

# Result Analysis of Smoke Detection in Video for Early Warnings using Static and Dynamic Features

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## ABSTRACT

This paper presents result analysis of proposed method of smoke detection in video based on image processing to provide an early warning of anomalous events. The experimental results show that an adaptive background subtraction method, HSV color model and SVM classifier provides more accurate results in the segmentation and detection of smoke region in video. Also it shows that smoke features helps in decision making that is whether the segmented region in video is of smoke or not, hence this improves the reliability of system. The proposed method reduces the false detection and increases the smoke detection rate.

This paper is organized into following sections. Section 1 contains introduction to smoke detection. Section 2 contains description of the proposed method. Section 3 contains result analysis of the proposed method. Section 4 contains the conclusion of the work.

## General Terms

Smoke detection in video.

## Keywords

Adaptive Background Subtraction, HSV color space, SVM classifier.

## 1. INTRODUCTION

Smoke detection in video systems are one of the most important components in video surveillance systems used to monitor anomalous events such as fire in factories, shopping malls, railways, houses, buses, offices, submarines, environment or cigarette smoking in public areas, etc. as part of an early warning mechanism that reports preferably the start of fire or other hazard.

An image processing approach to smoke detection in video improves conventional passive detection system through automated smoke region detection and segmentation of smoke region. Smoke detection have initiated a wide variety of applications in access control, damage control, hence helps to mitigate effects of fire and smoke.

So, the aim is to detect the smoke using smoke features, as early as possible [1-3] to give more accurate and fast response. Early detection is essential in order to provide an effective response to emergencies and damages and also to provide appropriate actions to mitigate the effects of the smoke and fire can be taken. These actions generally include the evacuation of occupants from danger zone to a safe place and the initiation of extinguishment activities either automatic or manual [3].

In the proposed methodology image processing approach to smoke detection is used [5] [7]. In the initial phase of

detection process motion and color features of smoke are used to separate or differentiate stationary, non-stationary smoke region and region with smoke color. For this purpose adaptive background subtraction and HSV color model is used. In the decision or classification step smoke area and other features are used, these features are used to train SVM classifier for classifying segmented region as smoke or non smoke.

## 2. SMOKE DETECTION METHOD

The propose method has four phases for detecting presence of smoke in video: In first phase, all the moving region in video are detected using adaptive background subtraction method; In second phase, detecting objects that match with smoke color from moving object in video; In third step, area and perimeter disorder of segmented smoke regions are calculated; In fourth step, SVM classifier is trained with calculated smoke features to classify the detected region as smoke or non-smoke with warning message on screen.

The flow of proposed method for smoke detection in video is shown Fig 1.

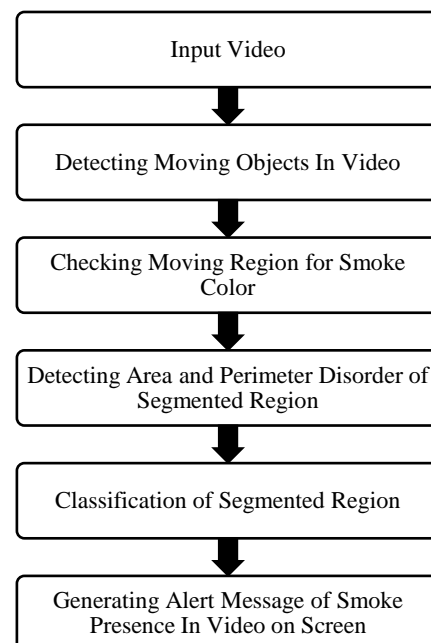


Fig 1: Flow chart of smoke detection in video

Initially, a video is given as input to the system from video dataset, then frames are obtained from input video and further processing is done on frames. To reduce or minimize noise, etc. from video some sort of preprocessing is also performed. The main steps of proposed methods are:

## 2.1 Detecting moving objects in a video using adaptive background subtraction method

As, smoke detection system can be used for indoor as well as in outdoor environment videos, the background model need to adapt itself to the dynamic changes such as global illumination, etc. Hence, here adaptive background subtraction method is used [3], in which reference background and threshold is dynamically updated with incoming frames. According to adaptive background subtraction method, first, background frame is set as:

$$Bframe = \begin{cases} Bframe & \text{when, current frame is first frame} \\ ((1-u) * thisFrame) + (u * Bframe) & \text{Otherwise} \end{cases}$$

Where, Bframe is background frame, thisFrame is current frame, and u is real and positive constant close to one.

