FOREST FIRE DETECTION

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Project Link : https://github.com/PriyaEnuganti/ForestFireDetector
video Link:
https://drive.google.com/file/d/13i1BSouMjBiCJOa3uWTolSI6nyet_a9S/view?usp=sharing

GOALS AND OBJECTIVES

1. To understand the relevant variables present in the data, and transform them as necessary before training models.
2. To try out combinations of different feature engineering techniques which contribute to the model's accuracy.
3. To find the most efficient and precise solution by utilizing a variety of feature engineering techniques and studying different performance metrics.
4. To observe effects of application of variations of feature engineering concepts on image data.

MOTIVATION

The Motivation behind development of this project is to experiment with various means of extracting relevant features from image data to generate an optimum set of features that result in optimum accuracy from the model. A model can be only as good as the patterns it can derive from the data that is being used to train it. The model uses the data features to highlight key unique characteristics in the data that separates one class from another. While some features are apparent the others do not necessarily come to attention. Hence, a series of feature engineering techniques like feature scaling, edges/ridges extraction, noise filtering, color extraction, feature matching and more will be explored to finally combine selected one among the pool of these features for the model to train from.

SIGNIFICANCE

The project's importance lies in the model's ability to accurately identify and distinguish between one condition seen in the image from another. There are numerous unique objects in the image data set but only the most important ones must be selected and in order to train our model with best accuracy. For instance, the images with forest fires have smoke coming out in them. At the same time, we have other images that have fog in it. In such cases it would be convenient for the image to identify fog as first fire detection as well. To avoid such cases we extract an image feature that detects fire and looks for occurrences of fire along with the smoke in the images. A model is as good as the feature that it learns while it trains. Hence, the project is heavily focused on feature selection and extraction so that the model can capture relevant and diverse possibilities as they come.

OBJECTIVES

The main objective here is to develop a system that is capable of detecting a fire, especially the forest fire which spreads at a faster rate and causes most destruction to the ecosystem. The project being purely dependent on image data, needs to tackle certain false alarms which may signal fire. False alarms being, a cloud cover or foggy atmosphere which appears to be smoke or trees with yellow leaves creating an illusion of fire. These challenges in detecting a real fire will be tackled with certain feature engineering techniques which will in turn increase the prediction accuracy of the system.

Features from Dataset

1. Color Transformation : Here images color is altered from RGB image to a specific color to understand the details better.

2. Thresholding: In this the pixels of the images are varied to analyze the areas of interest in the image.

3. Filtering Noise: Any kind of noise like salt and pepper noise or background noise that hinders the analysis of the image is removed.

4. Image Segmentation: This process is used to segment images to different parts like background, fire, smoke.

5. Augmentation : This technique is used to create multiple copies of an image by varying orientation, pixels,introducing noise to the image.

6. Edge detection: A method used to detect the edges or contours in images that would give a clear outline of what is in the picture.

Features for Implementation

1. Convolutional Neural Networks (CNN) : To train the model on the features that would result in detecting fire.

2. OpenCv: To perform Thresholding, color transformation

3. Scipy: To extract features from image

4. Scikit-Learn: To perform predefined feature extraction techniques

RELATED WORK (BACKGROUND)

A method to detect fire using smoke detection in video was illustrated by Forest Fire Smoke Detection in Video Based on Digital Image Processing Approach paper. This method is founded on digital image processing with static and dynamic characteristic analysis. The following steps make up the proposed method: the first is to identify the area of change in the current input frame in comparison to the background image; the second is to find regions of interest (ROIs) by connected component algorithm; the area of ROI is calculated by convex hull algorithm and segments the area of change from image; the third is to calculate static and dynamic characteristics; using this result, we determine whether to proceed with the proposed method. The outcome demonstrates how effective this technology is at detecting fire smoke.

A technique based on the wavelet model and a color model of the smoke was proposed by a paper which is Survey on Different Smoke Detection Techniques Using Image Processing. The suggested approach makes use of two features: the smoke's color model and the wavelet model's energy variation. Based on a decline in the energy ratio between background and current in the wavelet domain, smoke can be identified. The color model calculates the variance of the current pixel color. Combining these two features enables the Bayesian classifier to detect smoke.

Covariance Descriptors, Color Models, and SVM Classifiers are the foundation of the system developed by Osman Gunay and Habiboglu and were clarified in their paper, Flame Detection method in video using Covariance descriptors. This program makes use of video data. In this approach, the video data is divided into temporal blocks and covariance characteristics are computed using the spatio-temporal Covariance Matrix.

This feature is used to find the fire. Fire and fire-like regions are classified using the SVM Classifier. This technology does not support blurry data; it only supports clear data.

DATASET

There are a total of 6000 images in the dataset. It is classified into three classes

1.No fire: This denotes that there isn't any fire in the images

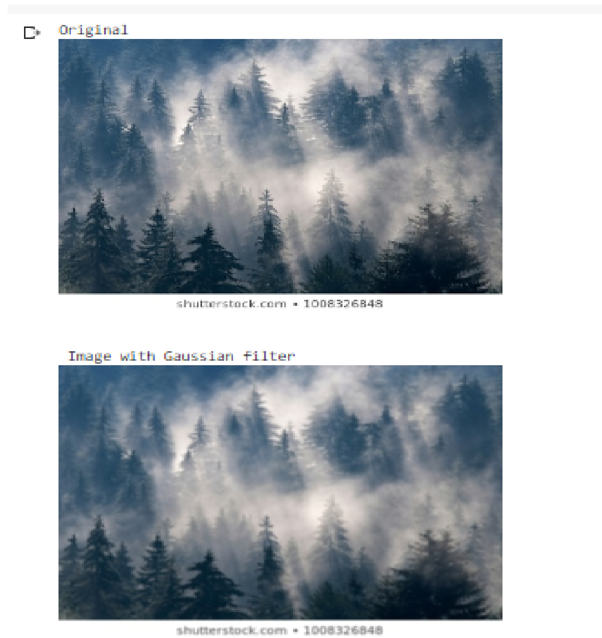
2.Start Fire: This shows that the fire is basically getting started and hasn't yet spread throughout the surroundings.

