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Detecting Smoke in an Image Using Cascade Classifiers

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Abstract

This paper proposes smoke detection using image processing technique. It has been a challenging problem for a decade or two because of its variation in color, texture and shape. In this project a machine learning based approach is considered to solve this problem. The smoke detection problem is posed as classification problem. The solution is modeled as binary classification problem. Therefore, support vector machine (SVM) is considered for classification. In order to train and test the SVM classifier, positive and negative samples are collected. Two SVM classifiers are used in cascade. The first classifier detects the presence of smoke, if smoke presents in a given input image, the second classifier is used to locate the region of smoke in a given input image. The size of the window is fixed to 32x32 and slided across the entire image to detect the smoke in a region of the window. The model is trained a training dataset and using linear kernel as a kernel function. Subsequently, the model is tested with a Test dataset. The first SVM classifier achieved a training accuracy of 100% and testing accuracy of 92.5%. The second SVM classifier achieved a training accuracy of 96.5% and testing accuracy of 91.5%.

Keywords: smoke detection, cascade classifiers, SVM.

1. INTRODUCTION

Smoke is an initial stage of most fires. It has its vast effects on human health, nature and its surroundings. If we detect the presence of smoke, then we can easily prevent the occurrence of fire. So, an efficient method to detect smoke is necessary. That's why we proposed a cascade classifier method to detect smoke.

This study is to discover the smoke before it became hearth. Smoke could be a visible suspension of carbon or different particles within the atmosphere that are emitted from the burning of substance. It's usually associated in nursing unwanted by-product of fires.

Smoke inhalation is that the primary reason behind most death in indoor fires. Several compounds of smoke area unit are extremely toxic and poisoning. The foremost dangerous is that the CO that causes CO poisoning. People who inhale large amount of smoke quickly lead to loss of consciousness. Moreover, a cloud of smoke combining with region element has the potential of being ignited either by another open flame in the area or by its own temperature. This leads to effects like back draft and discharge.

The existing strategies for smoke detection involves use of some kind quite hardware and this hardware vary from fancy smoke detector to infrared sensors. optical smoke detectors have a awfully high response time though they generate perfect results however the results doesn't seem to be low-cost as putting them in public areas might be dear and would need proper hardware management as they are easy to get tempered.

In this paper, a method is proposed which is quite efficient and cost effective than the traditional methods. This is done by using SVM classifier which divides into two classes i.e., images with smoke (positive images) and images without smoke (negative images).These images are used to train our own classifiers. They are given as input to SVM classifier 1. Then 32x32 patches of images is given as input to train SVM classifier 2. In order to test classifier 1 these images are fed to SVM classifier 1 which predicts whether 1 or 0. The predicted smoke images is given to classifier 2. By using window sliding, it finds the patches of smoke areas. Finally, it highlights the smoke region in the image.

2. RELATED ARTICLES AND DISCUSSIONS

Celik.T.,et.al, [1] provides a unique for fire and smoke detection using image process. The model use totally different color models for both fire and smoke. The images extracted by using statistical analysis that are extracted from totally different type of video sequences and pictures. The extracted models can be utilized in complete fire/smoke detection system which mixes color data with motion analysis.

In Chao-Ching Ho [2] a technique for automatic monitoring systems to find an early fireplace and smoke is represented, it uses motion history detection algorithm to register attainable smoke and fireplace positions given in a video and analyze the spectral, spatial and temporal properties within the stream of images.

The above paragraph don't allow to use the logic of spatial, temporal properties and the detection is done in an one image. This project is used to detect smoke areas in our surrounding by the assistance of images taken by the user and differentiate it with fog.

In Chao-Ching Ho [2] the spectral probability density is represented by comparing the flame and smoke histogram model, where HIS color space is used.

Chen-Ye-Lee.,et.al, [3] projected a technique of smoke detection using spatial and temporal analysis. The projected algorithmic rule provides bigger flexibility to smoke detection technique and additional reliable to figure beneath totally different conditions.

D.Kim.,et.al, [4] proposes a technique of smoke detection in stationary camera video using the multiple options of smoke. It does it in three steps, the primary uses YUV model for color filtering, the second step involves extracting the feature options and at last they are inputed to SVM (Support Vector Machine) classifier that makes decision on candidate smoke region.

