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Hybrid-FireID: Fire Identification using Hybrid Features Extraction for Combustible and Fluid Fire Segmentation

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ABSTRACT

Fire detection systems are implemented and intended to detect fires early so it can help the people on a building or house for safe evacuation and immediately notify the firemen. After the firemen put out the fire, that will be the time that they can conduct an investigation in determining the source or cause of fire which they often experience some difficulties. Therefore, this study proposed an algorithm for identification of combustible and fluid fire with hybrid feature extraction techniques. The algorithm use RGB model, applying HSV conversion and Canny edge detection for the growth of fire. Then combine the results of HSV and Canny edge detection and used image segmentation of color space for combustible and fluid fire. The algorithm got an accuracy of 94% for 50 fire images demonstrated usefulness and effectiveness.
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Key words: Edge Detection, Fire Detection, Image Processing, Image Segmentation

1. INTRODUCTION

Fire happens when some sort of fuel and oxygen do chemical reaction and occurs in many places like forest, houses, city, etc. Fire can devastate houses and properties less than an hour, and it can destroy an entire forest. It is a fearsome weapon; with almost limitless catastrophic power and every year, it kills more people than any other force of nature.

Accidents due to unnoticed fire have produced excessive cost to the world and current smoke, fire detectors are failing because of the incompetence of the device [1]. Some companies use fire alarm system placed on the building's wiring scheme that the defense of both property and human are secure [2],[3]. Two important ways to end the fire on time are early detection and early warning, this evade many victims and property damage. Therefore, it is important requirement to know the proper placing of intelligent fire alarm system particularly in the buildings where comprise of numerous individuals inside [4].

In the Philippines, Bureau of Fire Protection (BFP) an agency that protect and extinguish fire in the country having a problem in determining the cause of fire. It is important that the fire fighters knew what kind of fire they will encounter and what cause of the fire. Important mechanisms in surveillance system is to monitor buildings and environment [5]. So many studies build an image processing fire detection system attached in surveillance camera [6],[7], using motion estimation and color information [8], machine vision of fire from infra-red videos [9], and some combining it with smoke sensor [10].

Fire detection systems are intended to detect fires early so it can help the people on a building for safe evacuation. Fire localization is another helpful method aside in fire detection, one study uses an IOT based firefighting robot to detects fires and can be control to start initializing the fire location [11]. Using water jet robot that can fly 2 meters as firefighting is also a good way to extinguish fire [12]. Giving protection to all type of buildings became challenges to the fire rescue team. There are a lot of problems faced by fire fighters in the event of a fire breakout. So, one study uses a quadcopter with IR camera for fire detection [13].

Fire can be classified into three types: combustible, fluid and electrical fire. These three types of fire are big help for the fire fighters and fire detection system to solve the problem in determining the cause of fire. So, objective of this study is to create a fire detection algorithm based on image processing techniques to determine the cause of fire and this study focus for combustible and fluid fire only. Now deep learning or using convolutional neural network have a big impact in fire detection. Their application in fire detection systems will significantly progress in detection accuracy and will lessen fire incident [14].

Edge Detection is an image processing technique for discovering the borders of objects inside images. It is used for data extraction and image segmentation in areas of machine vision, computer vision and image processing. Many edge detection mechanisms can be used for image processing like Sobel edge detection, Prewitt edge detection, Laplacian edge detection and Roberts edge detection [15] and can be applied to fire detection for pre-processing of dataset.

Image segmentation is the image process of separating an image into numerous sections. Locating objects and boundaries in images is a process of image segmentation. Image decomposition could be used for image segmentation based on wavelet transform theory getting the detailed information of vertical, horizontal and diagonal direction [16].

2. METHODOLOGY

2.1 The image processing algorithm for Fire

The proposed hybrid feature extraction method shows in Figure 1. The first phase in the algorithm technique is to detect the color of the fire which are red-orange and blue. From the applied RGB method the algorithm next technique is to convert into HSV and get the result. The second phase is to detect the edges of the fire on the original image using the canny edge detection while removing threshold which is less than 100. Combining the result from the first phase and second phase to have an innovative result of fire [17]. Then the last phase applying the segmentation technique using color space for the fire.