3.Fire: This denotes the lighting of a disastrous fire.

DETAIL DESIGN OF FEATURES

1.Noise Filter:

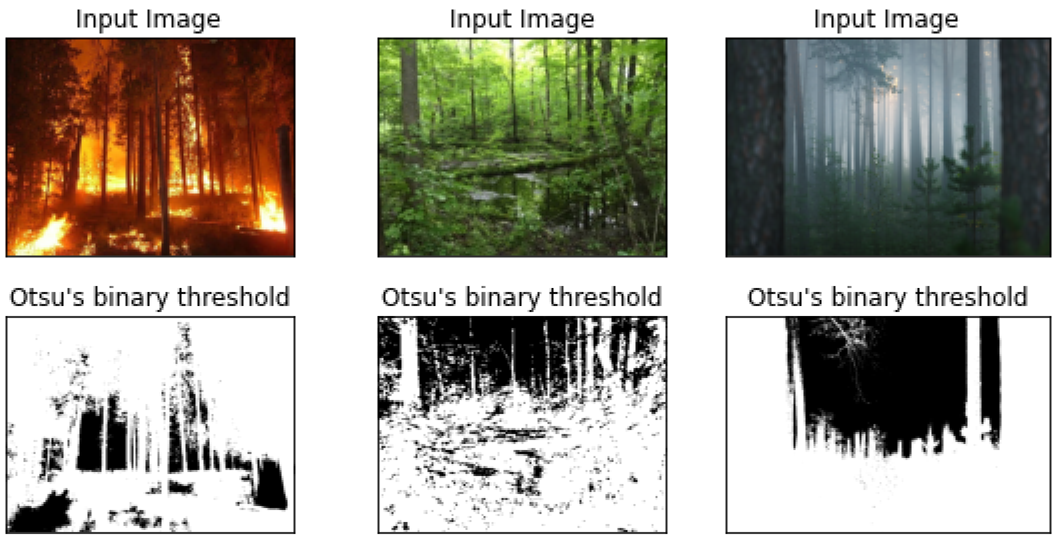
It's a variety of operations used to reduce the noise from data collected on the construction and infrastructure areas. We tried with three different filters to make our images clear and smooth before moving on to the next step in the image processing. The first filter we used was the Gaussian filter which is a Low pass filter that is used to remove noise and as we all know blurs images. The second filter we applied was the Bilateral Filter, which also uses a technique to smooth images while preserving edges. The third filter was the Median filter, which is well known for maintaining edges during noise removal also it uses in order to reduce random noise.



2. Image Segmentation:

The technique of dividing a picture into various portions and segments is known as image segmentation. This method is used to identify boundaries in an image as lines and curves, as well as to name each pixel in the image. Thus, segmentation aids in streamlining and altering an image's representation to make it simpler and more understandable to examine. Image segmentation is particularly helpful for splitting and grouping images. Machine learning, computer vision, artificial intelligence, medical imaging, recognition tasks, video surveillance, object detection, and other fields all use image segmentation extensively. It affects a variety of fields, including space research and healthcare.

We will use Otsu's segmentation which is categorized as a threshold-based segment. In Otsu's Segmentation, the input image is first processed before attempting to obtain the image's histogram, which will display the distribution of pixels in the image. Here, our attention is on peak value. The threshold value must then be calculated and compared to the image pixels in the following phase. If the value is more than the threshold but less than black, set the pixel to white. It carries out automatic thresholding as a result.



3. Color Transformation : RGB to LAB:

Designed using the frequently used and well known RGB color palette, LAB is another effective way of communicating colors. LAB is a color space with a much richer and vast color spectrum when compared with other color palettes like RGB, BGR or YCbCr. ‘L’ stands for lightness in the range of 0 to 100. A and B traverse all the colors from red to green and yellow to blue respectively. In the context of this project, color transformation has been applied to add a new flavor to the process of extracting features from the image. Additionally, fire and smoke being the vital higher level features for this project, can be detected only by studying the color changes throughout the image. As the spectrum of LAB captures much more minute details in the color patterns of the image, its use will only enhance the capabilities of the classifier.

