

Wildfire Smoke Detection Using Computational Intelligence Techniques Enhanced with Synthetic Smoke Plume Generation

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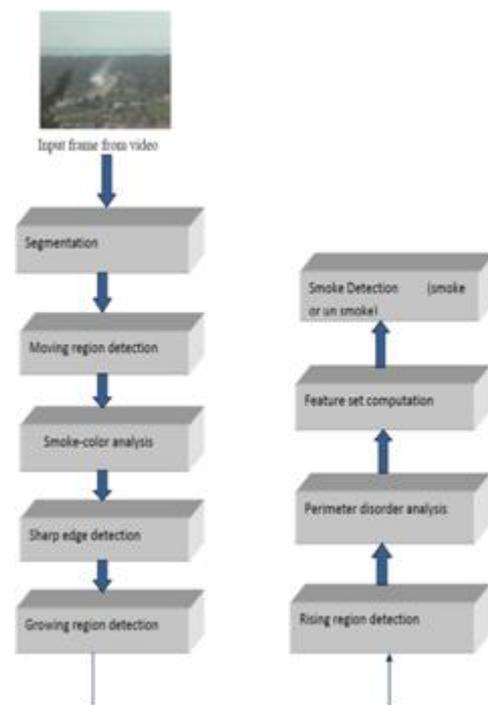
Abstract: Forest is a great biodiversity which is essential for both human and wild life. But by illegal human act and by natural forest fires these forest resources get damaged. Hence I develop a automated smoke detection unit to detect forest fires. Early wildfire detection is important in order to evaluate an effective response to damages. To detect the wildfire smoke from frame sequence that is taken from the long distance. Propose Dark channel priority is used to remove the white hashing from the frame sequence and also make the low quality frame sequence into high quality frame sequence. Computational techniques are used to detect wildfire smoke. Detect the wildfire smoke from the frame sequence by using several method such as moving region detection, colour detection using yuv transform, growing and rising region detection, and perimeter analysis for find whether the region is smoke or not . And also detect the edge by using canny edge detection.

Keywords: Computer vision, neural networks, simulation, smoke detection, virtual environment, wildfire.

1. Introduction

Early wildfire detection is essential in order to assess an effective response to emergencies and damages. In this paper, they propose a low-cost approach based on image processing and computational intelligence techniques, capable to adapt and identify wildfire smoke from heterogeneous sequences taken from a long distance. Since the collection of frame sequences can be difficult and expensive, they propose a virtual environment, based on a cellular model, for the computation of synthetic wildfire smoke sequences. . The proposed detection method is tested on both real and simulated frame sequences. I Propose the Dark channel priority algorithm for removing hazing from the frame sequence and also make the low quality frame sequence into high quality frame sequence. Detect the wildfire smoke from the frame sequence by using several method such as moving region detection, color detection using yuv transform, growing and rising region detection, and perimeter analysis for find whether the region is smoke or not . And also detect the edge by using canny edge detection.

2. Architectural Design



Initially convert the video into frame. Then segment the frame from the video after that if any moving region present means it will be detected. Then each frame is converted from RGB to luminance-chrominance color space. The sharp edge detection step aims to search high differences in the luma channel of adjacent frames, usually not present in the regions containing smoke clouds. Growing regions of the frame sequence are detected by considering the image computed as the difference between the moving regions at the time instants t and $t - 1$. Then the rising value of the frame also computed. Then, the area and perimeter are computed for each 8-connected region of the binary image. Feature value of each frame is also computed. Smoke is detected from the feature value.

3. Modules Specification

- Load & Pre-processing
- Dark channel priority
- Moving object detection
- Color detection
- Canny Edge detection
- Growing and rising region
- Perimeter analysis

3.1 Loading and Preprocessing

Load the MPEG Video from the hard disk and converted that image to frame using frame conversion technique. Split the video into number of frame sequence.

3.2 Dark Channel Prior

DCP removes white hash from the input video. The DCP process to be maintaining the minimum and maximum values from the frame sequence of video. Dark channel prior is used to remove the haze. The dark channel prior is a kind of statistics of the haze-free outdoor images. It is based on a key observation most local patches in haze-free outdoor images contain some pixels which have very low intensities in at least one colour channel. Using this prior with the haze imaging model, it can directly estimate the thickness of the haze and recover a high quality haze-free image. Results on a variety of outdoor haze images demonstrate the power of the proposed prior.

