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Implementation of Fire Image Processing for Land Fire Detection Using Color Filtering Method

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Abstract. Peat swamp forest fires are the process of burning widely dispersed organic matter, which can be caused by burning waste, peat, grass, twigs, weeds, shrubs, leaves and fresh trees. Forest fire monitoring can be done using satellite patterns or unmanned aerial vehicles (UAVs) with pattern modeling applications. The image is interpreted by a computer so that it can be understood by humans. The purpose of this study is to implement the color filtering method by determining the value (HSV) and thresholding value of the image of the fire on peatland. the image will be classified to obtain environmental pattern recognition data. The results obtained are a value of fire images in HSV. HSV value for HEU is in the range 0-18, saturation value: 75-166 and value: 200-230. While the error test results for every 46 HSV pixel values are 4, so the percentage of errors is 8.89%.

1. Introduction

Great fire incident in Indonesia's peatland happened almost every year, the last fire happened in 2014. Now the problem of peat fires recurred. Peat swamp forest fire is a process of organic material burning that spread wildly by consuming forest fossil fuels such as litter, humus, peat, grass, twigs, weeds, shrubs, foliage, and fresh trees. The result of research and experience so far has shown that trigger of the fire is closely related to the fire user for vegetation burning, burning in the utilization of natural resources, and unused land fire along land tenure. Supporting factors, the peat swamp forest fires are abundant peat fuel, El-Nino phenomenon, land tenure is too broad, improper land use allocation, forest degradation, and changes of population characteristics [1].

Forest fire monitoring can be done using satellite patterns or unmanned aerial vehicles (UAVs) with pattern modelling applications. UAV is an application of the robotics system. The can be used the robot for exploration in unknown environments, especially in dangerous environments. It is usually to employ an advanced robot for such tasks [2][3]. The camera placed on the UAV can take the image of a fire from a certain date. Forest and bush fire monitoring can be done using satellites pattern or camera with image processing method. Image processing is an activity of improving image quality in order to easily interpret by a human computer. Based on previous research [3], the detection system only used to detect fires in a room using webcam and PC as safety equipment with image processing using RGB (red, green, blue) color. The research had weakness in RGB color method that can only use in indoor that the lighting tends to be static, so it is not suitable for outdoor fire detections. Research [4] using Watershed method based RGB color space. The research uses only still image from satellite image as input manually. Then the next research [4] using thresholding method (HSV).

This research will design and apply infrared camera image processing by one of the computer vision methods on the unmanned aerial vehicle (UAV). The method is the thresholding process that felt good



enough to capture an image of moving objects such as UAV. Unmanned Aerial Vehicle (UAV) is an unmanned aircraft control, which the aircraft can be controlled using a remote control or automatically controlled. UAV is currently a control system in demand and not infrequently to be the focus of research. Types of known UAV are fixed wing, wing axial, coaxial wing and multicopter. The obtained data in the research still has interventions from other colors. Based on the problem, this research will focus on designing and implementing the thresholding of HSV color filtering combined with the histogram method. The combination of both methods will process the indoor and outdoor fire image data stably and real time.

2. Overview

2.1. Land Fire

Indonesia has the largest agricultural land among tropical countries, which is about 21 million hectares scattered mainly in Sumatera, Kalimantan and Papua (BB Litbang SDLP, 2008). Damage of land and shrubs ecosystems have a major impact on the local environment (in situ) and its surroundings (ex situ). Flood in watershed downstream is one of the impacts the damage of land and shrubs ecosystems. Deforestation and land use on an agricultural system that requires deep drainage (>30cm) and burning or fire cause CO₂ emissions become extremely high [1]. Forest fire monitoring can be done using satellite image or unmanned aerial vehicle (UAV) with image processing applications. Figure 1 below is monitoring of bush and peat land fires



Figure 1. Land Fire

2.2. Color Filtering

Several methods can be used to process and detect object patterns such as feature detection or based on color. Fixed color features based on geometric transformations (scaling, translation, and rotation) of an image. Colors in digital systems represent various color models. Image processing hardware, in general, applies RGB color models with consideration of the ease of displaying technical colors. Other color models focus on the perception of the human eye on color, such as HSV. This color model represents colors as three components, Hue (H), Saturation (S) and Value (V). The HSV color space defines color in terms of Hue, Saturation, and Value. HSV channels are described as follows, Hue: Describes a pure color (e.g. pure yellow, orange or red). Saturation: Describes how much a pure color is diluted with white light. Value: Refers to the brightness of the color [4]. In order to be processed into HSV color model, RGB image must be converted to HSV color model. HSV color model is a nonlinear transformation of RGB color model. Calculation of RGB to HSV conversion can use equation (1) and (2) below [4].

