification. Firstly, The CNN takes an image as input and outputs region proposals by convolution, pooling, etc. Secondly, the region-based object detection CNN decides the presence or absence of fire in proposal regions through convolutional layers, pooling layers, fully-connected layers, etc.

Coming to project build first create a dataset with train and test folders then Data pre-processing step (the externally important step in any project). I highly recommend going through the "Basics of image processing using Python we use Keras" ImageDataGenerator class to perform data augmentation. i.e, we are using some kind of parameters to process our collected data. The word “augment” means to make something “greater” or “increase” something (in this case, data). The ImageDataGenerator transforms each image in the batch by a series of random translations, these translations are based on the arguments and then Apply ImageDataGenerator Functionality to trainset and testset. After that Build a model: in that Importing the libraries, Initializing the model, Adding CNN (Convolution Neural Network) Layers, Adding Dense layers. After building a model next step is video processing for the video processing used the tool openCV. this openCV is useful to genarate a video and predict the image. after prediction will send an email with an alert message .if we found any place with fire inside the forest we send email with an alert message.

3. THEORETICAL ANALYSIS

Forest fire destroys millions of hectares of forest, pollutes the environment, causes severe casualties, and has a significant economic impact on government budgets every year. Detecting a wildfire promptly, before it is out of control, is still a difficult challenge. According to the combustion materials, a wildfire is generally classified into three types: underground fire, surface fire, or crown fire. An underground fire is caused by spontaneous combustion or combustion in other channels after coal strata meet combustion conditions under the surface; and a surface fire, when not acted upon by external forces, usually spreads along the surface of forest areas. The surface fire is easily affected by wind, causing the flames to disperse everywhere, eventually falling on the crown and branches, causing a crown fire to occur. Crown fires have exceptionally high temperatures and ferocious behavior, which makes them challenging to be extinguished, making them extremely dangerous. In addition, a crown fire always spreads more than 100 times faster than a surface fire and is more destructive. Thus, because of this phenomenon, it is essential to determine the type of wildfire as early as possible in early wildfire detection, for the sake of adopting efficient strategies to fight the wildfire and reduce the casualties and economic losses.

This section describes the projected system for efficient forest fire detection. The input fed to the system is the spatial data matching to the forest regions. Data mining, image processing and artificial intelligence techniques support the detection of fire from the images of spatial data.

Convolutional neural networks.Sounds like a weird combination of biology and math with a little CS sprinkled in, but these networks have been some of the most influential innovations in the field of computer vision and image processing. The Convolutional neural networks are regularized versions of multilayer perceptron (MLP). They were developed based on the working of the neurons of the fire visual cortex.

