International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Real-Time Fire and Smoke Detection Using Deep Learning For Enhanced Safety

Ms. ASHFIYA A[1] , Ms. A DEEPA[2]

Student of 11 MSC (Computer Science), Department of Science with Computer Science, V LB Janakiammal College of Arts and Science, Kovaipudur, Coimbatore, India.

MCA., M.Phil., M.Com., Assistant Professor, Department of Science with Computer Science, VLB Janakiammal College of Arts and Science, Kovaipudur, Coimbatore, India

ABSTRACT :

In today's world, the frequency of fire incidents and the associated risks to life, property, and the environment highlight the need for advanced and rapid detection techniques. Traditional fire detection systems, which rely on smoke and heat sensors, often struggle in large or open spaces, and their delayed response can result in disastrous outcomes. This project focuses on designing and implementing a deep learning model that processes video input in real time. The model scans each frame meticulously for distinct features characteristic of fire and smoke, including color, texture, and movement patterns. This immediate response mechanism is crucial for preventing loss and ensuring safety. Our methodology involves collecting and preprocessing a diverse dataset of images and videos that depict various fire and smoke scenarios. This dataset will be used to train the CNN model, enhancing its robustness and accuracy in detecting fire and smoke across different environments and conditions.

Keywords: Fire Detection, Deep Learning (DL), Machine Learning (ML), Convolution neural network (CNN).

INTRODUCTION :

As we all know, the occurrence of disasters is increasing daily, with one major type being fires that start in homes and offices. Currently, fire-fighting technology relies heavily on manual methods, such as fire extinguishers. By the time someone responds to extinguish the fire, it may have already spread. To address this issue, we propose developing an automated fire alert system that activates as soon as a fire ignites. Our project aims to create an advanced device based on image processing technology to extinguish the fire immediately upon detection. The system will be fully automated, eliminating the need for human intervention. In executing tasks related to computer vision, we can gather information about objects using various techniques such as image processing, image models, RGB/HSV conversion methods, and HAAR cascade classifiers. The "Fire Detection Using Deep Learning" project exemplifies the transformative potential of artificial intelligence in enhancing public safety and emergency response. By leveraging innovative deep learning applications, it offers a vital tool in the ongoing effort to protect lives and property from the persistent threat of fire.

OBJECTIVE :

The objective of this project is to improve the accuracy of target area detection and to reduce the time required to scan each image. The scanning window size is adjusted adaptively by the classifier. During the classification process, the model identifies the optimal rectangles based on the objects and the scanning window. This project aims to detect fires using image processing technology, which will provide early alerts to people in the event of a fire. Existing automatic fire alarm systems that rely on sensors have limitations, as they are designed to detect fires only in limited areas and typically require the presence of smoke. To address these limitations and enhance current technology, we propose a computer vision-based Early Fire Detection system that utilizes machine learning.

SCOPE OF STUDY :

The Fire incidents can cause significant damage to lives and property. In this paper, we propose a deep learning-based method for fire detection using video sequences, which mimics the human process of detecting fires. Our proposed approach utilizes a Faster Region-based Convolutional Neural Network (R-CNN) to identify suspected regions of fire (SRoFs) and non-fire areas based on their spatial features.

The objective of this project is to improve the accuracy of target area detection and to reduce the time required to scan each image. The scanning window size is adjusted adaptively by the classifier. During the classification process, the model identifies the optimal rectangles based on the objects and the scanning window. This project aims to detect fires using image processing technology, which will provide early alerts to people in the event of a fire.

Existing automatic fire alarm systems that rely on sensors have limitations, as they are designed to detect fires only in limited areas and typically require the presence of smoke. To address these limitations and enhance current technology, we propose a computer vision-based Early Fire Detection system that utilizes machine learning.

PROBLEM DEFINITION :

Fires can occur in various settings, including private areas, woodlands, or open spaces. The most straightforward way to detect a fire in private spaces is by using smoke alarms or similar sensors, which are typically sensitive to ionization or obscuration. However, these devices can sometimes trigger false alarms. For instance, in noisy environments, activities like smoking a cigarette or toasting bread can mistakenly activate the alarm. Computer vision-based fire detection, utilizing image processing techniques, offers a promising alternative, especially in situations where traditional methods may not be effective. Various fire detection technologies are available, including infrared sensors, thermal detectors, smoke detectors, flame detectors, and optical smoke detectors. However, these methods are not always reliable, as they may detect indirect signs of fire—such as smoke, heat, infrared, ultraviolet radiation, or gases—rather than the fire itself. This can lead to numerous false alarms. By employing computer vision and image processing techniques, we can achieve more accurate fire detection compared to conventional systems, as images can provide more reliable and direct information about the presence of a fire.

