Real-Time Fire Surveillance with Machine Learning Twilio Integration

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Abstract

Fire threats pose significant risks to people and property, necessitating efficient surveillance systems. A complete fire surveillance system is proposed using machine learning and artificial intelligence to monitor fire incidents in real time. The system is built using React.js for frontend development and MongoDB for backend storage. Node.js is integrated for server-side operations, ensuring data management and user interaction. The system sends alerts via WhatsApp when image analysis identifies a fire concern, leveraging Twilio for seamless messaging. Robo Flow simplifies computer vision model management, while YOLOv8, a cutting-edge object recognition algorithm, enhances detection speed and accuracy. YOLOv8 is widely used in real-time object identification applications like robotics, autonomous cars and surveillance systems. Twilio is a cloud communication platform that allows developers to integrate voice, video, and SMS into their apps, enabling notifications, alarms, and two-way communication. The research utilizes Machine Learning, React.js, MongoDB, YOLOv8, and Twilio to offer efficient real-time fire surveillance.

Keywords: MongoDB, React, Twilio, YOLOv8, Object recognition.

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1. Introduction

1.1 YOLOV Object Detection

The world is moving towards an era which needs safety in everything. As we already know the smart automations have been developing overnight and the concerns regarding safety can be implemented using various techniques. The main focus of this product is to identify areas where fire accidents have occurred by using the object detection algorithms of YOLOv8. The research mainly focuses on the detection of objects that are under fire and the intimation of it to the customer. YOLOv8 has introduced many packages for object detection. We have used the most satisfying model for this kind of detection purposes. We have created a model by labelling datasets and training this with the object detection algorithms. The model for object detection which contains trained data of images is maintained in Roboflow. The model can be used everywhere.[1]

1.2 Smart File Detection

Introducing the Smart Fire Detection System (SFDS), a cutting-edge solution designed for smart cities. Utilizing YOLOv8's deep learning capabilities, SFDS accurately identifies fire-related characteristics in real-time, reducing false alarms. With a 97.1% accuracy rate, SFDS is a valuable tool for applications such as public safety and forest fire monitoring. [2].

1.3 YOLOV8 Models

This research explores how forest and grassland fires affect people and the economy. It uses special YOLOv8 models, trained on tailored datasets, to test how well they can spot and label fires. They found that the YOLOv8n model, which is the smallest version, works best for lightweight machines which could be useful for finding fires and assessing risk [3].

1.4 MobileNet’s CNN

To improve fire detection in surveillance systems, a cost-saving Convolutional Neural Network (CNN)[4-6] was proposed. It combines MobileNet's key features with depth wise separable convolution and squeeze-and-excitation modules. This architecture achieved an

outstanding 95.44% accuracy in fire detection, surpassing other networks while using 38.50% fewer parameters than MobileNetV2.

1.5 RoboFlow

YOLOv8, a powerful object detection algorithm, is now available through RoboFlow. This tool is specifically designed to help farmers identify nine common tomato leaf diseases, enabling them to take timely action to minimize crop damage. These results demonstrate YOLOv8's effectiveness in accurately classifying tomato leaf diseases, providing farmers with a reliable tool to protect their crops from disease-related losses.

1.6 RoboFlow Model Deployment

Creating robots that can be programmed by people without specialized coding knowledge, specifically designed for certain settings to guarantee reliable performance. RoboFlow, a visual programming language that uses flowcharts to simplify the development of versatile mobile manipulation tasks. RoboFlow tests on a PR2 mobile manipulator, demonstrating its versatility and ability to handle errors in typical tasks encountered in human environments.

1.7 RoboFlow

RoboFlow, a flow-based visual programming language aimed at enabling end-users to program generalizable mobile manipulation tasks for robots. The main goal is to simplify the programming process for users by allowing them to program the robot in their specific context of use, rather than trying to cover all possible environments. RoboFlow emphasizes both robust low-level implementation of procedures and intuitive high-level programming, aiming to minimize user errors while enabling expressive programs involving branching, looping, and nesting [7].

