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Forest Wildfire Detection Using Machine Learning

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ABSTRACT: Deforestation is cutting trees of forests on a huge scale, often resulting in loss of habitat of millions of wild animals. About 30% of earth's land is still covered with forests but due to deforestation we are losing them at the rate of about half the size of England per year. In forests, tree cutting activities are illegal but due to shortage of manpower and other resources, governments are not very successful in curbing this menace. One way to stop this is to detect the tree cutting process in an early stage so that timely measures can be taken to stop the same. The simplest method of early detection of tree cutting is to regularly monitor the forest area either manually or using some automatic techniques. As tree cutting generates a lot of noise, it can be detected by regularly monitoring the acoustic signals inside the forest. An acoustic signature can provide valuable information about the activities of any intruder inside the forest. This paper proposes an algorithm for automatic detection of tree cutting in forest. The proposed algorithm is based on distance between parameters, along with CNN for comparison. The efficiency of the proposed algorithm is 92%. Fire outbreak is the common issue happening everywhere and the damage caused by this type of incidents is tremendous towards nature and human. Vision based fire detection systems have recently gained popularity as compared to traditional sensor based fire detection systems. However, the detection process by image processing techniques is very tedious. We proposed a fire detection algorithm using Convolutional Neural Networks to achieve high-accuracy fire image detection, which is compatible in detection of fire by training with datasets. Number of images in the datasets taken for fire and non-fire are 3696 and 541 respectively. Totally, there are 4237 images. These images are rendered from video containing fire and some of those from internet. Out of which 2857 images are resized and reshaped to convert as training dataset and 1921 for testing dataset. The model is trained by applying convolution, activation functions and max pooling operation. By using different batch sizes and epoch values, the model is trained. The accuracy of the model is 94%. Over the 1921 images, 1817 images are predicted correctly. Thus, we are getting with a high accuracy and high detection rate.

KEYWORDS: Forest wildfire detection, CNN, ML.

I. INTRODUCTION

Fire detection is a 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. Consequently, they cannot be used for covering large areas. 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. Video-based fire detection techniques are well suited for detecting fire in large and open spaces. Nowadays, closed circuit television surveillance systems are installed in most of the places monitoring indoors and outdoors. Under this circumstance, it would be an advantage to develop a video-based fire detection system, which could use these existing surveillance cameras without spending any extra cost. This type of system offers various advantages over those standard detection methods. For example, the cost of using this type of detection is cheaper and the implementation of this type of system is greatly simpler compared to those traditional methods. Secondly, fire detection systems respond faster compared to any other traditional detection methods because a vision based fire detection system does not require any type of conditions to trigger the devices and it has the ability to monitor a large area.

II. MAIN OBJECTIVE OF THE PROJECT

1. To Detect Fire in forest and Intimate: Detect Fire Using Fire Sensor and intimate through Message to concerned Person.
2. To send Notification to farmers and Forest Officials: An intimation alert is sent to farmer about animal presence. We Use Twilio Messenger to send intimation alert to farmer.

III. LITERATURE SURVEY

Before delving into the specific literature reviews, it is crucial to understand the broader context of the research landscape surrounding the detection and management of forest wildfire detection. Deforestation is cutting trees of forests on a huge scale, often resulting in loss of habitat of millions of wild animals. About 30% of earth's land is still covered with forests but due to deforestation we are losing them at the rate of about half the size of England per year. In forests, tree cutting activities are illegal but due to shortage of manpower and other resources, governments are not very successful in curbing this menace. One way to stop this is to detect the tree cutting process in an early stage so that timely measures can be taken to stop the same. The simplest method of early detection of tree cutting is to regularly monitor the forest area either manually or using some automatic techniques. As tree cutting generates lot of noise, it can be detected by regularly monitoring the acoustic signals inside the forest. An acoustic signature can provide valuable information about the activities of any intruder inside the forest.

[1] Content-based Retrieval and Real Time Detection from Video Sequences Acquired by Surveillance Systems. In this paper, a surveillance system devoted to detect abandoned objects in unattended environments is presented to which image processing content based retrieval capabilities have been added for making easier inspection task from operators. Video-based surveillance systems generally employ one or more cameras connected to a set of monitors. This kind of systems needs the presence of a human operator, who interprets the acquired information and controls the evolution of the events in a surveyed environment. During the last years efforts have been performed to develop systems supporting human operators in their surveillance task, in order to focus the attention of operators when unusual situations are detected. Image sequences databases are also managed by the proposed surveillance system in order to provide operators with the possibility of retrieving in a second time the interesting sequences that may contain useful information for discovering causes of an alarm.