After this, difference frame for detecting moving objects in frame using background (Bframe) frame and current frame (thisFrame) calculated, as:

$$dif = (thisFrame - (Bframe));$$

Then, adaptive threshold is applied to difference image obtained from current and background frame, as:

$$Th = \begin{cases} 1 & \text{when, current frame is first frame} \\ ((u*0.1) + ((1-u)*(2*thl))); & \text{Otherwise} \end{cases}$$

Where, Th is threshold, u is real positive constant and thl is threshold level obtained from graythresh method.

Finally using Bframe and Th difference frame is obtained as:

$$dif = im2bw (grayImage, Th);$$

Where, dif is difference frame, grayImage is obtained from rgb image of dif and Th is the threshold

## 2.2 Detecting objects that match with smoke color using HSV color model

As, smoke has static feature of color i.e. gray color it can be used to separate it from non-smoke moving object which is the output of the previous step [2]. In this step, difference frames in RGB color space are converted into HSV color space using standard RGB to HSV.

$$hsvImage = rgb2hsv (dif);$$

The values of the three components H, S, and V are computed and then, setting low and high threshold to H, S, and V images band respectively obtain the segmented region having same color as color of smoke. In this step region having the smoke color is find out which is consider as a candidate region for further processing.

## 2.3 Calculating area and perimeter disorder of segmented region

In the classification process dynamic features of smoke like area and perimeter disorder of segmented smoke region are used for differentiating between smoke and non smoke region

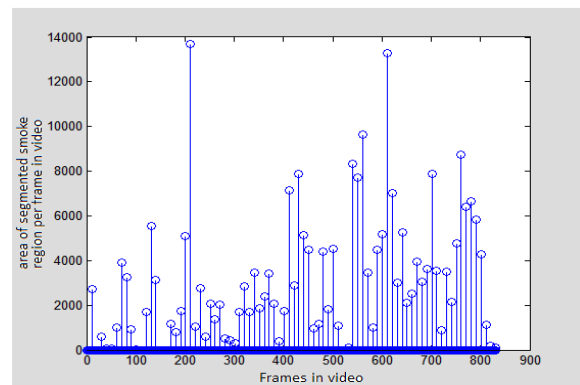
from detected region in previous steps [2][6]. As an example of this step results are shown in Fig 2:



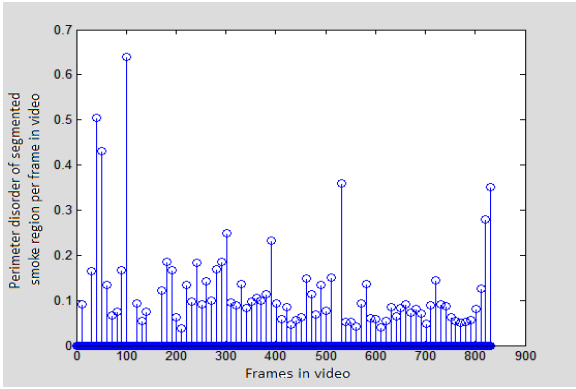
(a)



(b)



(c)



(d)

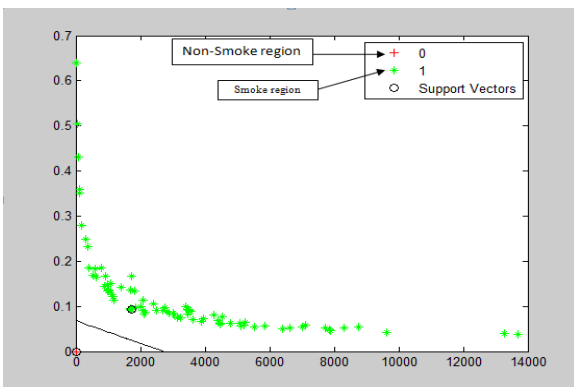
**Fig 2:** (a) a video having smoke, (b) segmented region of interest, (c) & (d) area & perimeter disorder resp. of segmented smoke per frame in corresponding video.