LITERATURE REVIEW :

Research on video analysis for fire detection has become a hot topic in computer vision. However, the conventional algorithms use exclusively rule-based models and features vector to classify whether a frame is fire or not. These features are difficult to define and depend largely on the kind of fire observed. The outcome leads to low detection rate and high false-alarm rate. A different approach for this problem is to use a learning algorithm to extract the useful features instead of using an expert to build them. In this paper, we propose a convolutional neural network (CNN) for identifying fire in videos. Convolutional neural network are shown to perform very well in the area of object classification. This network has the ability to perform feature extraction and classification within the same architecture. Tested on real video sequences, the proposed approach achieves better classification performance as some of relevant conventional video fire detection methods and indicates that using CNN to detect fire in videos is very promising [S.Frizzi and E.Moreau – ―Convolutional Neural Network (CNN) for Video Fire Detection].

In this work we investigate the automatic detection of fire pixel regions in video (or still) imagery within real-time bounds without reliance on temporal scene information. As an extension to prior work in the field, we consider the performance of experimentally defined, reduced complexity deep convolutional neural network architectures for this task. Contrary to contemporary trends in the field, our work illustrates maximal accuracy of 0.93 for whole image binary fire detection, with 0.89 accuracy within our super pixel localization framework can be achieved, via network architecture of significantly reduced complexity. These reduced architectures additionally offer a 3-4 fold increase in computational performance offering up to 17 fps processing on contemporary hardware independent of temporal information. We show the relative performance achieved against prior work using benchmark datasets to illustrate maximally robust real-time fire region detection [Dunnings and Breckon–―Experimental CNN Architecture for Real-Time Fire Detection"].

Aiming at the problem that the existing target detection algorithms are difficult to detect sudden fire with high precision in real-time in the complex forest environment, an improved forest fire detection algorithm based on YOLOv5 is proposed by us. Firstly, the k-means clustering algorithm based on 1－IoU distance is used to preprocess the forest fire data set. Secondly, the Transformer attention mechanism is added to the model backbone network to improve the detection accuracy, and the regression box loss function GIoU-NMS is changed to EIoU NMS. Finally, the network structure is changed, and the deep separable convolution is added to reduce the parameters. Comparing the algorithm we propose with the original YOLOv5 algorithm and the mainstream target algorithm, the experimental results show that the algorithm can have more efficient and high-precision detection results in fewer samples and complex environments and prove its feasibility and effectiveness [Shuailong Yu – "Forest fire detection algorithm based on Improved YOLOv5"].

In recent years, the frequency and severity of forest fire occurrence have increased, compelling the research communities to actively search for early forest fire detection and suppression methods. Remote sensing using computer vision techniques can provide early detection from a large field of view along with providing additional information such as location and severity of the fire.. This paper adds to the existing research by proposing a novel method of detecting forest fire using color and multi-color space local binary pattern of both flame and smoke signatures and a single artificial neural network. The training and evaluation images in this paper have been mostly obtained from aerial platforms with challenging circumstances such as minuscule flame pixels, varying illumination and range, complex backgrounds, occluded flame and smoke regions, and smoke blending into the background. The proposed method has achieved F1 scores of 0.84 for flame and 0.90 for smoke while maintaining a processing speed of 19 frames per second. It has outperformed support vector machine, random forest, Bayesian classifiers and YOLOv3, and has demonstrated the capability of detecting challenging flame and smoke regions of a wide range of sizes, colours, textures, and opacity [F.M. Anim Hossain, Youmin M. Zhang– "Forest fire flame and smoke detection from UAV-captured images using fire-specific color features and multi-color space local binary pattern"].

METHODOLOGY :

This proposed system analyzes data in real-time, enabling the immediate identification of potential risk factors and timely fire predictions. By utilizing advanced data mining algorithms and deep learning models, the system enhances the accuracy of fire predictions compared to manual methods. With timely and precise predictions, authorities can proactively implement preventive measures, thereby reducing the likelihood and severity of fires.
Moreover, accurate predictions allow authorities to identify areas at high risk for fire incidents, facilitating targeted infrastructure improvements and safety enhancements. It is essential to gather a comprehensive dataset that includes images and videos of various fire and smoke scenarios, such as forest fires and house fires, along with different smoke densities, backgrounds, and lighting conditions. Utilizing publicly available datasets and potentially partnering with fire departments or forestry services for additional footage will enrich this dataset.

Image Preprocessing

Annotate the dataset by labeling frames that contain fire. Use bounding boxes to help with localization tasks. Resize images and videos to a uniform dimension while maintaining the aspect ratio to reduce computational load.
Augment the data by applying transformations such as rotation, scaling, and color adjustment. This will enhance the model's robustness against variations in real-world conditions. Additionally, improves the quality of input video frames by correcting lighting conditions and filtering out noise.

