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SAFEGUARDING FOREST ECOSYSTEM FROM WILDFIRE AND SMOKE USING DEEP LEARNING TECHNIQUES

Dr.N.Priya[1], Neethu Veronika R[2], C. Yamini[3]

[1]Associate professor, Head of the Department, PG Department of Computer Science,
Shrimathi Devkunvar Nanalal Bhatt Vaishnav College for Women,Chrompet,Chennai-44
[2]M.Sc Computer Science, PG Department of Computer Science,
Shrimathi Devkunvar Nanalal Bhatt Vaishnav College for Women,Chrompet,Chennai-44
[3]Research Scholar, Department of Computer Science,
Shrimathi Devkunvar Nanalal Bhatt Vaishnav College for Women,Chrompet,Chennai-44
Email: drnpriya2015@gmail.com[1], neethuveronica27@gmail.com[2], chivkulayamini@gmail.com[3]

ABSTRACT

Ecosystems, human lives and property faces threats due to wildfire. Detecting them and forming a prompt response system are crucial to mitigate the devastating impacts of wildfires. Detection of forest fire and its corresponding smoke detection using deep learning techniques has become a notable one in recent years, offering the potential for enhanced accuracy and efficiency in early fire detection systems. This project is carried out in manual net ,squeeze net , shuffle net and analyse various types of data, including satellite imagery, thermal images, and video feeds, to identify patterns indicative of fire and smoke outbreaks. By training these models on diverse datasets and incorporating advanced algorithms for feature extraction and classification, such approaches have demonstrated the capability to swiftly and accurately detect forest fires, enabling timely intervention to mitigate their devastating impacts on ecosystems and human communities.

KEYWORDS: *Forest fire, Wildlife, Smoke-detection, Temperature.*

INTRODUCTION

The detection of forest fires is crucial for timely response and mitigation of their devastating impacts on ecosystems, wildlife, and human lives. Sensor-based systems or human detectors were the traditional methods of forest fire detection, which can be limited by factors such as coverage area, sensitivity, and real-time data processing capabilities. In recent years, there are various advance techniques discovered that shows promise in enhancing both the accuracy and efficiency of forest fire detection systems.

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The deep learning-based approaches offer the potential to revolutionize forest fire detection by providing faster, more reliable, and scalable solutions for early fire detection and prevention. In this project, deep learning techniques are explored as well as their effects and challenges being highlighted and future research progress being updated.

LITERATURE SURVEY

Marta Pena et.al[1] speaks about the implementation of Deep-Learning based detection of forest fire using an open-source dataset and a novel multi-task learning approach. The efficacy of using RGB imagesfor detection of forest fire through deep learningalong withtheirpros and cons are discussed. Here, wildlife dataset is considered with various types of forests and geographical locations. It intends to reduce the number of times there are false alarm in fire-detection. The study aims to improve discriminatory research and reduce false positives. They exhibit superior performance and lowered false alarm rates comparatively.

Syed Mohammed Usman et.al[2] has implemented the detection of forest fires with the use of aerial images. The urgent need of early wildfire detection is discussed, emphasizing the substantial impact of these destructive events on both ecosystems and lives. Focusing on UAV-monitored fire locations, the research introduces a deep learning model based on YOLOv5 for forest fire detection. By analysing video frames systematically, the model attains high accuracy when compared to existing systems, with a notable F1-score of 94.44% on Fire Net and FLAME aerial picture datasets. The above-described method speaks on enhancing forest fire management as well as reducing risks for firefighters, with the use of recent advancements in aerial imagery and UAV technology.

Chakma Bashar et.al[3] has implemented the Wildfire and Smoke Detection Using Staged YOLO Model and Ensemble CNN. The research contributes to existing knowledge by proposing a two-stage ensemble approach, leveraging multiple CNN architectures for wildfire and smoke detection. The model integrates YOLO architecture and a voting ensemble CNN, functioning sequentially to classify abnormal frames and precisely locate smoke or fire. Notably, the model achieves high performance metrics, including a 0.95 F1-score and 0.99 accuracy for classification, and an 0.85 mAP@0.5 score for smoke detection. Despite encountering issues related to the scarcity of high-quality real-world UAV-captured images, there is promising experimental results received.

