ISSN 2277-2685
IJESR/June. 2025/ Vol-15/Issue-3s/427-433
Annu Haripriya *et. al.*, / International Journal of Engineering & Science Research

Wildfire Detection

Bathini Pravalika, Annu Haripriya, Batkiri Harika
[1]assistant Professor, Department Of Cse, Bhoj Reddy Engineering College For Women, India.
[2,3,4]B. Tech Students, Department Of Cse, Bhoj Reddy Engineering College For Women, India.

ABSTRACT

Wildfires are becoming one of the most severe environmental challenges, posing significant threats to ecosystems, infrastructure, and human lives. The increasing frequency and intensity of wildfires, driven by climate change, deforestation, and human activities, demand efficient detection and mitigation strategies. This study Keywords on leveraging advanced deep learning techniques combined with satellite imagery to improve wildfire detection. By utilizing cutting-edge convolutional neural networks (CNNs), the proposed approach analyzes multi-spectral satellite data to identify fire-prone areas, detect active fires, and predict potential spread patterns. Real-time data integration from satellites such as Sentinel and MODIS enhances the system's accuracy, scalability, and response time. The model aims to revolutionize wildfire management by offering a robust, scalable, and efficient approach to early detection and prediction, ultimately reducing the devastating impacts of wildfires.

1. INTRODUCTION

Wildfires are among the most destructive natural disasters, causing immense harm to ecosystems, wildlife, human lives, and infrastructure. As climate change accelerates, the frequency and intensity of wildfires have risen significantly, making early detection and rapid response more crucial than ever.

The proposed system aims to address this challenge by leveraging advanced deep learning techniques, particularly Convolutional Neural Networks (CNNs), to process and analyse multi-spectral satellite imagery. These technologies enable accurate detection of fire-prone regions, identification of wildfire zones.

CNNs are employed for spatial feature extraction from satellite images, efficiently identifying fire signatures like heat zones and smoke patterns.

To ensure timely action, the system includes an automated email alert mechanism. Upon detecting a potential or active wildfire, the system immediately sends real-time alerts via email to relevant authorities, disaster response teams, and nearby residents. These alerts contain vital information, enabling quick mobilization of firefighting resources and evacuation procedures if necessary.

This intelligent, end-to-end wildfire monitoring framework not only improves detection accuracy and response speed but also plays a vital role in minimizing environmental and human losses.

Existing system

Traditional wildfire detection methods primarily depend on a combination of ground-based sensors, human patrols, and aerial surveillance techniques like drones or helicopters. These methods involve physical monitoring of forests and vulnerable areas to identify signs of wildfire outbreaks, such as smoke, rising temperatures, or direct fire observation.

While these systems have contributed significantly to wildfire monitoring, they come with various challenges that limit their effectiveness.

Proposed System

The proposed system is an advanced wildfire detection framework that leverages deep learning techniques, specifically Convolutional Neural Networks (CNNs), to analyse and interpret satellite imagery for the early and accurate identification of wildfires. Unlike traditional methods that rely heavily on human observation, ground sensors, or aerial patrols, this system is designed to operate autonomously by processing multi-spectral satellite data, including optical, thermal, and infrared bands.

CNNs are capable of learning complex spatial features and patterns, enabling the model to detect early fire indicators such as heat signatures, smoke plumes, burn scars, and abrupt changes in vegetation. The model is trained using a large, labelled dataset of wildfire and non-wildfire satellite images, which helps it differentiate real fire outbreaks from other heat sources like urban structures, solar reflections, or industrial emissions. Once a fire is detected, the system immediately generates a visual output highlighting the affected area and then triggers an automated real-time email alert mechanism. These alerts are sent to emergency response teams, forest departments, disaster management authorities, and local communities, containing essential information such as the exact coordinates, timestamp, confidence level of detection, and an image snippet of the fire zone.

This integration of intelligent image analysis and real-time communication ensures faster response, improved coordination, and efficient resource mobilization. Furthermore, the system is scalable and adaptable to different geographical regions and can be retrained with new data to improve detection capabilities. With high accuracy, speed, and automation, the proposed system provides a significant technological advancement in wildfire monitoring, helping to mitigate environmental damage and safeguard human lives.

2-REQUIREMENTS ANALYSIS

Functional Requirements

The system comprises 1 module. It is as follows:

User:

Input test data: User can select their input image.

