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RESEARCH ARTICLE

# Frame Difference Method to Detect Fire and Compare the Accuracy and Precision with Vibe Method

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**ABSTRACT**

**Aim:** In this paper, the main aim is to detect fire using a novel frame difference method and compare it with conventional method. This is based on video processing and computational methods to reduce the computational complexity. **Materials and method:** The method was performed over a sample size of 20. Same samples were applied for both the control group and experimental group. Improved accuracy detection was obtained using the proposed method. **Results:** The Accuracy and precision was found (94.03, 64.62) and (86.24,57.19) was obtained for the frame difference method and conventional method. It also shows a significance of 0.048 for accuracy and 0.018 for precision which is less than 0.05. **Conclusion:** It would be concluded that the frame difference method is producing high accuracy and precision when compared with the Vibe method. It is applicable for monitoring systems and home security.

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## Introduction

Generally, Forest fires are happening in many countries. It has to be controlled before it destroys the natural resources. Many incidents happened and many people have died, some are injured and 3.72 acres of the forest destroyed(Gong et al. 2019) ; (Boesak and Hansen 2009). By capturing the video and dividing the video into frames (Yaoming et al. 2017).Each and every frame is monitored and then noticed that, whether the fire is presented or not. The fire is in rgb color, It can take all three color fires(Kim, Kim, and Jeong 2014).. It is important to use efficient equipment and qualified manpower to control the forest fire. Also the sufficient spaces and continuous maintenance of extinguishing devices are necessary for monitoring the spread of fire. extinguishing devices. Proper training should be given for the staff for fighting with the fire (Krüll et al. 2012). Hence a method is proposed to overcome all the above drawbacks.

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It is a fast and efficient detection system to allow the early detection of fire and prevents the spread of fire. The proposed method is low cost with high efficiency (Töreyin et al. 2006).The proposed detection system can be implemented in all real-time cameras to monitority, the fires in forest. Also for monitoring the residential and commercial buildings.

Several research articles are published on fire detection in the past five years.39 research articles were published in IEEE explore and 89 were published in google scholar. Fire detectors based on chemical sensors were designed for ensuring high detection rate. Though it was efficient, still the chemicals used were harmful. Sensor drift were also the problems to be faced. Color and motion sequences from the videos were used for detecting the fire. The proposed method detects change in color and motion of overall regions for detecting fire and it can be implemented in both fixed and pan/zoom cameras. But the proposed method gets confused with clouds with smoke (Fonollosa, Solórzano, and Marco 2018; Lee et al. 2017).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S.R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

A method was proposed in which images are filtered out using the threshold of the features. The research method has less computational time. Still the algorithm shows more false alarm rate which is caused by the shaking of camera (Hsu et al. 2020).The optical remoting sensing system is used in the fire warning system to alert the people who are living nearby the forest. This system depends on the camera resolution and view of the angel. It is fixed in it's positions (Barmpoutis et al. 2020). This proposed method detects the color, motion and area dispersion to detect fire in video data (Patel and Tiwari 2012).This proposed method has a spatial segmentation and temporal segmentation and these classifications are used to detect fire from the video sequence. In convolution network automatically extracted the images. It has stronger robustness. (Li and Zhao 2020).The threshold is best when compared with other methods it can minimize the consequences in the forest fire and it resolves the false positive rate and to improve the true positive rate. Authors are expertised in the field of image classification and we have published peer reviewed publication in the above mentioned field. Overall aim of the present study is to develop an efficient fire detection system to protect the environment.

## Materials and Methods

This method includes the processing of the frames of the fire images. The study was performed in the Department of Electronics and Communication engineering, Saveetha School of Engineering. Ethical approval is not needed since the samples were taken from the online source. A total of 20 samples with and without fire was taken for the experiment. Experiment was performed by evaluating the two groups using the same samples. The sample size was estimated to be 20 for each group using G power of 80 with inputs fed from mivia.unisa. Sample size was calculated by using previous study results.(Gong et al. 2019).

For group 1 20 videos have been used in order to test the scheme for fire detection. The samples are collected from mivia.com and the samples are taken by http://mivia.unisa it/datasets/video-analysis://mivia.unisa it/. The samples are of two types. The first 10 samples include the videos with fire and the last 10 videos do not contain any event of interest. Some of the videos were obtained from real time and some from the web.

Sample were the same for both control group and experimental group. Experimental group is the proposed frame difference method and the control group is the Vibe method.

Windows 10 with i7 core 7th generation intel processor is used for the testing. MATLAB (2014 a)software with required add ons is installed.

Experimental algorithm for frame difference method was followed as per the standard protocol of (Zhang, Wang, and Qu 2012).

The performance of the proposed methodology was analysed using the dataset videos. The sequence includes fire-colored and non fire colored videos Finally, the video sequences were recorded at different times of the day. Accuracy was used as the parameter. True positive(TP), True Negative(TN), False Negative(FN) and False positive(FP) values were noted down. With this accuracy was calculated.