### 2.4 Classification using SVM classifier

SVM is a set of related supervised learning methods that analyze data and recognize patterns, thus it is employed in detection method for features based classification. To train the SVM, features of segmented smoke regions are computed and collected from video frames. With the help of these features, obtain the main parameters for SVM. Therefore, the segmented candidate smoke regions are further checked by the trained SVM classifier and the false regions can be avoided. Of course, static features can help filter the candidate regions segmented from video frames, but are not enough to describe the smoke changing in video sequences, so use along with it dynamic features to show segmented smoke region. As an example of this step results are shown in Fig 3:



(a)



(b)

**Fig 3:** (a) a video having smoke (b) results of SVM.

### 2.5 Generating alert message of smoke

On the basis of result of classification phase i.e. whether the segmented region is smoke or non smoke an alert message of smoke presence in video is generated on screen [4].

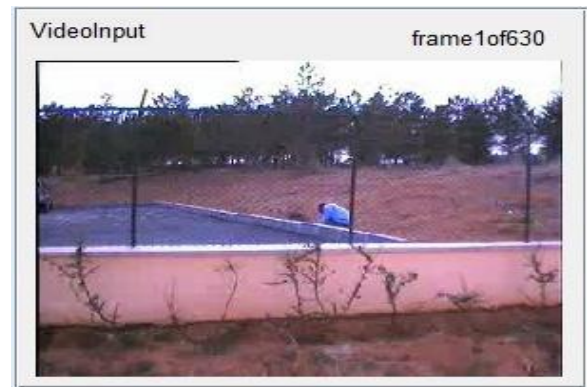
## 3. EXPERIMENTAL RESULTS

The proposed method of smoke detection in video is implemented on Intel Core 2 Duo, 2.20 GHz processor, with 4 GB RAM, Windows Vista OS, and using MATLAB software.

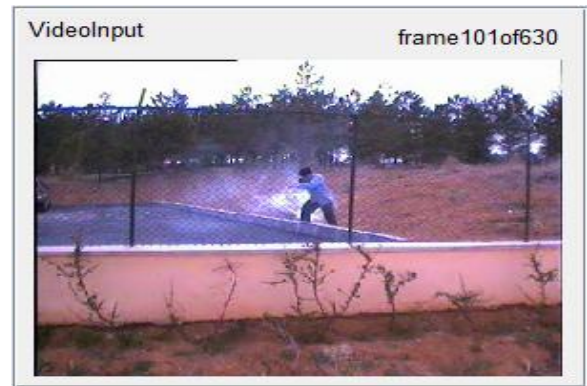
The summary of smoke detection test results in following video input is shown below:

### 3.1 Video Input

Fig 4: (a)-(d) shows video input at frame=1,101,201,301 as an example for result analysis.



