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Early Forest Fire Recognition using Deep Learning

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Abstract
Currently many research organizations are under going to develop a reliable and an efficient methods to predict the fire disasters, which may urge to serious social impact as well as heavy property loss. From a video sequence of fire, we are going to implement deep learning method which counterfeit humans. In traditional method they employed human as inspector to detect the forest fire, but human resource is very expensive and also such approach has very low efficiency. To detect the particles like smoke or fire, temperature, relative humidity the fire sensors are implied. To achieve high accuracy rate of fire, it can be achieved by applying deep recurrence neural network. Here, the fire soldiers can move from the other side of the forest to save the forest.

Keywords: *Forest Fire Recognition, Deep Learning*

1. Introduction

An well-organized vision based fire detecting algorithm is judgemental for early forest fire detection. A Significant dispute to human life, animals and nature is forest fire. We should promptly extinguished the fire or else, it will have bad impact on society. Due to interference between human and forest ecosystem has tremendously increases the forest fire incidences. As per the forest survey of India (FSI) analysis more than 95 % of the forest fire in India are manmade. The study was made by Forest survey of India. In that 1.45 million hectares of forest area are affected annually in country. Although early symptoms of forest fire is smoke. Smoke identification also focused on forest fire monitoring system. Vision-based smoke detection sensors have some limitations. These algorithm usually combines feature extraction, motion detection. Spatial features and temporal features form the single frame image is analysed using video based detection. In this we are proposing a deep learning based fire detection method. Compared with image based and short term video based method long term video based method can improves the fire detection accuracy successfully. And also it reduce false detection and misdetection. Sunset, chimney smoke and clouds are some of the examples that are often includes error in computer vision during fire detection.

Deep learning with convolutional neural network are good at modelling and processing sequence data for prediction. In [1] this research proposed a deep normalization and convolution neural network is a traditional convolutional layer to accelerate the smoke detection.

In forest fire detection one of the important feature is dynamic feature. The vision system of human is admirable at recognizing moving fire in sequence of image, because it analyses the dynamic characteristics. Dynamic features where collected and extracted to improve the recognition accuracy. There are many researches where going related to forest fire using deep learning [2] proposes faster RCNN and 3d CNN as a joint frame work. To avoid large computational complexity, an algorithm like CNN is not suitable. Recognition of forest fire becomes difficult due to two reasons, (1) it is difficult to pursue efficient spatiotemporal fire (2) there are different motion saliency feature of fire in each frame, so we must pay attention to different frames. In Other neural network are independent of each other. And all the inputs are related to each other in RNN. To extend the effective use of pixels neighbourhood it is extended to use RNN.

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2. Related Work

As recommended in the earlier section, based on that there are two types of detection to detect forest fire are: image based method and video based method.

A. Video Based Method

In circuit television surveillance scenarios are some of the place where computer vision based fire detection algorithm where applied with controlled background. [3] This method can is not only applied for surveillance and also for the classification of video automatically for retrieval of fire tragic. And also analyses the colour, surface coarseness area size, boundary roughness and skewness frame to frame changes of specific low-level features with in estimated regions. [4] To test whether a pixel belongs to that fire region for that Wavelet was used, and to describe the contour of fire area fast Fourier transform has been used. [5] Probabilistic model of fire is generated based on that pixel value of fire constantly change in the consecutive frames. In this model they uses the Bayesian network model. [6]

To distinguish temporal flame flicker from flame colored moving object for that markov flame ordinary moving objects are used. From an ordinary camera data are collected and further used to detect flame in video for the future uses.

B. Image Based Method

A novel approach to detect fire, there are vast survey about the statistics characteristics [7] compared to other techniques Vision based fire detection is very useful. This visual image sequence consist of spectral, temporal and spatial model of fire regions.

Figure 1: Image based method

[7] They proposed that by using image processing model how to detect the fire and smoke more novel. From the samples extracted from different type of video sequences and image for statistical analysis used for extracting the color model. [8] In this paper states that from the original frame the visual features are extracted directly. And also it separates background such as visual features from the smoke.

C. Deep Learning Method

[9] It is difficult to extracting long term dependencies from sequential data, for both probabilistic model like hidden markov model and deterministic dynamical system like recurrent network. Deep learning neural network is an artificial neural network with multiple layers. The correct mathematical manipulation to turn the input into the output is by using the deep learning neural network, whether it be a linear relationship or a non-linear relationship. Deep learning is also a new 'superpower' that will let you build AI system that just weren't possible a new year ago. [8]Instead, learning from data's collected from observation, and solving with own solution to the problem. Till 2006 we did not know how to solve problems traditionally, due to lack in neural network training except few problems. Deep learning network achieve outstanding performance of many important problem speech recognition, natural language processing and computer vision. Microsoft, Google, Facebook has been deployed in very large scale. [9] Today the speed of computation is a minuscule fraction of human brain. Rosenblatt's perception algorithm was seen as a fundamental milestone of neural networks.

