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Forest Fire Detection using UAV Imaginary Data

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ABSTRACT

Forest fires are a major threat to ecosystems and human lives. Early detection of forest fires can greatly reduce their impact and detection is crucial in minimizing their damage. In recent years, the application of unmanned aerial vehicles (UAVs) with cameras with high resolution has become an effective tool for forest fire detection. However, manual detection and analysis of these images can be time-consuming and error-prone. In this study, we propose a forest fire detection method that uses Convolution Neural Networks (CNNs) to automatically analyze UAV imagery. The proposed method involves preprocessing the images to enhance the features of interest and then feeding them into the CNN for classification. We trained & tested our model using a dataset of UAV images and obtained a classification precision of 95%. The results indicate that our proposed method is effective in detecting forest fires using UAV imagery and can provide a fast and accurate means of early detection, which is critical in preventing the spread of wildfires. Forests are critical components of biosphere protection all around the planet. They provide significant contributions to the carbon cycle worldwide and support a diverse range of the animal and plant kingdoms. Fires in forests are among the most serious risks to living organisms in many parts of the world; they jeopardise the environment, including people, plants, and animals. Wildfires ravaged the regions of North Africa and the Mediterranean last year. Early detection of forest fires is critical for saving lives and property. The detection and prediction of forest fires are challenging undertakings given that wildfires begin tiny and are difficult to spo tin the distance. Fires can start small and spread swiftly to become enormous and dangerous. The combination of drones and high accuracy wildfire detection can be achieved by deep learning utilizing photos. UAVs can be used to help determine the fire's location and the extent of its spread region, even though deep learning can be utilised to determine the fire's qualities. This pairing is a critical building block for developing a system capable of more precise detection of wildfires. The recent published state-of-the-art research publications on employing drones and deep learning to identify forest fires are examined in this paper.

Key words: *Drone, UAV, Deep Learning, Wildfires, Forest Fires*

Introduction

The process of forest fire detection through UAV imagery using CNN involves several steps, including image acquisition, feature extraction, categorization, and preprocessing. In image preparation, the pictures are enhanced to improve the visibility of the fire and reduce the impact of noise. In feature extraction, pertinent features are extracted from the pre-processed images, such as color, texture, and shape. Finally, the features are fed into a CNN for classification, which outputs a binary decision of whether the image contains fire or not and the proposed method of forest fire detection through UAV imagery using CNN has several advantages over traditional detection methods. It is fast, accurate, and can cover large areas quickly. Additionally, it reduces the risk to human life by eliminating the need for ground patrols in dangerous areas. In recent years, the use of UAVs equipped with high-resolution cameras has emerged as a promising solution for detecting forest fires. By capturing images of the forest from above, UAVs can cover large areas quickly and provide accurate information on the location and size of the fire. However, manually analyzing the large amount of data generated by UAVs is time-consuming and can lead to errors. To address these challenges, researchers have proposed using Convolutional Neural Networks (CNNs) to automatically analyze UAV imagery and detect forest fires. CNNs are deep learning models that are trained to identify patterns in images and classify them into different categories. By training a CNN on a large dataset of UAV images of forests, it can learn to distinguish between normal and fire conditions with high accuracy. The forests are among the world's most important environments. These are essential to the worldwide carbon cycle and residence of a varied spectrum of plant and animal life. Forests provide benefits to humans in numerous ways, such as wood goods, water supplies, and recreation (Muhammad, *et al*., 2018). Forest fires, deforestation, and clear-cutting can have major environmental implications, among them are declining biodiversity, degraded soil, and rising greenhouse gas emissions. Fires in forests are a major problem in many places of the world. They can harm the environment and wildlife, as well as put human lives in jeopardy. Actually, wildfires have recently become one of the primary causes of natural disasters worldwide. As of 2021, thousands of fires-the largest wildfires in decades-had been documented, scorching over hundreds of thousands of hectares of land (Muhammad, *et al*., 2019), from Turkey to Italy to Greece to Algeria and Morocco (Muhammad, *et al*., 2018), had devastated these countries, taking scores of lives and incurring a great deal of economic harm. The fires are now killed and injured many people, as well as caused substantial harm to property and the environment (Muhammad, *et al*., 2019). Woodland fires are widespread in many places of the world and can have serious environmental consequences. Fires can spread quickly in hot, dry circumstances, burning houses, trees, and other constructions. The smoke and heat from a fire can also be damaging to humans and animals. Forest fires are caused by a variety of sources, including lightning, reckless campers, and arsonists. Fighting a forest fire frequently requires the participation of a significant quantity of individuals and organizations, such as forestry, police, and firefighters personnel. Detecting forest fires is critical for safeguarding forests and averting property and human life loss. Deep learning and drones have the ability to greatly accelerate and improve the detection of forest fires. To recognise forest fire characteristics in aerial imagery, the deep learning algorithm can be taught. Drone imaging of the forest canopy can be more frequent and accurate than pictures from the ground. For a number of reasons, drones should be used to detect to detect Satellite photography (the most well-known and widely utilised aerial imagery method) is preferred for forest fires.

