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Deep Learning Based Fire Detection and Fire Extinguisher Using Sound Wave

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Abstract: Forest fires pose a significant threat to both human life and the environment, resulting in devastating losses of forests, properties, and homes. These recurring disasters are a global concern, prompting extensive research and the development of various solutions to address the issue. Detecting and combating forest fires have been particularly challenging, especially when dealing with vast forested areas. In this study, we propose a novel approach that leverages modern technologies, specifically Artificial Intelligence (AI) and computer vision methods. By utilizing convolutional neural networks, our platform aims to accurately recognize and detect smoke and fire from still images or video input obtained through cameras. The success of the method relies on the choice of the algorithm and the quality of the datasets used, which will be split into training and testing sets for evaluation. Through this innovative approach, we hope to contribute to the effective prevention and early detection of forest fires, safeguarding ecologically healthy forests and the environment.

Index Terms: Forest fires, natural properties, ecological menace, global disasters, research solutions, forest fire detection, ecologically healthy forests, environmental protection.

I. INTRODUCTION

Forests play a crucial role in maintaining the ecological balance of the Earth. However, forest fires often go unnoticed until they have spread extensively, making control and containment challenging, and leading to devastating losses and irreversible damage to the environment and atmosphere. Forest fires are a significant source of carbon dioxide (CO2) emissions, contributing to global warming and disrupting local weather patterns. Detecting and responding to fires rapidly is essential to prevent their uncontrollable spread. Efficient forest fire detection requires early identification and swift action. It involves deploying fire-fighting equipment and skilled personnel to the fire's origin promptly. A comprehensive approach to forest fire detection and suppression includes various systems tailored to wildfire risks, area size, and human presence. These systems encompass early detection methods, remote sensing techniques, logistics, personnel training through simulation, and the use of fire-fighting vehicles. Different sensing techniques are applied based on risk levels, area size, and human presence. Local staff may observe small high-risk areas, while satellite and aero monitoring are suitable for vast and low-risk regions. In some areas, camera-based systems installed on observation towers are used to monitor forests. When a fire is detected, an alarm is triggered, alerting the fire brigade for immediate action. Wireless Sensor Networks (WSNs) are integral to the Internet of Things (IoT) systems, offering valuable applications for environmental monitoring. Implementing gas sensors and smoke detectors in the sensor system enhances early fire detection, especially when video-based systems encounter disturbances like steam, fog, or dust pollution, leading to false alarms. The gas sensors can analyze fire gases carried by the airflow and are protected from external factors like dust and humidity, ensuring accurate and reliable detection. For early forest fire detection, a platform employing unmanned aerial vehicles (drones) equipped with specialized optical and thermal cameras is proposed. These drones will patrol the designated areas continuously, capturing multispectral images and videos to monitor fire-related events effectively. Unlike stationary cameras, the drones provide flexibility and a dynamic view of the territory, improving the efficiency of forest fire detection in outdoor environments.

II. EXISTING SYSTEM

Detecting forest fires early is crucial to prevent their rapid spread and escalation into larger, more dangerous blazes. The previous project utilized data from topography, weather, population, and drought conditions for forest fire monitoring. Sensors were employed to identify potential fire sources, and a machine learning model was developed to predict early forest fires.

1) False alarms: Dust, humidity, or temperature changes can trigger false alarms, leading to unnecessary panic.
2) Limited coverage: Installing multiple sensors is often necessary, increasing installation and maintenance costs.
3) Maintenance requirements: Regular maintenance is essential, as failure to do so can result in false alarms or failure to detect real fires.

4) Cost: Sensors can be expensive to install and maintain, especially in larger areas.

III. PROPOSED SYSTEM

1) Forest fires have significant environmental impact, leading to habitat destruction, biodiversity loss, and soil damage. Detecting fires early and responding promptly can minimize ecosystem damage.
2) The proposed system uses a CNN algorithm, a powerful machine learning model, to accurately classify images as "fire" or "no fire."
3) The system is trained on a large dataset of labeled images, enabling it to learn complex features and patterns through multiple layers of convolutional and pooling
4) Improved accuracy: CNNs excel at pattern recognition, achieving high accuracy in image classification tasks
5) Faster response times: Deep learning algorithms like CNNs enable swift responses in fire detection events
6) Scalability: The system can adapt to various environments, from small to large areas.
7) Automated monitoring: It can autonomously monitor extensive regions, detecting fires without human intervention.