In other words, the minimum intensity in such a patch In other words, the minimum intensity in such a patch should have a very low value. Formally, for an image \mathbf{J} , define as $J_{\text{dark}}(\mathbf{x}) = \min_c(\min_{\Omega(\mathbf{x})} J_c(\mathbf{y}))$

Where J_c is a color channel of \mathbf{J} and $\Omega(\mathbf{x})$ is a local patch centered at \mathbf{x} . Our observation says that except for the sky region, the intensity of J_{dark} is low and tends to be zero, if \mathbf{J} is a haze-free outdoor image.

3.3 Moving Object Detection

The detection of moving regions consists in the extraction of the candidate smoke regions by estimating the differences between a frame and a reference background image. A pixel is considered as moving if

$$\begin{aligned} |I(x, y, t) - I(x, y, t - 1)| &> T_l(x, y, t) \\ |I(x, y, t) - I(x, y, t - 2)| &> T_l(x, y, t) \end{aligned}$$

Where $I(x, y, t-1)$ is the intensity of the pixel (x, y) in the $(t-1)$ th frame of I and $T_l(x, y, t)$ is an adaptive threshold value. The value of $T_l(x, y, t)$ is updated according to $T_l(x, y, t + 1) =$

$$\begin{cases} bT_l(t) + (1 - b)(c|I(x, y, t) - B(x, y, t)|) & \text{if } (x, y) \text{ is stationary} \\ T_l(t) & \text{if } (x, y) \text{ is a moving pixel} \end{cases}$$

Where $B(x, y, t)$ is the intensity of the estimated background related to the frame t at the position (x, y) and c and d are two real positive constants

3.4 Color Detection

The frame is converted from the RGB colour into the luminance-chrominance YUV colour space. Then a smoke – colour feature matrix is computed for each pixel (x, y, t) by using the following equation

$$D_c(x, y, t) = \begin{cases} 1 - \frac{|U(x, y, t) - 128| + |V(x, y, t) - 128|}{128} & \text{if } (Y(x, y, t) - U(x, y, t) > T_1) \\ & \text{and } (Y(x, y, t) - V(x, y, t) > T_2) \\ & \text{and } (T_3 \leq Y(x, y, t) \leq T_4) \\ 0 & \text{otherwise} \end{cases}$$

Here $T_1, T_2, T_3,$ and T_4 is the threshold value. It is a fixed value. If the value of $D_c(x, y)$ is less than the threshold value T_c the the value is set to zero in order to reduce the areas which is not represent the smoke cloud.

3.5 Canny Edge Detection

The Canny Edge Detector is one of the most commonly used image processing tools, detecting edges in a very robust manner. It is a multi-step process, which can be implemented on the GPU as a sequence of filters. First convert the image to greyscale using some sort of RGB to greyscale or RGB to luminance conversion. Compute the derivatives ($D_x(x, y)$ and $D_y(x, y)$) of the image in the x and y directions.

3.6 Rising and Growing Region Detection

Growing regions of the frame sequence are detected by considering the image computed as the difference between the moving regions at the time instants t and $t - 1$

$$D_{M-diff}(x, y, t) = D_M(x, y, t) - D_M(x, y, t - 1)$$

The summation of the resulting matrix is then computed. In order to avoid excessive data fluctuations, only positive values of $DM-diff$ are considered

$$D_G(t) = \sum_{x, y} (D_{M-diff}(x, y, t)) \forall D_{M-diff}(x, y, t) > 0$$

Where $D_G(t)$ is related to the time instant t and represents the growing of the region. D_G is then normalized between two empirically estimated thresholds TGL and TGH . The range of values between TGL and TGH is defined in order to match all the possible values of $D_G(t)$ related to growing smoke clouds.

The rising value is computed as the difference between the y coordinates of the moving pixel with the lowest y value at the frames $t - n$ and t . For each frame, the location of the moving pixel with the lowest y coordinate is extracted

$$\begin{aligned} D_{M0}(x, y, t) &= D_M(x, y, t) > 0 \\ H(t) &= \min_y D_{M0}(x, y, t) \end{aligned}$$

The rising value $DR(t)$ is then computed $DR(t) = H(t) - H(t-n)$

Two empirically estimated thresholds TRL and TRH are then used to normalize the values of DR in order to better match the values of the previously computed rising smoke regions.