3. Convolutional Neural Network

Convolution neural network is similar like feed forward network that is used for object classification and image recognition. While recurrent neural network principle is, by saving the output of that layer and then feeding this back to the input to estimate the output of the layer.

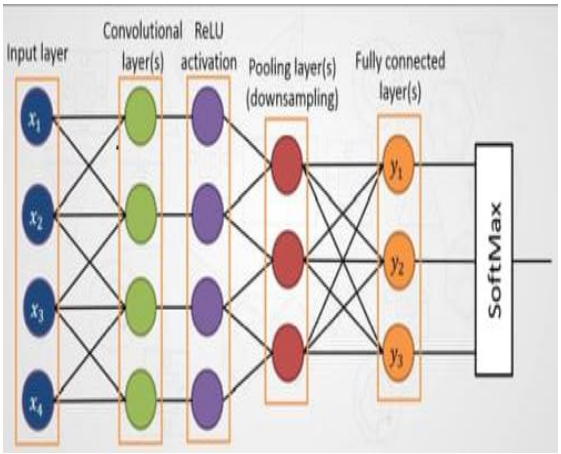

Figure 2: CNN

4. CNN Layers

To build convNet architecture there are three main types of layers. They are (a) convolutional layer, (b) pooling layer, and (c) fully-connected layer.

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Layer1- (a) convolution layer consist of input, output layer, and also multiple layers of hidden layers. The hidden layer further consist of series of convolutional layer with multiple or other dot product. In multiclass function the neural network is allowed to run by soft max layer. It will now allow us to determine the probability of the fire in the image, as well as the probability that additional abject are included as well.

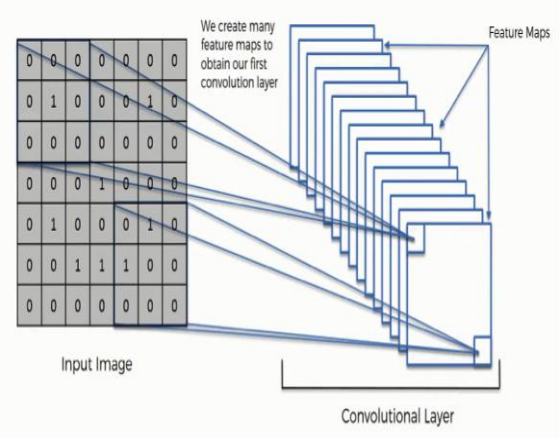
(W-K+2P/S)+1

Where, W is input volume size,

K is kernel field of convolutional layer neuron,

S the stride which is applied, and

P is amount of zero padding used on border.



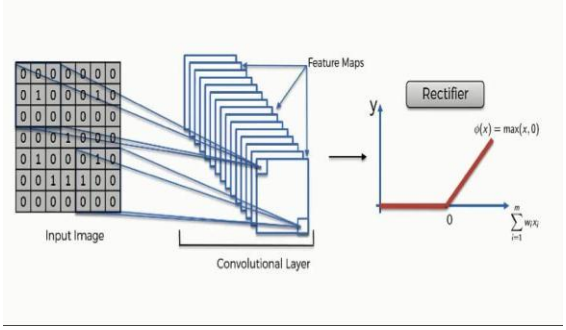
(b) ReLU layer. Rectified linear unit, or ReLU, commonly deployed activation function for the output of the CNN neuron. The derivation of the soft plus function is the sigmoid function. ReLU is one important component of the convolutional neural networks process. We can increase the non-linearity of the image by applying the rectifier function.

$$F(x) = \max(0, x)$$

is non-saturating activation function, which removes negative value.

$$f(x) = \tanh(x)$$

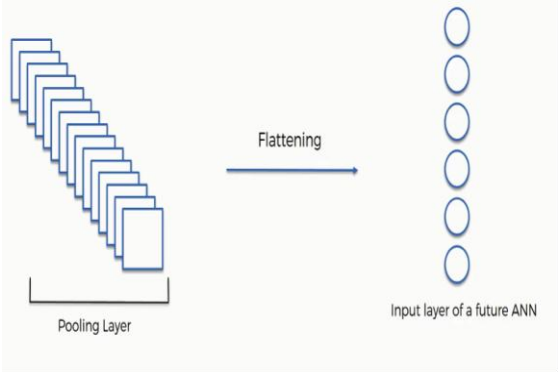
Other function used to increase non-linearity



Layer2- Another building block of a CNN is a pooling layer. It can operates independently on each feature map. Its main function is to continuously reduce the amount of parameter and computation in the network. Benefits of having down sampling layer are reducing the number of parameters ensures higher computational speeds, a layer such as max pooling layer or averaging layer ensures translation equivarience. This means that your output is tolerant to small translation changes in the input.

