Available online @ https://jjem.jnnce.ac.in
https: www.doi.org/10.37314/JJEM.SP0233
Indexed in International Scientific Indiexing (ISI)
Impact factor: 1.395 for 2021-22
Published on: 08 December 2024

Intelligent Fire Detection with Automated Recognition and Alerting using YOLOv8 Deep Learning Method

Jayanth C L[1], Manjunath H T[2]

[1*]Student, Department of MCA, Jawaharlal Nehru New College of Engineering, Shivamogga, India.

[2]Assistant Professor, Department of MCA, Jawaharlal Nehru New College of Engineering, Shivamogga, India

jayanthcl431049@gmail.com, manjudeepa@jnnce.ac.in

Abstract

Nowadays fire detection technology was playing special role in minimize the damage of the properties from the fire. We experiencing numerous problems, including fires in apartments, factories and other industrial areas many more. It uses smart computer vision technology to detect fires faster than traditional smoke or flame sensors. The intelligent fire detection with automated recognition and alerting system uses the computer vision technology to detect fire from long distance and reduce risks. The proposed methodology uses the YOLOv8 algorithm to detect fire from the camera. The proposed system uses the numerous fire datasets collected from kaggle to train and test the fire datasets, we can use the CCTV cameras to detect the fire from the distance because nowadays we are using the CCTV cameras everywhere if we include this technology along with the cameras that would significantly reduce the loss of human life and property. This system can spot fires quickly from far away using CCTV cameras, helping to save lives and property.

Keyword: *YOLOv8, Computer vision, CCTV camera.*

1. Introduction:

Fire is one of the most harmful natural disasters today, causing significant societal and economic losses. The aim of the proposed methodology is to prevent such incidents and save human lives and properties. It helps prevent property damage from fire and quickly alerts people, reducing the risk of injury. This methodology uses the YOLOv8 (You Only Look Once) algorithm to detect fire, minimize damage, and ultimately save lives. The proposed system uses YOLOv8, a modern algorithm for object detection, to identify fire through cameras [1]. By utilizing computer vision technology and the YOLOv8 algorithm, the system can detect fires from a distance rapidly, providing earlier warnings compared to smoke and flame sensors. The system captures images or videos through the camera

and feeds them to the YOLOv8 model. The YOLOv8 model, trained with various fire datasets, scans the entire picture instead of part by part. It splits the image into a grid of squares and checks each part for the presence of fire. The YOLOv8 model predicts the bounding boxes of detected objects, assigns a confidence score to each box, and classifies the objects as either fire or non-fire. The reason for adopting computer vision technology to detect fire is the widespread use of CCTV cameras, which operate 24 hours a day [2]. Implementing this technology with CCTV cameras can effectively detect fires wherever the cameras can reach. Compared to sensors, this technology offers a quicker response, making the job easier. Integrating this technology with necessary CCTV cameras will alert people in the area through alarms and send messages to the fire safety department. The methodology uses a fire safety module that hasn't been widely implemented by many researchers in recent times. This innovative approach to fire safety will significantly impact how fires are managed and controlled in various environments, from residential buildings to industrial complexes. Applying this technology alongside traditional safety measures could provide a higher level of protection for people and property.

2. Literature Survey:

The proposed system reviews several related works with various methodologies and algorithms. Aigulim Bayegizova et al. [1] proposed a fire detection system by using deep learning methods with YOLOv4 and fast R-CNN. Their system achieved 98.9% accuracy in fire detection. It showcases the power of detection techniques in high-precision fire detection applications. Swaraj Singh et al. [2] projected fire detection system for preventing forest fires using CNN algorithm, and achieved an accuracy rate of 93% highlighting its effectiveness in early fire detection. S. Saponara et al. [3] developed an anti-fire surveillance system for fire detection through video using the CNN algorithm, achieving 94% accuracy and demonstrate its timely and accurate fire detection. E. K. Hassan et al. [4] presented a system for measuring and classifying wildfires in Australia using remote sensing land covers. Their system utilized the SVM algorithm and GIS, focusing on accurate wildfire classification through advanced geographic information systems. Y. Vasavi et al. [5] worked on a real-time fire detection system by using live video surveillance with Maixduino AI Controller and Automatic Extinguishers focusing on effective fire control measures through advance AI. K. Muhammad et al. [6] implemented a method for fire detection using surveillance videos with the CNN algorithm, achieving a 97% accuracy rate, highlighting its robustness in detecting fires from video footage. Sidhant Goyal et al. [7] developed a system for quick forest fire detection using the YOLO algorithm, its efficiency in rapidly detecting forest fires with accuracy rate of 93%. M. Mohamed Ismail et al. [8] worked on a fire detection system using Python OpenCV for IoT-based applications using Raspberry Pi successfully integrating alerting technology for timely fire detection and response. K. Murali et al. K. Murali et al. [9] designed a fire detection project using image processing technology, incorporating methods such as motion detection and fire color classification for accurate fire detection. Asan Nainar M et al. [10] implemented a machine learning-based fire detection system using computer vision technology. Their system achieved a high accuracy of 98.9% with a low false detection rate of 1.1%. By leveraging different strengths of these technologies, future systems can achieve higher accuracy, faster response times, and more robust performance in various environments. The proposed system aims to employing the YOLOv8 algorithm, known for its efficiency and accuracy in object detection. Utilizing existing CCTV camera infrastructure, the system can continuously monitor areas for potential fires, providing early warnings and reducing the risk of extensive damage. YOLOv8 versions offering improved speed and precision, more advanced architecture and better performance in diverse conditions enhancing the overall effectiveness of fire detection systems with real-time video feeds for quick identification and response.