3.7 Perimeter Analysis

The matrix $DM(x, y, t)$, which describes the motions of the frame regions, is binarized by using the threshold value TM . Then, the area and perimeter are computed for each 8-connected region of the binary image. The value that describes the perimeter disorder for each region is computed as

$$R_p(i, t) = \frac{P_i}{A_i} \forall 1 < i < N_b$$

where $R_p(i, t)$ is the perimeter disorder of the i th 8-connected region at the time instant t , P_i and A_i are the perimeter and area of the i th region, and N_b is the number of considered regions. A matrix $DP(x, y, t)$ that contains the values of $R_p(i, t)$ related to each pixel is then computed.

1) Algorithm Used:

Only a small number of frames, ranging from five to ten, are kept under consideration during the feature extraction step; then, the computed features are reduced using a sequential forward feature selection algorithm, applied separately on every particular scenario. Computational intelligence techniques are then used to classify the features and adapt the system to the considered environment. The proposed approach includes two distinct algorithms.

i) Color based segmentation Algorithm:

It performs the segmentation of the smoke area for each frame of a frame sequence. First, a set of features is extracted from the frame sequence. The computed features are then used as inputs of classifiers based on computational intelligence techniques, which output a Boolean value that represents the classes "smoke" and "non smoke."

ii) RGB extraction Algorithm:

It is used for Feature Extraction. It also uses computational intelligence classifiers in order to detect the frames containing smoke plumes. In long-range wildfire smoke plumes, frequency analysis is not sufficiently distinctive. The focus is then on features related to the movement and shape. Algorithm A and Algorithm B use the same feature extraction steps:

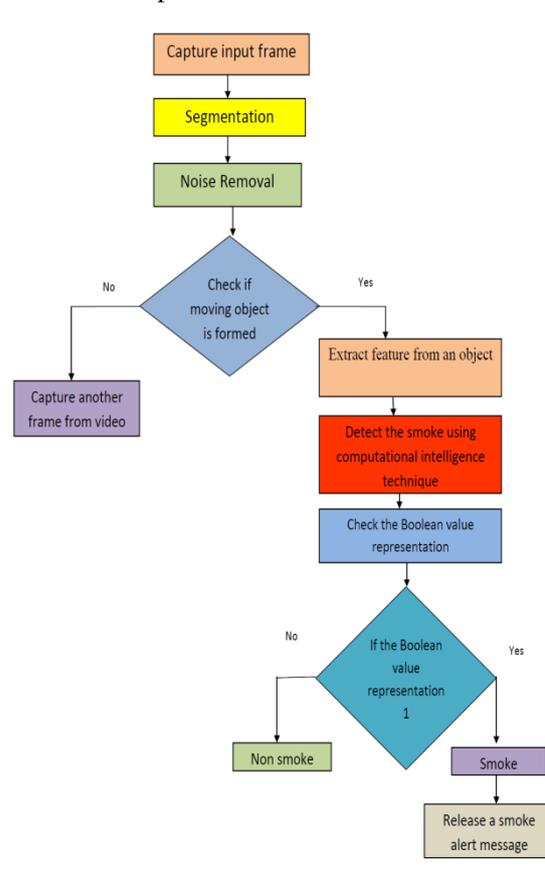
- a) Moving region detection;
- b) smoke-color analysis;
- c) Sharp edge detection;
- d) Growing region detection;
- e) Rising region detection;
- f) Perimeter disorder analysis;
- g) Feature set computation.

The feature set computation is performed in different manners by the two proposed algorithms.

2) Data Flow Diagram

Initially convert the video into frame. Then segment the frame from the video then if any noise present in the image means it will be removed. Then check if the moving object is present in the image or not. If the moving object is present means extract the feature value from the object else capture the another one image. Using the computational intelligence technique detect the smoke from the feature value. If the

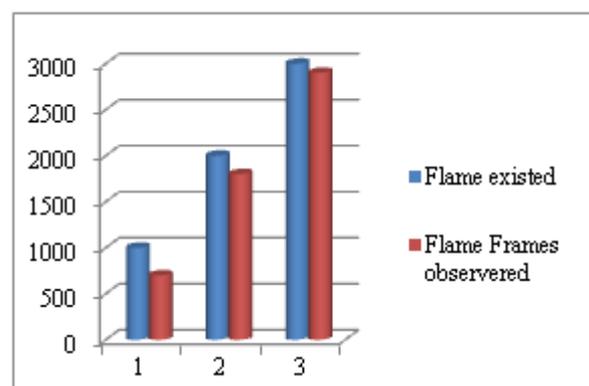
Boolean value is one means smoke is present otherwise smoke will not be present.