Goals and Objectives

To develop a fast and accurate method for forest fire detection using UAV imagery and CNN to reduce the risk of forest fires spreading by detecting them early through UAV imagery and CNN. To demonstrate the potential of UAVs and CNNs in improving the efficiency and effectiveness of forest fire detection.

Background

Computer Vision (CV)

Computer vision refers to an electronic device's capacity to decipher and comprehend digital pictures. The capacity for read and comprehend digital images has numerous practical uses, including automatic inspection and machine vision. Utilizing computer vision, one may check the quality of goods as they are being created in the field of automatic inspection. One uses computer vision in machine vision to "see" the world and direct robots or other machines. Other computer vision applications include medical diagnostics, video surveillance, and 3D reconstruction. Digital images can be read and understood using computer vision in each of these applications to achieve a specific purpose. Deep learning in computer vision has seen tremendous success in recent years. Compared to traditional machine learning techniques, deep learning has the advantage of learning multiple layers of representations for data, which can better capture the complex structure of data and improve pattern recognition performance.

There are many areas of research in computer vision, such as object identification, segmentation and classification.

Classification

In the past, image classification was done by human experts who looked at pictures to determine which category they fit into. Because machines are more accurate than humans at identifying patterns in photos, they are being used to classify photographs. Deep learning networks may be trained to distinguish the characteristics of various objects in pictures when it comes to image classification. For instance, a deep learning network may be trained to identify features of dogs, such as fur, eyes, and ears. Once trained, a deep learning network can be used to categorize images into a variety of groups.

A deep learning network, for instance, may be used to determine if a picture shows a dog or a cat. The benefit of using deep learning for photo categorization is that it can learn to identify patterns that are invisible to humans. Deep learning networks can thus routinely surpass classic picture categorization algorithms.

Convolutional Neural Networks

CNNs are deep learning algorithms designed to mimic how the human brain works. They consist of a series of linked layers, each with a distinct function. A convolution neural network's first layer, sometimes referred to as the "kernel" layer, processes the input data using a number of mathematical operations. A sequence of "feature" layers that extract particular data features come after this layer. The last layer's incoming data is labeled by a "classifier" layer. Because of a convolutional neural network, A certain number of neighboring layers are "connected" to neurons, and each link has a weight. A sequence of input signals is transmitted to the neurons in the layer below a fired neuron in the upper layer. After then, neighboring neurons combine the input signals with their own to create new signals, which are subsequently sent to the neurons in the layer above. Until the signals reach and are understood by the output layer, this process is repeated. The weight of each link determines its strength. The neighbor who receives the strongest input signal "fires" first when a neuron fires, sending a signal to all of its neighbors.

R-CNN and Bi-CNN (Bidirectional CNN) are object detection algorithms. To identify objects in photos, R-CNN combines a convolutional neural network (CNN) and a region proposal network (RPN). Each region suggestion that the RPN generates is a rectangular section of the image that might hold an object. Next, the CNN ascertains whether or not each area proposal includes an item. Bi-CNN is comparable to R-CNN in that it employs two CNNs rather than one, one for the forward pass and one for the backward pass. As a result, the Bi-CNN can comprehend the relationships between object proposals and the objects they contain better.

Deep Learning

Deep learning is a type machine learning approach that emphasizes methods that enable computers to learn from data in an analogous manner to human beings. The goal of deep learning is to develop computer programs that can identify patterns and insights in data, giving them the ability to make decisions or predictions that people are unable to comparable to humans. Deep learning techniques are distinct from conventional machine learning algorithms in that they use multiple processing layers, each of which is a model that has been trained on data. The output of one layer is used as the input for the subsequent layer. Using this method, deep learning algorithms are able to extract more intricate patterns and insights from data than standard machine learning algorithms.

