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Forest Fire Prediction Using Image Processing And Machine Learning

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Abstract

Forest-fires are real threats to human lives, environmental systems and infrastructure. It is predicted that forest fires could destroy half of the world's forests by the year 2030. The only efficient way to minimize the forest fires damage is to adopt early fire detection mechanisms. Thus, forest-fire detection systems are gaining a lot of attention. Predicting the source and spread of forest fires could have impressive advantages for human wellbeing and life, the economy and the climate. This could assist with recognizing regions with higher danger - for instance, with restricted asset, the specialists could decide to zero in on observing explicit regions. In this study, image processing based has been used due to several reasons such as quick development of digital cameras' technology, the camera can cover huge regions with amazing outcomes, the reaction season of picture handling strategies is superior to that of the current sensor frameworks, and the general expense of the picture preparing frameworks is lower than sensor frameworks.

1. Introduction

After years have been extraordinary in the degree of consumed spaces of out of control fires, especially in forested locales across the world, that inexorably sway significant populace regions. This features the critical need to work on our capacity to foresee and better comprehend the variables impacting complete consumed regions prone to happen in specific conditions, and ongoing, out of control fire spread displaying. This requires proficient and infiltrating information mining of datasets of recorded rapidly spreading fire episodes. It is fundamental to recognize the key variables affecting the effects of woods fires in explicit areas and climatic zones, as worldwide environment conditions appear prone to develop quickly and as human land use grows.

One of the natural resources that must be protected and explored wisely and securely, as well as sustainability concepts, is the tropical forest. However, poor exploitation has resulted in certain issues. Forest fires are one type of calamity. This calamity not only destroys forest natural resources, but also causes additional problems such as fogging and ecosystem disruption. On the other hand, research in intelligence systems, particularly machine learning aided by image sensing algorithms and neurofuzzy, results in a design system capable of monitoring real data, proceeding with a rule base derived from human reasoning, and producing prediction systems and supporting information for decision-making.

Forest fires (also known as wildfires) are a major environmental hazard that threaten forest preservation, cause economic and ecological damage, and cause human suffering. Multiple factors contribute to this occurrence, including: Degradation of watershed areas and loss of rich timber resources. Loss of biodiversity and elimination of plants and creatures, just as loss of untamed life territory and consumption of untamed life, just as regular recovery and timberland cover decay.

The main objective of the work is to apply image sensing and machine learning in the aim of forest fire prediction with the input stream of images. It uses image processing, background subtraction and special wavelet analysis. We also use SVM for classifying the candidate region to either real fire or non-fire. We use the faster R-CNN object detection model, which has full image convolutional features. The algorithm uses YCbCr color space after processing the RGB color space.

The fast improvement of computerized camera innovation has brought about a quick expansion in picture quality and diminished expense of the cameras. Furthermore, the way that computerized cameras can cover bigger regions with astounding outcomes, assists us with picking them over sensors. And sensors have the ability to get themselves perished in the disaster situation easily when compared to the latest digital cameras.

A web-based application system to help users to predict whether a forest fire will occur or not from the input stream of images which is user-friendly, cost-effective and mobile. Comparison between existing and proposed model is carried out. Faster R-CNN is the object detection model which is used. The alternate models are Single Shot Multibox Detector (SSMD) and FCN. The predictions will be given after image processing and can be used for automatic forest-fire alarm systems. The technique to fire detection hasn't altered in the last 40 years – a system will see smoke, smell smoke, or detect heat. While this is undeniably a sound strategy, there is always the possibility of a game-changing breakthrough that will turn the industry on its head. Fire detectors are becoming increasingly reliable, but they are also being modified to reduce the risk of false alerts. False alarms are currently one of the most serious problems in fire protection. Not only is this clearly a waste of resources that diverts assistance away from potentially life-threatening situations, but it also has an impact on the fire strategies of different fire departments across the country.

2. Literature Survey

Wildfires, especially in inhabited regions, are a dangerous and detrimental phenomenon for people and the environment. Human activities are the principal cause of ignition in these places. In Europe, for example, people are thought to be responsible for 95 percent of wildfires. ML is built on algorithms that can learn from and forecast data by modelling hidden relationships between a collection of input and output variables, which reflect the predisposing factors (independent variables) and the occurrences of the phenomena (dependent variable). Forest fires pose a serious threat to people's lives, the environment, and infrastructure. By 2030, backwoods fires are relied upon to have obliterated portion of the world's woodlands. Early fire location techniques are the main powerful way to deal with decrease the harm brought about by woodland fires.Celik et al. [1] proposed a conventional model for fire Color. The creators consolidated their model with straightforward moving article identification. The items are recognized by the foundation deduction procedure. Later on, they have proposed a fluffy rationale improved methodology which utilizes transcendently luminance data to supplant the current heuristic guidelines which are utilized in identification of fire-pixels. Han et.al [2] isolated the fire location calculation into two calculations which are fire recognition and smoke Detection. They utilize removed components like movement, glimmering, edge obscuring area from a video, utilizing wavelet change and foundation deduction for assurance of smoke. They use shape and shading provisions to identify events of fire.