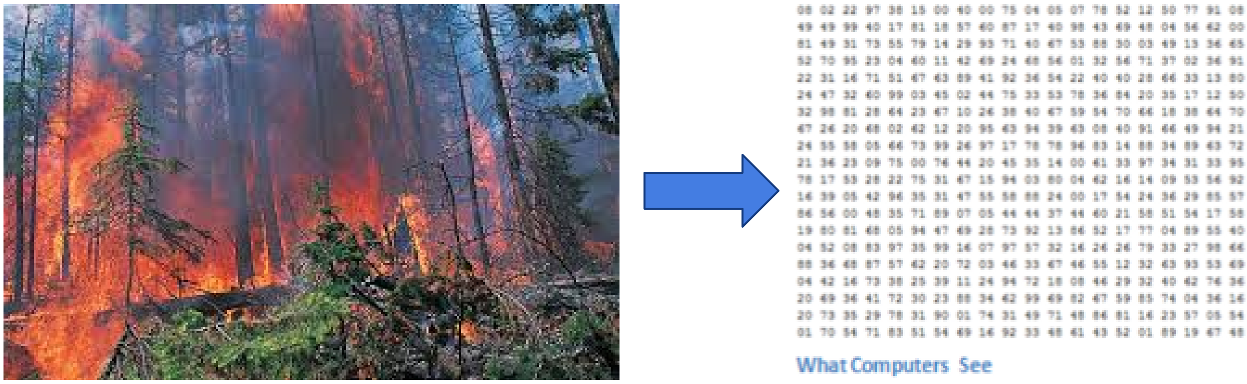


figure: Binary image visualization

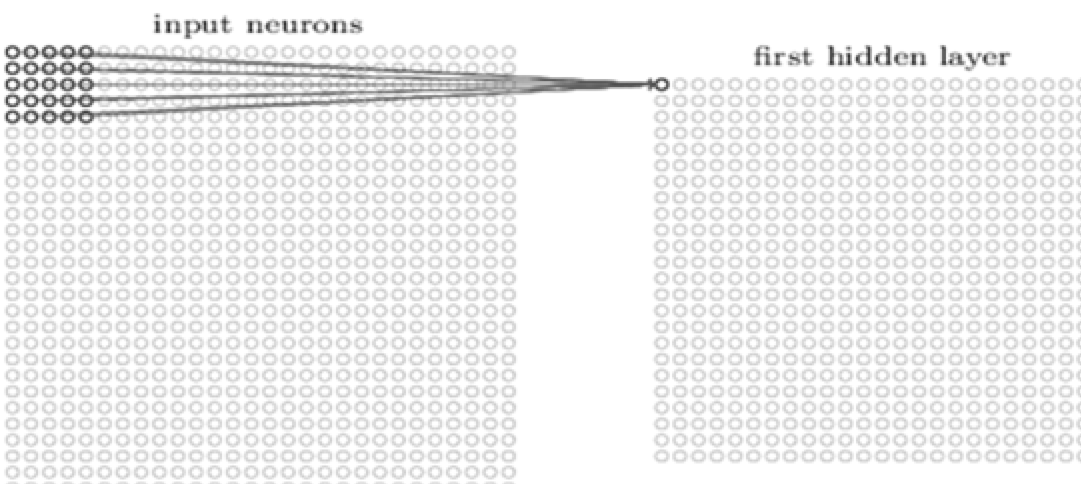
Let’s say we have a color image in JPG form and its size is 480 x 480. The representative array will be 480 x 480 x 3. Each of these numbers is given a value from 0 to 255 which describes the pixel intensity at that point. RGB intensity values of the image are visualized by the computer for processing.

The objective of using the CNN:

The idea is that you give the computer this array of numbers and it will output numbers that describe the probability of the image being a certain class (.80 for a forest fire, .15 for a forest without fire, .05 for a forest fire etc.). It works similar to how our brain works. When we look at a picture of a forest, we can classify it as such if the picture has identifiable features such as with fire or 4 with out fire. In a similar way, the computer is able to perform image classification by looking for low-level features such as edges and curves and then building up to more abstract concepts through a series of convolutional layers. The computer uses low-level features obtained at the initial levels to generate high-level features such as forest with fire or without fire to identify the object. The image is resized to an optimal size and is fed as input to the convolutional layer. Let us consider the input as 32x32x3 array of pixel values.

figure: Forest fire image in pixel

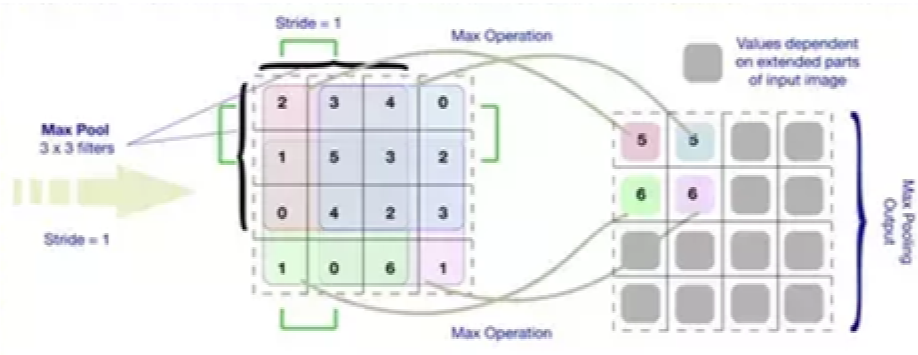
There exists a filter or neuron or kernel which lays over some of the pixels of the input image depending on the dimensions of the Kernel size. Let the dimensions of the kernel of the filter be 5x5x3.