$F_{x,y}(s)=\max_{a,b=0}\ s_{2x+a,2y+b.}$

Layer3- In flattening step the pooled feature map into a column. We're going to need to insert this into an artificial neural network.



Layer4- fully-connected layer in CNN represent the feature vector for the input when the network gets trained, this feature vector is then further uses for classification, regression, or input into other network like RNN for translation into other types of output. It is also being used as a encoded vector. The activation function node that can be put at the end of the neural network or in between the neural networks. These activation function helps to decide whether the neuron would fire or not. Over the input signal we do non-linear function. And then the output which is transformed from input signal is sent to the next layer of neuron as input.

5. Model Architecture

The proposed architecture is to collect data from surveillance video and process them in real-time. By this architecture, the data will getting rich and model will be getting better at predicting with more accuracy. This architecture to detect fire is considered to be cost-effective as there won't be a big change in the existing infrastructure, and various surveillance systems are used to detect fire.

GOOGLE NET

Googlenet is also known as inception V1. An error rate of 6.67% is achieved from googlenet, this is very close to human performance. In order to beat googlenet accuracy, we need to work hard to do some human training. The network used a CNN inspired by LeNet module.

22 layer of deep CNN are there in this architecture but consist of reduced number of parameters from 60 million

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to 4 million. There are many advantages of using googlenet which has better classification accuracy compared to other modules like LeNet, AlexNet and also, it's a small sized model which is also suitable for implementation on FPGAs and other hardware architectures having memory constraints.

With existing pre-trained connections, CNN needs less dataset to achieve better accuracy. The dataset for now consist of one video characterized by the presence of fire. The video has been converted into dataset of over 800 images by splitting the video frames by frame. The exact image with fire is 650. For training, 60% of dataset has been used, 20% for testing and remaining 20% for validation.

6. Methodology

For implementation we are using python. Which is relatively easy learning and many open source machine learning framework, python was used in experiment and prototyping. Google colab, is a research developed by google and tool for learning machine learning researches and education.an environment called jupyter notebook that comes with pre- installed machine learning tools and libraries. The dataset is loaded in google colab, pre-processed, split into training, validation and testing set, then used for Training pre-trained models and then tested. Python, Matplolib library is mostly used in this for data visualization.

A. Preprocessing

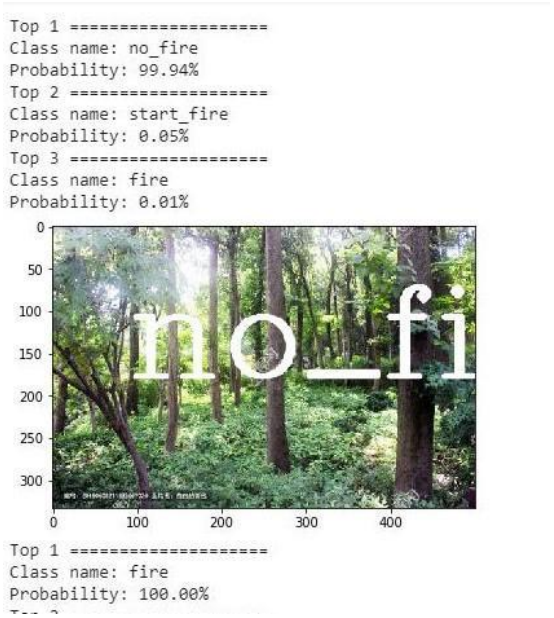
The data set is downloaded in google colab. Using OpenCV library, the video frames has been split into training, validation and testing dataset. One of the standard ratio was used, 60% for training, 20% for validation and 20% for testing.

B. Training and Testing

Inception model V1 or GoogleNet model. The last layer is removed and standard output layer of 2 perceptron is added. The model is trained on the training dataset batch-wise. After many trial and error, the model has been set up. After training, the model is tested on the test dataset.

6. Result and Observations

The model was developed and run on a Google Colab GPU for training and testing. The validation and accuracy obtained on this dataset for the proposed model is 96% and a testing accuracy of a range 98%.



7. Conclusion

A database of the fire color was constructed by selecting pixels of fire from the images collected from the database, the pixels of fire were remapped to a 2-dimensional color space. It is known that, there is a relationship between the R, G and B values of the fire pixels. This relation is further measured by HSI space to build norm for the segmentation and extraction of fire in video images. By adjusting the fire segmentation, fire flame oscillation feature was studied. This results indicated that the, image processing could be used to detect the fire oscillation. The difference in the frequency for the pool fires in the container, it also proves for video flame detection, the oscillation information help very much. It is noticed for that reason video cameras are placed at different locations with different view angles, this could be affect the reliability of the results. However

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robust oscillation, exact location of the fire detection should be developed in the future works.

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