A. Kansal et.al [3] clarifies Wireless Sensor Networks (WSN) has acquired consideration as it has been helpful in notice about calamities. Anticipating cataclysmic events like hailstorms, fire, precipitation and so forth by WSN are rare and stochastic. This is a significant subject of exploration. Recognition of these debacles ought to be quick and precise as they might cause harm and annihilation at a huge scope. In this paper, examination of different AI methods like SVM, relapse, choice trees, neural organizations and so on has been accomplished for expectation of backwoods fires.

D.Sathya et.al [4] have proposed a strategy, a shading spatial division, worldly division, worldwide movement pay, Support Vector Machine (SVM) groupings are utilized to recognize the fire and to section the fire from the video succession. The technique is carried out throughout the two ongoing informational indexes. The proposed technique is generally appropriate for sectioning fire occasions throughout unconstrained recordings continuously.

D.Cheng et.al [5] proposed a various leveled district combining way to deal with consequently remove the ocean region and utilize edge coordinated diagram cut (GC) to achieve the last division. First and foremost, a picture is portioned into super pixels and a diagram based consolidating strategy is utilized to separate the most extreme space of ocean locale (MASR). Then, at that point, the non-associated ocean areas are recognized by estimating the distance between their super pixels and the MASR.

T. Nguyen et al. [6] fostered a technique that concentrates shading and movement from video successions to distinguish fire. The aftereffects of this paper had the option to create a strategy which can play out the district developing division to recognize shading pixels in the scene and afterward distinguish the fire locale. The system utilized are YCBCR shading space model and district developing method which looks at all unallocated adjoining pixels to the area.

J. Ramiro Dios et.al [7] presents PC vision procedures for woodland fire discernment including estimation of backwoods fire properties (fire front, fire tallness, fire tendency point, fire base width) needed for the execution of cutting edge timberland putting out fires techniques. The framework processes a 3D insight model of the fire and could likewise be utilized for imagining the fire development in distant PC frameworks. The introduced framework coordinates the handling of pictures from visual and infrared cameras.

Mubarak An et.al [8] recommended that Forest flames address a genuine danger to living souls, natural frameworks, and foundation. Numerous business fire recognition sensor frameworks exist, yet every one of them are hard to apply everywhere open spaces like woods in view of their reaction delay, vital support required, significant expense, and different issues. In this paper a woodland fire identification calculation is proposed, and it comprises of the accompanying stages.

Divya TL et.al [9] have suggested that Forest Fire expectation assumes a vital part in security of the woods and untamed life. There are a few structures accessible which anticipate woods fires. These structures utilize different procedures like fire planning and observing. The current structure is expected to do the comparative undertaking by estimating the force chart of the fire in a picture.

V Tuba et.al [10] clarifies a calculation for woodland fires recognition dependent on shading highlights. Various attributes of the shading parts of the YCbCr shading model were utilized to recognize fire dependent on the predefined limit esteems and blend of the part's qualities. After pixel grouping morphological activities were performed to eliminate erroneous arranged pixels. The proposed technique effectively recognized fire locales in woodland pictures with various lightning conditions.

Mubarak An et.al [11] have introduced another video-based, picture handling woodland fires recognition strategy, which comprises of four phases. Initial, a foundation deduction calculation is applied to identify moving locales. Besides, competitor fire not really settled utilizing CIE L∗a∗b∗ shading space. Thirdly, unique wavelet investigation is utilized to separate between real fire and fire-like items, on the grounds that competitor districts may contain moving fire-like articles.

Panagiotis B et.al [12] clarifies in their paper that Large-scale backwoods fires are one of the most hurtful regular dangers influencing environmental change and life all throughout the planet. In this way, to limit their effects on individuals and nature, the reception of all around arranged and firmly organized successful avoidance, early admonition, and reaction approaches are important.

Yu Xia [13] proposed the land and ocean region division, by utilizing Local Binary Pattern (LBP). LBP is more reasonable for remote detecting picture handling. For a land pixel, LBP discovers to consistently be zero and to the genuine land pixel from satellite pictures, LBP is consistently not zero. LBP is an incredible surface component descriptor, which has been broadly utilized in surface investigation, face acknowledgment and different applications.

Zhang et al. [14] proposed a fire identification framework dependent on ZigBee WSN. The primary reason behind their exploration is to plan a framework that can screen stickiness and temperature in a substantially more exact and in an additional time effective way. As indicated by their exploration the framework is equipped for checking ongoing boundaries and inside no time sends these deliberate qualities to the PC investigation focus.