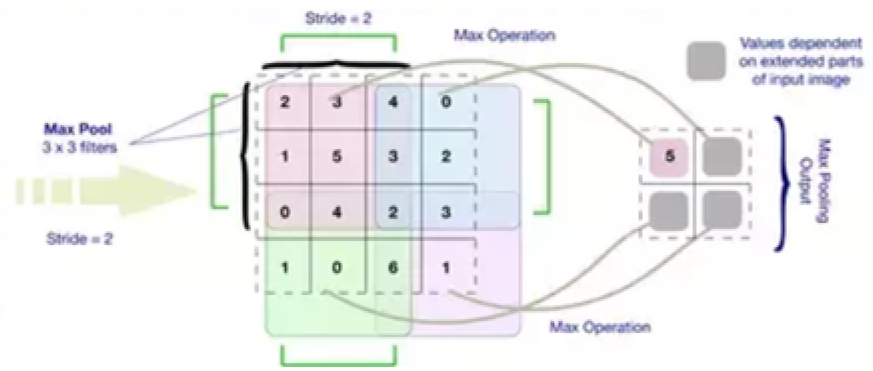


Visualization of 5 x 5 filter convolving around an input volume and producing an activation map

figure: Activation map

Max pooling operation Using CNN





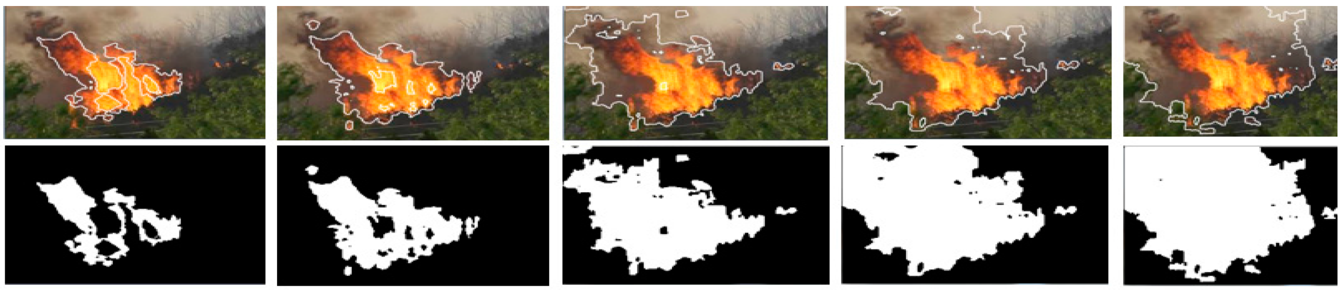
Detecting moving regions is a key factor in most of the video based fire detection systems because fire boundaries continuously fluctuate. So background subtraction is used to select candidate regions of fire. A pixel located at (x, y) is supposed to be moving if the following condition is satisfied.

$$\left|I_n(x, y) - B_n(x, y)\right| > thr$$

(x,y) represents the intensity value of the pixelat location (x, y) in the n th gray-leve for the current frame and Bn (x, y)represent the background intensity value at the same pixel location,and the is a threshold value experimentally set to. The background is continuously updated using:

$$B_{n+1}(i, j) = \begin{cases} B_n(x, y) + 1 & if\ I_n(x, y) > B_n(x, y) \\ B_n(x, y) - 1 & if\ I_n(x, y) < B_n(x, y) \\ B_n(x, y) & if\ I_n(x, y) = B_n(x, y) \end{cases}$$

where +1(x, y) and (x, y) represent the intensity of the pixel value at location (x, y) for the current and previous backgrounds.



$\rho\ min = 0.1$ $\rho = 0.5$ $\rho = 0.75$ $\rho = 1$ $\rho\ max = 1.5$

Converting RGB Images to YCbCr

Due to the fact that different kinds of moving objects can be included after applying background subtraction, such as trees, animals, birds, and people, therefore images from the background subtraction stage are converted to YCbCr to select candidate fire regions using Figure shows original RGB image and YCbCr component. The mean values of the YCbCr channel are then calculated.

