

FIRE DETECTION AND EXTINGUISHER SYSTEM USING IMAGE PROCESSING

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Abstract - The proposed system focuses on the development of a fire detection and extinguisher system using image processing techniques and the Maixduino AI controller. The system aims to enhance fire safety by employing real-time image analysis to detect fire incidents. The image processing algorithms analyze video or image input from cameras to identify the presence of fire and its location. Upon detection, the system triggers an automatic extinguisher mechanism to suppress the fire effectively. This system combines computer vision, artificial intelligence, and hardware integration to create an intelligent fire safety solution with potential applications in various environments, including homes, offices, and industrial settings. The aim of this system is to develop an advanced fire detection and extinguisher system by leveraging the power of image processing techniques and utilizing the Maixduino AI controller. The primary objective is to enhance fire safety by employing real-time image analysis to detect fire incidents with a high level of accuracy and efficiency. By utilizing computer vision algorithms and machine learning models, the system can analyze video or image input from cameras placed in strategic locations to identify the presence of fire and accurately determine its location within the scene.

Key Words: Fire detection, image processing, Maixduino AI controller, temperature sensor, Feature extraction

1. INTRODUCTION

Fire safety is a critical concern in both residential and commercial settings, and the timely detection and suppression of fires can save lives and prevent extensive damage. Traditional fire detection systems often rely on smoke detectors or heat sensors, which have limitations in terms of accuracy and response time. In recent years, the advancement of image processing techniques and artificial intelligence has opened up new possibilities for more efficient and reliable fire detection systems. This system focuses on the development of a fire detection and extinguisher system using image processing, with the utilization of the Maixduino AI controller.

The primary objective of this system is to leverage real-time image analysis to enhance fire safety by accurately and promptly detecting fire incidents. By employing computer vision algorithms and machine learning models, the system aims to analyze video or image input from strategically placed cameras to identify the presence of fire and determine its location within the scene. This enables early detection, allowing for swift response and effective mitigation measures. The image processing algorithms utilized in this system go beyond simple pixel-based analysis and incorporate advanced techniques such as edge detection, color segmentation, and flame pattern recognition. By implementing these methods, the system can effectively distinguish flames from other sources of light or objects that may cause false alarms. This ensures reliable fire detection, reducing the risk of false positives or missed fire incidents. Upon the detection of a fire, the system is designed to trigger an automatic extinguisher mechanism. The mechanism can be integrated with various types of fire suppression systems, such as sprinklers, foam dispensers, or gas-based extinguishers, depending on the specific requirements of the environment. By automating the extinguishing process, the system minimizes response time, allowing for a rapid and effective suppression of the fire before it spreads and causes further damage. The Maixduino AI controller serves as the core platform for this system. It provides the necessary computational power and connectivity to handle the image processing tasks. Equipped with a high-performance processor and sufficient memory capacity, the controller can handle the computational demands of real-time image analysis. Additionally, it offers interfaces to connect cameras and actuators, enabling seamless integration with the overall system.

The developed fire detection and extinguisher system holds immense potential for deployment in various environments, including residential buildings, commercial establishments, and industrial facilities. It offers an added layer of safety by continuously monitoring the premises for fire hazards and initiating appropriate actions to mitigate risks. Additionally, the system can generate alerts or notifications to inform occupants or authorities about the fire incident, enabling prompt evacuation and timely emergency response.

A. Motivation

The motive of this proposed method is to address the critical need for enhanced fire safety through the development of an advanced fire detection and extinguisher system using image processing. The proposed system aims to leverage cutting-edge technology and algorithms to overcome the limitations of traditional fire detection systems and improve the accuracy and speed of fire detection. By integrating real-time image analysis with the Maixduino AI controller, the system aims to promptly detect fire incidents, allowing for swift response and effective mitigation measures. The motive is to create a reliable, automated system that can significantly reduce the risk of fire-related hazards, protect lives, and minimize property damage. The proposed system's ultimate goal is to provide a comprehensive fire safety solution that offers early detection, precise localization, and automated extinguishing capabilities, thereby making a positive impact on fire prevention and emergency response efforts in various environments.

2. LITERATURE REVIEW

This proposed system presents a review of various techniques used for fire detection using image processing. The authors compare and analyze different algorithms and methods used for fire detection, such as edge detection, segmentation, and texture analysis[1]. This system proposes a real-time fire detection and localization system that combines image processing techniques, such as color analysis and contour detection, with machine learning algorithms. The system aims to accurately detect and locate fires in video streams[4]. This proposed system presents a fire detection system specifically designed for forest environments. It utilizes image processing techniques, such as edge detection and texture analysis, in conjunction with machine learning algorithms to detect and classify fires in forest images[5].