(a) At frame=1



(b) At frame =101

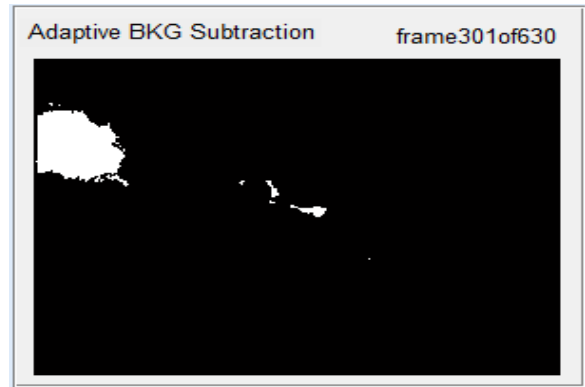


(c) At frame=201



(d) At frame=301

Fig 4: Video input to smoke detection system



(d) At frame=301

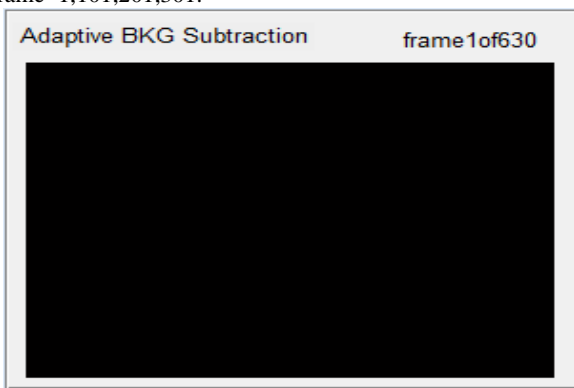
Fig 5: Detection of moving region

### 3.2 Detection of moving region

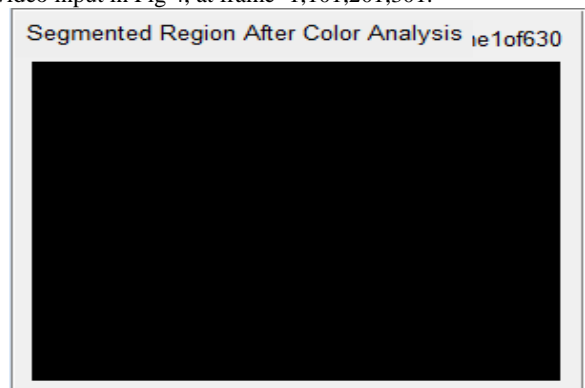
Fig 5: (a)-(d) shows moving region in video input in Fig 4, at frame=1,101,201,301.

### 3.3 Detection of region having smoke color

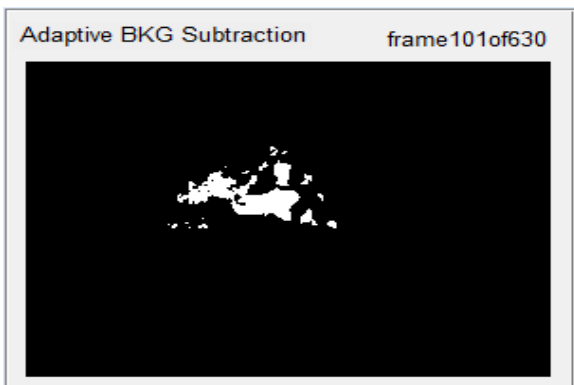
Fig 6: (a)-(d) shows region that match with smoke color in video input in Fig 4, at frame=1,101,201,301.