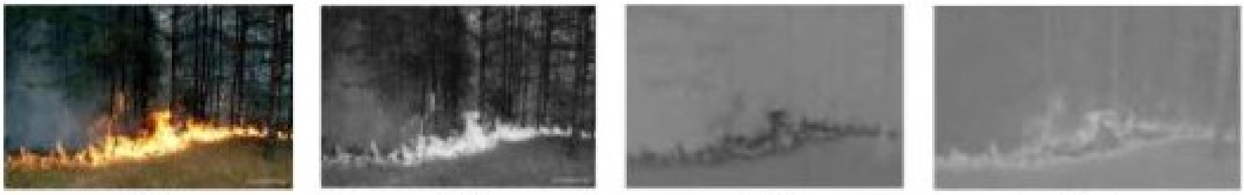
$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.2568 & 0.5041 & 0.0979 \\ -0.1482 & -0.2910 & 0.4392 \\ 0.4392 & -0.3678 & -0.0714 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix}$$

$$Y_{mean} = \frac{1}{N * M} \sum_{x=1}^{N} \sum_{y=1}^{M} Y(x, y)$$

$$Cb_{mean} = \frac{1}{N * M} \sum_{x=1}^{N} \sum_{y=1}^{M} Cb(x, y)$$

$$Cr_{mean} = \frac{1}{N * M} \sum_{x=1}^{N} \sum_{y=1}^{M} Cr(x, y)$$

where , ,and arethemean values forthe YCbCr channels; Y (x,y),Cb (x, y), and Cr (x,y) are YCbCr channel values forpixel at specific location (x,y);and N∗M is the total number of pixels.



(a) (Y) (Cb) (Cr)

For any detection method, there are four potential results. If an image has fire pixels, and it was determined by the method as fire, then it is true-positive. If the same image is determined to be not a fire pixel by the algorithm, it is false-negative. If an image has no fire, and it was detected by the method as no fire, it is a true-negative, but if it was detected as fire by the method, it counts as a false-positive. Fire detection algorithms are evaluated using the following equations:

(i)TP-rate: obtained TP divided by the total number of fire images.

(ii)TN-rate: obtained TN divided by the total number of nonfire images.

(iii)FN-rate: obtained FN divided by the total number of fire images.

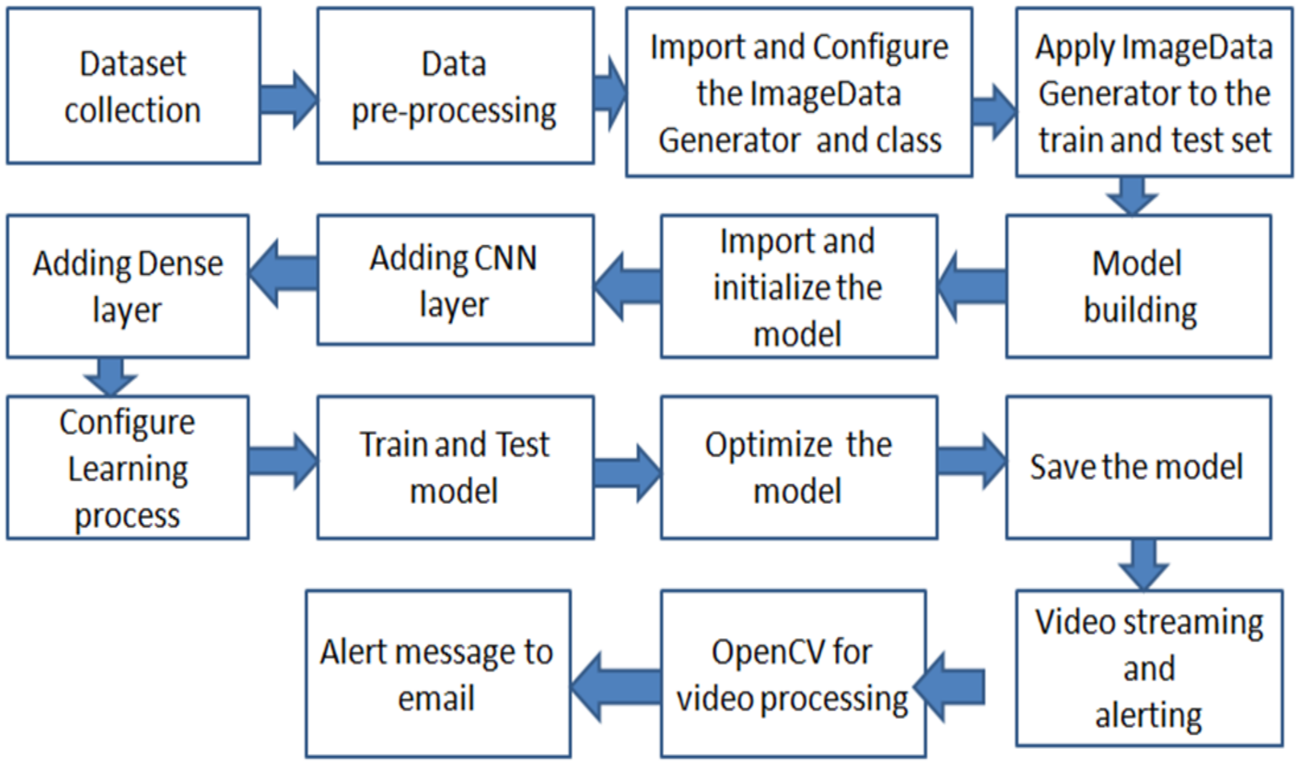
(iv)FP-rate: obtained FP divided by the total number of nonfire images.