The proposed system presents a fire extinguishing robot that utilizes image processing techniques for fire detection and localization. The robot employs computer vision algorithms, such as color-based segmentation and object tracking, to detect fires and extinguish them autonomously.[7] This System proposes a fire detection and localization system suitable for industrial environments. The system employs image processing techniques, such as feature extraction and classification, to detect and locate fires based on video input from surveillance cameras.[6]

This proposed system focuses on fire detection in outdoor environments and proposes an image processing-based fire detection system. It discusses the

challenges specific to outdoor fire detection and presents an efficient approach to address them[18]

This proposed system presents a fire detection system for indoor environments that combines image processing techniques with deep learning algorithms. The system utilizes convolutional neural networks (CNNs) to detect and classify fire-related objects in video frames[9]. The System proposes a real-time fire detection and monitoring system that integrates image processing techniques with IoT technologies. The system uses image processing algorithms to detect fires, and it employs IoT sensors and communication to provide timely alerts and remote monitoring.[10]

This proposed system presents a fire detection and localization system that combines image processing techniques with thermal imaging. The system utilizes color segmentation and thermal analysis to detect and localize fires in video streams, enhancing the accuracy of fire detection.[11]

The system proposes a fire detection and extinguishing system using image processing techniques. It discusses the use of color and motion analysis to detect fire, followed by an automated extinguishing mechanism[15].

A study involving an image processing-based fire detection and extinguisher system often offers a thorough examination of the suggested approach, experimental setting, and findings attained. It gives a thorough analysis of how image processing methods and AI technologies are used in the context of fire safety. The study article outlines the proposed system's inspiration, the problems with current fire detection methods, and the demand for more effective alternatives. It draws attention to the originality and contributions of the suggested approach, which incorporates the ESP8266 microcontroller and the Maix Dock AI controller.

The proposed system presents a fire detection algorithm that combines image processing techniques, such as color segmentation, texture analysis, and morphological operations, to detect fires in video sequences.[17]

This methodology presents a fire detection system that utilizes image processing techniques and artificial neural networks. The proposed system aims to improve fire detection accuracy and reduce false alarms[16].

3. PROPOSED SYSTEM

The proposed method for this System involves the integration of image processing algorithms, the Maix Dock AI controller, and various hardware components to create an effective fire detection and extinguisher system. The method follows a sequential process that includes image acquisition, real-time analysis, fire

detection, and automatic extinguisher activation. The first step is image acquisition. Cameras are strategically placed in the environment to capture video or image data of the monitored area. The cameras can be connected to the Maix Dock or the ESP8266 microcontroller, which acts as the interface between the cameras and the image processing algorithms. Once the image data is acquired, real-time analysis is performed using image processing techniques.

The algorithms implemented on the Maix Dock process the video frames or images to identify fire-related features. These techniques can include color-based segmentation, flame pattern recognition, and motion detection. The goal is to accurately detect flames while minimizing false alarms caused by other light sources or objects. After fire detection, the system triggers the automatic extinguisher mechanism. The microcontroller, such as the ESP8266, sends a signal to activate the relay, which controls the motor pump connected to the extinguisher system. The motor pump starts, releasing the appropriate extinguishing agent, such as water, foam, or gas, to suppress the fire.

This automated process ensures a quick response and effective fire suppression, reducing the risk of fire spreading and causing further damage. To provide visual feedback and information, an LCD 16x2 module can be integrated into the system. The module displays relevant details, such as fire status, location, or system status, in a user-friendly format. Additionally, a buzzer can be connected to provide audible alerts or alarms in case of fire detection, ensuring occupants are promptly informed about the potential danger. The proposed method leverages the power of the Maix Dock AI controller to handle the computational demands of real-time image processing and decision-making. The integration of hardware components, such as cameras, microcontrollers, relays, motor pumps, LCD modules, and buzzers, enables seamless communication and interaction between the image processing system and the physical extinguisher mechanism.

It is important to note that the specific implementation details may vary based on the chosen image processing algorithms, hardware components, and system requirements. Customization and calibration of the algorithms and hardware settings may be necessary to achieve optimal performance in different environments.

Additionally, proper safety measures should be followed during the integration and deployment of the system to ensure the overall effectiveness and reliability of the fire detection and extinguisher system.