$$r = \frac{R}{(R+G+B)}, g = \frac{G}{(R+G+B)}, b = \frac{B}{(R+G+B)} \quad \dots(1)$$

$$\begin{aligned}
 V &= \max(r, g, b) \\
 S &= \begin{cases} 0, & \text{jika } V = 0 \\ 1 - \frac{\min(r, g, b)}{V}, & V > 0 \end{cases} \\
 H &= \begin{cases} 0, & \text{jika } S = 0 \\ \frac{60 * (g - b)}{S * V}, & \text{jika } V = r \\ 60 * \left[2 + \frac{b - r}{S * V} \right], & \text{jika } V = g \\ 60 * \left[4 + \frac{r - g}{S * V} \right], & \text{jika } V = b \end{cases} \\
 H &= H + 360 \text{ jika } H < 0
 \end{aligned}
 \tag{2}$$

Thresholding is the process of converting gray-level images into binary or black-and-white images so that it can be known which areas include objects and backgrounds from the image clearly. Thresholding results are usually used further for object recognition and feature extraction processes. Thresholding technique provides an efficient way, both in terms of simplicity of implementation and data processing. The time needed for the image segmentation process also becomes shorter. Automatic image selection from the optimal threshold value remains a challenge in image segmentation [5].

$$T = T [x, y, p(x, y), f(x, y)]
 \tag{3}$$

T is thresholding value,
 x, y are coordinate point of thresholding value,
 p(x, y), f(x,y) are pixel point of grayscale.

3. System Implementation

3.1. Hardware Design

This section will design the hardware system to determine the characteristics, data retrieval and processing of sensor data. The environmental data such as fire image data. Wi-Fi digital camera will capture image of the field as environmental information. The data will be sent to laptop to process through tv tuner, the data will send to laptop or pc. By using camera image data processing application, it will get the result of environment image submitted. There are two components of tool that use for the image data transmission from air to ground station, the air component is a carried tool by quadcopter on the air and the land component is a tool used in ground station. Air components are digital camera and video transmitter. While the land components are video receiver, tv tuner and laptop. The captured image data by camera transmitted as video.



Figure 2. Mechanism of hardware design

Transmitted transmitter (VTx) data signal captured by video receiver (VRx). But the image data is an analog data carried by radio signal waves, then to convert video data into digital or initial data is called demodulation processed by tv tuner and the digital video data will display on the interface (laptop) that

will process data using processing image. When activated the system will work automatically to process all the input and produces an alarm sound and .jpg image format outputs. Figure 2 is an implementation of fire detection system using quadcopter.

3.2. Software Design

Software design of fire detection system by quadcopter use Visual Studio 2013 equipped OpenCV library with C# programming language as image data processor. Range value of HSV color used in the color filtering process obtained in previous research. Before activating the program, the HSV value entered in the fire object detection program to filter fire objects in a pattern frame. After HSV range value entered, the activated program will filter each pattern pixel. It works by comparing the color component each pattern pixel with a specific color.

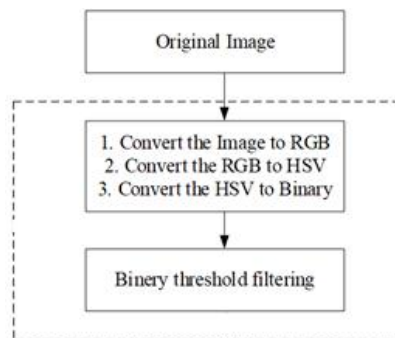


Figure 3. Mechanism of software design

Environment pattern classification is needed to validate the tool. Environment pattern will greatly affect in determine the output. The environment pattern that will test in this research consists of 2 patterns, color pattern and fire detection environment pattern. Color patterns divided into 3 patterns: red, yellow and green. While fire detection environment pattern consists of 3 images, indoor-outdoor image pattern, shrubs pattern and peatland pattern.