Othman O.Khalifa.,et.al, [5] projected a system wherever a smoke detector senses smoke activates its alarm, sends an occasional voltage signal to any or all other smoke detectors within the neck of the woods. This low voltage signal activates the individual relays within the alternative smoke detectors causing them to emit a tone that alerts residents that one of the smoke detector senses smoke.

P.Morerio.,et.al, [6] projected an approach for smoke detection that is mainly works on color features extraction and dynamics analysis. It includes five main modules: 1] change detection, 2] motion detection, 3] fire feature extraction, 4] smoke feature extraction, 5] chaotic feature extraction. This module gives a very known subtraction based algorithm to get pixels which are different than normal pixels of the background picture. The traditional methodology of smoke detection needed hardware like sensors and had several shortcomings like lifetime of hardware, battery of sensing element, substantial quantity of smoke for detection, proximity of smoke to the sensing element as mentioned in P.Morerio.,et.al, and P. Santana.,et.al, [6,7].

In the above method, the main problem with smoke detection is the matting problem that is specifying if a region of pixels contains smoke region or not as discussed in Sagar.,et.al, [8]. This problem arises because of the background present in any image.

S.E.Memane.,et.al, [9] describes fire detection technology based on video images in recent years. The above method of fire and smoke detection in both indoor and outdoor living places can be classified into two main categories: the characteristic detection of some and flame. The system performance can be improved by using optimal algorithms for detecting smoke area and extracting features of fire.

The spatial models for detecting smoke as discussed in Srinivasa G Narasimhan.,et.al, [10] which are highly important for matting problem as it helps in studying the structure of smoke. Srinivasa G Narasimhan.,et.al, [10] discusses the various effects of the atmospheric scattering, attenuation excreta.

3. PROPOSED SMOKE DETECTION APPROACH

A diagram of the proposed smoke detection technique is shown within the Figure.1.

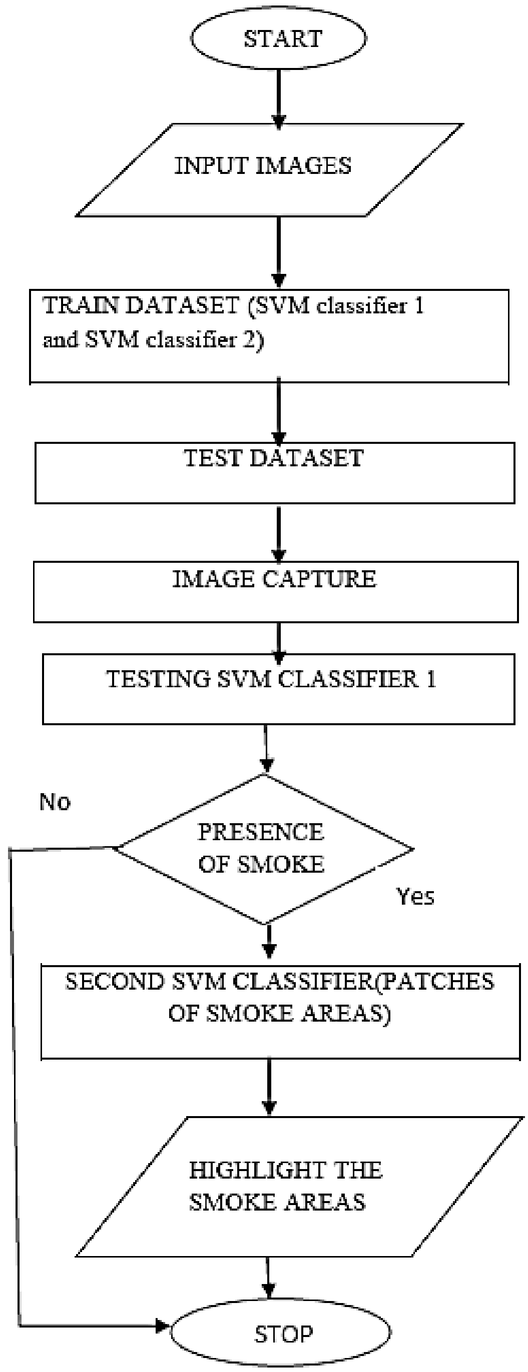

Figure 1. Proposed Smoke Detection technique

4. WORKING

A. Input Images

The input image contains both positive and negative images. Figure 2 are the input images given to SVM classifier 1. The dataset for area without and with smoke is not available anywhere. So by using real time videos, we run it and crop it and save it in the folder as positive and negative images. These images are given to linear SVM classifier 1 to train the image by labeling it. For linear SVM classifier 2, the patches from the positive images are cropped and stored as again positive and negative patches. These patches are labeled and given to linear SVM classifier 2.