3) Performance Analysis

Existing system

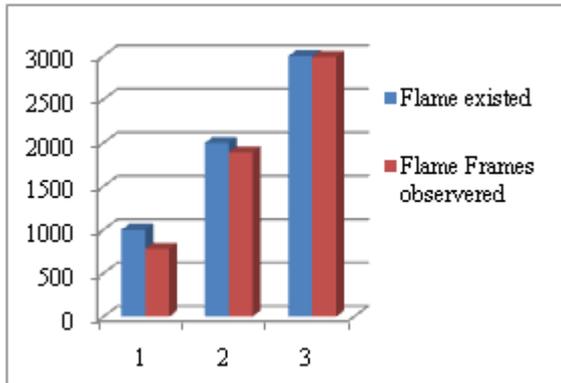
S.no	Flame existed	Flame Frames observed
1	1000	700
2	2000	1800
3	3000	2900



In an existing system only a small number of flames are only observed. For example if 1000 flames are existed means only 700 flames are observed. In a proposed system more than 90% of the flames are observed. For example if 3000 flames are existed means only 2900 flames are observed.

4) Proposed System

S. No	Flame existed	Flame Frames observed
1	1000	780
2	2000	1890
3	3000	2989



5) Screen Shots:



Figure 5.1.1: GUI form

Description

Graphical user interface is a type of user interface that allow the user interact with other devices though the graphical icons and visual indicators such as secondary notation, as opposed to text based interfaces,type command labels or text navigation.



Figure 5.1.2: Frame conversion

Description:

In the preprocessing stage get the video as a input and produce the number of frame as a output. This frames are used to for further process.

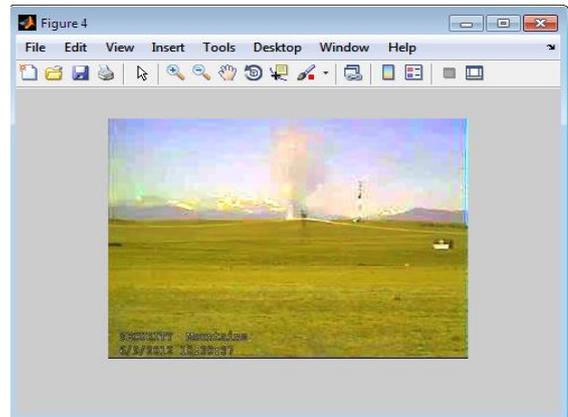


Figure 5.1.3: Enhancing Image

Description:

Dark channel prior algorithm is used to remove the hazing from the frame sequence. First it get the frame sequence as a input and enhance the image for the further process.

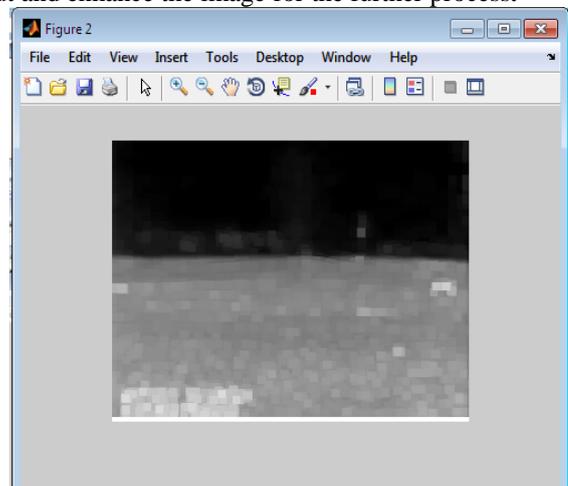


Figure 5.1.4: Remove white haze

Description:

In this step the white hazing is remove from the frame sequence. And this steps are used to remove the hazing other than the smoke. Smoke is not removed from the frame sequence.

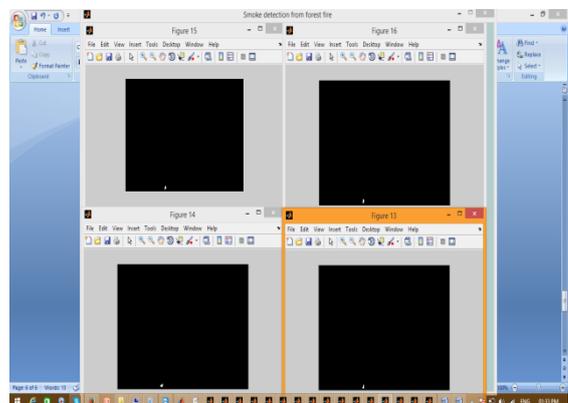


Figure 5.1.5: moving object detection

Description:

In the moving object detection method moving objects are detect from the frame sequence and this is used for differentiate the smoke from the frame sequence. To detect

which are all the moving object is present in the frame sequence.