This creator [15] proposes novel strategies for identifying and isolating smoke from a solitary picture outline. In particular, a picture development model is determined dependent on the climatic dissipating models. The division of an edge into semi smoke and semi foundation parts is figured as raised advancement that takes care of an inadequate portrayal issue utilizing double word references for the smoke and foundation parts individually. An original component is built as a link of the particular scanty coefficients for location. Also, a strategy dependent on the idea of picture matting is created to isolate the genuine smoke and foundation parts from the smoke location results. Having played out a broad writing review on our picked project, we have acquired monstrous information on the present status of-the-workmanship innovation being utilized.

3. Design and Implementation

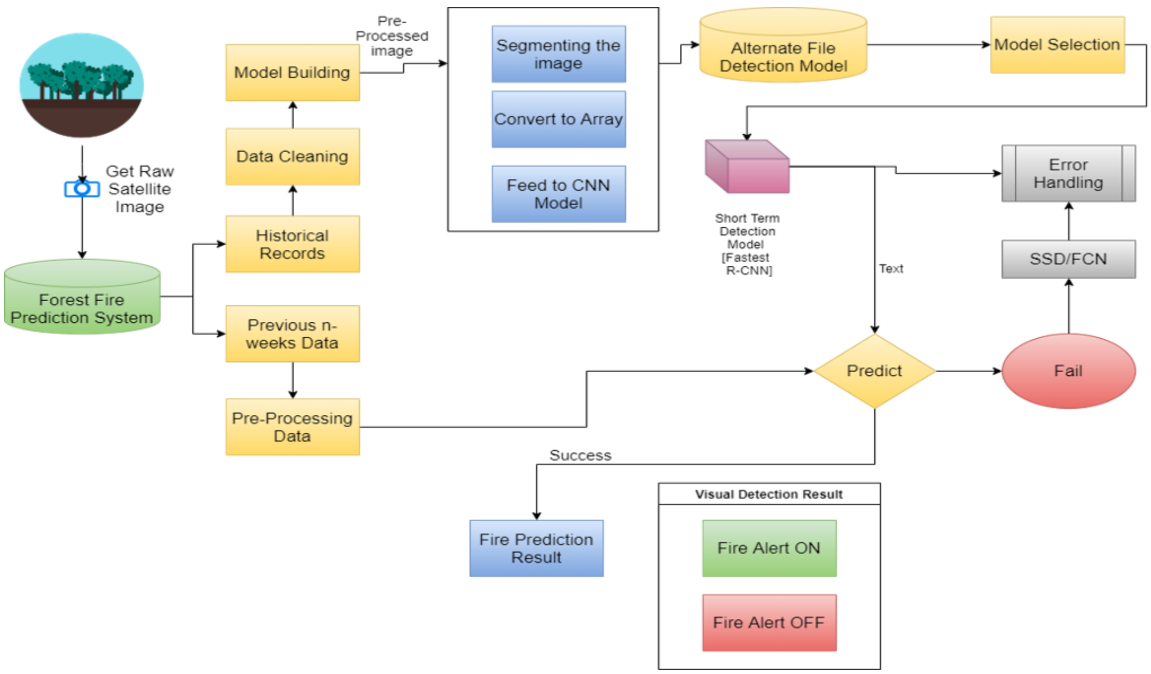

Fig. (i) Proposed System Architecture

The raw satellite images to be predicted are fed into the Forest fire prediction system. The images to be tested are fed into the historical records, and the training data set images are fed into the previous n-weeks data.

From the historical records, the images are followed by data cleaning where we fix images and change them to a fixed standard size of images for better computation, we also discard the corrupted image in this stage, later fed into model building preprocessing happens here.

The preprocessed images later undergo segmentation and then converted to probabilistic arrays and are fed into the CNN model. If the CNN model fails, the preprocessed images are fed into an alternate file detection model and hence model selection takes place.

Then the preprocessed image is fed into the Shortest Term Detection Model (Fastest R-CNN) and prediction takes place.

Errors are also handled when the prediction is not a success. If the fastest R-CNN fails, the preprocessed images are fed into the SSD/FCN model and the errors are handled here. Both the models have a Backbone model, and left with a profound neural organization that can remove semantic significance from the information picture while safeguarding the spatial construction of the picture, though at a lower goal is normally a pre-prepared picture order network as a component extractor.

The R-CNN model predicts the preprocessed image and gives the Fire Prediction Result. Based on the Visual Detection Result, the fire Prediction is a Boolean result either Yes or No.

The design starts at getting the image sequence as input. We then prepare the training dataset, and then convert our image to RGB Components.

After the Data Preprocessing is done, we check if prediction is possible

If yes:

1. We convert the RGB components to an array component.
2. And fetch the obtained outputs from above step to apply the fire detection rules.
3. We observe the temporal variations across the signals.
4. We then check if fire is detected and display the result

If no:

We go back again to apply background subtraction and repeat the procedure once again.