IV. MODULE DESCRIPTION

A. Image Capture

This module is responsible for capturing images or frames of the scene to be monitored using a camera or sensor. This could be a live video stream or still images.

B. Dataset Preprocessing

The raw data captured by the Image Capture module needs to be preprocessed before it can be used to train a model. This involves tasks such as image resizing, normalization, and augmentation to increase the diversity of the data.

C. Features Extraction

This module extracts relevant features from the preprocessed images. In the case of CNNs, this is typically done through convolutional layers that learn to detect low-level features such as edges and corners, which are then combined to learn more complex features.

D. Images Segmentation

This module segments the image into regions of interest, such as smoke or fire, based on the features extracted in the previous module. This could be done using techniques such as thresholding, edge detection, or clustering.

E. Classification

This module classifies the segmented regions as either smoke or fire. This is done using a trained model, such as a pre-trained CNN, that has learned to classify images based on their features.

F. Serial Communication with Arduino

Once the image has been processed and fire/smoke has been detected, this module establishes serial communication between the PC and the Arduino Uno microcontroller to send the relevant data to activate the Sonic Fire Extinguisher.

G. Sound waves fire Extinguisher

This module uses high-frequency sound waves to put off the fire detected by the CNN algorithm. The sound waves are generated by the speaker and amplifier circuit connected to the microcontroller, which is stored on the SD card. The microcontroller reads the sound files from the SD card and generates high-frequency sound waves to extinguish the fire.

V. ALGORITHM FORMULATION

A. Convolutional Neural Network

Convolutional Neural Network (CNN) is a type of deep learning algorithm used for computer vision tasks like image classification and face recognition. CNNs extract features from images and reduce their dimensions without losing essential characteristics.

They consist of various layers, including the input layer, convo layer (feature extractor), pooling layer (to reduce spatial volume), fully connected layer (for classification), and the surtax/logistic layer (for multi-classification). CNNs' advantages lie in their ability to handle large image datasets efficiently and automatically learn essential features, making them widely used in computer vision applications.