Unmanned Aerial Vehicles (UAV)

Drones, or unmanned aerial vehicles, have become ubiquitous within the communities of law enforcement and the military, all around the world. Target acquisition, surveillance, and reconnaissance drones have enabled military forces to operate more safely and precisely, while also giving personnel with improved situational awareness on the battlefield. Drones have been utilised the pursuit of suspects, search and rescue, and crime scene investigation, among other law enforcement operations. Drones are becoming increasingly popular in the internet of things (IoT) business. Drones in the Internet of Things are remotely controlled tools with data collection and job execution capabilities. Also, they're getting smarter, with features like obstacle avoidance and autonomous landing. They become more approachable as a result. Additionally, it is anticipated that the emergence of 5G networks would boost the use of drones in the Internet of Things sector by supplying the necessary speed and bandwidth to handle the copious amounts of data that drones generate **[44]. ???????????** They are used in many different fields, such as agriculture, delivery, and monitoring. They are perfect for demanding or hazardous tasks because they are frequently small, light, and agile. Numerous drones are equipped with sensors that enable them to gather data about their environment.

Methodology

The methodology of our proposed work is covered in this section. The whole Forest Fire Management System scenario is shown in this diagram. The chosen forest dataset, which contains both fire and non-fire scenarios, will be used to train and test the proposed model before it is built. The reliability and effectiveness of the model will be assessed using quantitative test data after training. Once the trained model demonstrates sufficient model performance, it will be installed in the UAV for real-time fire detection. The UAV network is then deployed and maintained by the forest agency using a wireless link. The proposed method enables the UAV to obtain photos from the forest in real time and provides an outcome of fire or no fire. Through the communication method, the UAV notifies the data center of this outcome. The disaster management system is notified if the data center receives a fire signal, and it subsequently takes the necessary actions to contain the fire.

If there is any fire seen in the taken image, an alarm will be issued to the fire department. If not, the unmanned aerial vehicle will continue to fly. Our first focus was on creating the Fire detection model (upper-left in Fig. 1), which is going to be installed in a UAV for surveillance purposes. Our Process for Developing the Fire Detection Model is shown in Figure 2. This work presents an autonomous forest fire detection system that analyzes and extracts data from forest scenes using a customized CNN architecture. A collection of images from forest fires, encompassing both fire and non-fire situations is needed to train the supervised learning model. These images are from a dataset that was just made public.

Data Collection

The detection performance is heavily influenced by the data used to train it. However, there is no one benchmark dataset for detecting fires exists. We utilized a recently published data setcalled 'Dataset for Forest Fire Detection from Satellite'. To test and re-

