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Literature Review: Image Processing-Based Forest Fire Detection

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***Abstract*-Forest fires pose a significant threat to ecosystems, the environment, and human life. Early detection of forest fires is crucial for effective firefighting efforts. In this research, we propose the utilization of image processing for forest fire detection with the aim of improving rapid and accurate response in fire monitoring. Image processing methods are employed to analyze visual information obtained from satellite imagery, drones, or other sensors. The process involves image segmentation, classification, and texture analysis to identify the burned areas. Fire point detection algorithms are implemented to monitor and predict fire propagation. Through image processing, we achieved faster and more accurate forest fire detection. The information gathered from the images can be used to report real-time fire development and facilitate effective firefighting strategies. The adoption of this technology offers advantages in reducing environmental damage, economic losses, and risks to human life**.

***Key words*- Accurate detection, Drone, Early detection, Forest fires, Fire monitoring, Image processing, Rapid response**

I. PRELIMINARY

Forest and land fires have become a recurring problem in Indonesia, particularly in the regions of Sumatra and Kalimantan [1]. These fires not only have local and national implications but also extend to affect neighboring regions. Over the past two decades, especially during 1997-1998, forest and land fires have escalated into widespread disasters. The resulting haze from these fires has caused significant losses to communities in Southeast Asian countries, notably Singapore, Malaysia, and Brunei Darussalam.

Remote sensing-based fire detection has been employed since the late 1970s and early 1980s, using Landsat and NOAA AVHRR satellite imagery. In Indonesia, current early fire detection relies solely on hotspot information generated by NOAA and MODIS satellites. However, according to the Disaster Task Force (SATGAS) of the National Institute of Aeronautics and Space (LAPAN), these satellites can only detect hotspots or areas with higher temperatures than their surroundings.

One of the contributing factors to the spread of forest fires is the difficulty in promptly identifying the locations of fire points. Many forest fires cannot be addressed early on because the fire points are situated in remote and inaccessible locations for firefighting personnel. These hard-to-reach locations are among the primary factors influencing the expansion of forest fires, alongside other contributing factors. Fire point extinguishment remains the primary focus of firefighting teams as early control of fire points is expected to prevent further spread and contain the impacts without giving rise to new challenges.

II. RELATED RESEARCH

A. Forest

Forests are ecosystems consisting of vast areas covered with various types of vegetation, such as trees, shrubs, wild plants, and diverse living organisms. Forests play a crucial role in maintaining ecological balance, providing habitats for various flora and fauna, and have a significant impact on climate, the environment, and humanity. Forests are often referred to as the "lungs of the world," making it imperative to preserve their sustainability [2].

B. Forest Fires

Forest fires are incidents of significant and extensive burning of forest or land areas. This event typically involves the combustion of vegetation such as trees, shrubs, grass, and other organic materials within the forest or specific land regions. Forest fires can occur naturally, for example, due to lightning, but are often caused by human activities, including agricultural practices, land clearing, burning of waste, or negligence in extinguishing fires after open activities [3].

C. Image

An image is a two-dimensional representation of real-world three-dimensional objects. Images can vary in their manifestations, ranging from static pictures in photographs to moving colored images on television. Digital images are a form of images that can be processed by computers. In digital form, images are represented by numbers that indicate the intensity values at each pixel. Hence, digital images can be processed using computers due to their numerical data format [4].

D. Image processing

Image processing is a mathematical process used to manipulate images using various forms of signal processing with the input being an image, such as a photograph or a video frame. The output of image processing can be a processed image or a set of characteristics or parameters related to the image. Digital image processing is the process of manipulating two-dimensional images using a computer. Digital images are represented by arrays of real or complex values, which are represented in a specific bit format [4].

III. RESEARCH METHODS

This research utilizes a literature review method to identify the methods used by researchers in identifying a disease on leaves using Digital Image. The stages conducted in this research are Comparison, Contrast, Criticizing, Synthesizing, and Summarizing.

A. Comparison: The technique involves reviewing multiple literature sources to identify similarities among them and drawing conclusions from the findings.
B. Contrast: The technique involves reviewing multiple literature sources to find differences among them and drawing conclusions from the findings.
C. Criticizing: The technique involves reviewing literature sources and providing one's own opinions and critiques of the material read.
D. Synthesizing: The technique involves reviewing multiple sources and combining them to form a new idea or concept.
E. Summarizing: The technique involves reviewing literature sources and rewriting the content in one's own words.

By employing these techniques, the researchers can gain insights into the various research stages, techniques, methods, or algorithms that can be utilized in future research on the topic.