1.8 Object Detection Tracking

The paper presents an Object Detection and Tracking System (ODTS) designed for automatic detection and monitoring of unexpected events in tunnel CCTV footage. The system combines the Faster R-CNN deep learning network for object detection with conventional

object tracking algorithms. It focuses on detecting events such as Wrong-Way Driving (WWD), Stop, Person out of vehicle in tunnel, and Fire.[8]

1.9 Importance of YOLOV8

Fires, especially in forest and grassland environments, pose severe threats due to their extensive scope and rapid spread. Therefore, effective flame recognition and disaster assessment methods are crucial for timely intervention and mitigation. The study utilizes various YOLOv8 models trained on a custom dataset to evaluate their performance in fire detection and classification. It also assesses their training speed and inference time, considering their suitability for deployment on lightweight machinery.[9]

1.10 Twilio and Messaging

The modern business landscape is characterized by a proliferation of goods, services, and products offered by organizations to customers. With the increasing variety of services provided, organizations face a growing volume of customer inquiries. To ensure customer satisfaction, organizations typically employ support teams to handle these queries. However, the sheer volume of inquiries often overwhelms human support teams, necessitating the implementation of real-time voice call processing systems.[10]

2. Related Works

The development of various ML algorithms used to manipulate various resources such as text, images, etc. The main process involved here is the detection. Let us show some of the works such as canny detection algorithm which involves sum of the preprocessing techniques involved with it and also used to determine signatures mainly with it. These detection ranges with respect to height and width of the area range. These detection methods paved a way for object detection. The convolutional neural networks are used which describes the detection of any object by converting the image data that has been trained into tensor formats and the data to be detected are also converted into tensors. The approximation is obtained with these tensors and the Object is being detected. The Data's involved are more important here which provides more precision. All the data that are involved required preprocessing to obtain more accurate

form. Some of the preprocessing techniques such as sobel are used here in this type of detection algorithms. Object detection here involves various requirements of data. All the object needed to be listed. Some of the detection algorithms have been implemented which finally helps in the creation of the YOLOv8. The YOLOv8 detection can be done for various aspects. There are separate classes for each object [11]. The YOLOv8 is somewhat more advanced in this scenario. The YOLOv8 detection is mainly used in tesla cars and is used for various use cases [12]. These are used in automatic cars in which each object is identified as a class and it gets trained for the identification of it. The Tesla cars have achieved a greater reward for its automatic cars. The Roboflow is used to maintain models that have been trained using YOLOv8 and an API call can be used for further processing using it [13]. The automation in CCTV cameras that have been developed by google smart house technologies provide a more applicable nature to many products that thrive as a way for the development of major automations with respect to each and every sector. Every product follows the same set of rules in it. That is, a dataset is formed which is pre-processed by pre-processing techniques. Other issues related to those are rectified and the dataset is labelled for each object is taken as a class and trained. All the YOLOV8 models use this type of process for detection but the more precision occurs at the dataset. Thus, the detection through preprocessing have been developed day by day and obtained a new range of development in detection systems [16-17].

3. Proposed System

The figure below (Fig. 1) depicts the flow of the proposed system.

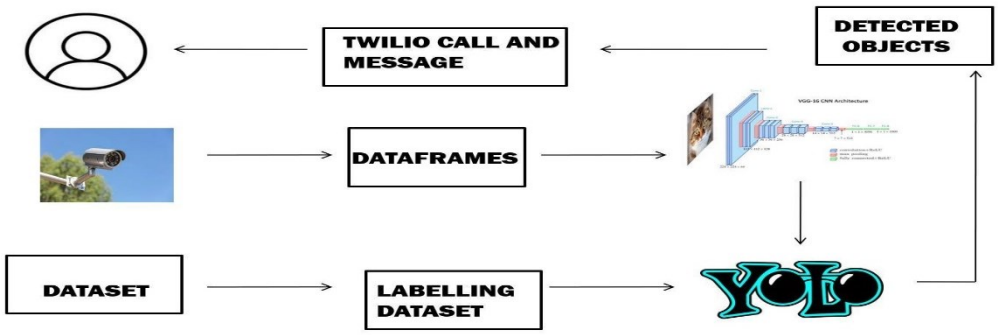

Figure 1. Flow Diagram of the Proposed System

3.1 Dataset: The Dataset has been collected for the various cases of fire, the images of various fire accidents in the below figure (Fig. 2) that have occurred and the objects at which the accidents have occurred have been decided in this dataset. The trail datasets have been taken into account. Nearly 60 samples images have been taken at the initial stages for training.

