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A Deep Learning-Based on Forest Wildfire Detection in Machine Vision Course

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Abstract -

Forest wildfires are one of the most destructive natural disasters, causing severe environmental, economic, and ecological damage. Early detection plays a crucial role in preventing the rapid spread of fire and reducing losses. This project proposes a deep learning–based wildfire detection system integrated with machine vision techniques to automatically identify fire and smoke in forest environments. The system uses a trained convolutional neural network (CNN) model to analyze real-time video or image inputs and classify potential wildfire occurrences with high accuracy.

The proposed model processes frames using feature extraction, pattern recognition, and probability-based classification to detect early signs of fire.

1.INTRODUCTION

Fire detection is crucial task for the safety of people. To prevent damages caused by fire, several fire detection systems were developed. One can find different technical solutions. Most of them are based on sensors, which is also generally limited to indoors. However, those methods have a fatal flaw where they will only work on reaching a certain condition. In the worst-case scenario, the sensors are damaged or not being configured properly can cause heavy casualty in case of real fire. Those sensors detect the particles produced by smoke and fire by ionization, which requires a close proximity to the fire.

To get over such limitations video fire detection systems are used. Due to rapid developments in digital cameras and video processing techniques, there is a significant tendency to switch to traditional fire detection methods with computer vision-based systems.

Secondly, fire detection system responds faster compared to any other traditional detection methods because a vision-based fire detection system does not require any type conditions to trigger the devices and it has the ability to monitor a large area. There are many technologies available for smoke and fire detection but still society is lacking reliable and accurate methods to predict smoke and fire at early stages, this deficiency may then lead to dangerous situations. This paper describes state of the art of different techniques used for smoke detection, fire detection and classification which may help to better understand the problem in hand.

2. PROPOSED METHODOLOGY

The proposed Methodology for forest fire detection leverages an integrated approach combining advanced sensor technologies, satellite imagery, and machine learning algorithms. Real-time data from temperature and smoke sensors strategically deployed in forested areas are collected and transmitted to a centralized system. Satellite imagery aids in monitoring larger areas and identifying potential fire outbreaks. Machine learning algorithms analyze the collected data to distinguish between normal environmental variations and the presence of an actual forest fire. In case of a detected fire, automated alerts are sent to relevant authorities, enabling swift response and mitigation efforts. The system aims to enhance early detection accuracy, reduce response time, and minimize the environmental impact of forest fires.

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3. IMPLEMENTATION

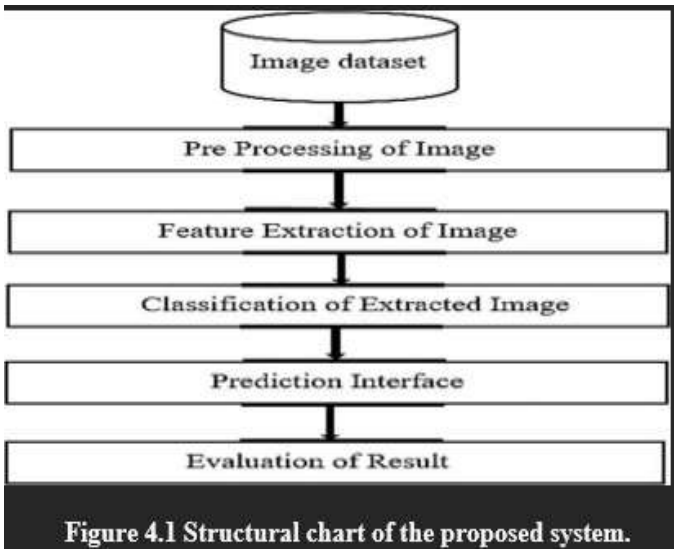

Figure 4.1 Structural chart of the proposed system.

The figure 4.1 shows that the proposed system involves the following steps. First step involves pre-processing of captured images.

The pre-processed image undergoes feature extraction, where various features of the fire and smoke and fire types are extracted and certain algorithms are applied. The data that is stored is compared with the pre-processed image and approximate result is generated.