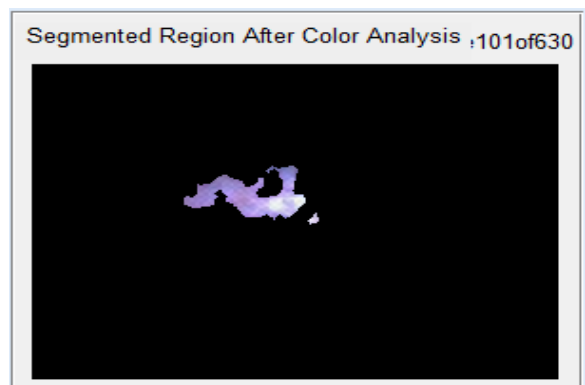
(a) At frame=1



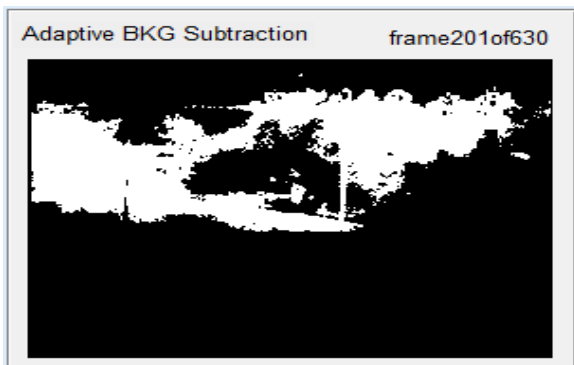
(a) At frame=1



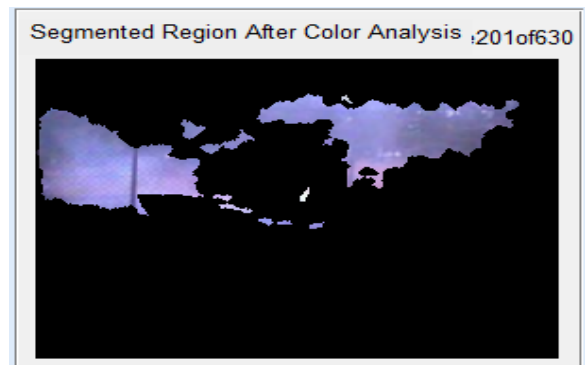
(b) At frame =101



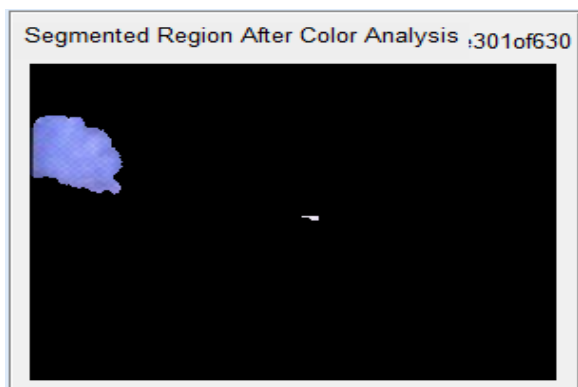
(b) At frame =101



(c) At frame=201



(c) At frame=201



(d) At frame=301

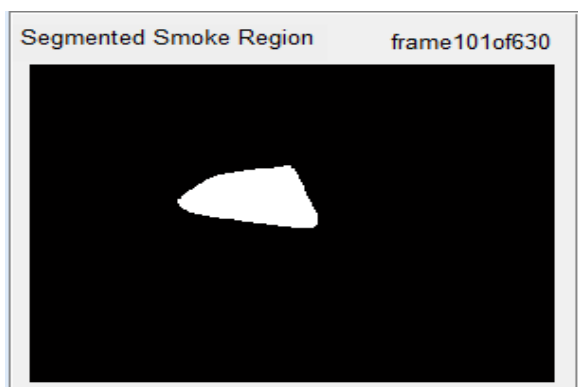
Fig 6: Detection of region that match with smoke color

### 3.4 Segmented smoke region

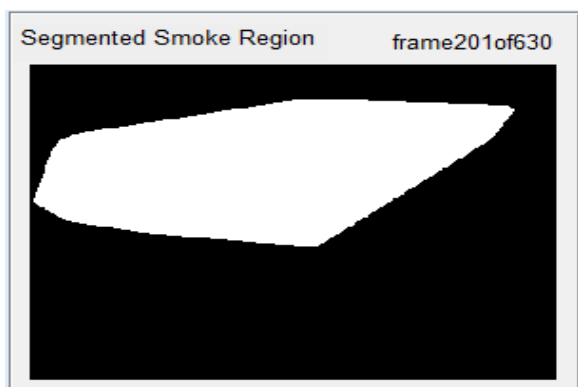
Fig 7: (a)-(d) shows segmented smoke region in video at frame=1,101,201,301 for the input video in Fig 4.



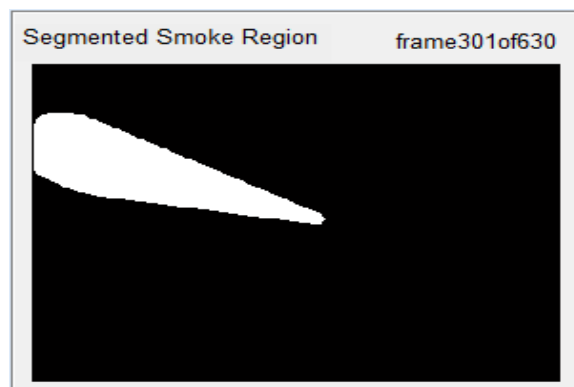
(a) At frame=1



(b) At frame =101



(c) At frame=201



(d) At frame=301

Fig 7: Segmented smoke region

### 3.5 Performance comparison

To measure the performance of proposed method the true positive rate (TPR) i.e. correctly detected smoke, the false positive rate (FPR) i.e. recognizing a non-smoke region as a smoke region, and the missing rate (MR) i.e. not recognizing real smoke region are calculated [10]. The proposed approach achieved an average TPR of 96.84% and an average MR of 3.16%; however an average FPR is 0%. These results are improved as compared to methods in [9] [10]. The test results performed on 5 videos are shown in the Table 1 below:

The performance test results between proposed method and comparative methods [9] and [10] are shown in Fig 8:

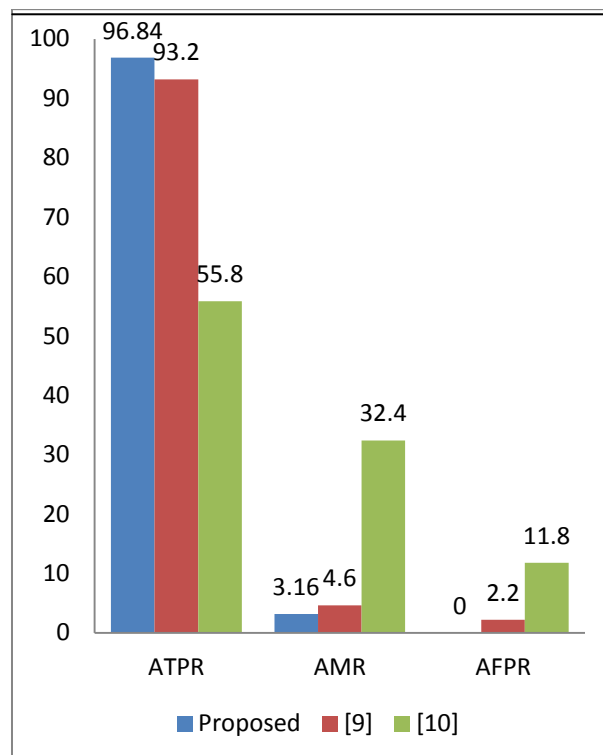


Fig 8: The performance test results between proposed method and comparative methods.

**Table 1. Smoke Detection results in 5 videos**

video Input (# of frames processed)	#Frame having smoke	# non smoke Frame	# Frame smoke detected	# Frame no smoke detected	Smoke Detected (Yes/No)	TPR	MR	FPR
sBehindtFence (62)	58	4	57	5	Yes	98.27	1.72	0
sMoky(89)	74	15	71	18	Yes	95.94	4.05	0
forest1(19)	19	0	18	1	Yes	94.74	5.26	0
forest5(21)	21	0	20	1	Yes	95.23	4.76	0
Viptraffic (12)	0	12	0	12	No	100	0	0
Total:5 videos(203)	172	31	166	37	Result=Yes/No	ATPR=96.84	AMR=3.16	AFPR=0

#### 4. CONCLUSION

An efficient and responsive method for smoke detection in video is proposed. In first step, all the moving object in video are detected, which are in second step, checked for smoke color and object not having smoke color are removed and object with smoke color are checked for smoke in next step. In classification or decision step area and perimeter disorder characteristic of smoke region are used. Hence the combination of motion, color and other dynamic features like area, perimeter disorder provide more accurate results.

The performance of the proposed method is tested on 5 sets of videos containing both smoke and non-smoke video. The method achieves up to 96.84% correct smoke detection rate and result in a 3.16% and 0% missing and false detection rate respectively.

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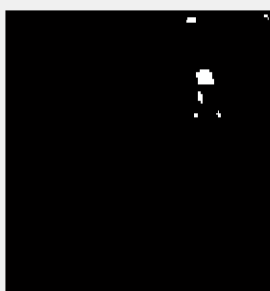
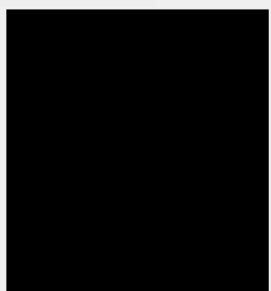
No.	Video Input	Adaptive Background Subtraction	Color Detection using HSV Model	Segmented Smoke Region
1	VideoInput frame481of630 	Adaptive BKG Subtraction frame481of630 	Segmented Region After Color Analysis ,481of630 	Segmented Smoke Region frame481of630 
2	VideoInput frame371of900 	Adaptive BKG Subtraction frame371of900 	Segmented Region After Color Analysis ,371of900 	Segmented Smoke Region frame371of900 
3	VideoInput frame131of216 	Adaptive BKG Subtraction frame131of216 	Segmented Region After Color Analysis ,131of216 	Segmented Smoke Region frame131of216 
4	VideoInput frame591of900 	Adaptive BKG Subtraction frame591of900 	Segmented Region After Color Analysis ,591of900 	Segmented Smoke Region frame591of900 
5	VideoInput frame111of120 	Adaptive BKG Subtraction frame111of120 	Segmented Region After Color Analysis ,111of120 	Segmented Smoke Region frame111of120 

Table 2. Demonstration of Smoke Detection in 5 videos (1-4 with smoke and 5 with non-smoke video).