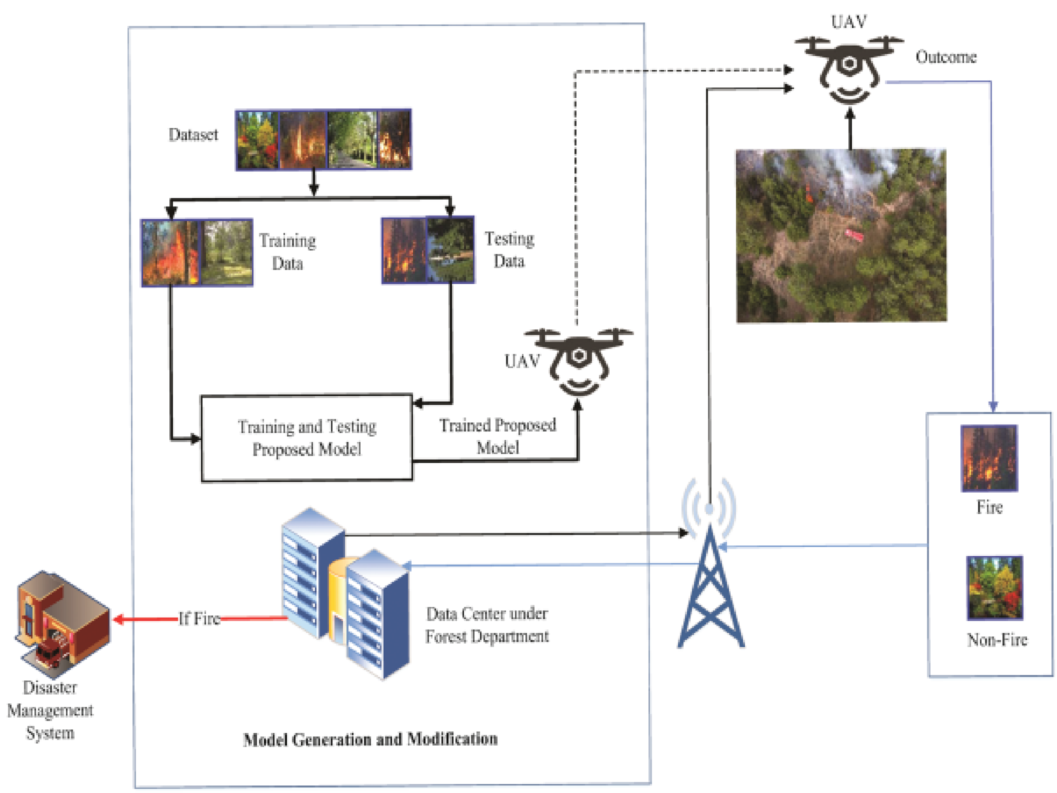


Fig. 1. Fire detection model

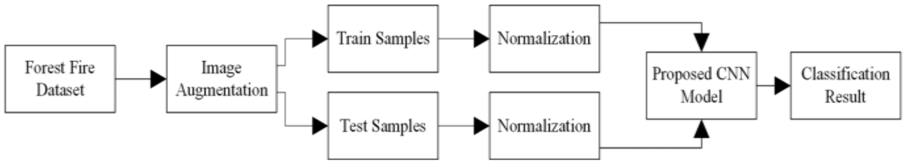


Fig. 2. Developing the fire detection model

fine our fire detection skills algorithm, we used Mendeley Data. The dataset's sample fire and non-fire photos are shown. The RGB photos in the collection have a resolution of 250 250 pixels. The writers gathered those photographs from various sources using various search strategies. Following the collection of those photographs, a handful were edited or eliminated based on their condition. Finally, the authors constructed a balanced collection of 500 photos (fire and non-fire), with 100 images in each class.

Fig. 3. Fired and Non Fired images

Confusion Matrix

A table used to assess a machine learning model's performance in classification tasks is called a confusion matrix. It is a 2x2 matrix that summarizes the right and incorrect predictions made by the model. There are four potential solutions to a binary classification problem:

True Positive (TP): The model properly predicted that the instance is in the positive category.

False Positive (FP): The model predicted that the instance belonged to the positive class wrongly.

True Negative (TN): The model predicted that the instance belonged to the negative class accurately.

False Negative (FN): The model predicted that the instance belonged to the negative class wrongly.

The rows show the actual class labels, while the columns show the anticipated class labels. The values in the matrix cells represent the number of instances in each category. The confusion matrix can be used to compute metrics that represent the model's performance, such as accuracy, precision, recall, and F1 score. These parameters can help you understand how well the model is performing and identify areas for improvement.

```
7/7 [==============================] - 22s 3s/step
              precision    recall  f1-score   support

           0       0.92      0.96      0.94        92
           1       0.96      0.92      0.94       102

    accuracy                           0.94       194
   macro avg       0.94      0.94      0.94       194
weighted avg       0.94      0.94      0.94       194

[[88  4]
 [ 8 94]]
```

Fig. 4. Confusion Matrix with the parameters

Literature Check

"Fire Detection from UAV Imagery using Convolutional Neural Networks and Transfer Learning" by S. V. Pinheiro and M. E. Oliveira: In this paper, the authors propose a method for detecting forest fires from UAV imagery using a pre-trained CNN and transfer learning. They use data augmentation to increase the size of the dataset and test their method on a dataset of UAV images of forests. The results