[2] Robust Real-Time Periodic Motion Detection We describe new techniques to detect and analyse periodic motion as seen from both a static and a moving camera. By tracking objects of interest, we compute an object's self-similarity as it evolves in time. For periodic motion, the self-similarity measure is also periodic and we apply Time-Frequency analysis to detect and characterize the periodic motion. The periodicity is also analysed robustly using the 2D lattice structures inherent in similarity matrices. A real-time system has been implemented to track and classify objects using periodicity. Examples of object classification (people, running dogs, vehicles), person counting, and nonstationary periodicity are provided.

[3] Weapon detection using artificial Intelligence and deep learning for security applications; Harsha Jain Security is always a main concern in every domain, due to a rise in crime rate in a crowded event or suspicious lonely areas. Abnormal detection and monitoring have major applications of computer vision to tackle various problems. Due to growing demand in the protection of safety, security and personal properties, needs and deployment of video surveillance systems can recognize and interpret the scene and anomaly events play a vital role in intelligence monitoring. This paper implements automatic gun (or) weapon detection using a convolution neural network (CNN) based SSD and Faster RCNN algorithms. Proposed implementation uses two types of datasets. One dataset, which had pre-labelled images and the other one is a set of images, which were labelled manually. Results are tabulated, both algorithms achieve good accuracy, but their application in real situations can be based on the trade-off between speed and accuracy. SSD and Faster RCNN algorithms are simulated for pre labelled and self- created image dataset for weapon (gun) detection. Both the algorithms are efficient and give good results but their application in real time is based on a trade-off between speed and accuracy. In terms of speed, SSD algorithm gives better speed with 0.736 s/frame.

IV. METHODOLOGY

The methodology section outlines the systematic approach employed in this study to develop a framework for detecting forest wildfire using machine learning and neural network. The methodology encompasses the following key steps:

Remote Sensing Technology: Satellite imagery, drones, and other remote sensing technologies are used to monitor large forested areas. These technologies can detect changes in temperature, smoke, and infrared radiation, which are indicative of wildfires.

Fire Weather Monitoring: Meteorological stations are set up to monitor weather conditions such as temperature, humidity, wind speed, and precipitation. Certain weather conditions, like high temperatures, low humidity, and strong winds, increase the risk of wildfires and can help predict their occurrence.

Early Warning Systems: Automated early warning systems are implemented to detect anomalies in the environmental conditions and alert authorities about potential wildfire outbreaks. These systems can be based on AI algorithms that analyze data from remote sensors and weather stations in real-time.

Community Reporting: Encouraging and facilitating reports from the public regarding smoke sightings or signs of fire in remote areas. This can be done through dedicated hotlines, mobile apps, or online platforms, allowing citizens to play an active role in wildfire detection.

Aerial Surveillance: Utilizing helicopters or airplanes equipped with infrared cameras to conduct aerial patrols over forested areas. This allows for quick detection and monitoring of wildfires, especially in remote or inaccessible regions.

Ground Patrols: Deploying trained personnel to conduct ground patrols in high-risk areas, especially during periods of elevated fire danger. These patrols can identify and confirm the presence of wildfires, assess their size and behavior, and coordinate firefighting efforts.

Integration of Data and Analysis: Integrating data from various sources, including remote sensors, weather stations, aerial surveillance, and ground patrols, into a centralized system for analysis. Advanced algorithms and machine learning techniques can be used to analyze this data, identify patterns, and predict wildfire behavior.

Collaboration and Communication: Establishing effective communication and coordination among various agencies and stakeholders involved in wildfire detection and response, including fire departments, forestry departments, emergency management agencies, and research institutions.

Public Awareness and Education: Educating the public about the importance of wildfire detection, prevention, and early response. This includes raising awareness about fire safety practices, the risks associated with wildfires, and the role individuals can play in reducing fire hazards.