NOTE: Each time background subtraction is done, we update the background model

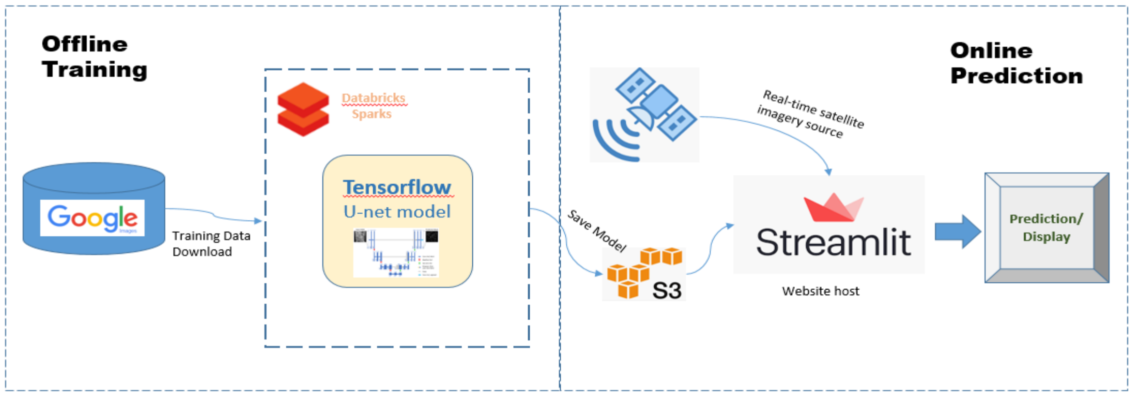

Fig. (ii) Implementation working

Download batches of images using Google image API.

Image segmentation is done using the TensorFlow U-net model and using data bricks sparks.

The satellite images are from a real time primary source which is fed into stream lit.

Our saved model and the temporary model in form of h5 file is also fed into Stream lit for displaying the results

The saved model after segmentation uses Stream lit for the front end or user interface, along with error handlers

Online prediction is eventually done using the CNN algorithm and Display is predicted to the user.

This work is based mainly on the CNN algorithm used to predict forest fires. Fundamentally, the CNN calculation is a Deep Learning calculation which can take in an information picture, dole out significance (learnable loads and predispositions) to different viewpoints/objects in the picture and have the option to separate one from the other.

After imported the input data into the model, there are 4 parts to building the CNN model, they are:

1. Convolution: an interaction where element maps are made out of our feedback picture. A capacity is then applied to channel maps.

2. Max-Pooling: empowers our CNN to distinguish a fire consuming region when given alteration.

3. Flattening: Level the information into an exhibit, so CNN can understand it.

4. Full Connection: The secret layer, which additionally computes the misfortune work for our model. First sight, it has a "U" shape. The design is symmetric and comprises of two significant parts — the left part is called contracting way, which is established by the general convolutional measure; the right part is broad way, which is established by translated 2d convolutional layers

The "U-Net" needn't bother with numerous races to perform picture division and can learn with not many named pictures that are appropriate for picture division in science or medication. U-Net is more fruitful than ordinary models, as far as design and as far as pixel-based picture division framed from convolutional neural organization layers. It's even powerful with restricted dataset pictures.

UNet is able to do image localization by predicting the image pixel by pixel, and the network is strong enough to do good prediction based on even a few data sets by using excessive data augmentation techniques.

First, uploading photos of different kinds of forest fires to the machine. The machine understands these images uploaded. Then the user opens the website and uploads a picture taken. The software used in our project scans the image for any fire like object, then it checks the vulnerability. The software also does a danger assessment and finally predicts whether the area in the uploaded image has fire or not.

In the work, first make a module for training our data set of images, we follow 70% of data for training and 30% of our data for testing. We Uniform Mask Size to be the same as Image Size then, uniform all images to be the same size - 720 * 480. We also Binarize Mask data size and choose the most common size of image for making our prediction.

In the next module, Data is preprocessed and taken for further steps:

1. Removing noisy data in order to remove unwanted data.

2. Integrating data obtained by taking image from different views.

3. Normalization of obtained data.

4. Generation of high quality data for further process.

5. Extraction of information from processed data.

Then combine all images back to original size and remove the ghost caused by CNN model prediction boundary artefacts by padding the same 4 pixels on the boundary

Predict batches of images, and return the probability array and convert the array back to [0, 255] for display.

Furthermore, we also make a module (frontend as website) for better user interface and visual ease using Streamlt. We preprocess the raw image and make Prediction using a prediction function based on our algorithm, on a temporary model which issaved in a form of ".h5 file". We combine the images, and convert to 0-255 for display and show the result and also calculate burnt area using predicted mask image. Furthermore, we further also calculate CO2 emitted in tons using predefined formulas available using the various types of forest.