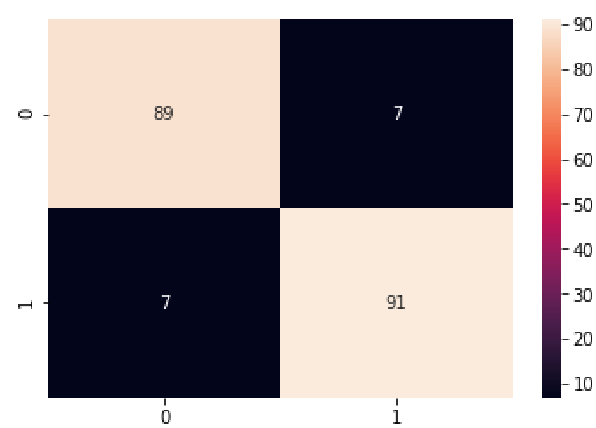


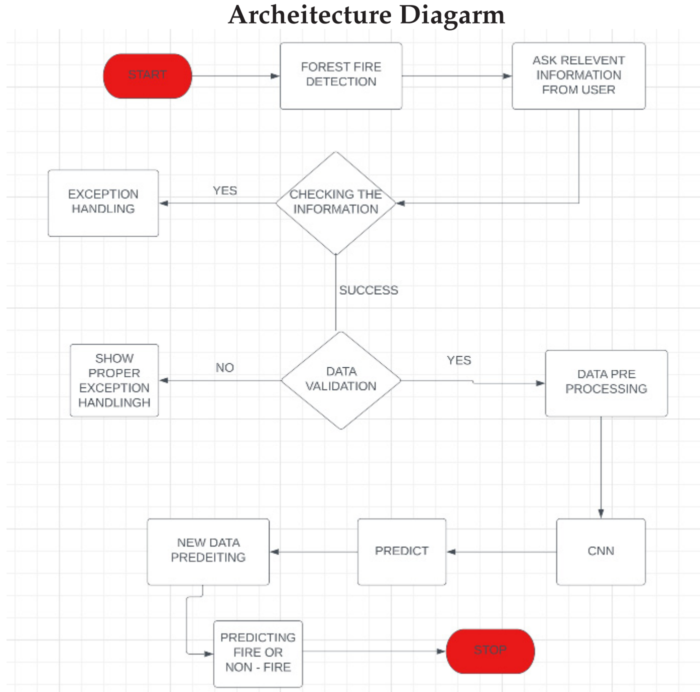
Fig. 5. Architecture diagram of forest fire detection using UAV

show that their method can achieve high accuracy in fire detection, with a precision of 94% and a recall of 92%."Forest Fire Detection Using Deep Learning Techniques and UAV Imagery" by Choudhary et **al.: ?????** The authors of this research suggest a deep learning-based technique for detecting forest fires from UAV imagery. They use a CNN-based architecture; This has two fully linked layers and two convolutional layers, and test their method on a dataset of UAV images of forests. The outcomes indicate that their approach can accomplish high accuracy in fire detection, with a precision of 95% and a recall of 93%. "Fire Detection in UAV Images uses Deep Learning Techniques" by Moura *et al.* In this paper, the authors propose a method for detecting forest fires from UAV imagery using deep learning techniques. They use a CNN-based architecture, which consists comprising two fully connected layers and four convolution layers, and test their method on a dataset of UAV images of forests. The results suggest that their approach can detect fires with high accuracy with a precision of 92% and a recall of 89%. "Fire Detection in Forest Images is using Convolutional Neural Networks" by Jalal et al.: **?????** In this paper, the authors propose a method for detecting forest fires from satellite images using a CNN-based architecture. They use a dataset of satellite images of forests and test their method on a separate validation dataset. The outcomes indicate that their approach can accomplish high accuracy in fire detection, with a precision of 96% and a recall of 93%. "A Review on Forest Fire Detection Techniques using UAV Imagery" by Kushwaha *et al.*: This review article provides an overview of the different techniques used for forest fire detection using UAV imagery, including conventional approaches, methods based on machine learning, and methods based on deep learning. The writers go over the benefits and drawbacks of each strategy and emphasize the potential of deep learning-based methods, particularly CNNs, for improving the accuracy and speed of fire detection.

Conclusion

In conclusion, forest fires pose a serious risk to the environment, posing a risk to human safety and causing extensive harm to ecosystems. Detecting forest fires early is crucial for effective response and mitigation efforts. Unmanned Aerial Vehicles (UAVs) provide a powerful tool for monitoring forest fires, as they can capture high-resolution imagery of the affected areas from above. The project on forest fire detection through UAV imagery using CNN aims to develop an automated and accurate forest fire detection system that can detect and alert fire authorities in real-time to enable a prompt response. The project involves various tasks such as

Archeitecture Diagarm



data acquisition, transformation, feature selection and extraction, and feature engineering. The data collected from UAVs need to be processed and pre-processed to extract meaningful information that can be fed into the CNN model for accurate detection. The CNN model is designed to learn from the extracted features and classify the input images as either containing a forest fire or not. To achieve high accuracy, various optimization techniques such as data augmentation, regularization, and hyper parameter tuning can be employed. The achievements of the project include the development of a robust and accurate forest fire detection system that can detect forest fires in real-time using UAV imagery. The system can be integrated with fire authorities' control rooms to provide real-time alerts, enabling a prompt response to forest fires. The project has several benefits, including improving forest fire detection and response time, reducing the environmental and economic impacts of forest fires, and enhancing public safety. Additionally, the use of UAVs and CNNs in forest fire detection can reduce the risks associated with manual monitoring by human operators, thereby improving the safety of fire authorities. Overall, the project represents a significant contribution to the field of forest fire detection and has the potential to save lives, protect property, and preserve the environment.

Conflict of Interest: None

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