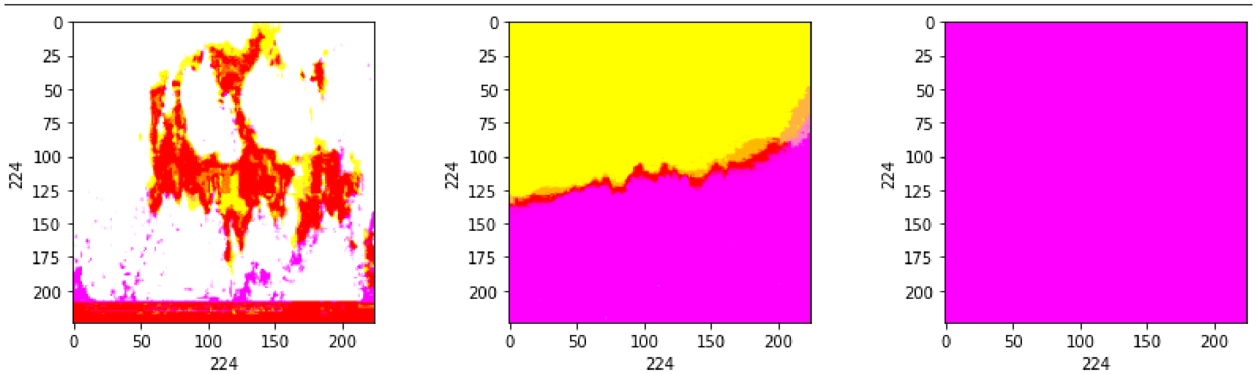
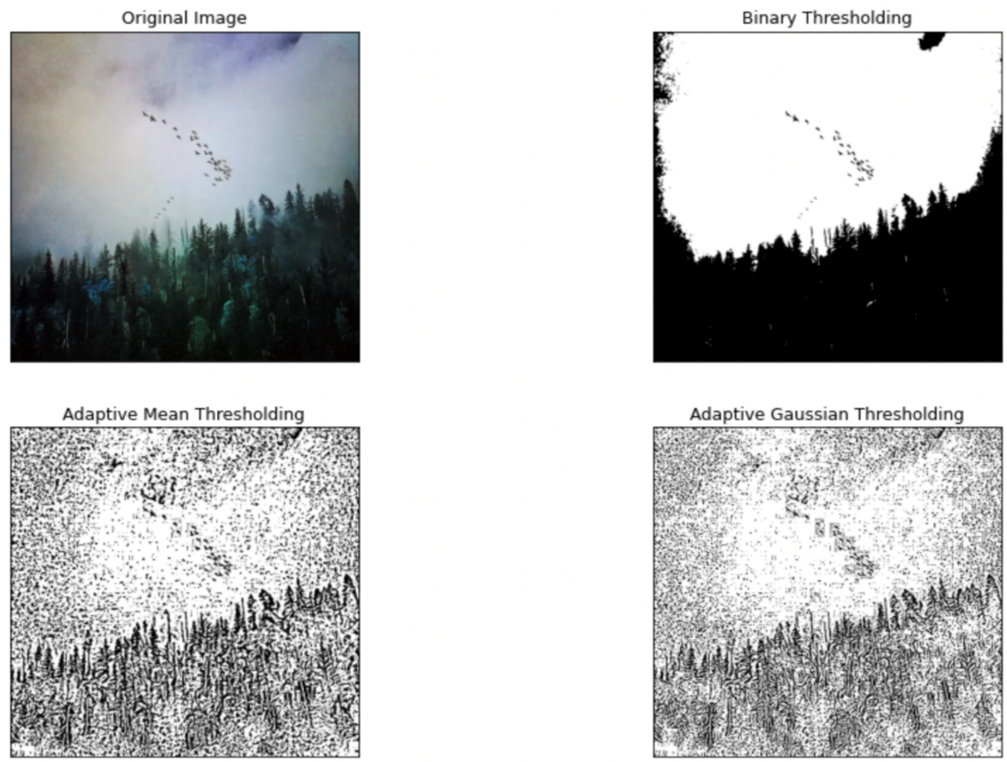


Fig. RGB to LAB color transformation

4. Thresholding :

Thresholding is a technique used for image segmentation and is achieved by varying pixels. This helps to better analyze the image. Particularly for this dataset, thresholding helps in segmenting fire/smoke and forest background. This will help the model learn to differentiate the details better from the image.

Here two types of thresholding are applied to images. The first is binary thresholding which outputs a binary image and it can be applied to both gray scale and colored images. The second is Adaptive thresholding which is subclassified into Adaptive Gaussian, Adaptive Mean thresholding. It is observed that binary thresholding has given better image segmentation for analysis.



5. Edge Detection:

Edge detection here is being done to check if the edges can separate the fire entity in the image. Through edge detection the discontinuity in the brightness is checked when one image section changes to another. It is understood that the image section with the fire must have a sudden change in the intensity of brightness and the change in edge should give some indication of the image segment with fire in it. The images were not grayscale before applying edge detection techniques as it is also necessary that the hue is detected in the image as hue is an important factor to detect fire in the image. First the horizontal and the vertical edges were checked to see if significant segments of images are detected through these edges. Further, the vertical edges were also checked to identify similar edges. Then further the vertical and horizontal edges were combined to see if any significant difference is observed in the images with and without fire where the images with fire have distinct characteristic differences compared to the ones without fire.

A Sobel filter has been used to identify the edges. Sobel filter calculates the gradient of the intensity of each pixel. Using sobel filter the intensity changes in the image was identified