3. Methodology:

The methodology for fire detection uses the YOLO (You Only Look Once) algorithm to improve the speed and accuracy in fire detection using the computer vision technology. This system utilizes the existing CCTV cameras for monitor the fired areas continuously and provide early warning of fire incidents. The methodology contains followings i.Fire Datasets, ii.Pre-Processing, iii. Data Split, iv. Validation, training, vi. YOLO model, vii.Post-process with R-CCN model and viii.F ire Detected. In the process flow diagram as shown in Figure-1.

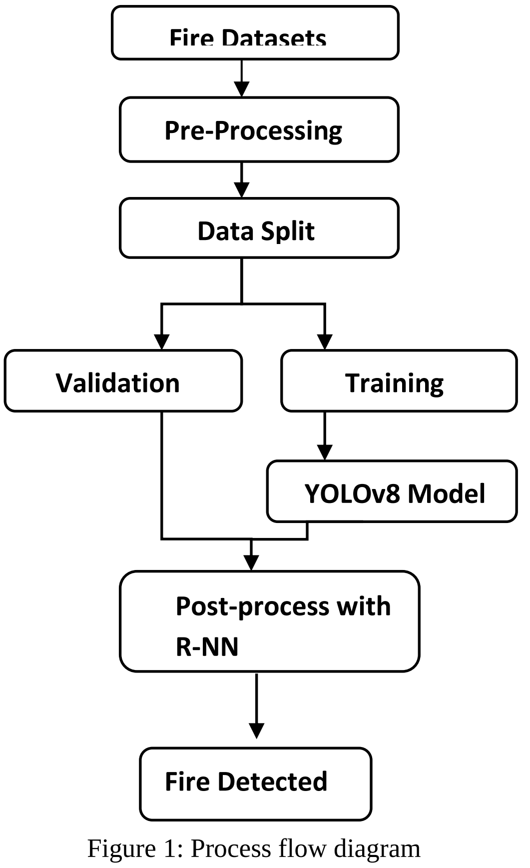

Figure 1: Process flow diagram

3.1 Data Collection and Pre-processing:

The process begins with the collection of a numerous types of fire datasets. Collect datasets from kaggle and google images of fire under various conditions. These datasets include different environments such as residential buildings, industrial areas and open spaces. The collected datasets undergo pre-processing this step involves annotation and labeling tasks. The annotation process involves the creation of bounding boxes around fire in order to prepare the data for training purposes. This step is crucial for training the YOLO model accurately. The images contain the manually annotated bounding boxes and labels shown in figure-2.

Figure 2: Annotation and Labeling

3.2 Data Split, Validation and Training:

The datasets after pre-processing undergoes data splitting into two subsets training data and validation data. The training data was uses to train the YOLO model, and the validation data will evaluate the model's performance. Train the YOLO model using annotated and pre-processed datasets. During in training model, they learn to detect the fire and classify by predicting bounding boxes and class probabilities. The model used to input images into the grid and assigns confidence scores for potential fire regions allows for quick and effective detection. Pré-processed datasets are split into training and validation subsets to train and evaluate the YOLO model, which detects fire by predicting bounding boxes and class probabilities with confidence scores.

3.3 YOLOv8 Model:

YOLOv8, released in May 2023, is the latest version of the YOLO (You Only Look Once) family of object detection algorithms, renowned for their speed and accuracy. Built on deep convolutional neural network (CNN) architecture, YOLOv8 divides the input image into a grid of cells. For each cell, it predicts bounding boxes and class probabilities, then uses a non-maxima suppression (NMS) algorithm to filter out overlapping boxes and select the most likely bounding boxes for each object. YOLO models require a fixed input image size of 640x640 pixels, so images must be resized while maintaining aspect ratio and padded to fit this size. Corresponding bounding boxes must be adjusted to reflect changes in position, size, and orientation, and annotations must be formatted to include the class label, normalized center coordinates (x, y), and normalized width and height of the bounding box.