View result: It predicts the presence of wildfire based on the image

Non - Functional Requirements

Accuracy

Accuracy is one of the most critical aspects of the wildfire detection system. The system must be designed to identify the presence of wildfires with high precision, ensuring that both false positives (incorrectly identifying fire when there is none) and false negatives (failing to detect an actual wildfire) are minimized. This is particularly crucial in emergency response scenarios, where a false positive may trigger unnecessary resource deployment and public panic, whereas a false negative can lead to catastrophic environmental and human consequences. The deep learning model, particularly the CNN, should be trained on a large, diverse dataset that covers various terrains, lighting conditions, seasons, and fire types to ensure robust and accurate predictions across different scenarios. Continuous evaluation using metrics like Precision, Recall, F1 Score, and Confusion Matrix analysis will ensure the system maintains its high standards of accuracy over time.

Reliability

Reliability refers to the system's ability to operate continuously and correctly under predefined conditions without unexpected failures or breakdowns. For wildfire detection, reliability is paramount as the system is often deployed in critical, real-time monitoring environments where any downtime or incorrect functioning can delay necessary actions. The system should be stress-tested against a wide range of environmental inputs, such as cloud cover, smoke, fog, and varying resolutions of satellite images. It should also handle large file uploads and concurrent user requests without performance degradation. Furthermore, regular system updates, error handling mechanisms, fallback operations, and system health monitoring tools should be integrated to ensure consistent and uninterrupted operation.

Performance

Performance in this context refers to the speed and efficiency with which the system processes large volumes of satellite data and delivers detection results. Given the potential size of satellite images and the need for rapid response in the event of a wildfire, the system must employ high-performance computing techniques and optimized CNN architectures to reduce processing time. Techniques like GPU acceleration, image tiling, and parallel processing can be implemented to ensure that detection results are generated in real-time or near-real-time. The goal is to allow authorities to react swiftly, minimizing the spread of fire and mitigating damage. Benchmarking against defined latency thresholds and load testing under peak conditions should also be performed to validate the system's performance.

Hardware Resources

- Processor : i5 processor
- RAM : 4GB
- Hard Disk : 50GB

Software Resources

- Operating System : Windows 11
- Programming Languages : HTML, CSS, Python
- Framework : Flask
- Tool manager : Anaconda Navigator
- IDE : Visual Studio

3. DESIGN

The system architecture consists of a front-end built with HTML, CSS, and JavaScript for user interaction, and a back-end using Python to process satellite images through a CNN model. It enables users to upload satellite images and receive wildfire detection results in real-time. The architecture ensures smooth communication between the user interface and the processing logic, providing an efficient and user-friendly wildfire detection and alerting system.

Software Architecture:

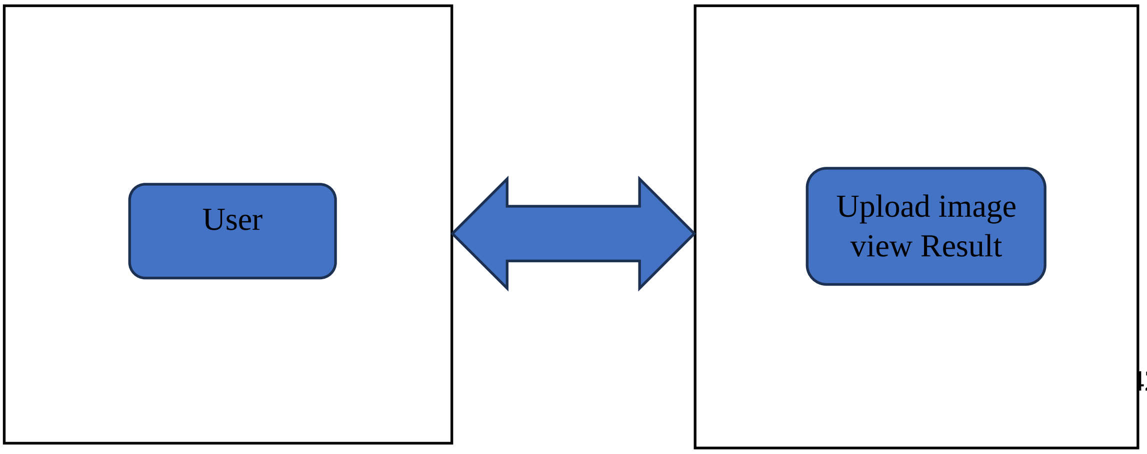


Fig 3.1 Software Architecture

Technical Architecture

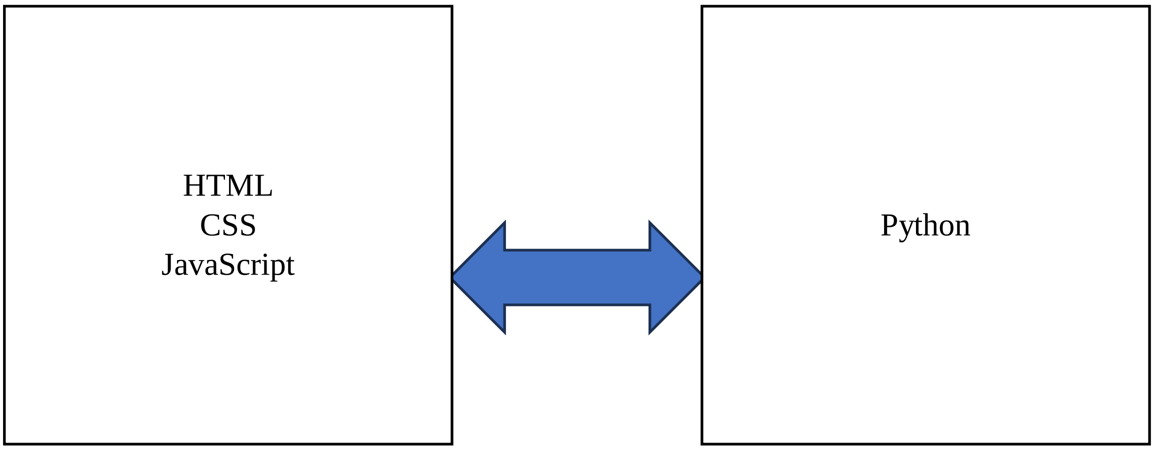


Fig 3.2 Technical Architecture

4-IMPLEMENTATION

Python

Python is a powerful, high-level, and general-purpose programming language that emphasizes code readability and simplicity. It was created by Guido van Rossum and first released in 1991. Since its inception, Python has gained immense popularity across various domains such as web development, data analysis, artificial intelligence, machine learning, automation, and scientific computing. One of the main reasons for Python's widespread adoption is its easy-to-understand syntax, which allows developers to write fewer lines of code compared to other programming languages. This simplicity makes Python an excellent choice for beginners, while its rich set of libraries and frameworks makes it highly effective for advanced applications. Python is an interpreted language, meaning code is executed line-by-line, which helps in faster debugging and prototyping. It also supports multiple programming paradigms including procedural, object-oriented, and functional programming, offering great flexibility to developers. The language boasts a vast ecosystem of libraries that cater to a wide range of tasks. In the field of machine learning and deep learning, libraries like TensorFlow, Keras, PyTorch, and OpenCV provide powerful tools for building and training complex models. These features make Python the preferred language for researchers and developers working on intelligent systems like our wildfire detection project.

Features of Python

Simple and Easy to Learn: Python has a clean and straightforward syntax that is similar to English, making it easy to read and write. It is especially beginner-friendly and ideal for students, researchers, and professionals alike.

Interpreted Language: Python is an interpreted language, meaning code is executed line by line. This makes debugging easier and allows for quick testing and development.

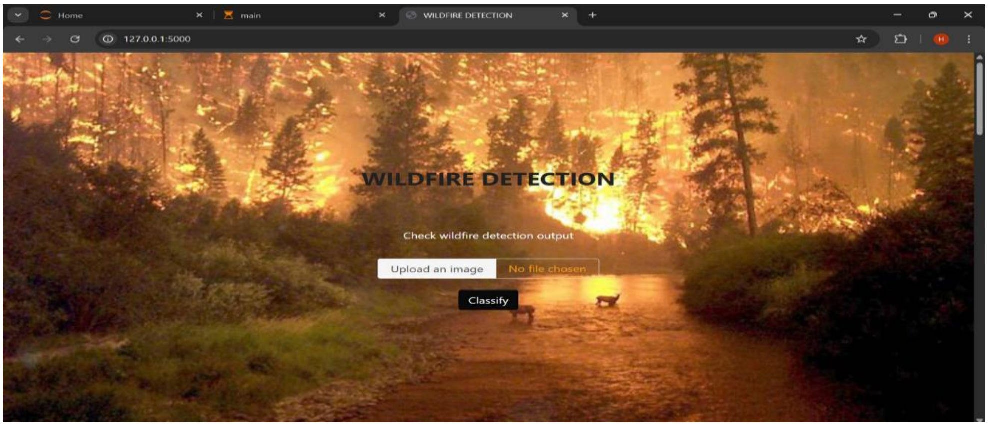
Dynamically Typed: There is no need to declare the data type of a variable explicitly. Python automatically identifies the type during execution, making the code more flexible and concise.

High-Level Language: Being a high-level language, Python abstracts many low-level details such as memory management, allowing developers to focus on problem-solving rather than hardware complexities.