Figure 2. Dataset

3.2 Labelling Dataset: The datasets that have been collected have been labelled at this stage shown in the figure (Fig. 3). As said earlier it's a fire surveillance system that detects areas of smoke, fire, and objects where accidents have occurred. The labelling is done with

```
<annotation>
  <folder>fire-detection</folder>
  <filename>1.jpg</filename>
  <path>/fire-detection/1.jpg</path>
  <source>
    <database>Unspecified</database>
  </source>
  <size>
    <width>1000</width>
    <height>710</height>
    <depth>3</depth>
  </size>
  <object>
    <name>smoke</name>
    <pose>Unspecified</pose>
    <truncated>0</truncated>
    <difficult>0</difficult>
    <bndbox>
      <xmin>70</xmin>
      <ymin>21</ymin>
      <xmax>976</xmax>
      <ymax>710</ymax>
    </bndbox>
  </object>
</annotation>
```

the help of Makesense.AI. After, labeling each object such as smoke, fire, tables, chairs, etc are taken into account as a class and each class will be predicted.

Figure 3. Labelling Dataset

3.3 YOLOV8: The YOLOv8, is trained as shown in Figure 4. The labeled dataset has been converted into an XML format, which is more readable and understandable for the YOLOv8 model. This process of changing these datasets into YOLOv8 understandable format is called the YOLOv8 XML parsing. The model gets trained and maintained using Roboflow. Under normal conditions, the YOLOv8 model has been trained for nearly 5 epochs to prevent overfitting, as the dataset collection is extensive. [14].

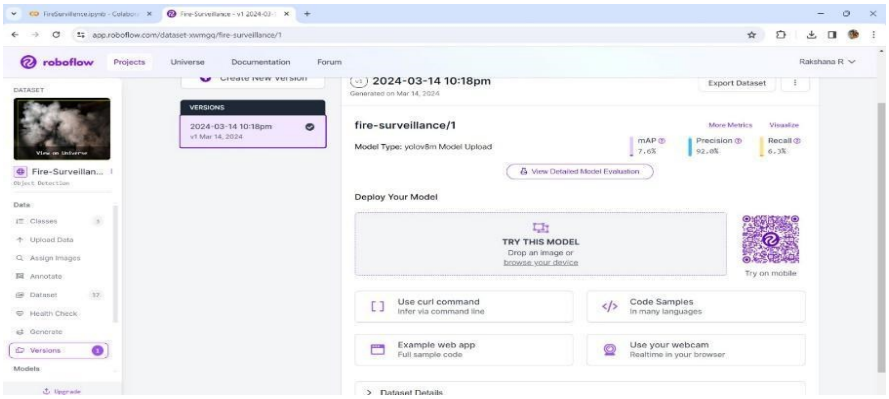

Figure 4. YOLOV8 Model Training

3.4 Detected Objects: The detection of the object is done by the following ways in the figure (Fig. 5). Firstly, the model has been deployed into the Roboflow and an API is generated for the model with which the object detection is included in the production. The data that is to be monitored have been taken from the CCTV cameras connected to the application and there are acquired in the form of data frames. These data Frames are gone through a network of layers. These layers include the layers similar to CNN. YOLOv8 also uses the same procedure as CNN uses. The YOLOv8 model now detects the trained classes and provides the accuracy of its prediction for each class which can be retrieved using the API used. Also, the access to the live camera shows the areas affected with the help of a bounding box algorithm.