$$F = 2 * \frac{(precision.reall)}{(precision + recall)}$$

$$precision = \frac{TP}{(TP + FP)}$$

$$recall = \frac{TP}{(TP + FN)}$$

3.1 Block diagram



3.2 Software Designing

- Jupyter Notebook Environment
- Machine Learning Algorithms
- Python (Numpy, ImageDataGenerator, Model building, CNN layers, video processing algorithms)

We developed this forest fire prediction by using the Python language which is a interpreted and high level programming language and usng the Machine Learning algorithms. for coding we used the Jupyter Notebook environment of the Anaconda distributions , it is an integrated scientific programming in the python language.

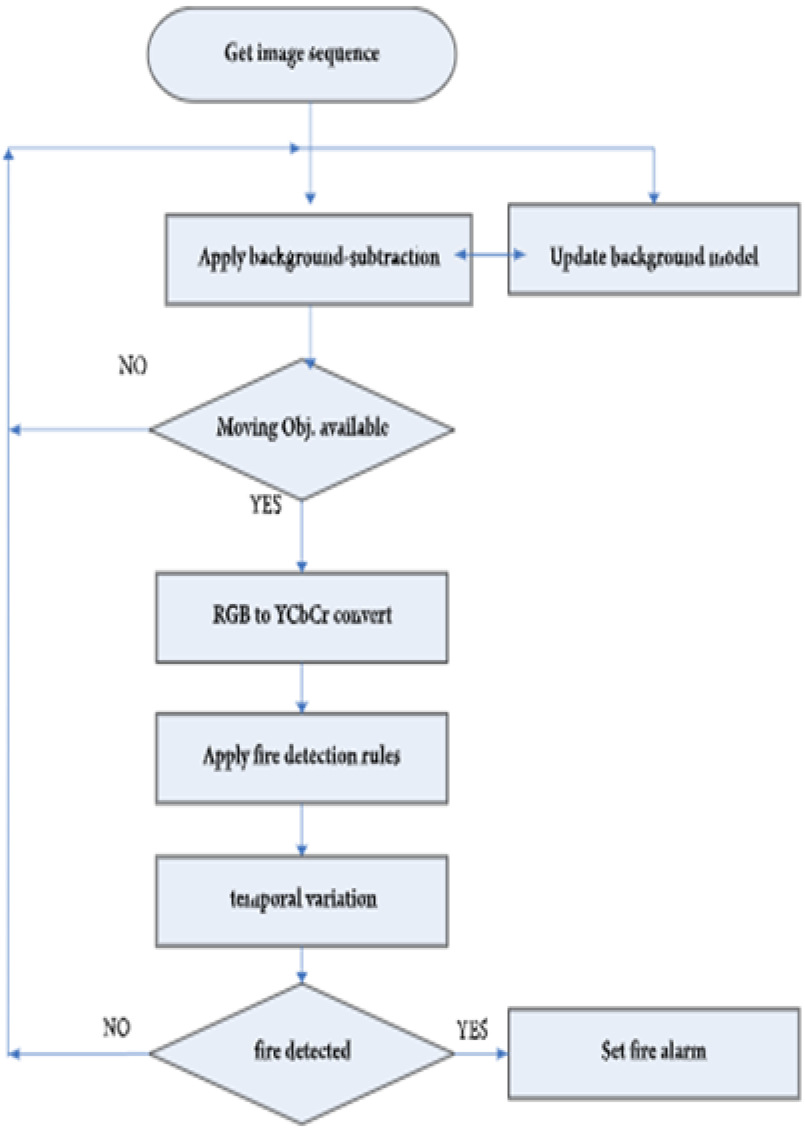
4. EXPERIMENTAL INVESTIGATION

In this project we created a dataset with collection of forest images with fire and without fire. In the forest dataset we created two sub folders one is testset another one traine set. In each folder we created another two sub folders one is forest with fire and forest without fire. Those collection of forest dataset images are given below:

Forest without fire