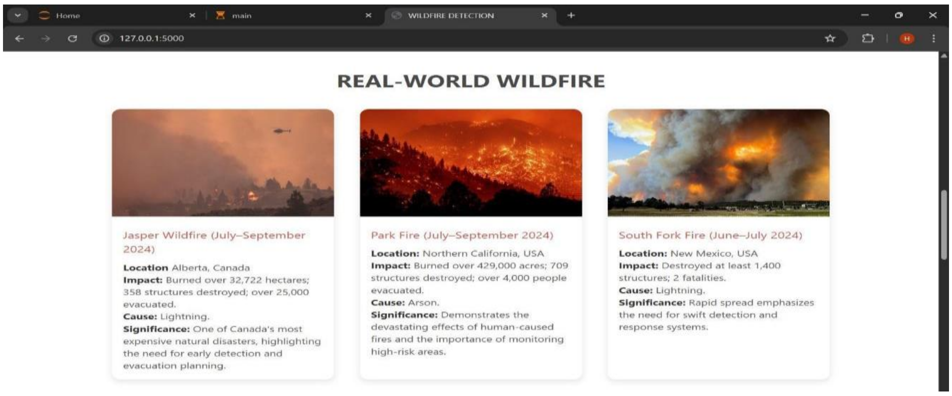
Extensive Standard Library: Python comes with a rich standard library that supports many common tasks such as file handling, regular expressions, threading, database interaction, and more—without needing to install external packages.

Portable and Cross-Platform: Python code is platform-independent. You can write a program on one operating system (like Windows) and run it on another (like Linux or macOS) with little or no modification.