Mubarak A et.al[4] has implemented theForest Fire Detection with the use of Rule Based Image Processing Algorithm alongside with Temporal Variation Forest fires pose a significant threat to both economic properties and public safety, with over 200,000 incidents reported annually worldwide, resulting in the destruction of millions of hectares of land. Traditional sensor-based fire detection systems, relying on physical and chemical parameters, face challenges in large open areas due to high costs, energy consumption, and susceptibility to physical damage. These systems also exhibit high false alarm rates and delayed response times. The literature suggests a shift towards image processing-based methods for fire detection, capitalizing on advancements in digital camera technology, cost-effectiveness, and the ability to cover large areas efficiently. The advantages of this method would be that the costs are lowered and faster response times and this provides us a promising avenue for wildfire prediction.

Byeong-Uk Lee et.al[5]Researchers have developed a large-scale synthetic dataset for disaster scenarios, featuring over 300K high-resolution stereo image pairs. The dataset consists of images taken after and before earthquakes and other disasters along with their locations tagged. This dataset is taken here to train the model for better localization as well as to recognize disaster situations quickly. Their method includes a CNN-based egocentric localization approach, where the changes in the location due to these disasters are found as well. A new model is proposed where shape-based representations of locations are considered. Experimental results demonstrate the reliability of their approach in predicting camera poses despite significant changes in scene layout.

N V Ganapathi Raju1 et.al[6] The paper proposes using Convolutional Neural Networks (CNNs) for detecting cyclones and earthquakes, aiming to improve disaster preparedness and management. Data from Kaggle is utilized for training the models. In case of communication failures, the system sends SMS alerts to notify people. The study includes a comparison of CNN and its variants for disaster detection. Overall, the application focuses on forecasting, warning, and managing natural disasters.

TABLE 1: Literature Review

S.NO	AUTHOR	YEAR	METHOD USED	BENEFITS
1.	Mubarak A	2018	Image Processing-Based Fire Detection	Cost-effective with lower overall system costs
2.	Marta Pena	2021	Deep Learning Models, Multi-Task Learning	Explores the extent of RGB research data and its optimum capability to aid the research
3	Syed Mohammed Usman	2022	YOLOv5, Deep Learning, Aerial Imagery, Drones, UAVs	Improved fire management and forecasting
4.	Chakma Bashar	2023	YOLO Architecture, Convolutional Neural Network(CNNs), Ensemble Learning	Early discovery of forest fires and smoke
5.	Byeong-uk lee	2023	Proposed Egocentric Localization Method	Annotation of Ground-truth Data

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CHALLENGES

Creating a good wildfire detection system using advanced tech is hard. It needs to work well in different situations and use lots of data for training. Making Convolutional Neural Networks (CNNs) and Sci-Kit Learn work together needs careful adjustments for accuracy and speed. Understanding why the system predicts wildfires is also important for trust and improvement. Handling real-time processing challenges for quick responses is tough, needing the system to be fast.

Making sure the system can grow and stay effective as wildfires change and tech improves is an ongoing challenge.