### *Statistical Analysis*

All analyzes were conducted using SPSS. Descriptive statistics (mean, standard deviation, and standard error) were carried out for each method. An independent sample test was performed to compare variables across the study groups.

The independent variables in this study are different types of pixels with ranges and images with fire. The dependent variables are the accuracy and detection rate. The analysis \was done for video of different pixel ranges. By analysing the true positive, true negative, false positive and false negative were obtained.

## Results


**Fig. 1.** Fire detection using frame difference method. (a)The input frame image. (b)The current frame image. (c)Image after thresholding. (d) Region of moving pixel. (e) The binary image after expansion

In Table 1, it was observed that for fire dataset detection, accuracy, precision performance of frame difference method was significantly better than vibe method. From the above dataset, it was clearly evident that the Frame difference method performed significant better than the vibe method.

In Table 2, it was found that the mean, and standard deviation of the frame difference method is significant than the vibe method. Frame difference method was found to

achieve a high accuracy 94.03. Further increase in the iteration, it was found to give constant accuracy.

**Table 1.** Demonstrates the true positive (TP), true negative (TN), false positive (FP), and false negative (FN), for the video that was given as input. The average of precision and accuracy is determined using this method. Maximum accuracy is obtained for the video11.

| Samples | Fire frames | Non fire Frames | TP | FN | FP | TN | Accuray | Precision |
|---|---|---|---|---|---|---|---|---|
| Video 1 | 127 | 1 | 127 | 0 | 0 | 1 | 95.29 | 89.75 |
| Video 2 | 111 | 20 | 111 | 0 | 1 | 20 | 98.23 | 93.46 |
| Video 3 | 142 | 0 | 142 | 2 | 1 | 0 | 89.52 | 83.52 |
| Video 4 | 111 | 94 | 111 | 1 | 2 | 94 | 82.17 | 81.17 |
| Video 5 | 207 | 37 | 207 | 0 | 0 | 37 | 78.25 | 72.32 |
| Video 6 | 127 | 103 | 127 | 0 | 1 | 103 | 75.60 | 70.04 |
| Video 7 | 139 | 0 | 139 | 0 | 0 | 1 | 78.49 | 82.75 |
| Video 8 | 147 | 1 | 147 | 1 | 0 | 11 | 86.37 | 81.45 |
| Video 9 | 168 | 0 | 168 | 2 | 1 | 3 | 92.56 | 78.72 |
| Video10 | 217 | 1 | 217 | 1 | 2 | 1 | 89.67 | 84.65 |
| Video11 | 234 | 17 | 234 | 0 | 1 | 0 | 96.56 | 83.78 |
| Video 12 | 144 | 0 | 144 | 1 | 0 | 12 | 93.34 | 75.89 |
| Video 13 | 107 | 13 | 107 | 0 | 1 | 0 | 87.24 | 78.34 |
| Video 14 | 154 | 12 | 154 | 1 | 0 | 1 | 91.34 | 85.23 |
| Video 15 | 194 | 1 | 194 | 0 | 1 | 13 | 86.46 | 81.45 |
| **Average** | | | | | | | **94.03** | **86.24** |

**Table 2.** Means, standard deviation and standard error mean of the accuracy and precision in frame difference and Vibe method. The mean values of the accuracy and precision were (94.03%,64.62% and 86.64%,57.19%). A statistically significant difference was noted in the mean accuracy of the frame difference method comparison with the Vibe method.

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| accuracy | frame difference method | 20 | 94.0345 | 5.19643 | 1.16196 |
| - | Vibe method | 20 | 64.6275 | 2.88854 | .64590 |
| precision | frame difference method | 20 | 86.6445 | 3.07485 | .68756 |
| - | Vibe method | 20 | 57.1970 | 4.89976 | 1.09562 |

From Fig. 2, the accuracy and precision of frame difference method is increased than the conventional method. Frame difference methods have high significant accuracy than the vibe.

All the major parameters like accuracy, precision that influence the frame method were found to be statistically significant ($p<0.001$), this implies that accuracy rate seems to be stable in Table 3. Independent t-test, was used to compare the accuracy of two algorithms and a statically significant difference was noticed $p<0.048$.frame difference method obtained 94.03 accuracy in Fig. 2. When compared with the other algorithms performance of the proposed frame difference method achieved better performance than the vibe method.