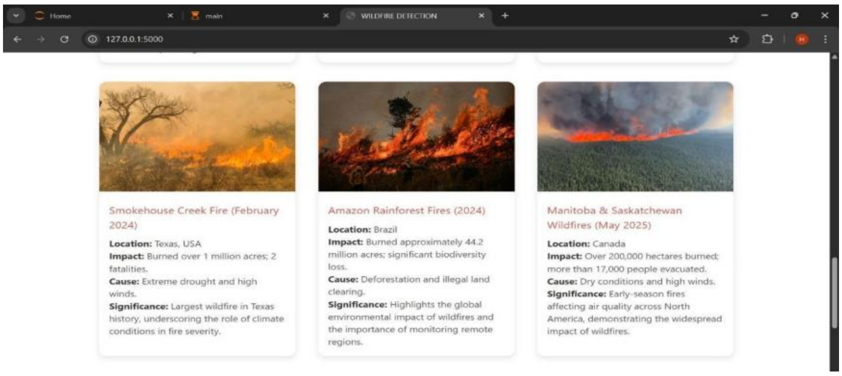
5-SCREENSHOTS



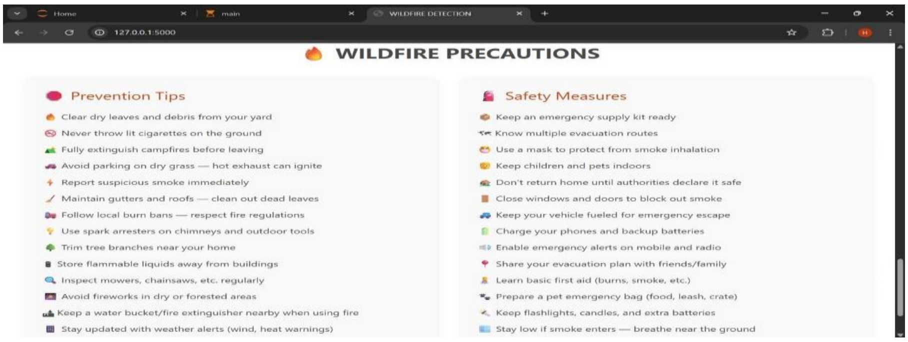
1 Homepage for the website



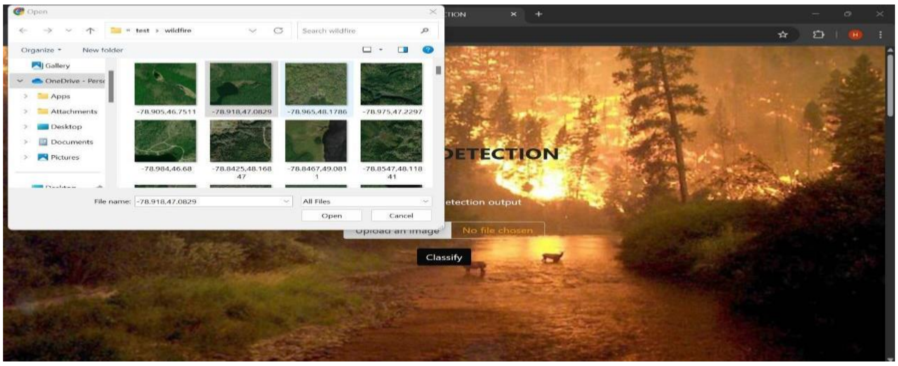
2 Homepage for the website



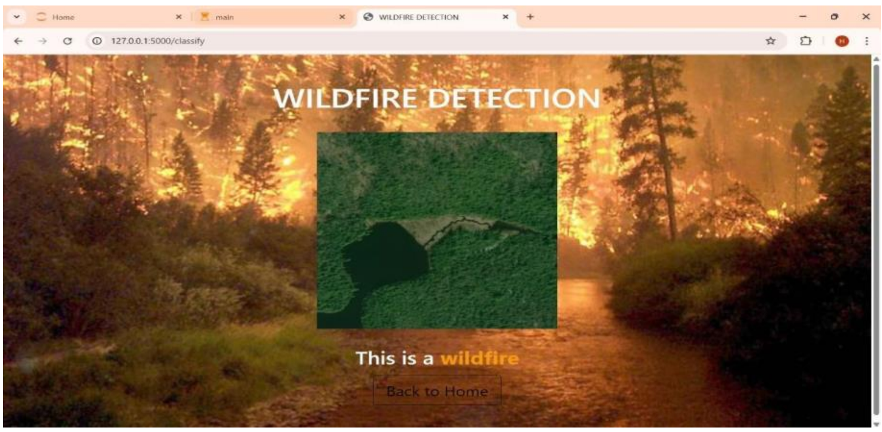
3 Homepage for the website



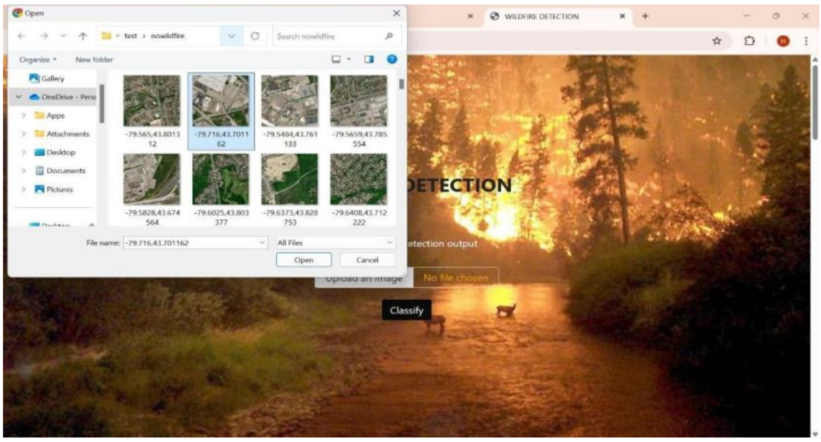
4 Homepage for the website



5 Image uploading for detection



6 Wildfire Detected



7 Image uploading for detection

6-CONCLUSION

The wildfire detection system developed using Convolutional Neural Networks (CNN) successfully demonstrates the capability of deep learning techniques in accurately identifying wildfire occurrences from images. Through effective training and testing, the model achieved promising results in distinguishing wildfire scenes from non-wildfire images, highlighting its potential for early detection and prevention efforts. This project showcases how Python and CNN can be leveraged to build intelligent systems that aid in mitigating wildfire risks, ultimately contributing to environmental protection and public safety. Further improvements and real-time deployment can enhance the system's practical impact.

REFERENCES

[1] D.L. Martell, H. Sun, "The impact of fire suppression, vegetation, and weather on the area burned by lightning-caused forest fires", in Ontario. Canadian Journal of Forest Research-revue Canadienne De Recherche Forestiere, 2020, pp. 1547-1563.

[2] M. Flannigan, B. Amiro, K. Logan, B. Stocks, M. Wottom, "Forest Fires and Climate Change", in the 21st Century. Mitigation and Adaptation Strategies for Global Change, 2021, pp. 847-859.

[3] H. Huang, C. Li, X. Wang, X. Zhou, "Integration of multi-resource remotely sensed data and allometric models for forest aboveground biomass estimation in China", Remote Sensing of Environment, 2021. Vol. 221. Pp. 225-234.

[4] O. Ghorbanzadeh, T. Blaschke, K. Gholamnia, D. Tiede, "Evaluation of different machine learning methods and deep-learning convolutional neural networks for landslide detection", Remote Sensing, 2020. Vol 11(2). Pp. 1-21.