VI. SYSTEM DESIGN

A. Architecture Diagram

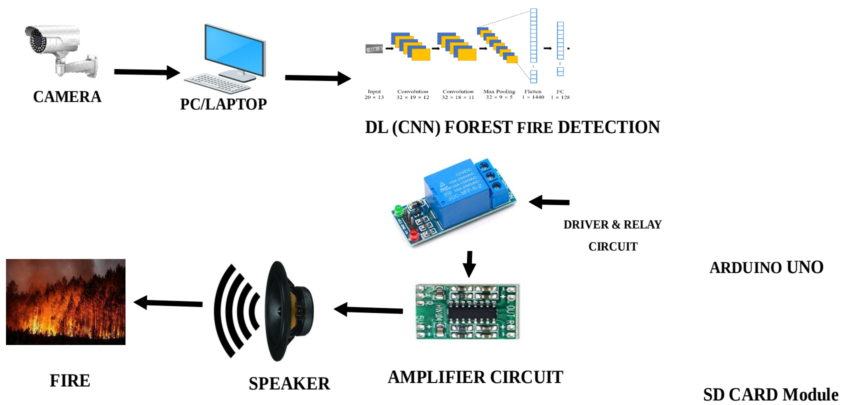

Fig1. Architecture Diagram

B. Hardware Kit

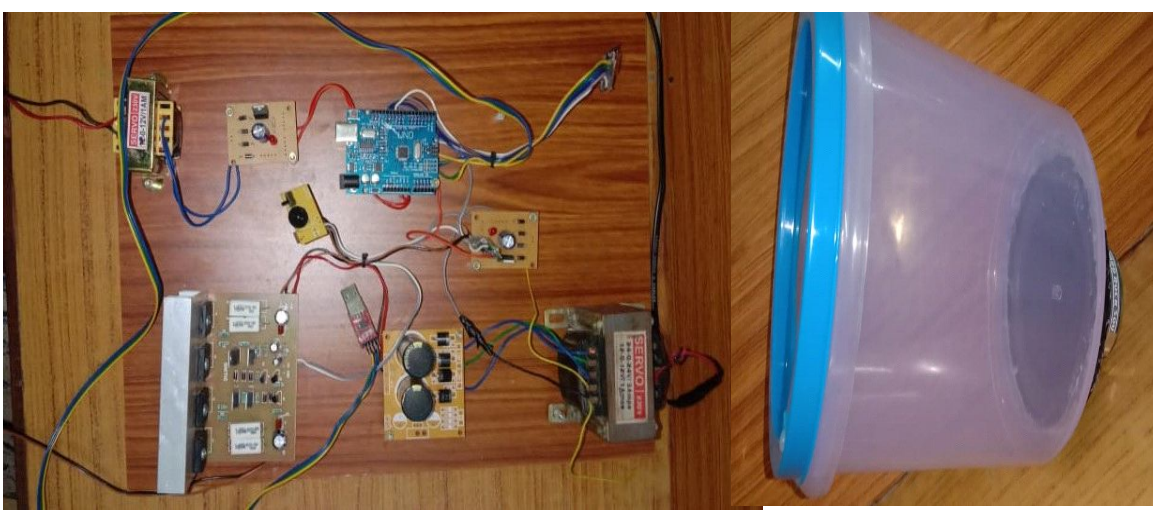

Fig2. Hardware Kit

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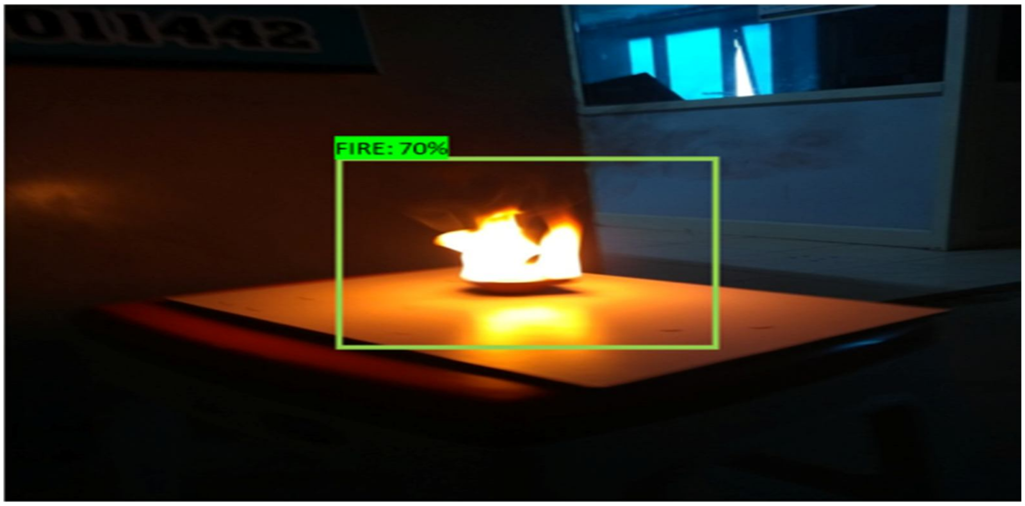
VII. OUTPUT SCREEN



FIRE
Fig 3. Fire

NO FIRE
Fig 4. No Fire

VIII. CONCLUSION

The recent advancements in smart devices have shown promising potential in surveillance systems for detecting various abnormal events, such as fires, accidents, and emergencies. Fire, being a dangerous event with potentially significant losses, underscores the need for early fire detection systems. This research article proposes a cost-effective CNN architecture for forest fire detection. Although the accuracy of flame detection has improved, there is still a high number of false alarms, warranting further research in this area. Additionally, fine-tuning the current flame detection frameworks can enhance video surveillance systems in forests to handle complex real-world situations. Translations and content mining are allowed for academic research purposes.

IX. FUTURE ENHANCEMENT

1) Improve understanding of forest fires and their impact.
2) Raise awareness about the causes of catastrophic forest fires.
3) Support managers in implementing fire management programs.
4) Involve local communities in planning and management.
5) Develop and enforce land-use laws for ecologically appropriate fire use.