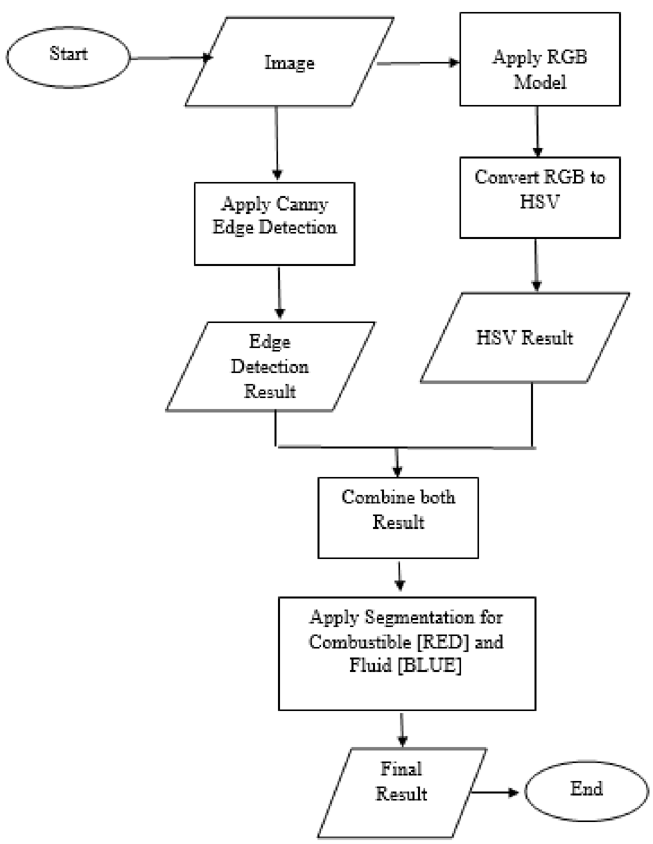

Figure 1: Flowchart of hybrid feature extraction algorithm

2.2 Gathering of images and Types of Fire

There are 500 images gathered for dataset with two fire types such as ordinary combustible and fluid. The images were mostly capture by camera with a resolution of 40x40 to 640x640 pixels. All data has been captured by the researchers at home, forest, backyard, and internet. Table 1 shows the type, definition and sample output of fires.

Table 1: Combustible and Fluid Identification

Type	Definition	Sample Output
Combustible Solid	Ability of burning and igniting easily. Typically color yellow, red and orange the flames. ex. Wood, paper	
Fluid	Color of flames are bluish and sometimes bluish near to source and yellowish on the edges. ex. gases, tars, oils, or alcohols	

2.3 RGB Color Model

The RGB color model is used for color representation method and most widely used in computer. It has three primary colors R(red), G(green) and B(blue) that used a color coordinate system. RGB color model is cast-off to sense red color and blue color data in image. In fire color detection R and B should be more stressed than the other component, and hence R becomes the domination color channel in an RGB image for combustible fire [17] while B color for fluid fire.

2.4 Converting Hue, Saturation and Value (HSV)

To convert RGB image to HSV, use the RGB result to extract a colored object. In HSV, it is easy to characterize a color than RGB color-space. In this phase extracting a blue colored object for fluid fire and red color for combustible fire. Thresholding the HSV image for a range of blue color and red color. Figure 2 shows the combustible HSV image result and Figure 3 shows the fluid HSV image result.