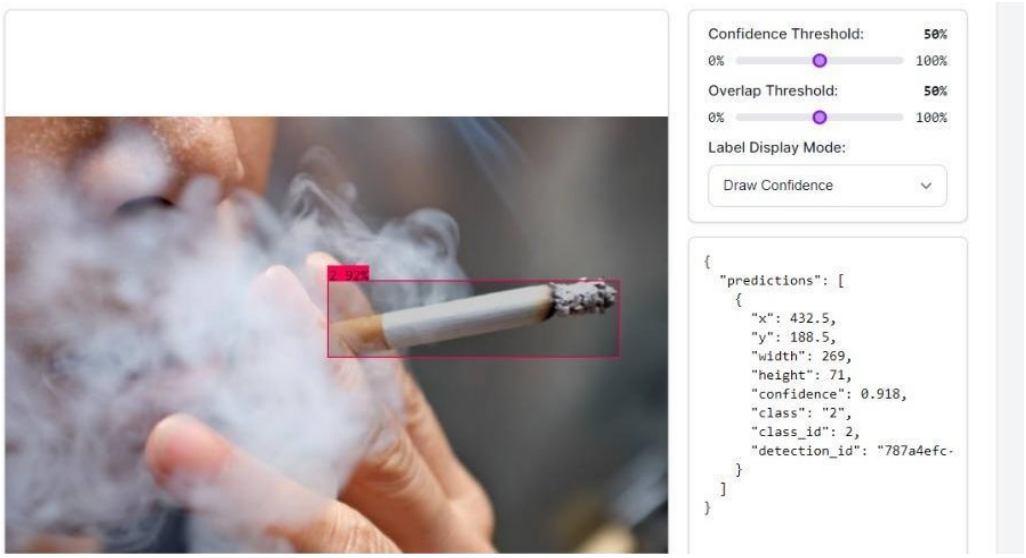

Figure 5. Object Detection

3.5 Twilio Messaging: The Twilio is a package in python which is for commercial use and is used to send messages with the users that if any accidents occurred that if the product predicts if any fire have been occurred then the Twilio will send the messages to the user regarding this accident [15].

4. Discussion

The proposed fire surveillance system represents a significant advancement in the realm of fire detection and response, offering a multifaceted approach to addressing the challenges posed by fire threats. By integrating cutting-edge technology and innovative design principles, the system provides a comprehensive solution that enhances both detection capabilities and response mechanisms. At the core of the system lies its ability to monitor fire incidents in real-

time, made possible through the utilization of machine learning and artificial intelligence algorithms. This enables the system to swiftly identify potential fire concerns, allowing for immediate action to be taken to mitigate risks and prevent further escalation. Additionally, the inclusion of YOLOv8, an advanced object recognition algorithm, enhances the speed and accuracy of fire detection, ensuring that even small or rapidly developing fires are promptly identified and addressed.

One of the system's key advantages is its efficient alert system, which leverages image analysis and WhatsApp alerts to provide timely notifications when fire concerns are detected. This proactive approach enables swift coordination among stakeholders, including emergency responders, property owners, and residents, facilitating a more effective response to fire incidents.

Table 1. Performance of the Proposed

Performance Indicators	High	Low	Good
Accuracy	✓		
Resilience	✓		
User Satisfaction			✓
Cost		✓	
Response Rate			✓

5. Conclusion and Future work

The Fire Surveillance and Prevention System is a thorough and effective solution for detecting and managing fire incidents in various settings. By analyzing multiple performance indicators, including accuracy, real-time capabilities, resilience, user satisfaction, and cost-effectiveness, the system has demonstrated its efficiency in boosting safety measures. With its extremely precise detection rates and quick response times, the system effectively detects fire and smoke and issues timely warnings. Moreover, its resilience to environmental factors, adaptability to dynamic conditions, and seamless interoperability with existing systems

underscore its versatility and practicality in real-world scenarios. Continuous maintenance, updates, and improvement efforts ensure the system's sustained performance and alignment with evolving safety standards and user needs. Overall, the Fire Surveillance and Prevention System stands as a vital tool in fire prevention and safety management, contributing significantly to the protection of lives and assets from the devastating effects of fire incidents. Incorporating predictive analytics capabilities to forecast potential fire risks based on historical data, environmental factors, and patterns of behaviour would make the system more useful. This proactive approach enables preemptive measures to be taken to mitigate fire hazards before they escalate. Developing an interactive dashboards and visualization tools will help stakeholders with real-time situational awareness of fire incidents and response efforts. This includes tracking the movement of personnel, equipment, and resources to coordinate effective emergency responses. Integrating the system with smart building technologies, such as Building Management Systems (BMS), enables seamless communication and coordination between fire detection systems and building infrastructure. This facilitates automated responses, such as closing fire doors, activating ventilation systems, and evacuating occupants.

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