IV. RESULTS AND DISCUSSION

The results of the analysis of the journals used in this literature review can be seen in the following table:

No	Author	Tittle	Accreditation
1	(Rizal Endar Wibowo, Rony Teguh, & Ariesta Lestari, 2021)	Deteksi Dini Kebakaran Hutan dan Lahan Memanfaatkan Ekstraksi EXIF Pada Informasi Gambar Berbasis Pengolahan Citra	Sinta 3
2	(Any Zubaidah, Sayidah Sulma, Suwarsini & Indah Prasasti, 2019)	Pemanfaatan Citra VIIRS untuk Deteksi Asap Kebakaran Hutan dan Lahan di Indonesia	Sinta 2
3	(Alpon Sepriando, Hartono, & Retnadi Heru Jatmiko, 2019)	Deteksi Kebakaran Hutan dan Lahan Menggunakan Citra Satelit Himawari-8 di Kalimantan Tengah	Sinta 2
4	(Mirzha Hanifah, Lailan Syaufina & Indah Prasasti, 2016)	Deteksi Area Bekas Kebakaran Hutan Dan Lahan Menggunakan Data Citra Resolusi Menengah Modis Dengan Pendekatan Indeks Kebakaran	Sinta 2
5	(Rimba Pasasti, Nufri Wilis &	Segmentasi Citra Menggunakan Metode	Sinta 3

	Achmad Zulfahmi. 2021)	Watershed Transform Dengan Kombinasi Threshold, HSV, Graysacale dan Morphology Untuk Mendeteksi Sebaran Api	
6	(Diyana Kinaneva, Georgi Hristov, Jordan Raychev & Plamen Zahariev, 2019)	Early Forest Fire Detection Using Drones and Artificial Intelligence	Q1
7	(Shixiao Wu, Libing Zhang, 2019)	Using Popular Object Detection Methods for Real Time Forest Fire Detection	Q1
8	(Zhentian Jiao, Youmin Zhang, Jing Xin, Yingmin Yi, Han Liu & Ding Liu, 2019)	A Deep Learning Based Forest Fire Detection Approach Using UAV and YOLOv3	Q1

A. Deteksi Dini Kebakaran Hutan dan Lahan Memanfaatkan Ekstraksi EXIF Pada Informasi Gambar Berbasis Pengolahan Citra

This research utilized various data sources, including images from Google, data from the Disaster Control and Operation Center (Pusdalops PB) of BPBD Pulang Pisau, as well as direct image capture using mobile phone cameras. The collected data consisted of training and testing data for classification purposes. The training data consisted of 25 smoke images and 25 fire images, while the testing data consisted of 20 smoke images and 20 fire images.In the process of classifying fire images, the researchers used YCbCr color space conversion to transform RGB images into the appropriate format. Meanwhile, for smoke image classification, conversion from RGB to HSV and Grayscale was employed. The results of the classification testing will be visualized using a confusion matrix. The confusion matrix provides valuable information for comparing the classification results performed by the system or model with the actual classification results. By using the confusion matrix, the researchers can evaluate the performance of the fire detection system in classifying smoke and fire images by calculating accuracy, precision, recall, and other evaluation metrics. This information can help assess the reliability and effectiveness of the fire detection system developed in this research [1].

B. Pemanfaatan Citra VIIRS untuk Deteksi Asap Kebakaran Hutan dan Lahan di Indonesia

The VIIRS image is quite effective for detecting the distribution of forest/land fire smoke using the multi-threshold model and the modified Li et al. (2015) method. The multi-threshold model yields higher accuracy compared to the modified Li et al. (2015) model. The multi-threshold model achieves an average accuracy of 82.2% with a Commission error of 9.8% and an Omission error of 10%, while the modified Li et al. (2015) model has an average accuracy of 72.3% with a Commission error of 0.3% and an Omission error of 27.4%. The multi-threshold model can detect fire smoke even in thin smoke conditions, whereas the modified Li et al. (2015) model is only capable of detecting thick fire smoke [5].

C. Deteksi Kebakaran Hutan dan Lahan Menggunakan Citra Satelit Himawari-8 di Kalimantan Tengah

This research was conducted in the Kalimantan Province and utilized various data from different sources for forest fire detection analysis. The data used includes Himawari-8 Advanced Himawari Imager Satellite Imagery from the Meteorology, Climatology, and Geophysics Agency (BMKG), MODIS and VIIRS hotspot data from the NASA FIRMS website, as well as MODIS and VIIRS True Color imagery for daytime and thermal infrared imagery for nighttime obtained from the NASA Earthdata website. The forest fire detection method employed in this study is the AFMA (Active Fire Monitoring Algorithm) developed by Hassini et al. (2009). AFMA is an active monitoring algorithm used to acquire hotspot information from geostationary satellites, such as Himawari-8. Data processing was performed using Python programming language version 2.7 on the Windows 10 operating system. Python was utilized as the software for analyzing and processing data from various satellite imagery and hotspot sources to detect forest fires. By utilizing diverse data from different sources and adopting AFMA as the detection method, this research aims to comprehend and monitor forest fire occurrences in the Kalimantan Province with the aid of satellite imagery technology and analysis using the Python programming language [6].