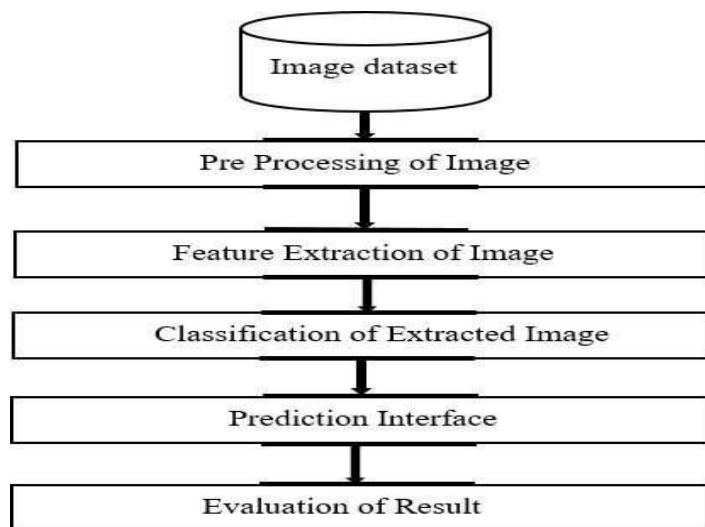


Fig 1: Image Segmentation

The methodology described above provides a structured approach for the development and validation of an integrated system for detecting and diagnosing vitamin deficiencies using image processing and neural network technologies.

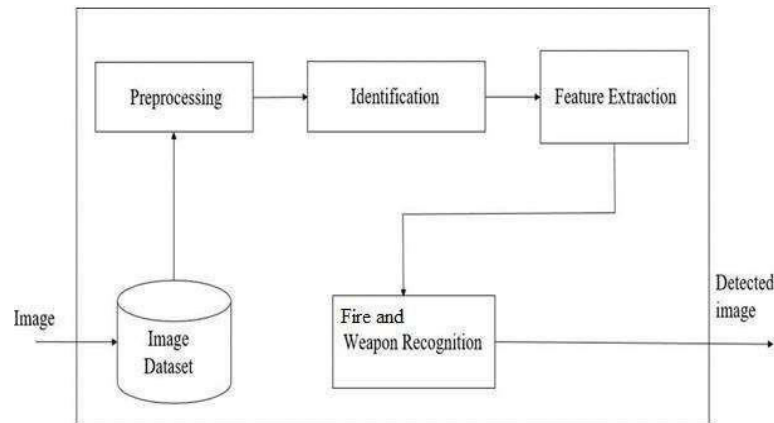


Fig 2: Architecture

V. EXISTING SYSTEM

Existing forest wildfire detection systems using machine learning integrate various data sources such as satellite imagery, weather data, and historical wildfire records. Through preprocessing and feature extraction, relevant information is extracted from these sources. Machine learning models, including decision trees, random forests, support vector machines, and deep learning architectures like convolutional neural networks, are trained on this data to classify potential wildfire occurrences. Once integrated into the detection system, these models continuously analyze incoming data to generate alerts when wildfire-like patterns are detected. Human verification ensures the reliability of alerts, and feedback loops facilitate ongoing improvement of the system's accuracy and efficiency over time.

VI. PROPOSED SYSTEM

The proposed system aims to overcome the limitations of existing methods by leveraging advancements in machine learning and neural network technologies. It comprises the following components:

Data Collection: Gather various data sources including satellite imagery, weather forecasts, historical wildfire records, and possibly ground sensor data.

Preprocessing: Clean and preprocess the collected data, including tasks like image preprocessing, data normalization, and feature extraction.

Feature Extraction: Identify relevant features indicative of wildfire risk such as vegetation density, weather patterns, terrain characteristics, and historical fire data.

Model Training: Train machine learning models on the extracted features using algorithms like decision trees, random forests, support vector machines, or deep learning architectures.

Real-time Analysis: Implement the trained models to analyze incoming data streams in real-time, continuously monitoring for anomalies suggestive of wildfire activity.

Alert Generation: Automatically generate alerts when the system detects potential wildfire occurrences based on the analyzed data, sending alerts to relevant authorities for rapid response.

Human Verification: Incorporate human verification to validate the alerts and reduce false positives, ensuring the reliability of the detection system.

Feedback Loop: Establish a feedback mechanism to iteratively improve the system's performance based on human feedback, adjusting model parameters and data sources as needed.

Scalability and Adaptability: Design the system to be scalable and adaptable to different geographical regions and environmental conditions, allowing for widespread deployment and effectiveness in diverse settings.