4. Results and Performance Analysis

Use case-1:

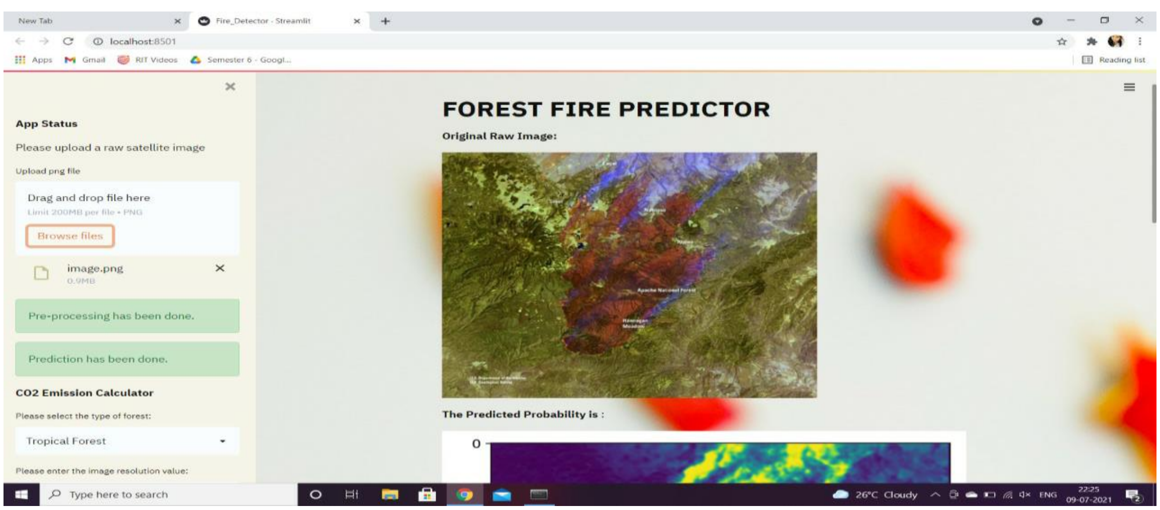

Fig. (iii) Input to the fire predictor

Figure 3 shows the original raw image fed into the forest fire predictor. The image to be uploaded must be a PNG file with image size less than 200 MB.

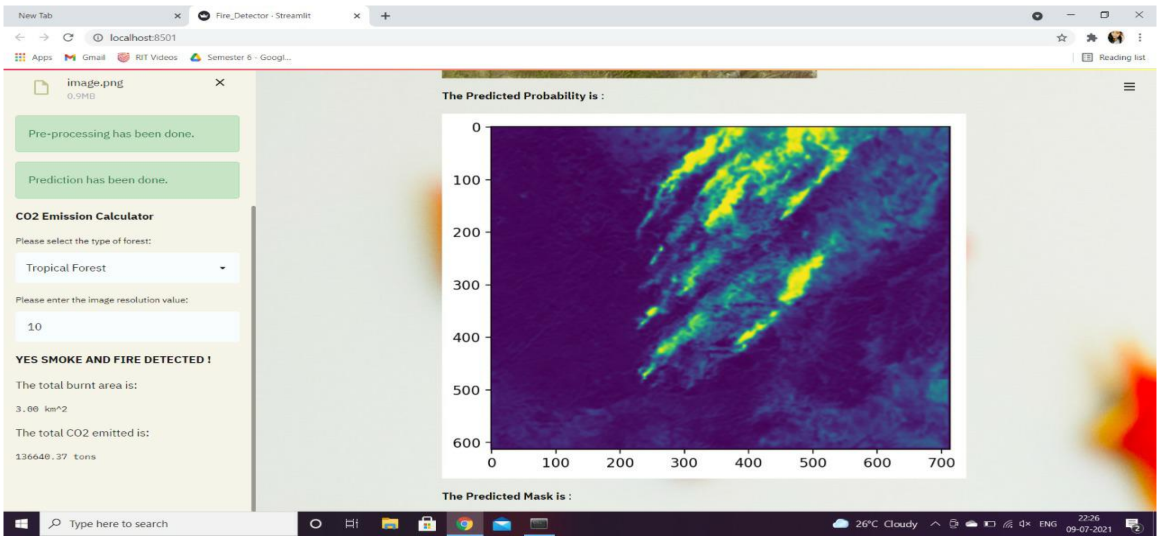

Fig. (iv) Preprocessing of the Input

After the raw image has been fed into the forest fire predictor, preprocessing and prediction takes place. Figure 4 shows the predicted probability that shows affected burnt areas with the green and yellow contour. The yellow parts show the most affected areas.

The intensity of the fire is also shown here.