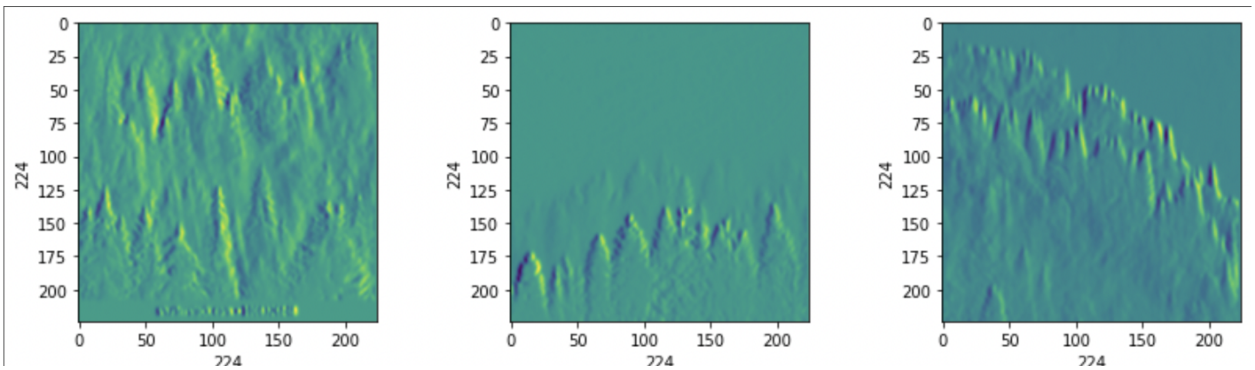


Fig : Horizontal Edge Detection

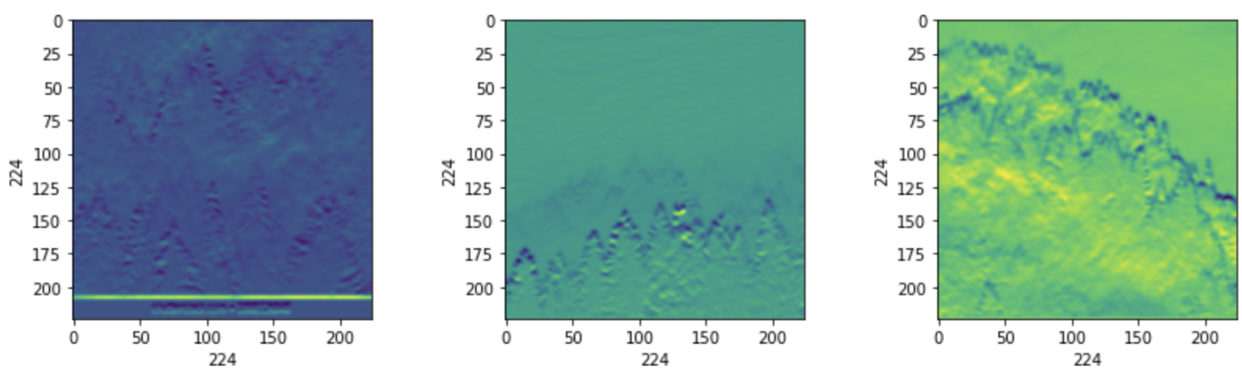


Fig : Vertical Edge Detection

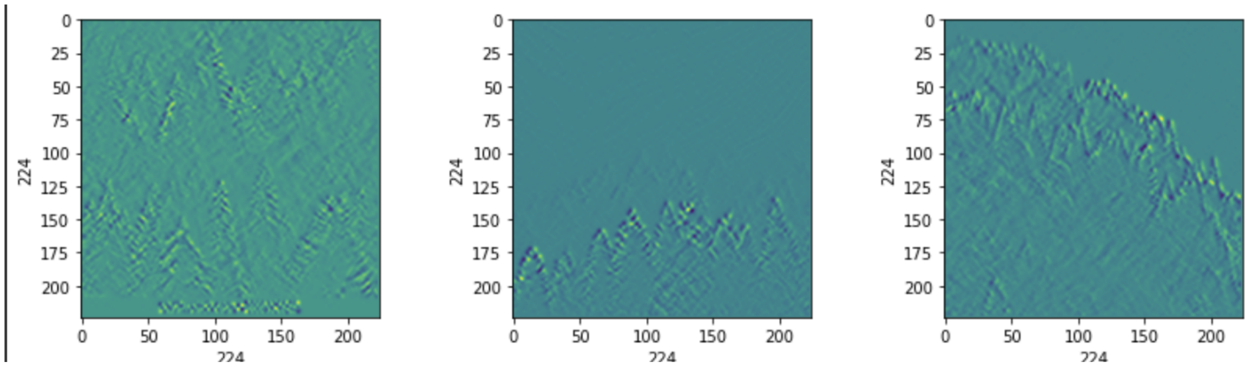


Fig : Horizontal and Vertical Edges Combined

6. ORB Keypoint Detection:

ORB(Oriented FAST and Rotated BRIEF) is an amalgamation of two different Image Processing Techniques. FAST (Features from Accelerated Segment Testing) which is an open source adaptation of a keypoint detector like SIFT or SURF. BRIEF (Binary Robust Independent Elementary Features) is an effective keypoint descriptor algorithm which is usually used in tandem with a keypoint extractor. The purpose of ORB in the project is to detect sudden shifts in the pixel intensities, which can be looked upon as detecting corners in the image. Output generated in the notebook file suggests that the algorithm detects corners of the trees, sharp rocky edges,etc. in the images. A set of descriptors generated by the BRIEF part in ORB is beneficial in matching the key points of a certain image with any other image. This comes in handy for the classifier model to train itself with this information and further predict an outcome based on the learnt keypoint descriptors.