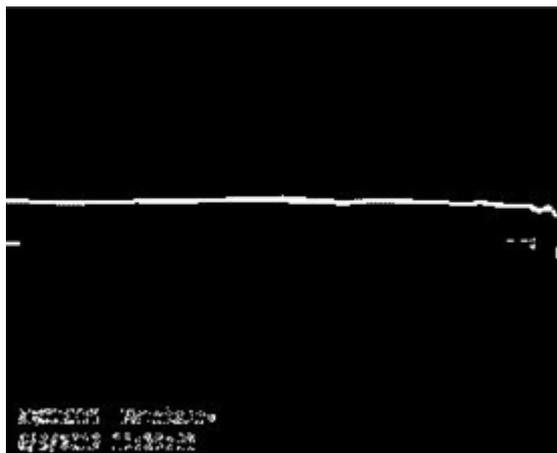


Figure 5.1.6: Color Detection

Description:

In the color detection method smoke color is detected in the frame sequence. Which means the method is used for differentiate the smoke color from all other color region. And it is used to detect the smoke.

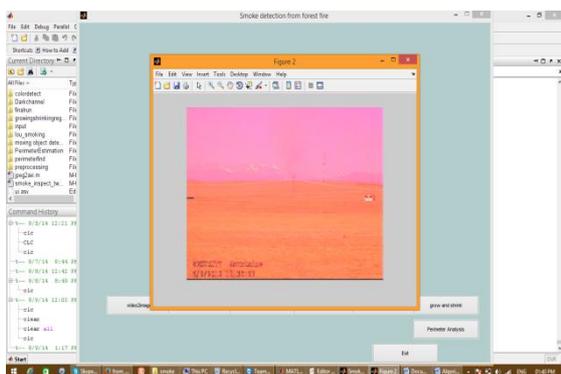


Figure 5.1.7: Grow and shrink

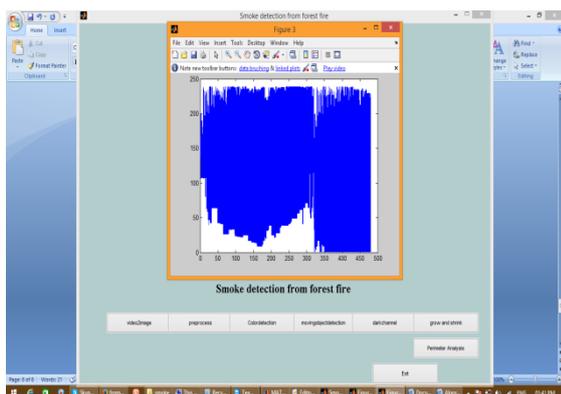


Figure 5.1.8: Perimeter analysis

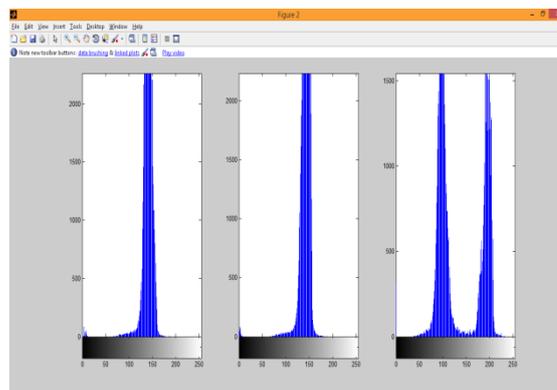


Figure 5.1.9: Histogram

4. Conclusion and Future Works

8.1 Conclusion

Thus this paper introduced a dark channel prior algorithm for removing the hazing from the given frame sequence. This algorithm is used to convert the low quality image into high quality image. And also I proposed the intelligent techniques to detect the smoke from the frame sequence.

8.2 Future Works

In future work I can explore of the proposed algorithm with canny edge detection method. In the future Algorithm I have planned to improve the performance. And I will use canny edge detection method to detect the correct region from the frame sequence. Finally growing and rising region detection methods are used to detect the smoke from the frame sequence.

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