Fire Detection And Tracking

Detect fires within video frames to enable real-time accident prediction. Utilize deep learning models specifically designed for fire detection. Implement algorithms to associate detected fires across consecutive frames. Develop a module to process video feeds, extracting frames at a specified frames-per-second (FPS) rate to balance real-time performance with computational feasibility. Pass the extracted frames through a trained convolutional neural network (CNN) model to identify the presence of fire and/or smoke. For each frame, analyze the model's output to determine the presence of fire or smoke, taking confidence scores into account to minimize false positives.

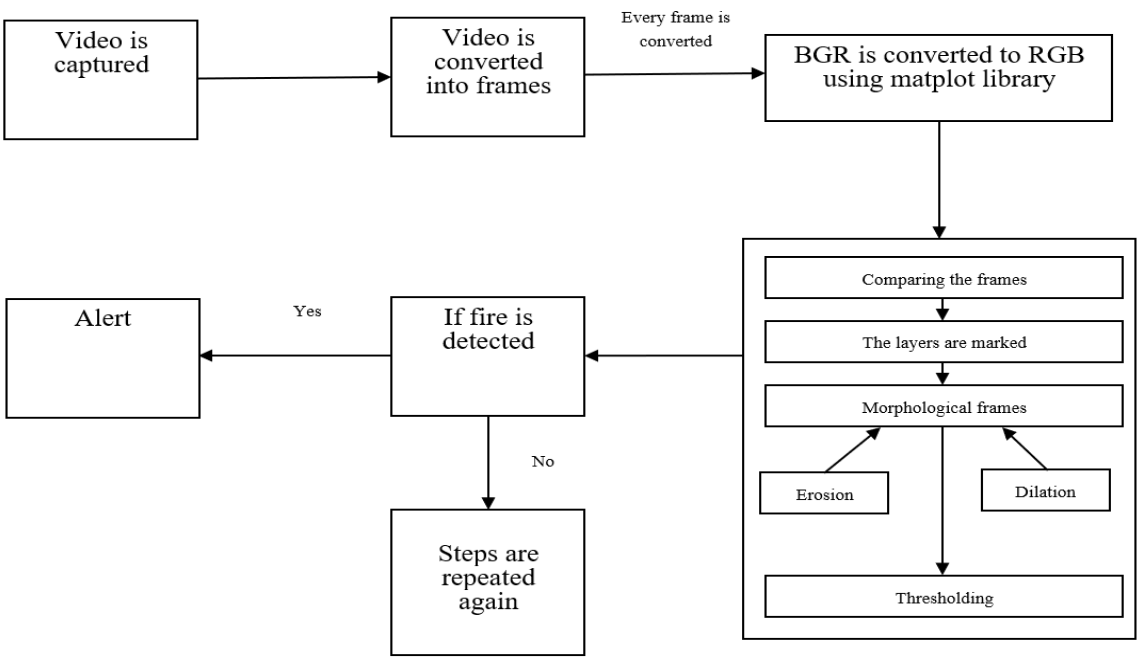
Fire Detection Analysis

The procedure for detecting fire classifies images primarily based on the value of simple features extracted from a picture or video. The frames are converted into BGR format using the CV2 library, and then, with the help of the Matplotlib library, the images are transformed into RGB format. Detected fire images are stored in a designated folder, and notifications with these images are sent via email. Additionally, the system identifies features such as edges and brightness levels from the fire images. The data collected from the pixels is then compiled, which assists in determining the location of the fire.

User Interface

This Provide a user-friendly interface for system monitoring and control. Design a graphical user interface using Python GUI frameworks to display real-time fire probability, and a user-friendly dashboard

SYSTEM ARCHITECTURE :



Input design is the process of converting user-oriented data into a format that a computer can process. The primary goal of input design is to make data entry easier, more logical, and error-free. Errors in input data are managed through effective input design, as the quality of the input directly influences the quality of the system's output. The entire data entry screen is interactive, allowing users to enter data based on prompted messages. Additionally, users are given the option to select appropriate inputs from a list of values, which helps to reduce the likelihood of errors that could occur if they were to enter the data manually. In Input design, user-oriented inputs are transformed into a format that computers can utilize. Conversely, output design focuses on producing hard copies of the requested information or displaying the output on a screen in a predefined format. The proposed system's input design incorporates several key features to enhance user experience.