Figure 2: Combustible HSV Image

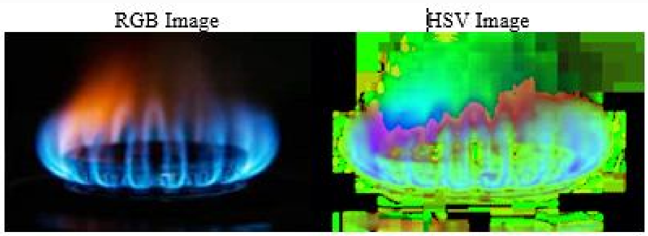

Figure 3: Converted Fluid fire to HSV Image

2.5 Canny Edge Detection

The next phase is using canny edge detection to detect the edges of the fire within the images and it is a multi-step process that can detect edges of the fire with also have noise suppressed. Result of the technique Canny edge detection as below Figure 4 and Figure 5.

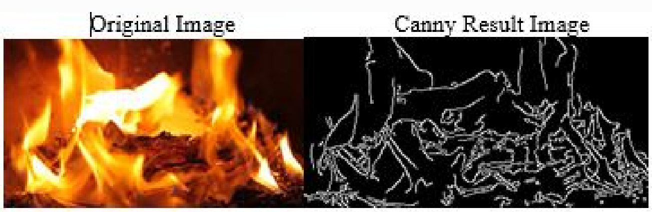

Figure 4: Combustible Canny Result Image

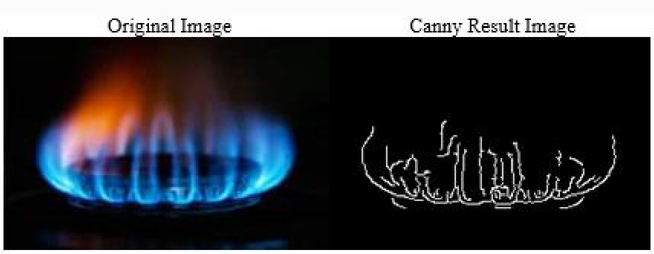

Figure 5: Fluid Canny Result Image

2.6 Combining First and Second Phase

This phase used a python code to combine the two images.

2.7 Segmentation using Color Space

This phase uses the technique segmentation, using color space, Red Green Blue (RGB), colors are characterized in terms of their red, green, and blue properties. To segment the combustible fire, the range of light orange and dark orange were used for color space. While to segment the fluid fire, it used the range of light blue and dark blue color space. The Figure 6 and Figure 7 shows the final result of the image processing algorithm for combustible and fluid fire.

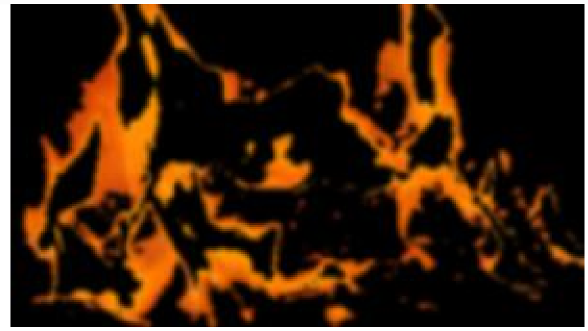

Figure 6: Combustible Final Result Image

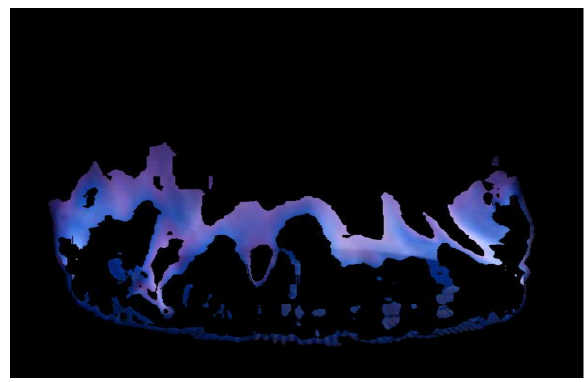

Figure 7: Fluid Final Result Image

3. RESULT AND DISCUSSION

The testing and validation were performed under the python programming platform installed to the computer with 2 NVIDIA GeForce 1080 Ti for GPU acceleration, Inter (R) Core (TM) i7-7700k CPU and 32G memory. During the testing, 50 fire images were selected to apply the image processing algorithm. The images applied by HSV and canny edge detection, then combine the two results. The final output of fire was segmented using color space by red for combustible and blue for fluid fire.