Overall, the proposed method combines advanced image processing techniques, intelligent hardware integration, and real-time decision-making to create an innovative fire detection and extinguisher system. By leveraging these technologies, the system aims to enhance fire safety, provide swift response to fire incidents, and minimize the potential risks associated with fires in various environments

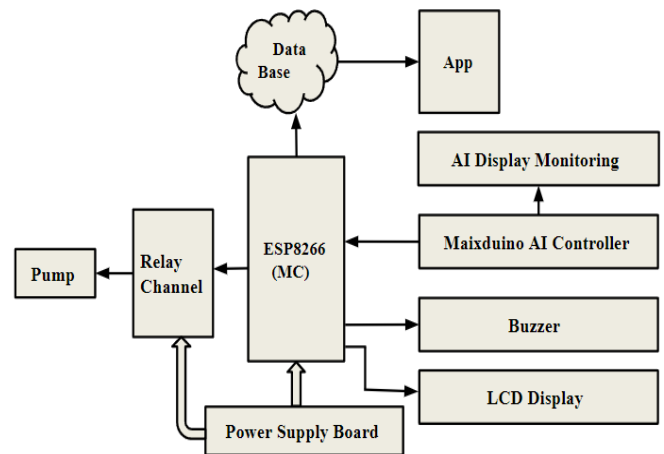


Figure 1: Block diagram for fire detection and extinguisher system using image processing

A. Integration

Image/Video Acquisition: The system captures images or video frames of the monitored area using cameras strategically placed in the environment.

Preprocessing: The acquired images or video frames undergo preprocessing to enhance their quality and prepare them for further analysis. This preprocessing may include tasks such as resizing, noise reduction, contrast enhancement, or color space conversion.

Fire Detection Algorithms: Image processing algorithms are applied to the preprocessed images or video frames to detect fire-related features.

Feature Extraction: Relevant features related to fire, such as color histograms, texture descriptors, or motion vectors, are extracted from the analyzed images or video frames. These features help to distinguish fire-related patterns from non-fire elements and background clutter.

Decision-making and Classification: The extracted features are used to make decisions regarding the presence of fire.

Alerting and Response: When a fire is detected, the system triggers an alert or alarm to notify relevant personnel or authorities. This involve sounding alarms, displaying visual notifications, sending notifications to a central monitoring station.

4. IMPLEMENTATION OF COMPONENTS

ESP8266 (Micro Controller): The ESP8266 12-E chip comes with 17 GPIO pins.

The ESP8266 only supports analog reading in one GPIO. That GPIO is called ADC0 and it is usually marked on the silkscreen as A0.

The maximum input voltage of the ADC0 pin is 0 to 1V if you're using the ESP8266 bare chip. the ESP8266 microcontroller collects sensor data, wirelessly communicating with other devices, and controlling various components of the system. The ESP8266 is connected to sensors such as temperature sensors or smoke detectors, which provide input about the environment. It reads the sensor data and transmits it wirelessly to a central processing unit for analysis. Additionally, the ESP8266 can interface with camera modules to capture visual data and transmit it for fire detection analysis. When a fire is detected, the ESP8266 can trigger the activation of relays, which control devices like motor pumps or extinguishing systems to suppress the fire. Furthermore, the ESP8266 can provide a user interface by connecting to an LCD module, displaying relevant information such as fire status or system alerts. Overall, the ESP8266 serves as a vital component that facilitates data acquisition, communication, and control in the fire detection system.



Figure 2 : ESP8266 (Micro Controller)

MAIX DOCK: SIPEED MaixDock is a development board compatible with Arduino based on the M1 module (main control: Kendryte K210).

The module has a built-in 64-bit dual-core processor chip and 8MB on-chip SRAM.

MaixDock integrates camera, TF card slot, user buttons, Maix Dock expansion interface, etc., users can use Maix Dock to easily build a face recognition access control system, and also reserve development and debugging interfaces.

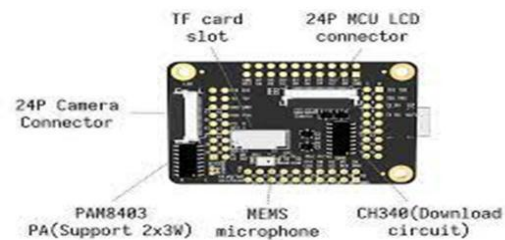


Figure 3: Maix Dock

MICRO CAMERA: The 0.3MP OV7670 camera module with high-quality SCCB connector is a low voltage CMOS image sensor; that provides the full functionality of a single-chip VGA(Video Graphics Array) camera and image processor in a small footprint package.

The OV7670/OV7171 provides full-frame, sub-sampled or windowed 8-bit images in a wide range of formats In addition, OV7670 CAMERA CHIPS use proprietary sensor technology to improve image quality by reducing; or eliminating common lighting/electrical sources of image contamination; such as fixed pattern noise (FPN), smearing, blooming, etc., to produce a clean, fully stable color image.



Figure 4: Micro Camera

5. WORKING OF THE MODEL

The device uses a camera that is strategically positioned in the area being watched to record photos or video streams. The Maixduino AI controller makes it easier to capture and process images. In order to improve the quality of the acquired photos and get them ready for fire detection analysis, preprocessing techniques are applied to them. This involves lowering the noise level, shrinking the image, and adjusting the contrast. The processed images are then analyzed using image processing algorithms implemented on the Maixduino AI controller. These algorithms employ techniques such as background subtraction, color-based fire detection, and object recognition to identify potential fire sources within the images.