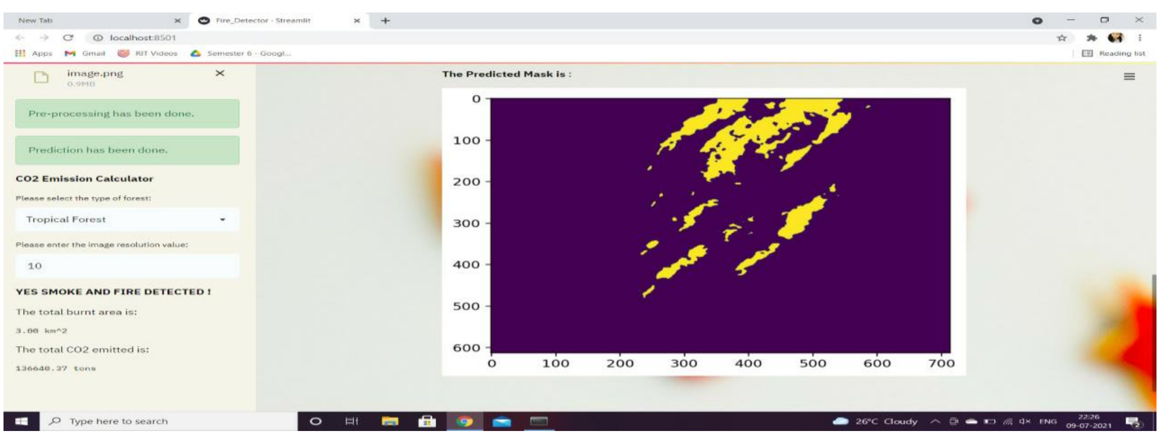

Fig. (v) Intensity of fire

Figure 5 shows the predicted mask, i.e. the exact portion of affected areas without denoting the intensity. The yellow portion denotes the forest fire affected areas.

After the preprocessing and prediction has been done, the CO2 emission is estimated.

A drop-down menu is displayed that allows the user to choose the type of forest. And the user must also enter the resolution value.

After the calculations are done, the final prediction is displayed to the user.

In the above case, fire is detected and is displayed to the user as **"YES SMOKE AND FIRE DETECTED !"** The total burnt area is displayed as 3.00 km^2 and the total CO2 emitted is 136640.37 tons

Use case-2:

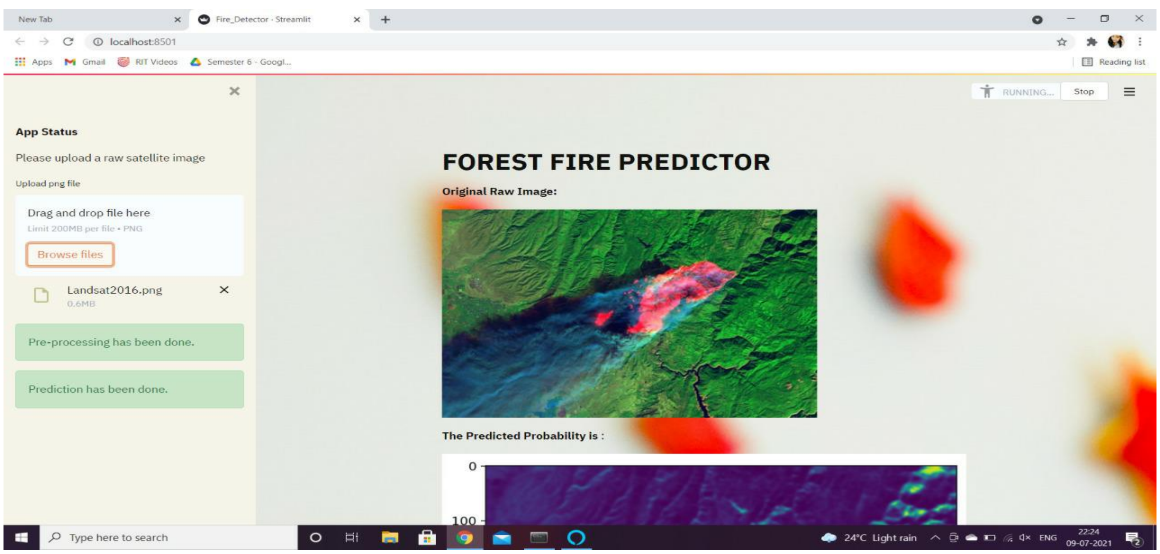

Fig. (vi) Raw Image as in Input to the predictor

Figure 6 shows the original raw image fed into the forest fire predictor. After the image preprocessing and prediction has been done, the predicted probability and predicted mask are displayed to the user.