3.4 Post-Process with R-CNN Model:

In the initial stages datasets are detected using YOLO model then improve by removing impurities in data using R-CNN (Region-based Convolutional Neural Network) model. R-CNN usually takes place for high accuracy in object detection. In this stage the model uses post-process includes YOLO model datasets will analyze and filter out the false positives improve the model for detecting fire during in challenging stages.

1. Identify areas in images where objects are likely to be found using algorithms like selective search.

2. Each region proposal is processed through a Convolutional Neural Network (CNN) to extract feature vectors.

3. Combine the YOLO model with R-CNN to leverage the strengths of both approaches.

4. Achieve higher accuracy and improve the fire detection system with the integrated approach. By combining YOLO with R-CNN, the strengths of both models are leveraged to improve accuracy. The integration results in better fire detection performance, especially in challenging conditions, by filtering out false positives and refining detection results.

3.4 Detection and Alert System:

After detecting fire, the YOLO model gives the confidence scores for the image. If the confidence score breaks the system verify the presence of a fire in the area. Implemented with alert system that automatically triggers and notify to emergency services which helps to evacuate people and reduce risk. Adapting the alarm system in the monitored area that will activates if any fire incident occurs. This assists for evacuate people quickly before situation going to worse. Use of metrics such as precision, recall, and F1-score for evaluating the effectiveness of the system developed using YOLO. Update with new data the YOLO model will improve accuracy and adaptability to different fire conditions. Our system's live fire detection shown in figure-3 and test with image shown in figure-4.

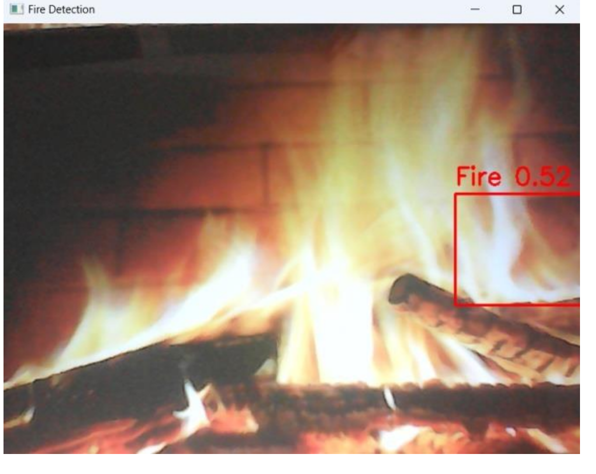

Figure 3: Live fire detection of our proposed system.

Figure 4: Testing with image.

4. Experimental Results:

The model contains fire datasets which are from different environment, during training and testing we used the 200 of fire images. Fire image include the different type of fire such as flames, glowing embers and fire with smoke for improve the accuracy of the system. The proposed system detects the fire accurately when we observed during the experiment. Here some of brief explanation regarding to our system results.

Confusion matrix for our fire detection system was shown in table-1.

	Predicted Fire	Predicted No Fire
Actual Fire	TP= 70	FN= 5
No Fire	FP= 10	TN=115

Table 1: confusion matrix for fire detection

TP=True positive

FN=False negative

FP=False positive

TN=True negative

1. Accuracy: The ratio of correctly predicted instances both true positive and true negative, against the total number of instances.

$$Accuracy = \frac{\text{TP+TN+FP+FN}}{\text{TP+TN}} \quad (1)$$

2. Precision: It is the ratio of the true positive classified to the sum of the positive classified examples, giving the precision of the positive predictions.

$$Precision = \frac{\text{TP}}{\text{TP+FP}} \quad (2)$$

3. Recall: The ratio of true positive predictions to the total number of actual positive instances, indicating the ability to identify all positive instances.

$$Recall = \frac{\text{TP}}{\text{TP+FN}} \quad (3)$$

4. F1 Score: It's the harmonic mean of precision and recall, so it provides just the right middle ground between these two metrics.

$$F1\ Score = 2 \times \frac{\text{Precision}\times\text{Recall}}{\text{Precision+Recall}} \quad (4)$$

Performance metrics for our fire detection system was shown in table-2.

Accuracy	Precision	Recall	F1score
0.925	0.875	0.933	0.902

Table 2: Performance metrics table.