The Maixduino AI controller, equipped with a powerful RISC-V dual-core processor and a dedicated CNN accelerator, accelerates the image recognition process. This enables fast and accurate detection of fire patterns and shapes within the images. The system employs a trained machine learning model, often a CNN, to classify the detected regions as either fire or non-fire. The model is trained on a large dataset of fire and non-fire images to achieve high accuracy in distinguishing between normal activities and fire incidents.

When a fire is detected and classified, the system triggers an alert or notification mechanism, which can be integrated with existing fire alarm systems or emergency notification systems. Real-time information about the fire incident is relayed to relevant personnel, enabling swift response and appropriate evacuation procedures. The system continuously captures and analyzes images, updating the fire detection and classification process in real-time. The data logging feature of the Maixduino AI controller allows for the analysis of fire incidents, enabling the refinement and improvement of the system's performance over time.

By utilizing the Maixduino AI controller's processing power and image recognition capabilities, the fire detection system effectively detects and classifies fire incidents in real-time. It offers an efficient and proactive approach to fire safety, enabling prompt response and reducing the risks associated with fires. In addition to the Maixduino AI controller incorporates the ESP8266 module for transferring information to the Firebase Cloud interface, enabling seamless communication and remote control.

Once a fire is detected and classified, the Maixduino AI controller sends the relevant information, such as the location and severity of the fire, to the Firebase Cloud interface. The ESP8266 module, integrated with the controller, establishes a connection with Firebase for secure data transmission. The Firebase Cloud interface receives the fire incident information and triggers a notification mechanism. This notification is then sent to a Java application, designed to receive and process the notifications in real-time. The Java application can run on a desktop computer, mobile device, or any compatible platform.

The Java application provides a user-friendly interface that allows authorized personnel to receive the fire notification and take necessary actions. The interface displays relevant information about the fire incident, such as the location and severity. It also provides controls to remotely operate the sprinklers, water pump, and buzzer alarm. Remote Activation and Deactivation: Through the Java application, authorized

users can remotely activate or deactivate the sprinklers, water pump, and buzzer alarm, depending on the severity of the fire incident. This provides an efficient way to control the fire suppression mechanisms without physical intervention, ensuring swift and effective response.

The system continuously monitors the fire incident status and updates the Java application interface accordingly. Users can receive real-time feedback on the current state of the fire suppression mechanisms and make informed decisions based on the situation. By incorporating the ESP8266 module for data transfer to the Firebase Cloud interface and leveraging a Java application for notifications and control, the fire detection system offers a comprehensive and remote monitoring solution. This integration enables efficient communication, notification delivery, and remote control over the sprinklers, water pump, and buzzer alarm through a user-friendly interface.

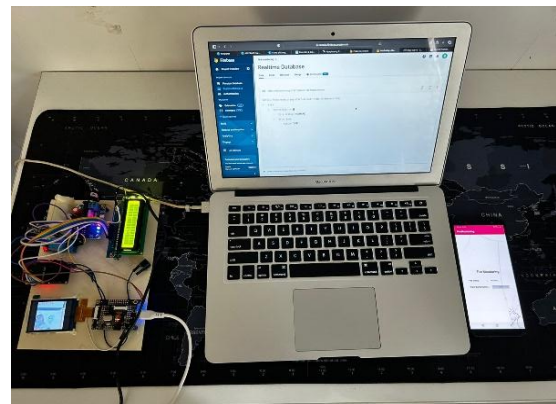


Figure 5 : Working Model with User interface

6. RESULTS

This proposed system is a highly efficient fire detection and extinguisher system using image processing. The system incorporates advanced image analysis algorithms and intelligent hardware integration to achieve accurate and prompt fire detection. By leveraging real-time video analysis, the system can identify fire incidents with high precision while minimizing false alarms. Upon detecting a fire, the system triggers an automatic extinguisher mechanism, allowing for swift and effective fire suppression. The integration of the ESP8266 microcontroller and the Maix Dock AI controller provides seamless connectivity, data acquisition, and control capabilities. Overall, the result of this proposed system is a reliable and comprehensive fire safety solution that significantly enhances fire prevention, emergency response, and minimizes the potential risks associated with fire incidents.

7. CONCLUSION

This proposed system successfully illustrates how to integrate the ESP8266 microcontroller and Maix Dock AI controller with image processing techniques to construct a fire detection and extinguisher system. To accurately identify fires and respond quickly, the system integrates real-time video analysis, cutting-edge image processing algorithms, and intelligent hardware components. The technology significantly reduces the danger of fire-related hazards, protecting lives and minimising property damage by automating the extinguishing procedure upon fire detection. The study demonstrates how image processing and AI technology can be used to improve fire safety, and it has enormous value for a variety of contexts by providing a dependable and effective method of preventing fire occurrences.

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