D. Deteksi Area Bekas Kebakaran Hutan Dan Lahan Menggunakan Data Citra Resolusi Menengah Modis Dengan Pendekatan Indeks Kebakaran

The NDFI and MNDFI indices demonstrate excellent capability in identifying post-fire areas in West Kalimantan

during the period of January-April 2014. The MNDFI index exhibits slightly higher accuracy compared to the NDFI index. Based on these research findings, the researchers recommend further assessment of the MNDFI and NDFI indices in other vulnerable regions to forest and land fire incidents in Indonesia. Additionally, the inclusion of climate and topographic parameters in identifying post-fire areas is considered to achieve improved and representative results of forest and land fire characteristics in various regions of Indonesia. Furthermore, utilizing a longer time interval between the image acquisition dates is suggested for more comprehensive analysis [7].

E. Segmentasi Citra Menggunakan Metode Watershed Transform Dengan Kombinasi Threshold, HSV, Graysacale dan Morphology Untuk Mendeteksi Sebaran Api

This research attempts an effective new method for detecting fire spread and separating fire images from complex backgrounds and foregrounds. By utilizing a combination of thresholding, HSV, and grayscale techniques, even with significant noise, the fire images are successfully isolated, and the color of the fire is detected. However, some areas that do not represent fire spread are still detected as fire regions, leading to suboptimal watershed segmentation. In future research, the opportunity lies in separating objects other than fire that have similar colors to fire images to reduce the possibility of false detections or missed detections. The detection and localization using the watershed transform with a combination of thresholding, HSV, and grayscale will aid in accurately detecting fire spread from forest fires and can be easily applied with high accuracy [8].

F. Early Forest Fire Detection Using Drones and Artificial Intelligence

The early forest fire detection system is still in the development phase. We are still awaiting the purchase of some equipment, but we have planned and discussed the actual implementation. We have conducted thorough research and several simulation experiments, and we believe that we are following the right approach to achieve our goals. We also believe that we have implemented an adequate and up-to-date approach. We think that the system can enhance the available platform for fire detection, and we hope that this improvement can significantly reduce the damages caused by untimely or delayed fire detection [9].

G. Using Popular Object Detection Methods for Real Time Forest Fire Detection

In this paper, we focus on three issues, namely forest fire detection, real-time detection, and early fire detection, as well as false detection. For the first time, we use classical object detection methods to detect forest fires: Faster R-CNN, YOLO (tiny-yolo-voc, tiny-yolo-voc1, yolo-voc.2.0, and yolov3), and SSD, with SSD showing superior real-time properties, higher detection accuracy, and early fire detection capabilities. We establish fire and smoke benchmarks, utilizing a new smoke class and changes in fire area to minimize false detections. Meanwhile, we adapt the YOLO tiny-yolo-voc structure and propose a new structure, tiny-yolo-voc1, which experimentally proves to enhance the fire detection accuracy. This paper is highly practical for forest security and real-time forest monitoring [10].

H. A Deep Learning Based Forest Fire Detection Approach Using UAV and YOLOv3

This research aims to develop an efficient and reliable UAV testing and image-based fire detection method that can be implemented on a small-scale UAV. Therefore, the hardware platform for forest fire detection is developed first. Simultaneously, based on the UAV hardware platform, a suitable YOLOv3 image detection algorithm is proposed. The results of experimental testing demonstrate that the accuracy and speed have reached the expected level, validating the effectiveness and feasibility of the developed UAV platform and deep learning-based fire detection algorithm. However, we have also encountered some issues in the experiments. The detection algorithm is sensitive to large-scale forest fires, and its performance requires further improvement in small-scale settings (such as small fire spots in the forest). This is mainly due to the lack of a substantial number of initial forest fire datasets available for training sets. As our future work, we will conduct more in-depth studies to achieve better detection performance to meet practical requirements towards early detection and rapid and accurate prevention of forest fires [11].

V. CONCLUSION

Based on the results of the forest fire detection study using image processing, it can be concluded that the percentage of classification accuracy is highly influenced by the training data used in the model training process. Training data is the data used to "teach" the system to recognize and classify fire objects. The better and more representative the training data used, the higher the accuracy of the fire detection system produced. Furthermore, the conversion from the RGB color space to other image formats, such as HSV or Grayscale, also impacts the results of fire detection. The chosen conversion function will affect how the system processes color and brightness information in the image to detect fire points or smoke.

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