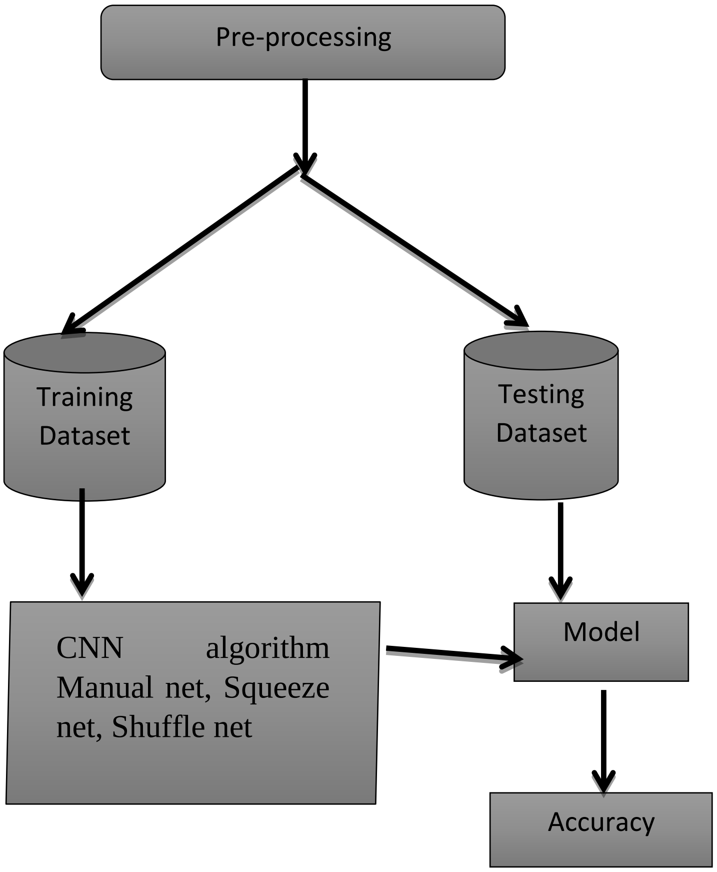
PROPOSED SYSTEM

- We develop a framework-based application for deployment purpose.
- Accuracy is improved.
- Our process requires less compute power.
- We compared three architectures to getting better accuracy level.

MODULES:

- DATASET
- MANUALNET
- SQUEEZENET
- SHUFFLENET
- DEPLOYMENT

Figure 1 – Flow Diagram Depicting the Proposed System



DATASET

The dataset consists of 876 images totally with them being divide into 3 different classes. The class containing 250 images for Fire dataset,non-fire dataset has 404 images and 222 images for smoke dataset. The dataset is split into test and train and the dataset is download from Kaggle.

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Figure 2 – Sample images-sets from dataset

MANUAL NET

The Keras preprocessing image data generator is used here toimport the data set where we can also create and resize, rescale, range, zoom range, horizontal flip the images. Then the image dataset is imported through the data generator function. Here we train the data, test the image data, and validate them also we set target size, batch size and class-mode from this function.

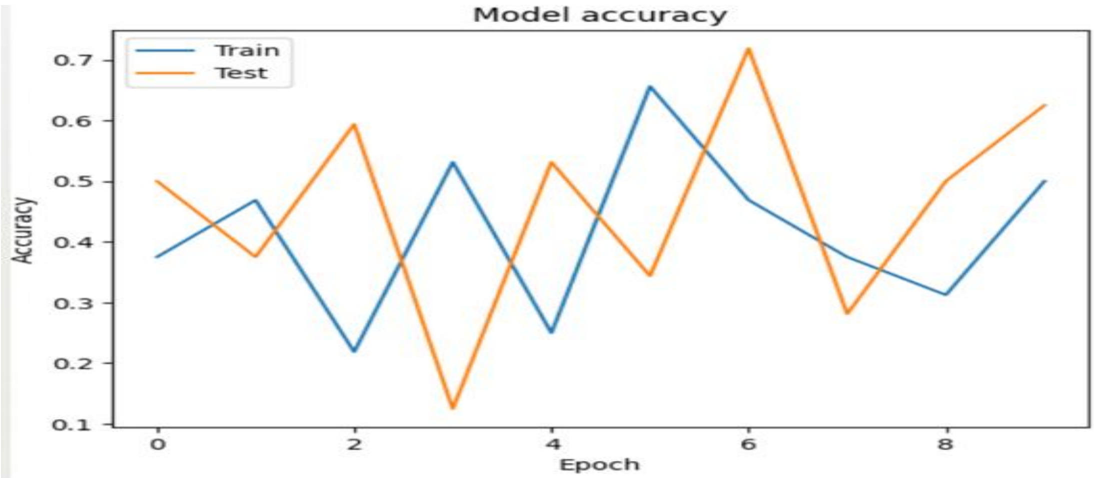

Figure 3 – Model accuracy in Manual net

SQUEEZE NET

A deep convolutional neural network architecture specifically designed to be lightweight and highly efficient, making it suitable for deployment on resource-constrained devices such as smartphones and embedded systems. Developed by researchers at DeepScale and UC Berkeley, SqueezeNet achieves remarkable compression without compromising accuracy by employing several innovative design strategies.