The output serves as the most important and direct source of information for the user. It should be presented in the most efficient and well-formatted way possible. Based on the options provided by both the user and the administrator, various types of output screens have been created. The computer output is essential for delivering information directly to the user. Designing efficient and clear output enhances the system's relationship with the user and aids in decision-making. The focus on output design was actively studied during the research phase. The objective of output design is to define the content and format of all documents and reports, ensuring they are presented in an attractive and useful manner.

FUTURE ENHANCEMENT :

There is a significant opportunity for future development of the software. The field of technology is constantly evolving, and what is popular today may be outdated tomorrow. To keep pace with technical advancements, the system requires refinement and improvement. Therefore, the development process is ongoing and will continue to progress with further enhancements. It is crucial to update the software as new solutions emerge that offer more advanced features. Consequently, further development is necessary. Currently, the methodologies used for fire detection in enclosed spaces appear to be outdated, highlighting the urgent need for new methods and systems to effectively manage such emergencies

The proposed project aims to address this gap by seeking and developing advanced technology. With increasing urbanization and improving lifestyles, many new structures, such as office buildings, large hospitals, malls, and auditoriums, encompass vast areas and are frequented by many people. An accidental fire in these settings could be devastating. Advanced fire detection technologies can play a critical role in protecting these infrastructures and the individuals within them in real time. To accurately identify fires and ensure a rapid response, the system integrates real-time video analysis, state-of-the-art image processing algorithms, and intelligent hardware components. This technology significantly reduces the risks associated with fire hazards by automating the extinguishing process upon detection, thereby safeguarding lives and minimizing property damage.

CONCLUSION :

In conclusion, the Fire Detection Using Deep Learning project marks a significant advancement in fire safety and emergency response. By utilizing the advanced capabilities of Convolutional Neural Networks (CNNs) for real-time video feed analysis, this innovative solution provides a more reliable and efficient method for detecting smoke and fire incidents. Unlike traditional fire detection systems, which often struggle in large or open environments and may have delays in detecting fires, our deep learning-based approach ensures rapid identification of fire and smoke signatures. This leads to immediate alerts, allowing for swift actions to mitigate potential damage.

The development and implementation of this system underscore the essential role of artificial intelligence in enhancing public safety measures. Through meticulous data collection, preprocessing, and the training of robust CNN models, our project aims to deliver high accuracy in fire and smoke detection across diverse environments and conditions. Furthermore, the integration of this technology into a user-friendly application increases its applicability, making it a versatile tool for use with surveillance cameras, drones, and smartphones.

As we progress, the Fire Detection Using Deep Learning project not only illustrates the potential of AI to tackle pressing societal challenges but also sets a new standard for proactive fire detection and emergency response. By continuing to refine and expand this technology, we can significantly reduce the hazards associated with fire incidents, protecting lives, property, and the environment for future generations. This deep learning system functions as a human eye would: when a fire is detected, the camera captures the video, and the software processes the images to alert the user. Its applications are vast, making it suitable for environments such as hospitals, railway stations, and forests, among others.

REFERENCES :

[1] PETKOVIC, M., GARVANOV, I., KNEZEVIC, D., & ALEKSIC, S. (2020). Optimization of Geographic Information Systems for Forest Fire Risk Assessment. 2020 21st International Symposium on Electrical Apparatus & Technologies (SIELA).

[2] Yen Feng, Luo Ningzhao, Wu Benxiang (2019) Design and Experimental research video detection system for ship fire, 2019 2nd International Conference on Safety Produce Infromation

[3] Xu, X., Wang, P., Yu, N., & Zhu, H. (2019). Experimental Study on Kitchen Fire Accidents in Different Scenarios *. 2019 9th International Conference on Fire Science and Fire Protection Engineering (ICFSFPE).

[4] Chen, K., Cheng, Y., Bai, H., Mou, C., & Zhang, Y. (2019). Research on Image Fire Detection Based on Support Vector Machine. 2019 9th International Conference on Fire Science and Fire Protection Engineering (ICFSFPE).

[5] Pritam, D., & Dewan, J. H. (2017). Detection of fire using image processing techniques with LUV color space. 2017 2nd International Conference for Convergence in Technology (I2CT).

[6] Feng, J., Feng, Y., Ningzhao, L., & Benxiang, W. (2019). Design and experimental research of video detection system for ship fire. 2019 2nd International Conference on Safety Produce Informatization (IICSPI).

[7] Dang-Ngoc, H., & Nguyen-Trung, H. (2019). Aerial Forest Fire Surveillance - Evaluation of Forest Fire Detection Model using Aerial Videos. 2019 International Conference on Advanced Technologies for Communications (ATC).

[8] Yang, X., Tang, L., Wang, H., & He, X. (2019). Early Detection of Forest Fire Based on Unmaned Aerial Vehicle Platform. 2019 IEEE International Conference on Signal, Information and Data Processing (ICSIDP).