6) Discourage harmful land management practices.
7) Promote strategies that mimic natural fire patterns.
8) Establish reliable fire monitoring systems.
9) Prevent further forest loss and reduce fire risk through restoration efforts.

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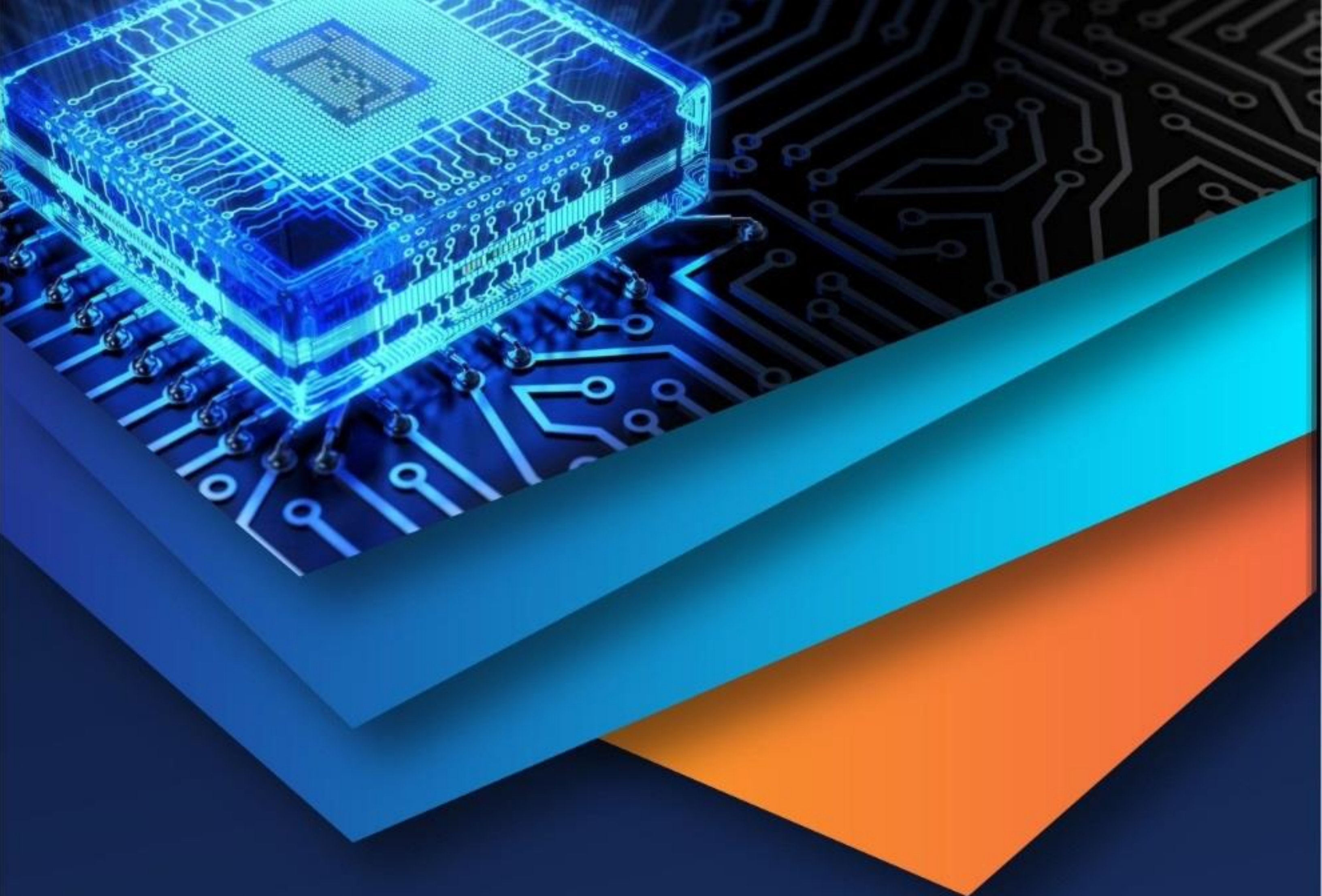

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