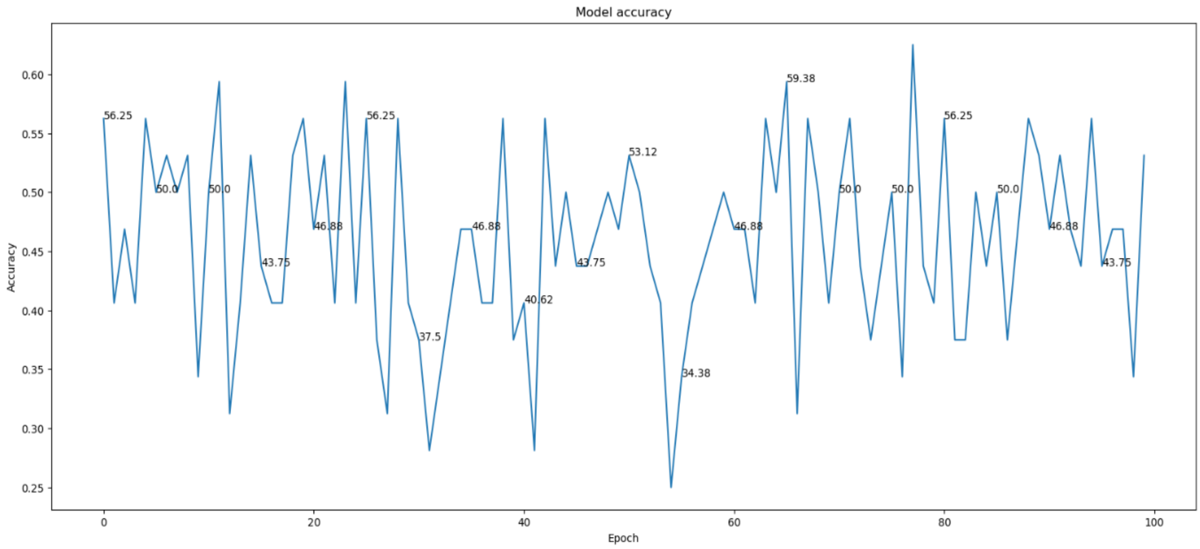

Figure 4 –Model accuracy in Squeeze net

SHUFFLE NET

Shuffle Net is a deep neural network architecture designed for efficient computation on resource-constrained devices. It was introduced to address the challenges of deploying large and computationally intensive models on devices with limited processing power and memory.