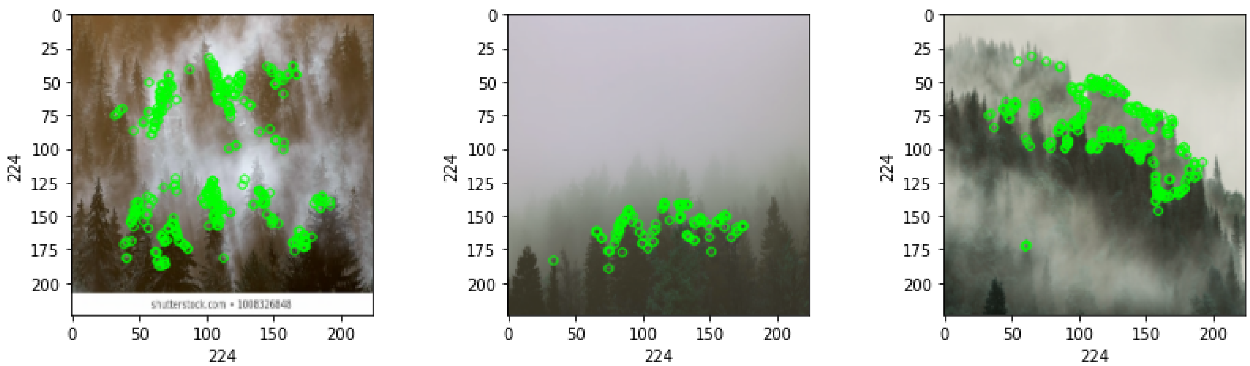
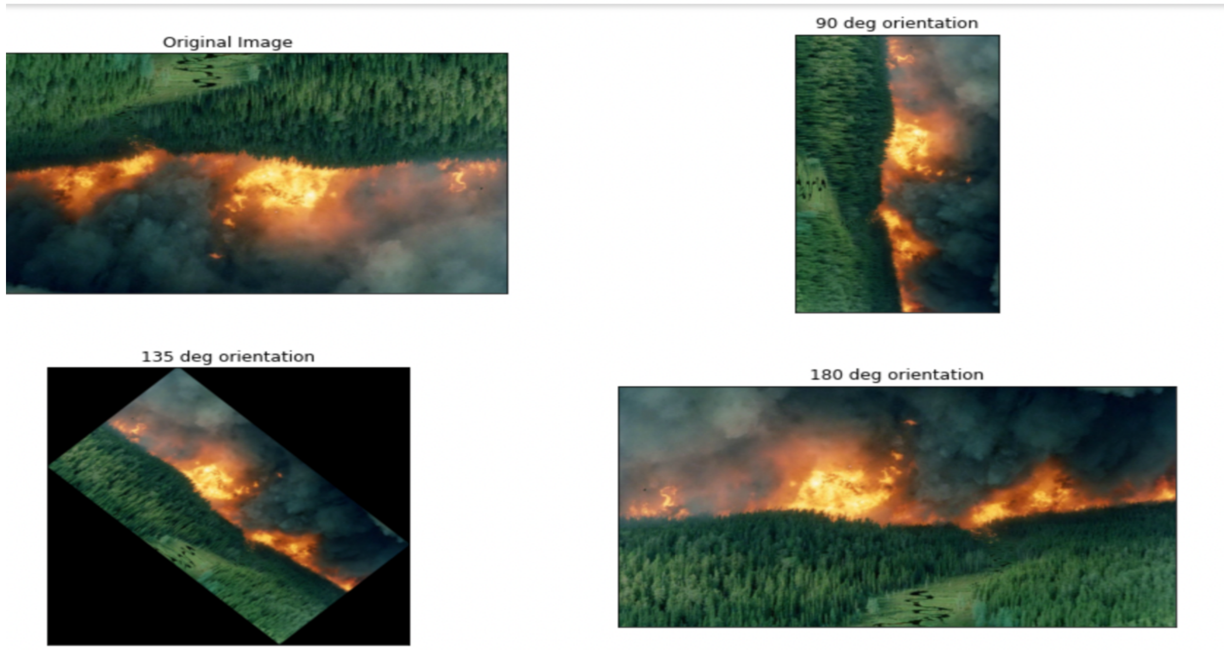


Fig. Oriented FAST and Rotated BRIEF keypoint detection

7. Image Orientation

Orientation is varying the angle of the image to get a desired real time scenario than an inverted or tilted image. This would ensure images of similar class and pattern are learnt as the same category by the model which avoids confusion while the model is learning by updating weights.



8. Censure and Corner Detection

Censure feature detector detects the significant features and is highly used in real time images to extract important details. Harris Corner detector as name suggest helps in locating the corners and helps in inferring image features.

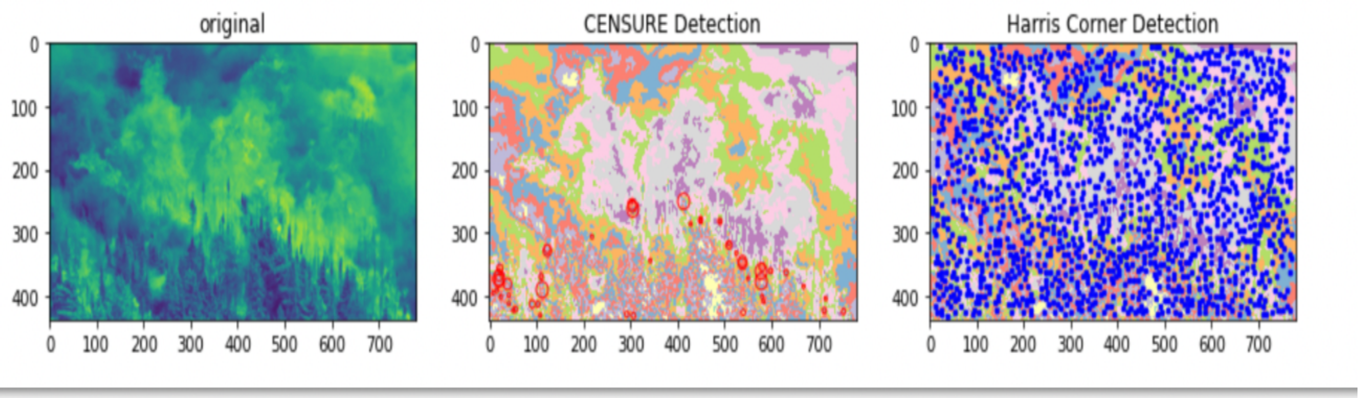


Fig. Images after censure and corner detection

Analysis:

Data Analysis:

The dataset consists of images with three classes namely fire, start_fire and no_fire. The images with no_fire class are the ones which have just the forested areas or areas with vegetation in their natural state. The image class fire has images with fire in them. The class with start_fire has all the initial signs that appear when forest fire starts like smoke and small patches of fire scattered in the images.

The dataset here is balanced as the data for all three classes have almost the same number of samples.