A truth model is used by the validation process, that the results were compared. The table for the specificity and sensitivity analyses for the validation process was given in Table 2 The true positive (TP) is correct classification and a false positive (FP) is when the outcome of the algorithm is incorrectly predicted when in reality it is actually present in the image.

The accuracy of the algorithm for fire identification specifies the ability in detecting color space. Formula is:
Accuracy = (TP/ (TP+FP)) *100%

Table 2. Testing and Result

Trial	Human Expert	Detected by the algorithm	Type of fire
1	Fire Present	True Positive (TP)	Combustible
2	Fire Present	True Positive (TP)	Combustible
3	Fire Present	True Positive (TP)	Combustible
4	Fire Present	True Positive (TP)	Combustible
5	Fire Present	True Positive (TP)	Combustible
6	Fire Present	True Positive (TP)	Combustible
7	Fire Present	True Positive (TP)	Combustible
8	Fire Present	True Positive (TP)	Combustible
9	Fire Present	True Positive (TP)	Combustible
10	Fire Present	True Positive (TP)	Combustible
11	Fire Present	True Positive (TP)	Combustible
12	Fire Present	True Positive (TP)	Combustible
13	Fire Present	True Positive (TP)	Combustible
14	Fire Present	True Positive (TP)	Combustible
15	Fire Present	True Positive (TP)	Combustible
16	Fire Present	True Positive (TP)	Combustible
17	Fire Present	True Positive (TP)	Combustible
18	Fire Present	True Positive (TP)	Combustible
19	Fire Present	True Positive (TP)	Combustible
20	Fire Present	True Positive (TP)	Combustible
21	Fire Present	True Positive (TP)	Combustible
22	Fire Present	True Positive (TP)	Combustible
23	Fire Present	True Positive (TP)	Combustible
24	Fire Present	True Positive (TP)	Combustible
25	Fire Present	True Positive (TP)	Combustible
26	Fire Present	True Positive (TP)	Fluid
27	Fire Present	True Positive (TP)	Fluid
28	Fire Present	True Positive (TP)	Fluid
29	Fire Present	True Positive (TP)	Fluid
30	Fire Present	True Positive (TP)	Fluid
31	Fire Present	True Positive (TP)	Fluid
32	Fire Present	True Positive (TP)	Fluid
33	Fire Present	True Positive (TP)	Fluid
34	Fire Present	True Positive (TP)	Fluid
35	Fire Present	False Positive (FP)	Fluid
36	Fire Present	True Positive (TP)	Fluid
37	Fire Present	True Positive (TP)	Fluid
38	Fire Present	True Positive (TP)	Fluid
39	Fire Present	False Positive (FP)	Fluid
40	Fire Present	True Positive (TP)	Fluid
41	Fire Present	True Positive (TP)	Fluid
42	Fire Present	True Positive (TP)	Fluid
43	Fire Present	True Positive (TP)	Fluid
44	Fire Present	True Positive (TP)	Fluid
45	Fire Present	True Positive (TP)	Fluid
46	Fire Present	True Positive (TP)	Fluid
47	Fire Present	True Positive (TP)	Fluid
48	Fire Present	False Positive (FP)	Fluid
49	Fire Present	True Positive (TP)	Fluid
50	Fire Present	True Positive (TP)	Fluid

4. CONCLUSION

The study proposed an algorithm with hybrid image processing techniques for fire identification of combustible and fluid. The testing successfully detected 25 out of 25 combustible fire for red color however detecting blue color for fluid fire had some struggle having 22 out of 25 results. Therefore, the accuracy of the algorithm got 94% demonstrated usefulness and effectiveness detecting fire and beneficial when there is a fire occurrence. For the future work, this algorithm can be integrated to deep learning, sensors and apply distributed system.

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