Forest with fire

5. FLOWCHART



Get image sequence
Apply background-subtraction
Update background model
NO
Moving Obj. available
YES
RGB to YCbCr convert
Apply fire detection rules
temporal variation
NO
fire detected
YES
Set fire alarm

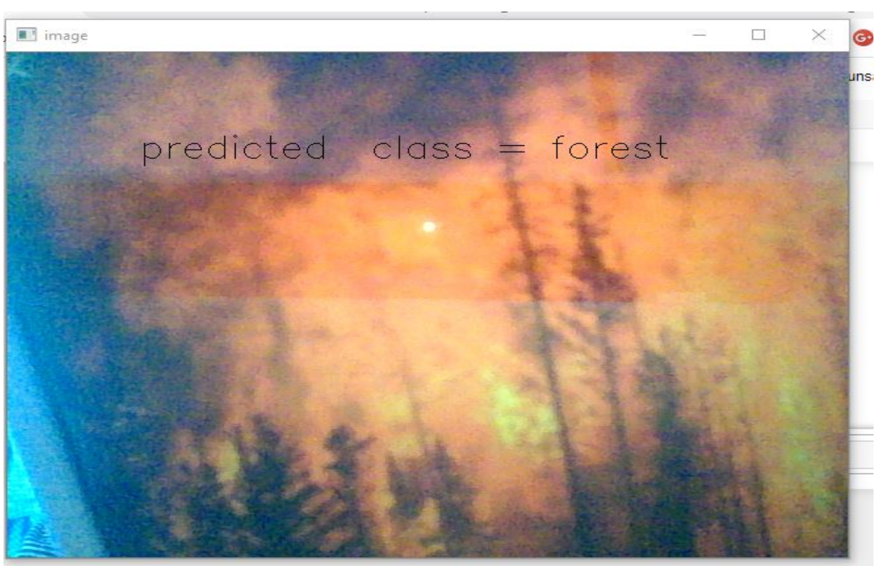
6. RESULT

To measure the performance of the proposed model, the images were collected from Internet. The figures shows the variety of forest fire condition images used in the test. A true-positive was counted if an image frame had fire pixels, and it was determined by the proposed model to be fire. In contrast, false-positive was counted, if the image frame has no fire, and the result was determined as a fire. finally we got alert message.

The above shows the prototype and the conversion models. The modules work independently of each other. Each modules converts video into frames and each frame is converted to bitmap image. In above images(Theoretical Analysis) the three clones of the bitmap is taken and converted into Y, Cb, Cr channels.

- Here the results of the image predictions:

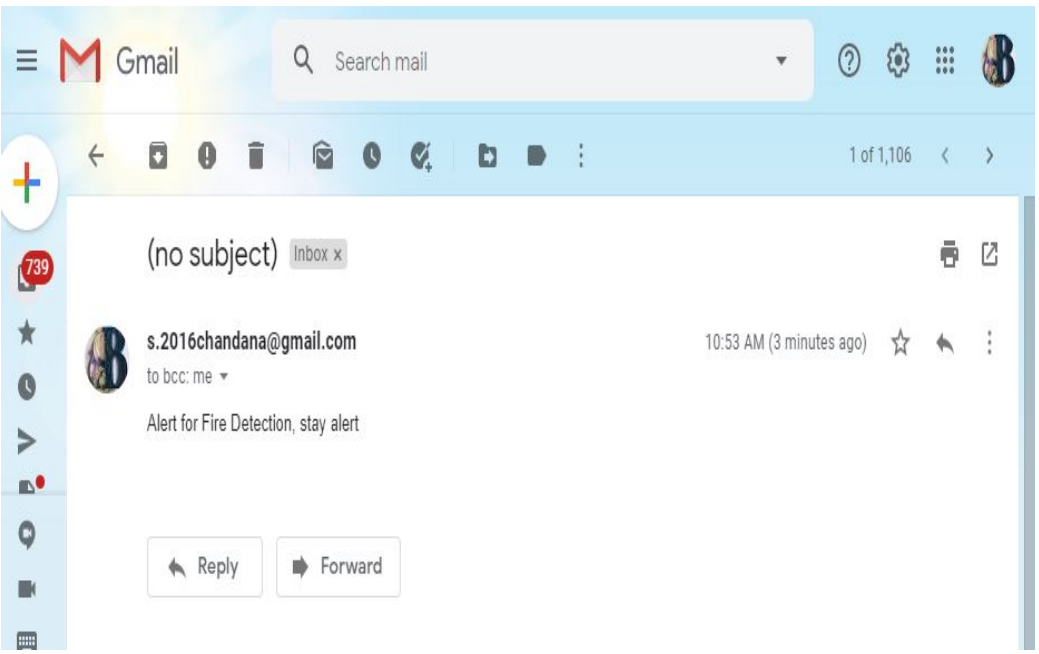
Predicted as Forest with fire



Program output when fire was detected

```
[[0]]
no danger
[[1]]
Fire Detected
Email sent!
[[0]]
```

Alert message is send to email



Predicted as forest without fire

Program output when there is no fire

```
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
[[0]]
no danger
```

7. ADVANTAGES

- The CNN can consider the correlation of adjacent spatial information, it has advantages in the study of problems with spatial and geographical correlation characteristics. Second, the CNN preserves the spatial relationships between pixels by learning the internal feature representations from factor vectors. The process of DL reveals the deep features and can distinguish the differences between different geographical units. The CNN was used to conduct multiple convolution and pooling operations to extract the characteristics. As the convolutions and pooling increased, these features became more advanced and more abstract. These abstract features depicted the degree of forest fire susceptibility, which was the decisive factor for determining forest fire susceptibility.
- Areas destroyed by these fires are large and produce more carbon monoxide than the overall automobile traffic.
- Monitoring of the potential risk areas and an early detection of fire can significantly shorten the reaction time and also reduce the potential damage as well as the cost of fire fighting.
- less expensive.
- low consumption.
- Reduce death rate.
- Simple, fast and easy to implement.
- Reduces significant economic impact on government budgets every year.
- Reduces the pollution of the environment.

8. DISADVANTAGES

- Possibility of lack of appropriate animals for special forests.
- Dtermining climate conditions, daily temperature differences, Seasonal normal temperature values etc.. are problematic.

- User can make mistakes while typing a message format.
- Moreover, each battery needs to be changed periodically,but capturing the MBS to do this is not easy.
- Netwrok issues.

9. APPLICATIONS

- If a node detects a fire it sends an alert message to the email.
- Need to detect fire before it spreding.
- It is used for Health, Military, Commercial applications.
- It use Multi-hop communication for large forest
- And also used for Environmental applications like Habitat Monitering and Forest fire detection.

10. CONCLUSION

This project proposes an effective forest fire detection method using CNN and max pooling operation techniques including movement containing region detection based on color segmentation. The performance of the proposed algorithm is tested on data set consisting of forest with and without fire images from the internet. TP-rate and TN-rate were calculated. The results show that the proposed algorithm achieves good detection rates. These results indicate that the proposed method is accurate and can be used in automatic forest fire-alarm systems. For future work, the system could be improved by using a combination of rules of different color spaces; however, the challenge is selecting the right rules from different color spaces to build the method.

11. FUTURE SCOPE

- In future, we will be updating the system with additional features like increase the range of sensing of the sensor, monitoring the count of animals present in the forest and can be prevented from being endangered.
- It can be further expanded with a voice interactive system fecility.

- Right now provide the conrol of alert message for the one device but it can be designed for more number of devices.
- A feedback system also be included which provide state of a device (whether it is on/off) to the remote device.
- To overcome disadvantages and looking for implementation of automatic fire detection.
- In place of alerting to emails, mobile calls and messages we sensors.

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