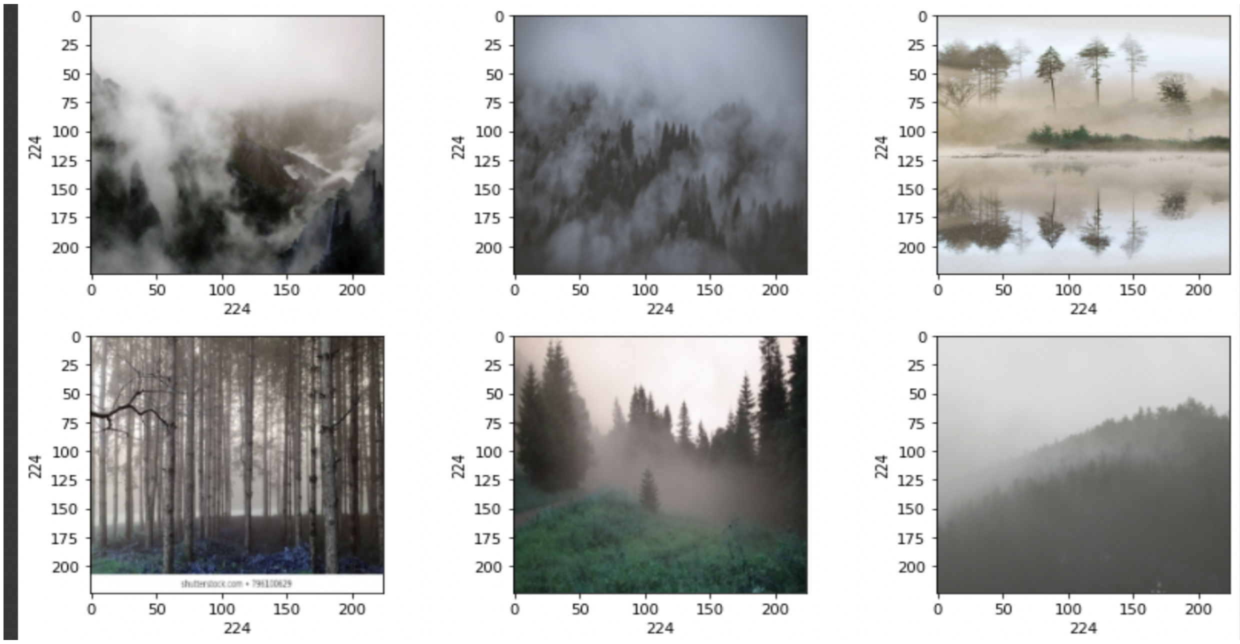


Fig. Sample images

The dataset was then further visualized as a histogram to inspect intensity changes within data samples. This was done to see if there are any apparent differences that histogram can show between the images with and without fire in them