(a) (b)

Figure 2. Input Images (a) Negative Images (without smoke) (b) Positive Images (with smoke)

B. Training SVM Classifier 1

The images that we are going to provide as a input is converted into numpy array. Next we are going to label the data. If there is a smoke in the image then it is labeled as “1” or otherwise it is labeled as “0”.

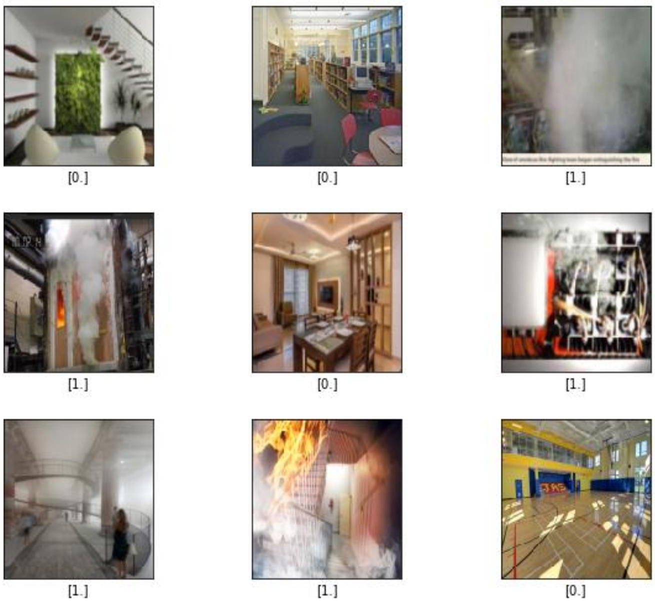

Figure 3. Input Images from Training Dataset

Then find out the shape of the numpy array. There are N images that we are used to train SVM classifier 1 and it is of maximum size 2^N. To check whether the image is properly labeled or not we randomly picked up some images with the label. Figure 3 represents the training dataset of the input image. From that images, we can surely tell that the images are trained properly.

C. Training SVM Classifier 2

For linear SVM classifier 2 there are N patches are given to the classifier and all images of maximum size of 2^N. For classifier 2 we are given the small portion of the smoke images with smoke and without smoke patches. This patch may contain the window size of 32*32 and each contains intensed smoke areas, gradient of smoke and area without smoke.

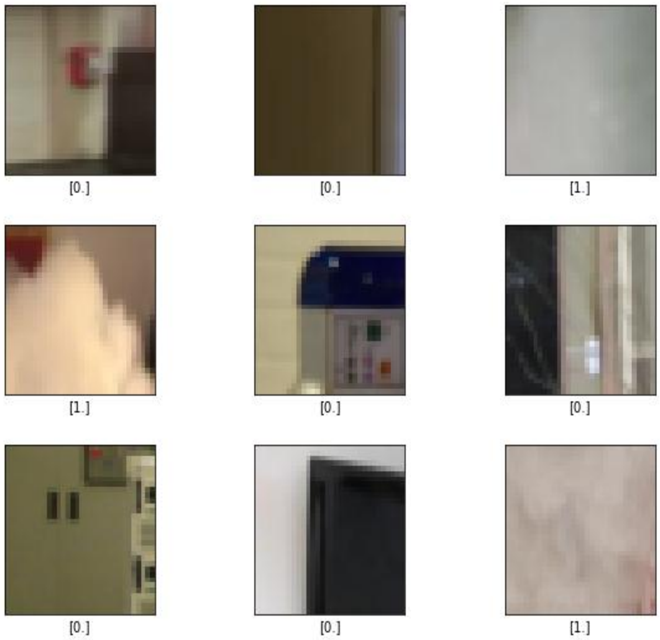

Figure 4. Patch images to SVM classifier 1

This is given as input to the classifier 2. The smoke areas are marked as 1 and areas without smoke are marked as 0. This is called LABELING. Figure 4 represents patches of input images to SVM classifier 2. To check the linear SVM classifier 2 is correctly labeled or not we randomly picked up some images from N images and display the label.