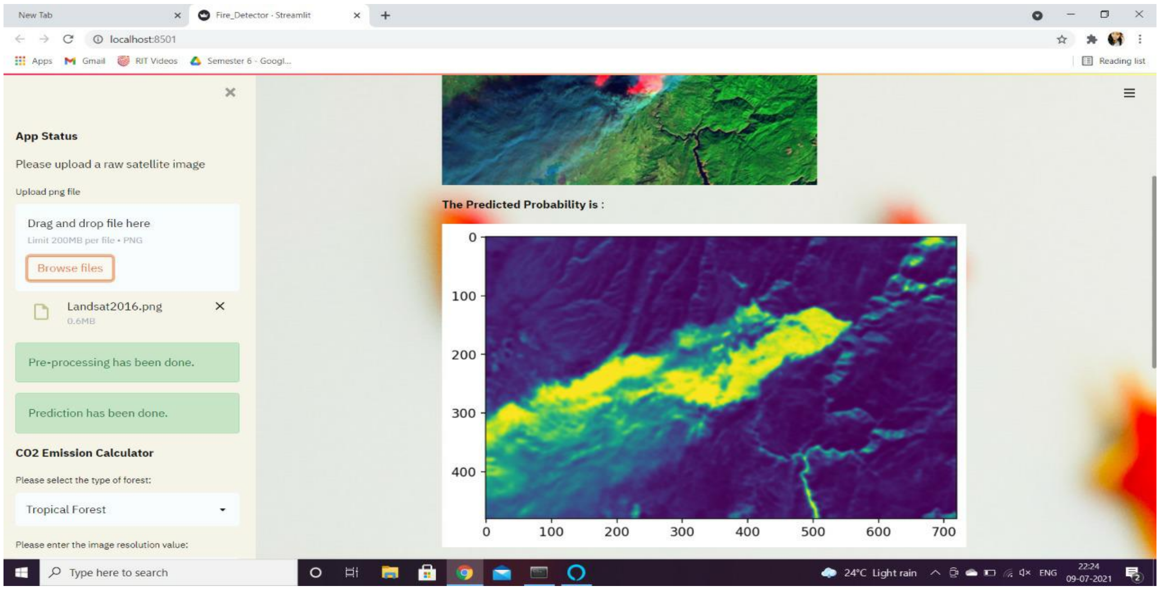

Fig. (vii) Intensity of the most affected area

Figure 7 shows the predicted probability with the green and yellow contour. The yellow portion shows the most affected area. The predicted probability clearly shows the intensity of the forest fire.

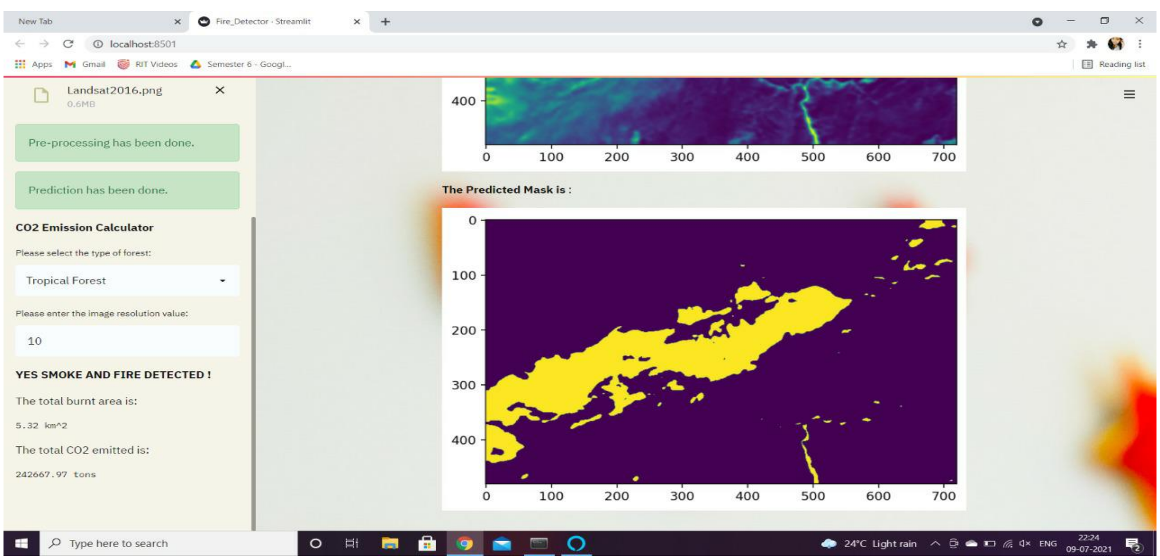

Fig. (viii) Variation in intensity

Figure 8 shows the predicted mask that shows the affected area in the yellow portion without showing the variation in intensity. In the above case, fire is detected and is displayed to the user as “YES SMOKE AND FIRE DETECTED !” The total burnt area is displayed as 5.32 km^2 and the total CO_2 emitted is 242667.97 tons.

Use case-3:

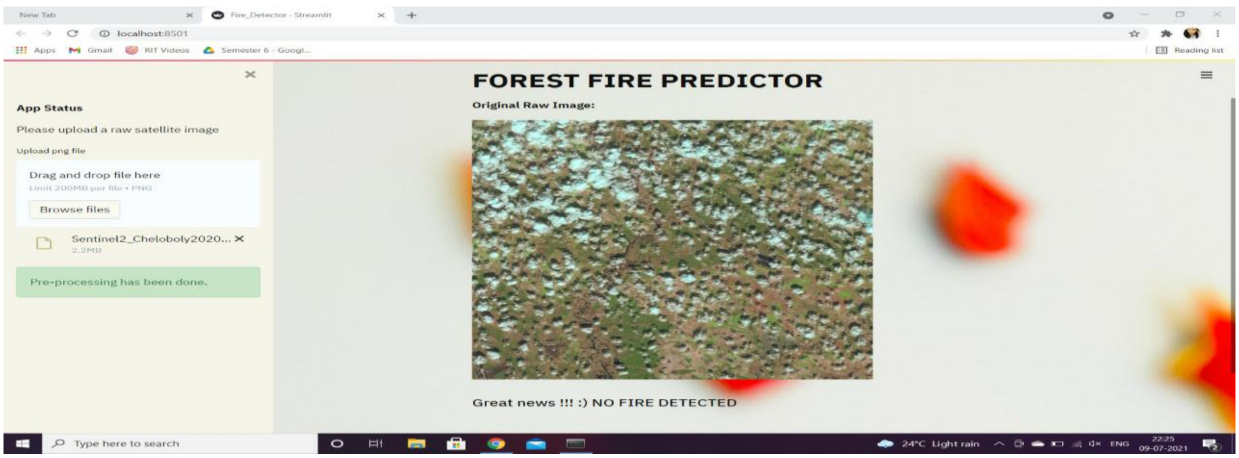

Fig. (ix) Another Raw Image as an input for the predictor

Figure 9 shows the raw input image fed into the forest fire predictor.

After the image preprocessing has been done, the final result is displayed to the user.In the above case, no fire is detected. And is displayed to the user as

“Great news !!! :) NO FIRE DETECTED”.

Hence, no CO_2 emission is calculated, and the execution ends here.Performance analysis

Confusion Matrix for testing data:

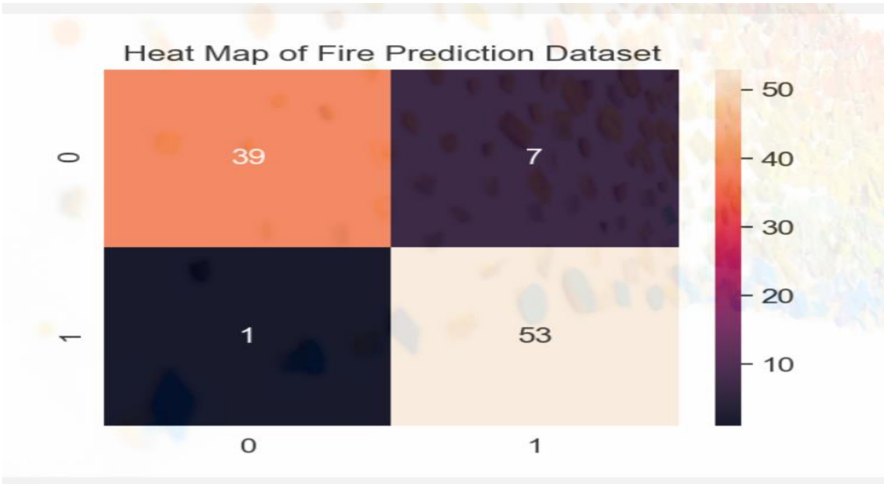

Fig. (x) Heat Map of our Model

```
array = [[39,7],
         [1,53]]

df_cm = pd.DataFrame(array, range(2), range(2))
# plt.figure(figsize=(10,7))

sn.set(font_scale=1.4) # for label size
model = sn.heatmap(df_cm, annot=True, annot_kws={"size": 16}) # font
plt.title('Heat Map of Fire Prediction Dataset')

plt.show()
```

From above confusion matrix

Total right predictions:-39 + 53 = 92

Total predictions:-39 + 7 + 1 + 53 = 100

Accuracy of model = (Total right predictions/Total predictions)*100

=(92/100)*100

=92%

Accuracy of model is 92%

Recall, Precision and F-measure:

(i) Recall = TP/(TP+FN)

= 39/(39+1)

= 0.975

(ii) Precision = TP/(TP+FP)

= 39/(39+7)

= 0.8478

(iii) F-measure = (2*recall*precision)/(recall+precision)

= (2*0.975*0.8478)/(0.975+0.8478)

= 0.907

Successfully created a model to detect forest fire with an accuracy of about 92%. The model is reliable and of decent accuracy, and thus the prediction model can be used in situations of emergency. Although the algorithm is relatively accurate, some improvements to increase the speed and accuracy can be made by collecting more training data.

Conclusion

The final results show that the proposed forest fire detection method detects fire-like items with a high detection rate (92%) and a low false-alarm rate (8%). Our model has a precision value of 0.84 and recall value of 0.97. These findings suggest that the proposed technology is accurate and suitable for application in automatic forest-fire detection systems. The method's accuracy could be enhanced in the future by extracting more fire features and expanding the training data set. We can further improve our model by changing the image size or adding more layers to our model and increasing our training time. However, our model will reach a point where additional training time will not improve accuracy. Successfully created a model to detect forest fires. The model is reliable and of decent accuracy, and thus the prediction model can be used in situations of emergency. Although the algorithm is relatively accurate, some improvements to increase the speed and accuracy can be made by collecting more training data. User-friendly, quite easy to operate. Cost-effective can be built at an affordable cost. Can be established or used in any type of terrain. Mobility and Light weight.

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