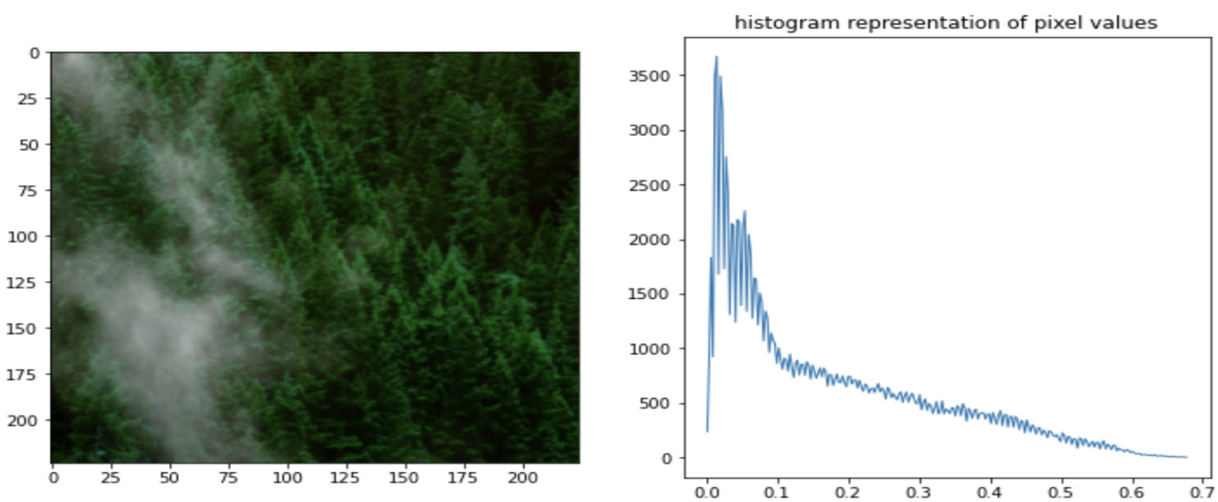


Fig: Histogram for start fire

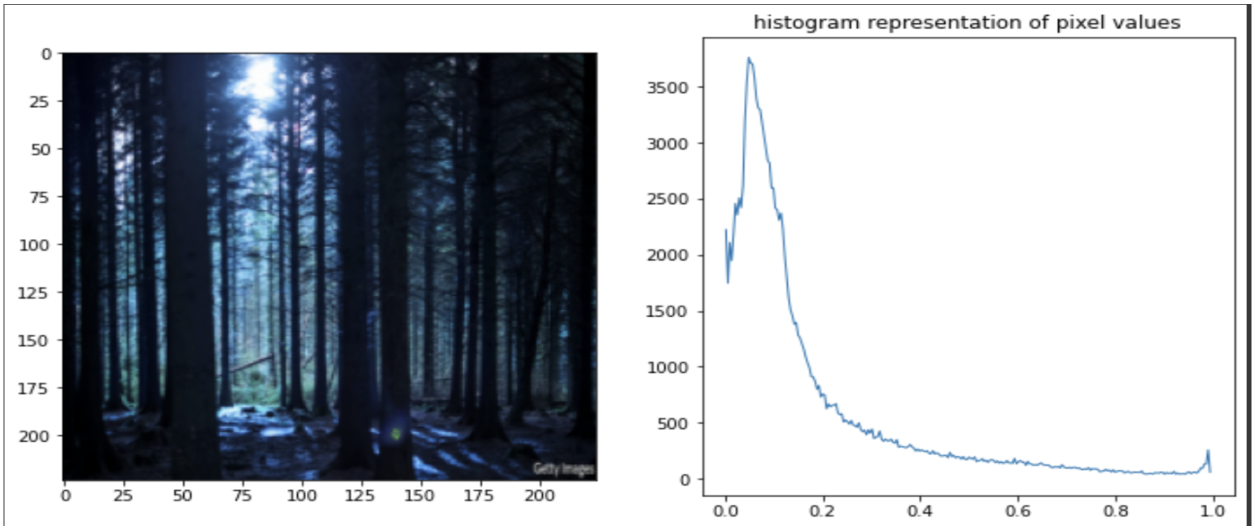


Fig: Histogram for no fire

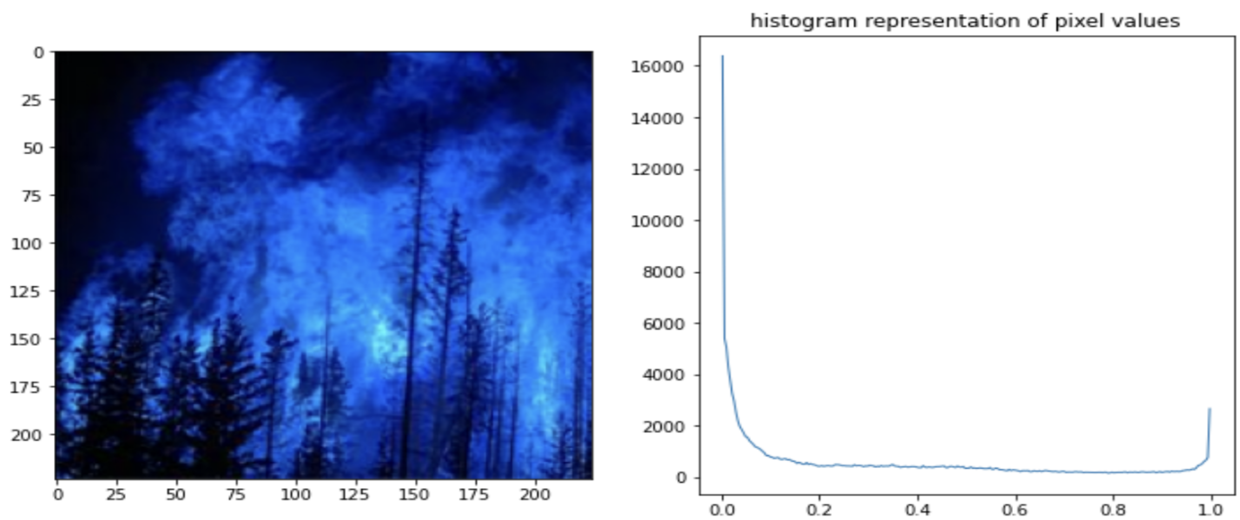


Fig: Histogram for fire

The reason to check the histogram of the image samples was to see if the images in all three classes would show distinct characteristics in pixels that would help the model understand how to separate one from another. However, it is clear that the histogram alone cannot give enough information and may further create confusion incase of ambiguity. Hence we implement feature engineering to look for relevant features.

Implementation:

Implementation is done in 5 steps. Starting with research where each of us looked into papers that worked on forest fires. We inferred that transfer learning on the Inception V3 model would eventually give better results. Next we proceed with data analysis, here we have gone through images across different classes in the dataset and inferred that certain feature extraction techniques would improve the model at the end result. We then worked on feature extraction techniques like edge detection, image segmentation, Noise filtering, Color Transformation ORB, Censure and corner detection e.t.c. After integrating and applying them to the dataset, we proceeded to build a basic transfer learning model on InceptionV3 with 5o epochs to test our architecture.

Next we will be working on tuning the model by varying the hyperparameters such as batch size, epocha, number of units. We would also measure the accuracy and other metrics using the ROC curve, confusion Matrix. Finally we would be testing the integrated application on all possible scenarios with video footage captured during forest fires.

Preliminary Results

After combining all the extracted features and training a simple Convolutional Neural Network for 50 epochs, we have achieved an accuracy of approximately 97% as the dataset is highly biased to the use of only a slice of data. Following are the loss and accuracy curves on training and validation sets.