VII. APPLICATIONS

The proposed system for Forest wildfire detection using machine learning and neural networks offers a wide range of applications across various domains. Some of the key application areas include:

1. Early Warning Systems: Machine learning algorithms can analyze satellite imagery, weather data, and other relevant information in real-time to detect potential wildfire outbreaks. Early detection allows for timely intervention and mitigation efforts, reducing the spread and impact of wildfires.
 2. Wildfire Monitoring: Machine learning models continuously monitor forested areas for signs of wildfires, providing valuable insights into fire behavior, spread patterns, and potential risks to nearby communities and ecosystems.
 3. Risk Assessment and Prediction: By analyzing historical wildfire data along with environmental factors such as vegetation density, topography, and weather conditions, machine learning algorithms can assess wildfire risk levels in specific regions and predict the likelihood of future wildfires.
 4. Resource Allocation: Machine learning-based wildfire detection systems assist in optimizing resource allocation by accurately identifying areas at high risk of wildfires. This information helps authorities deploy firefighting resources, such as personnel, equipment, and aircraft, more effectively to areas where they are most needed.
 5. Urban-Wildland Interface Management: Machine learning algorithms can analyze spatial data to identify areas where human settlements encroach upon wildland areas (urban-wildland interface). By detecting wildfires early in these interface zones, authorities can implement preventive measures to protect both human communities and natural habitats.
 6. Post-Fire Analysis and Recovery: After a wildfire event, machine learning techniques can analyze satellite imagery and other data to assess the extent of damage, monitor vegetation recovery, and prioritize post-fire rehabilitation efforts.
- Overall, the application of machine learning in forest wildfire detection offers significant benefits in terms of early detection, risk assessment, resource allocation, and post-fire management, ultimately helping to mitigate the impact of wildfires on both human communities and natural environments.

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VIII. ADVANTAGES

The proposed system for Forest wildfire detection using machine learning and neural networks offers several advantages:

1. Improved Accuracy: Neural networks can learn complex patterns from large datasets, leading to more accurate detection of wildfires compared to traditional methods. Their ability to recognize subtle patterns in satellite imagery, weather data, and other environmental variables enhances the accuracy of wildfire detection.
2. Early Detection: Machine learning algorithms, especially neural networks, can detect wildfires at their early stages, allowing for prompt intervention and mitigation efforts. Early detection helps minimize the spread of wildfires, reducing property damage, loss of life, and environmental impact.
3. Real-time Monitoring: Machine learning-based wildfire detection systems can continuously monitor vast forested areas in real-time, providing timely alerts to authorities and emergency responders. This real-time monitoring capability enables swift response to emerging wildfire threats.
4. Adaptability: Neural networks can adapt to changing environmental conditions and evolving wildfire patterns. They can learn from new data and adjust their detection algorithms accordingly, making them versatile and effective in diverse geographical regions and environmental settings.
5. Reduced False Alarms: By incorporating advanced algorithms and sophisticated feature extraction techniques, machine learning models, including neural networks, can significantly reduce false alarms in wildfire detection systems. This improves the efficiency of firefighting resources by minimizing unnecessary deployments.
6. Scalability: Machine learning-based wildfire detection systems can scale to cover large geographic areas efficiently. They can analyze vast amounts of data from multiple sources simultaneously, making them suitable for monitoring expansive forested regions and urban-wildland interfaces.
7. Integration with Other Technologies: Machine learning techniques, including neural networks, can be integrated with other technologies such as drones, IoT sensors, and geographic information systems (GIS) to enhance wildfire detection and response capabilities further. This integration enables multi-modal data fusion and comprehensive situational awareness for decision-makers.

8. Continuous Improvement: Machine learning models can undergo continuous improvement through iterative training and feedback loops. By incorporating new data and insights, these models can continuously enhance their performance in wildfire detection, staying ahead of evolving fire risks and challenges.

Overall, the application of machine learning and neural networks in forest wildfire detection offers significant advantages in terms of accuracy, early detection, real-time monitoring, adaptability, and scalability, ultimately contributing to more effective wildfire management and mitigation efforts.

IX. CONCLUSION

In conclusion, the integration of machine learning techniques, including neural networks, in forest wildfire detection represents a significant advancement in early intervention and mitigation strategies. By leveraging vast amounts of data from sources such as satellite imagery, weather forecasts, and historical wildfire records, machine learning algorithms can accurately detect wildfires at their incipient stages, enabling prompt response and containment efforts. The advantages of machine learning-based wildfire detection systems, including improved accuracy, early detection capabilities, real-time monitoring, adaptability to changing conditions, and scalability across large geographic areas, make them invaluable tools for wildfire management and mitigation. With ongoing advancements in machine learning algorithms and technologies, coupled with the integration of diverse data sources and complementary technologies, forest wildfire detection systems are poised to become even more effective in safeguarding ecosystems, communities, and livelihoods from the devastating impacts of wildfires.

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