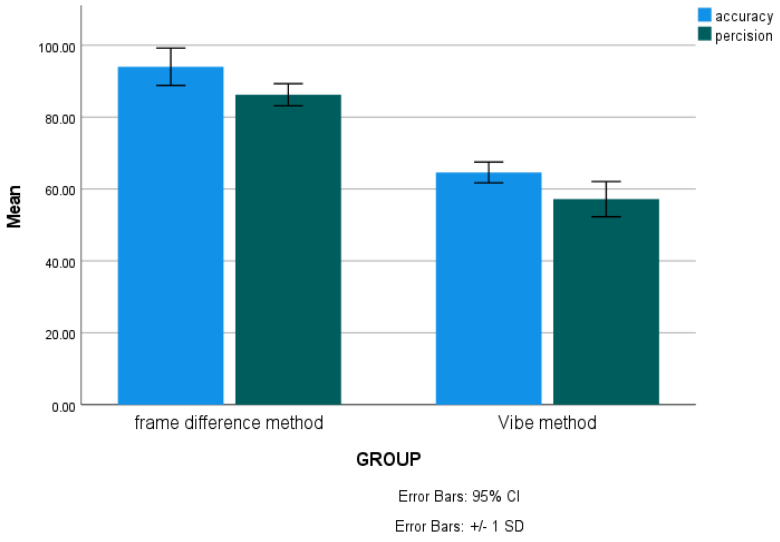


**Fig. 2.** Bar chart comparing the Mean accuracy of the two groups. There is a statistical significant difference between frame difference method and Vibe method. In X axis Accuracy and precision is taken. Y axis: Mean value for effective prediction ± 1 SD

**Table 3.** The mean standard deviation and significance difference of accuracy and precision for frame difference and vibe method. The significant difference was observed between the two groups (p=0.048, p<0.001) from the independent sample test(table3).

| | | F | Sig | t | df | Sig(2-tailed) | Mean difference | Std Error Difference | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|
| Accuracy | Equal variance assumed | 4.168 | .048 | 22.120 | 38 | <001 | 29.40700 | 1.32941 | 26.71575 | 32.09825 |
| | Equal variance not assumed | | | 22.120 | 28.718 | <001 | 29.40700 | 1.32941 | 26.69090 | 32.12310 |
| Precision | Equal variance assumed | 6.085 | .018 | 22.457 | 38 | <001 | 29.04750 | 1.29349 | 26.42897 | 31.66603 |
| | Equal variance not assumed | | | 22.457 | 31.956 | <001 | 29.04750 | 1.29349 | 26.41261 | 31.68239 |

## Discussion

The proposed method produces accuracy 94.03% compared to 64.62 % of vibe method. Also precision of 86.24 compared to 57.19 % of vibe method. It also shows a significance of 0.048 for accuracy and 0.018 for precision which is less than 0.05. Accuracy and precision of frame difference method appears to be gradually increasing than the vibe method. Statistically significant difference is noted in the mean accuracy of the frame difference method compared with the Vibe method.

To verify the effectiveness of the proposed method, two parameters accuracy and precision is chosen. The Statistical criteria is whether the program needs to correctly identify and to check the frame area in the fire. Accuracy of frame difference method appears to produce the most consistent results with mean ranging from 70's to 90's. whereas precision appears to produce the most variable results with ranging from 50's to 70's. In our study, the statistical significant difference (p=0.048, p<0.001) was observed between the frame difference method and vibe method. Also, it was observed that the frame difference method has obtained 94.03% as the accuracy rate which is found to be higher than vibe method 64.62% to detect the fire. The results are compared with other flame detection methods, which are carefully selected using the features used for fire detection. The results were also reported among the existing recent methods by achieving an accuracy of 93.55% (Muhammad et al. 2018). The detection rate was also compared with (Chen, Kao, and Chang, n.d.) and (Rong et al. 2013)found to be 90.7%.Successful fire detection tests on the benchmark video clips of different fire scenes have shown the accuracy of the detection algorithm.

Our institution is passionate about high quality evidence based research and has excelled in various fields ((Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019). We hope this study adds to this rich legacy.

The factors that affect the accuracy of the detection processes. It is the quality of the image. Image quality includes factors such as noise, contrast and distortion. As the limitation of the study, the modifications can be done by using different types of sensors to obtain a better accurate rate. By increasing the sample size the true rate of fire detection can be increased. Hence, it is safe to assume that the results of the present study lie within statistically acceptable limits. The shape and size information other than area can be used to improve the system's fire detection. The performance of the fire pixel can be improved by applying smoke detection in the early stage of fire along with the fire detection technique. It can be applied for real time application and can be checked for the detection speed. Accuracy is improved by taking more samples. It is possible to reduce the computational complexity and it is an easy technique to protect natural resources, humans and properties.

## Conclusion

The results of the study showed that frame difference method appears to have better accuracy rate 94.03% than the vibe method. It also outperforms the vibe algorithm 64.62%. According to the comparison graph shown above the proposed algorithm to detect fire works good for all situations.

## Declarations

### *Conflict of Interests*

No conflict of interest in this manuscript.

### *Authors Contributions*

Author ND was involved in data collection, data analysis, manuscript writing. Author JM was involved in conceptualization, data validation, and critical review of manuscript.

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