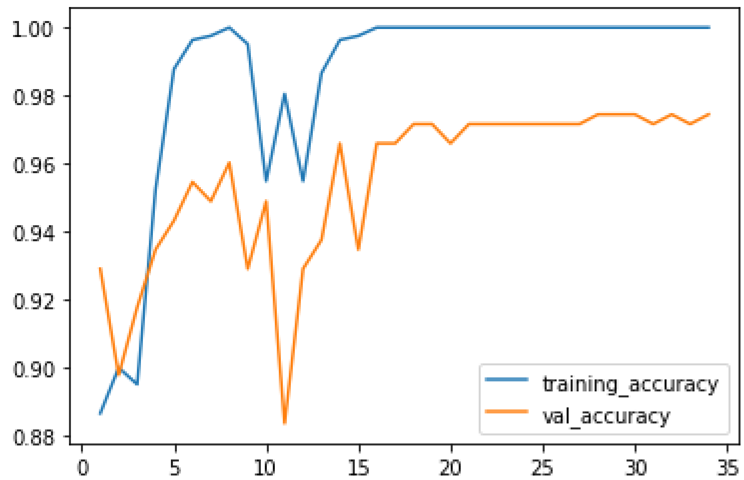


Fig. Accuracy Curves

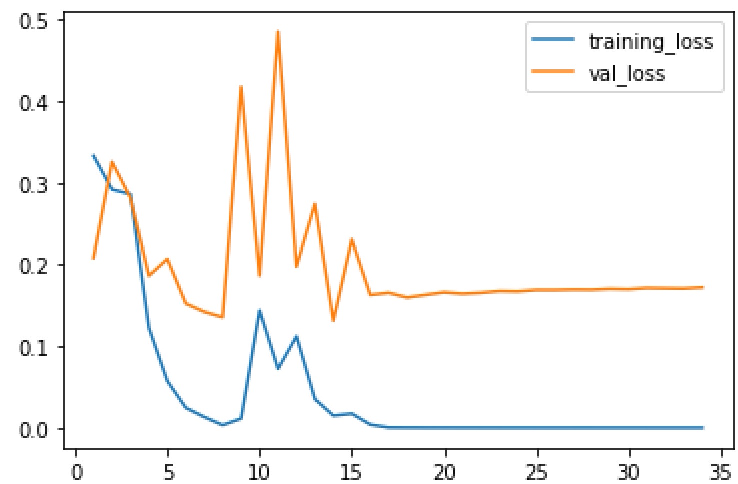


Fig. Loss Curves

The next task in the pipeline is to train this model using the extracted features on the entire dataset.

Project Management

Implementation status report

Various features are extracted from the images using different techniques. These features are then engineered to work in tandem in order to increase the classification accuracy of the classifier model. A simple CNN model is trained using the extracted features and a small slice of the entire dataset.

Work completed:

The work done in this increment is heavily leaning towards identifying the right feature engineering technique suitable for the project and using the available tools to apply those techniques into the sample data. So far, multiple features have been extracted and combined to train a model to test how it would perform altogether.

Task	Description	Person
Research	Going through papers related to similar work and getting knowledgeable insights that helped in designing and building the project.	Everyone
Data Analysis	Analyzing the three different classes present in the dataset and determining the possible patterns and count of images available for each pattern	Rana, Saja

Feature Extraction	Extracting various features from image applying different techniques like edge detection,corner detection,thresholding,colo r transformation,filtering e.t.c	Everyone has worked on this by splitting the task based on techniques
Building model Architecture	The task is to build a convolutional Neural Network and adding different layers for input, hidden and output and setting the basic parameters such as epochs,batch size	Shreeti
Integrating and Model Training	The task is to integrate all the work and train the basic model and check the performance.	Shridhar
VideoToImage Conversion	As the main focus is to detect fire from images which would be the input to our application, The task is to convert videoTo image which are then used to detect fire.	Priya

Contributions

Priya Enuganti:

Did research on a paper written for a similar project, shared insights and significant details with the team. Worked on image feature extraction by applying thresholding, changing orientation, Censure detection and harris corner detection. Developed the function to convert videoToImage which will be used at the final testing of the project. Contributed to make a report for the tasks I performed.

Saja Alkarawi:

Read articles relevant to similar projects and knowledge gained that was useful for designing and developing the project**.**Worked on feature extraction by applying three different noise filters (Gaussian filter, Bilateral filter ,Median filter), Inspecting the three classes in the dataset, Evaluating possible patterns, And counting the amount of images that fit to each pattern.

Rana Ghoneim:

Worked over research papers comparable to our project and attained expertise that assisted in project design and construction. Also, have applied otsu's segmentation, that is a type of image segmentation which is one of the features we extracted in our project. The segmentation was used on an example of three different images, fire, not fire and start fire, respectively. In addition, have assisted in writing the report for the duties achieved.

Shridhar :

Color scale transformation from RGB to LAB for more effective color pattern detection. Keypoint Feature detection using ORB keypoint extraction and descriptor algorithm to capture certain important characteristics of the images from all classes. Integrating and compiling all the features extracted and training a classification model using the same. Experimenting with different combinations of features to better the prediction accuracy.

Shreeti :

Worked on preliminary data analysis to check the nature of data, data dimensionality and data balance. Performed preliminary data processing to import and rescale image to fit the model requirement. Visualized data to understand the nature of the image data better. Further worked on extracting the features of the image by applying edge detection techniques using the sobel filter. Analyzed the feature to decide whether singular or combined edge extraction brings in more significance when training the model to identify the fire entity in the images.

Work to be completed

The work to be done in future increments would be more concerned with using the extracted features to train the model to maximize the accuracy and precision. Currently all extracted features are being tested with the assumption that they all contribute to the learning of the model. However, the model accuracy shows that there needs to be more work on refining and combining the right features. The second increment will be heavy on experimenting with different combinations of features to get the optimum result.

Task	Description	Person
Tuning	Model tuning by changing the hyperparameters such as epochs, batch size and number of units in each layer to achieve better performance	shridhar

Testing model	Testing the model performance on unseen data after each tuning done on the model	Rana
Accuracy/Performance Measures	Accuracy measures such as confusion matrix, ROC curves, Precision, Recall are to be calculated and visualized	Shreeti
Limitation and Future Scope	The task is to describe the tradeoffs or outliers in this project and what can to be done to further improve it	Saja
Integration and testing on real time video	Here All the modules will be integrated and testing would be done using various real time video footages of forest fire in different scenarios and would discuss on effectiveness of the application	Priya

Issues/Concerns

The characteristics of images where fire is just starting is just smoke coming out of a forested area. In most cases it is accompanied with scattered fire or the smoke is clearly distinguishable. However, some of these images can be easily mistaken for an image with a fog in it. More research is now being dedicated to finding a way to distinguish features with this sort of ambiguity.

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