D. Testing SVM Classifier 1

The trained images are stored in the form of pickle format. Then we declare the sliding window with window size and step size with increasing order. Then read the image that you want to test in form of RGB. Use Gaussian Filter to blur the image. Then predict whether it is 0 or 1. If it is 0 then it image without smoke. If it is 1 then by using window sliding detect the patch of the gradient motion of the smoke in the image.

The input images are given to the linear SVM classifier 1 and check whether the input images contain smoke or not. If it contains smoke then prediction will be 1 and if does not contain smoke then the prediction will be 0.

Figure 5. Output of SVM classifier 1

If the prediction is 1 then it will display as "SMOKE" and if the prediction is 0 then it will display as "NO SMOKE". Figure 5 represents the output of SVM classifier 1. The training is almost perfect in linear SVM classifier 1, so that testing images output are displayed as predicted. If once we give input images to test whether it contains smoke or not, linear SVM classifier 1 checks it with the trained image. If it nearly equals to compared smoke image then it will display "SMOKE". And if it does not equals the compared smoke image then it will display "NO SMOKE".

E. Testing SVM Classifier 2

Figure 6. Output of SVM classifier 2

If there is a smoke prediction in classifier 1 then it will move to classifier 2. It will then crop the image portion into 32*32 and predict that the patch is 0 or 1. Finally after this window sliding it will show the gradient portion of the image. Figure 6 provides the output of SVM classifier 2.

If smoke is present in SVM classifier 1, then it is given to SVM classifier 2. These linear SVM classifier 2 find out the patches is 1 or 0. Finally it shows whether the patches are 1 or 0.

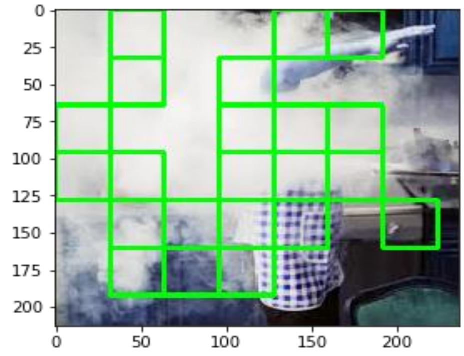

Figure 7. Highlighted Area of Smoke

By using SVM classifier 1 and SVM classifier 2 the area of the smoke in the given image was marked. Figure 7 highlighted the smoke in the image

5. PERFORMANCE MEASURE

This provides performance measure of this algorithm. Input images are classified into smoke and without smoke images.

Accuracy of this algorithm is calculated by = [(Number of predicted positive images+ Number of predicted negative images)/Total number of images] *100.

1000 Images		Detected	
		Positive	Negative
Original	Positive	500	-
	Negative	-	500

Table 1 Performance measure of Trained SVM classifer 1

Performance=[(500+500)/1000]= 100%

Precision=500/(500+0) =1

Recall=500/(500+0)=1

200 Images		Detected	
		Positive	Negative
Original	Positive	94	6
	Negative	9	91

Table 2 Performance measure of Tested SVM classifier 1

Performance=[(94+91)/200] *100

=92.5%

Precision=94/(94+6) =0.94

Recall=94/(94+9)=0.91

500 Images		Detected	
		Positive	Negative
Original	Positive	238	12
	Negative	6	244

Table 3 Performance measure of Trained SVM Classifier 2

Performance=[(238+244)/500] *100

=96.5%

Precision=238/(238+12) =0.95

Recall=238/(238+6)=0.97

120 Patches		Detected	
		Positive	Negative
Original	Positive	43	7
	Negative	3	67

Table 4 Performance measure of Tested SVM Classifier 2

Performance=[(43+67)/120] *100

=91.5%

Precision=43/(43+7) =0.86

Recall=43/(43+3)=0.93

6. CONCLUSION

Smoke detection problem were modeled as Binary Classification Problem. SVM based cascade classifier was developed to find the presence of smoke in a given image. The model was trained and tested on 1700 images. The SVM classifier 1 model achieved training and testing accuracy of 100% and 92.5%. The SVM classifier 2 model achieved training and testing accuracy of 96.5% and 91.5%. Though SVM classifiers are simple classifiers which require low memory to store the coefficients and also takes less interference time, its misclassification rate is significantly higher. Therefore, in the future more complex classifier such as Neural Network (NN) or Convolutional Neural Networks (CNN) may be considered for classification purpose.

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