4. Result and Analysis

4.1 Color Pattern

The result of the test using the basic color as the background. The colors are red, green, blue and yellow. T color object put out the 40cm distance from the camera. The result of the 4 colors is not detected by predefined HSV value of fire pattern. Based on the result of testing has been done on the different color object showed that fire detection system does not detect such objects as fire. Concluded the fire detection system is able to differentiate fire to other objects based on color by using the parameter of single HSV value as color filtering value to detect fire. Color image pattern in the background is not detected as fire because it is not included in range value of fire HSV color filtering

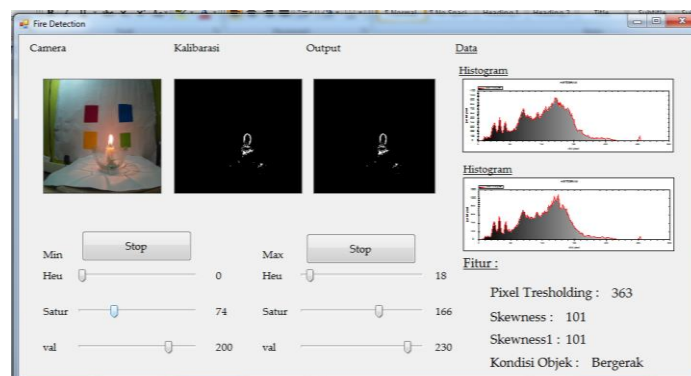


Figure 4. Result of color image pattern

4.2 Fire Pattern

Based on the calculation of the average HSV value of each object that will be a single HSV value for the fire detection test is the hue: 0-18, saturation: 74 - 166 and values: 200 - 230. This value will be used as color filtering for detection parameters fire and also as a pattern threshold. Average valuation techniques are used because the HSV values contained in each fire object are different. Then the average value can recognize all fire objects from the previous test. Details can be seen in Figure 4.

Table 1 Test the value of HSV

No	HSV Value			Description
	Hue	Saturation	Value	
1	0 – 13	744 – 161	200 - 225	Not Good
2	0 – 14	74 – 162	200 – 226	Good Enough
3	0 – 15	74 – 163	200 - 227	Good Enough
4	0 – 16	74 - 164	200 – 228	Good
5	0 – 17	74 - 165	200 – 229	Good
6	0 – 18	74 - 166	200 - 230	Good
7	0 – 19	74 – 167	200 – 231	Good
8	0 – 20	74 – 168	200 – 232	Good
9	0 – 21	74 – 169	200 – 233	Good Enough
10	0 – 22	74 – 170	200 – 234	Good Enough
11	0 - 23	74 - 171	200 – 235	Not Good

Background colors such as red, blue green and yellow can't be seen already. In figure 5 showed the color has well focused on fire image color and the background is not interference to other colors anymore. Table 1 shows the best value for HSV are hue in range of 0-16 up to 0-20, saturation in range 74-164 up to 74-168 and value in range 200-228 up to 200-233. Testing result of color filtering HSV value via Matlab, interface and manual count the fifth pixel can be seen in table 2.

Table 2 Result test of HSV error value

Methods		Testing Result				
		I	II	III	IV	V
Matlab	H (0 ⁰ – 18 ⁰)	Ok	Ok	Ok	Ok	Ok
	S(74 – 166)	Ok	Ok	Ok	Ok	Ok
	V (200 – 230)	Ok	Ok	Ok	Ok	Ok
Interface	H (0 ⁰ – 18 ⁰)	Ok	Ok	Ok	Ok	Ok
	S(74 – 166)	Ok	Ok	Ok	Ok	Ok
	V (200 – 230)	Ok	Ok	Ok	Ok	Ok
Manual	H (0 ⁰ – 18 ⁰)	Ok	Ok	Ok	Ok	Ok
	S(74 – 166)	Error	Ok	Error	Error	Error
	V (200 – 230)	Ok	Ok	Ok	Ok	Ok
Error Percentage		4/45 x100% = 8.88%				

According to table 2, the result of the error test in pixel value show there are 4 errors from all 46 HSV pixel values in S values. So, the error percentage is 8.89%. Refer to table 12 there is a very high H value outside the HSV color filtering range value because of the pixel value adjacent to point of fire, causing

overexposure on the pixel value. As we know that hue indicates color in the spectrum of HSC model color, if the pixel receives light with very high value causes the color has excess light or called overexposure. To obtain actual distance between fire object with camera carried on the air performed by diagonal calculating between altitude distance and distance groundstation. Result of tests summarized in table 3 below.

Table 3 Flying Height Data Result of Fire Detector Quadcopter

Distance between Fire with Camera	Result of fire detection tests
1 meter	Detected
2 meters	Detected
3 meters	Detected
4 meters	Detected
5 meters	Detected
6 meters	Detected
7 meters	Detected
8 meters	Not detected
9 meters	Not detected
10 meters	Not detected

5. Conclusion

From the test results, the system gets good image results at altitudes below 7 meters. The color pattern test results get good results because red, green and yellow are not included in fire detection. While the results of testing fire patterns for indoor works well. this is because the value of intervention noise is small and based on HSV values from observations of fire objects are included in the average range. While the results of testing errors in pixel values indicate there are 4 errors of all 46-pixel values of HSV in the value of S.

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