4.CONVOLUTION LAYER

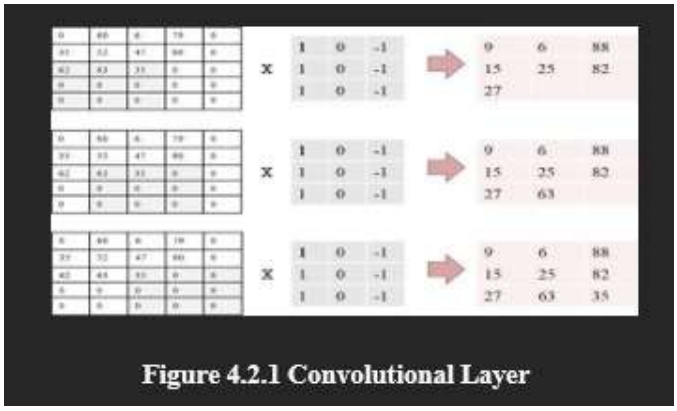

Figure 4.2.1 Convolutional Layer

In convolution layer after the computer reads an image in the form of pixels, then with the help of convolution layers we take a small patch of the images. These images or patches are called the features or the filters. By sending these rough feature matches is roughly the same position in the two images, convolutional layer gets a lot better at seeing similarities than whole image matching scenes. It creates a feature map to predict the class probabilities for each feature by applying a filter that scans the whole image, few pixels at a time.

5.Pooling Layer

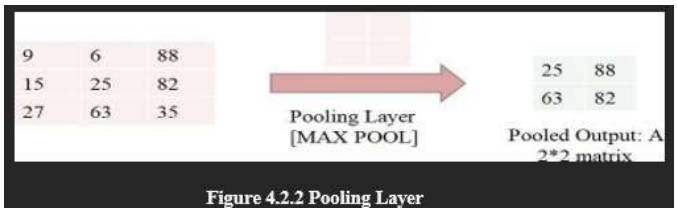

Figure 4.2.2 Pooling Layer

scales down the amount of information the convolutional layer generated for each feature and maintains the most essential information (the process of the convolutional and pooling layers usually repeats several times).

6.Fully Connected and Output Layer

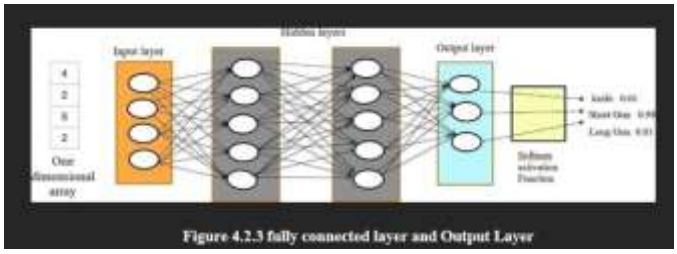

Figure 4.2.3 fully connected layer and Output Layer

The output of the pooling layer is flattened and this flattened matrix is fed into the Fully Connected Layer. In the fully connected layer there are many layers, Input layer, Hidden layer and Output layers are parts of it. Then this output is fed into the classifier, in this case SoftMax Activation Function is used to classify the image into smoke and fire present or not. Figure 5.17 shows the fully connected layer and Output Layer.

7.Results and Conclusion

As a result of our literature review, we are able to determine that it is possible for us to build a powerful system to detect the fire and smoke with good precision and accuracy. This system can be used in forest offices to get alerts based on the threat of fire in the forest.

In this project the training data is taken as huge number of images so that the system learns to classify them depending on the presence or absence of fire and/or smoke. Here the system processes the image containing fire and smoke based on RGB to grayscale conversion process. We used three CNN techniques namely LeNet-5, AlexNet, VGG-16. The forest predictor developed, was trained, and tested on all of the 3 models mentioned above and it was observed that the predictor produced a better accuracy in the LeNet 5 when compared to the rest of the models.

Fig 6.3 fire detected notification through telegram

Fig 6.4 Smoke detected notification through telegram

Fig 6.1 Fire detected

Fig 6.2 Smoke detected

CONCLUSIONS

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[1:02 pm, 13/12/2025] ~vrunda: The proposed forest fire detection technique is based on CNN. The algorithm takes a raw dataset and reshapes it according to the given specifications after which it trains the CNN model. When the images to be predicted are given to the trained model, an output as to whether the image contains forest fire or not is identified..

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