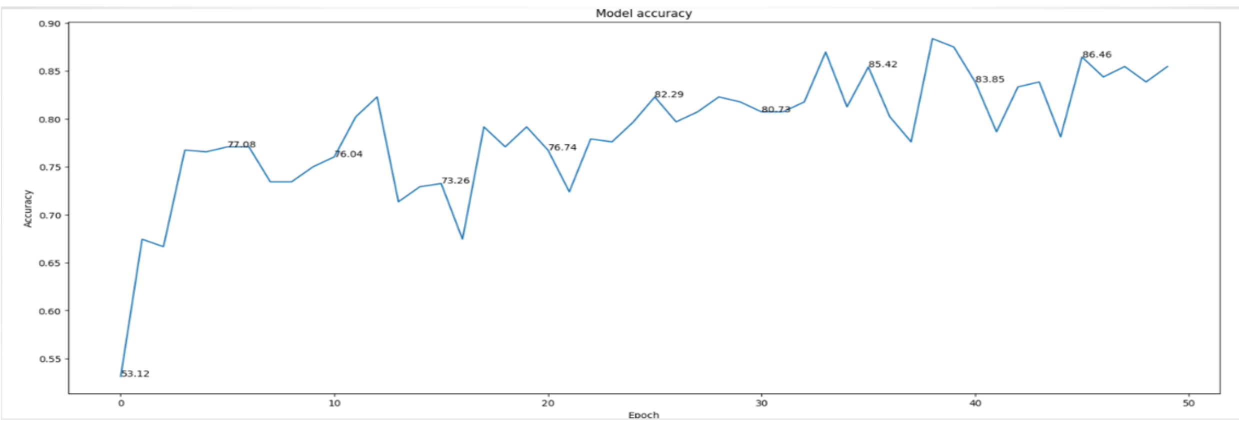

Figure 5 –Model accuracy in Shuffle Net

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DEPLOYMENT

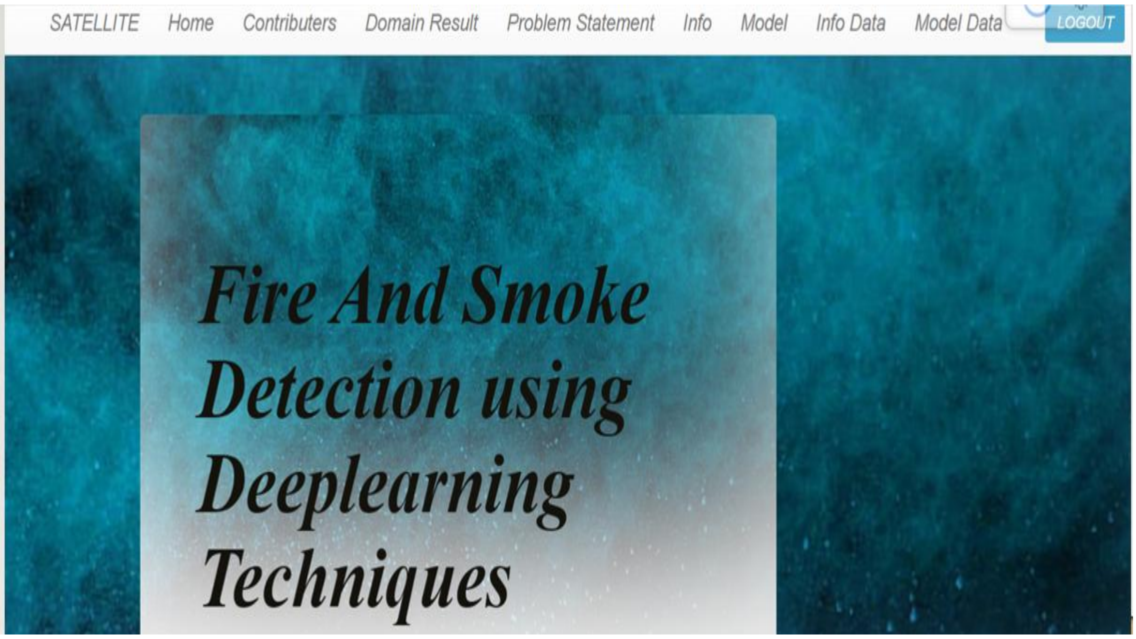

Figure 6 – Project Homepage

RESULTS

After the deployment of the mentioned algorithm, the results that are received are discussed below. Each result has been received after testing them using the wide range of the dataset mentioned. The accuracy of the models in testing are discussed through the figures 3 – for Manual Net, 4 – for Squeeze Net ,5 – for Shuffle Net. The below results discuss the findings where the presence of fire in the given image is available or not. Furthermore, the temperature detected is also given in the result itself.

Figure 7 describes the result where there if fire in the given image and also the approximate temperature detected is given for that image.

Figure 8 describes the result where in the given image no fire is present and then approximate temperature detected is given for that image.

Figure 9 describes the result where there is no fire in the given image, but the presence of smoke alone is depicted there and also the approximate temperature detected is given for that image.

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Figure 7 - Fire Image

Figure 8 - NON-FIRE IMAGE

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Figure 9 - SMOKE IMAGE

CONCLUSION

Detection of forest fires using deep learning techniques represents a significant advancement in early warning systems for environmental conservation and disaster management. By harnessing the power of convolutional neural networks (CNNs) and other deep learning architectures, this project enables the automated identification of smoke plumes, flames, and other indicators of wildfires from various sources like satellite imagery, drones, or surveillance cameras. By training these models on vast datasets containing images of both fire and non-fire scenarios, they can learn to accurately distinguish between normal environmental variations and potentially hazardous situations. Such systems offer the potential to provide timely alerts to authorities, allowing for swift response efforts to mitigate the spread of wildfires, thereby safeguarding ecosystems, property, and human lives.

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