The proposed work got 92.5% accuracy in order to detect the fire also in the challenging stages our system performs well here the result of the system with good accuracy mentioned in below Table-3. YOLOv8 was better option to get good result in fire detection. The proposed system alerts with an alarm sound 5 seconds after detecting fire and sends an SMS to the registered phone number. The system performance was shown in table-3.

Number of Images	Detected Images	False Detected	Accuracy
200	185	10	92.5%

Table-3: Image Detection Performance Table.

The proposed fire detection system using YOLOv8 combined with R-CNN achieves 92.5% accuracy, slightly lower than top-performing studies like Aigulim Bayegizova et al. and Asan Nainar M et al., which reach up to 98.9%. It benefits from YOLOv8's high-speed capabilities for efficient real-time performance. It leverages existing CCTV infrastructure for adaptability and widespread implementation, unlike some YOLO-based methods requiring specialized hardware. Additionally, the system includes automatic alerts and SMS notifications.

Study	Strengths	Limitations
Aigulim Bayegizova et al. [1]	High accuracy; effective combination of YOLOv4 and Fast R-CNN.	Limited details on real-time performance and adaptability.
Swaraj Singh et al. [2]	Effective for early fire detection, especially in forest fires.	May lack precision and speed compared to YOLO-based systems.
S. Saponara et al. [3]	Reliable for real-time video fire/smoke detection.	Similar speed and precision limitations as other CNN-based methods.
Sidhant Goyal et al. [7]	Efficient in rapid forest fire detection.	Accuracy may vary with different environmental conditions.
Proposed system	High-speed detection with YOLOv8; refined accuracy with R-CNN;	Slightly lower accuracy compared to top-performing methods; performance in extreme conditions needs further testing.

Table 4: comparative analysis table.

5. Conclusion:

The proposed fire detection system by the YOLOv8 algorithm is an enormous advancement in the technology for early fire detection. A number of places already have installed CCTV cameras that can be of great use and the high accuracy of the YOLOv8 model aiding the system to detect a fire at a very fast pace, raise an alarm in time to either prevent or reduce as much damage as possible, saving lives. Computer vision integrated with typical safety measures strengthens the posture of fire management. The results of the experiments show an accuracy of 92.5% in detection, thus proving the efficiency of the system under very difficult conditions. This new methodology holds good potential for improving fire safety in any environment.

References:

1. Aigulim Bayegizova, Gulzira Abdikerimova, Samal Kaliyeva, Aigul Shaikhanova, Gulmira Shangytbayeva, Laura Sugurova, Zharkynay Sugur, "Fire detection using deep learning methods" Vol. 14 | No. 1 | pp. 547~555, ISSN: 2088-8708, February 2024.

2. Swaraj Singh1, Manish Jha, Dr.Bijal Talati, Aditi Jaiswal ,"Forest fire detection using CNN" March 2024.

3. S Saponara, A Elhanashi, A Gagliardi, "Real-time video fire/smoke detection based on CNN in anti-fire surveillance systems" Vol. 18, pp. 889~900 ,2021.

4. E K Hassan, H M Saeed, A H T Al-Ghrairi, "Classification and Measurement of Land Cover of Wildfires in Australia Using Remote Sensing" Vol. 63, Issue.1, pp. 420~430, January 2022.

5. Y Vasavi, C Madhu, "Real-Time Fire Detection, Alerting and Suppression System Using Live Video Surveillance" Vol.06 | Issue. 32, ISSN: 6412-6415, November 2017.

6. K Muhammad, J Ahmad, I Mehmood, S Rho, S W Baik, "Convolutional Neural Networks Based Fire Detection in Surveillance Videos" Vol.6 , ISSN:18174-18183, 2018.

7. Sidhant Goyal, MD Shagill, Arwinder Kaur, Harpreet Vohra, Ashima Singh "A YOLO based Technique for Early Forest Fire Detection" ISSN: 2278-3075, Vol-9, Issue-6 April 2020.

8. M Mohamed Ismail, B Chouthri, M Chandru, Mr.V.Maheskumar M E,"Fire Detection System in Python using Opencv" Vol. 11 ,Issue 1, ISSN: 2278-1021, January 2022.

9. K Murali, K Uday Kumar, D Chandra, Mohan Babu, Akhil Sai,"Fire Detection using Image Processing"Vol.12 ,Issue 7 ,ISSN:2250-0588 , July 2022.

10. Asan Nainar M, Ishwariya P, Lakshmi Prabha R, Mythireyeni P V, Neelaveni M,"Computer Vision-Based Early Fire Detection Using Machine Learning" Vol: 09 Issue: 04 ,ISSN: 2395-0056 ,Apr 2022.