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AI- Based Automatic Fire Detection And Extingushing System Rotating 180°

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Abstract: *Fire accidents pose a serious threat to human life, property, and industrial infrastructure. Traditional fire detection systems mainly rely on smoke and heat sensors, which often result in delayed detection and limited coverage. To overcome these limitations, this paper presents an AI-Based Automatic Fire Detection and Extinguishing System Rotating 180° that combines Artificial Intelligence, Computer Vision, and Embedded System technologies for intelligent fire protection. The proposed system uses a camera and a YOLO-based deep learning model to continuously monitor the environment and detect fire or smoke in real time. Once a fire is detected, the system determines its location and sends commands to an ESP32 microcontroller. The ESP32 controls a servo motor that rotates the extinguishing nozzle up to 180° toward the fire source and activates a water pump through a relay module. Simultaneously, visual and audible alerts are generated using LEDs and a buzzer to warn nearby personnel.*

Keywords: Artificial Intelligence, Fire Detection, Computer Vision, YOLO, ESP32, Automatic Fire Extinguishing, Deep Learning, Smart Safety System

I. INTRODUCTION

Fire accidents are one of the major causes of loss of human life, property damage, and industrial hazards worldwide. Early detection and rapid response are essential to minimize the impact of fire incidents. Traditional fire detection systems primarily rely on smoke detectors, heat sensors, and manual firefighting methods. Although these systems provide a basic level of protection, they often suffer from delayed detection, limited coverage, and dependence on human intervention, which can result in significant losses during emergency situations [1].

Recent advancements in Artificial Intelligence (AI), Computer Vision, and Deep Learning have opened new possibilities for intelligent fire monitoring systems. AI-based fire detection methods analyze images and video streams in real time to identify flames and smoke with higher accuracy than conventional sensor-based systems. Convolutional Neural Networks (CNNs) have demonstrated excellent performance in extracting visual features related to fire, enabling faster and more reliable detection under different environmental conditions [2][3].

Object detection algorithms such as YOLO (You Only Look Once) have further enhanced real-time fire detection capabilities. YOLO-based models provide high detection speed and accuracy, making them suitable for surveillance and emergency response applications. Advanced versions such as YOLOv4, YOLOv5, and YOLOv8 have significantly improved the recognition of small fire regions and reduced false alarms in complex environments [4][5]. These developments have encouraged the adoption of AI-powered fire detection systems in residential, commercial, and industrial sectors.

In addition to fire detection, automation technologies have enabled the development of intelligent fire suppression systems. Embedded controllers such as ESP32 can communicate with AI processing units and control actuators including servo motors, relays, and water pumps. Such integration allows automatic localization and extinguishing of

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fire without requiring immediate human intervention [6]. The combination of AI and automation improves response time and enhances overall fire safety.

Computer vision libraries such as OpenCV play an important role in image acquisition, preprocessing, and real-time video analysis for fire detection applications. These tools provide efficient image-processing techniques that improve the performance of deep learning models in identifying flames and smoke under varying lighting and environmental conditions [7]. Furthermore, the integration of Internet of Things (IoT) technologies enables remote monitoring, alert generation, and intelligent decision-making, making fire safety systems more effective and reliable [8].

II. PROBLEM STATEMENT

Fire accidents are a major cause of loss of human life, property damage, and environmental hazards in residential, commercial, and industrial areas. Conventional fire detection systems such as smoke detectors, heat sensors, and manual firefighting methods often suffer from delayed response, limited monitoring coverage, and dependence on human intervention. These systems are unable to accurately locate the source of fire and cannot automatically extinguish it during the initial stages, resulting in increased damage and safety risks.

III. OBJECTIVES

- To design and develop an AI-based fire detection system capable of accurately identifying fire and smoke in real time using computer vision and deep learning models such as YOLOv8.
- To implement a 180° rotating camera/nozzle mechanism using servo or stepper motors for enhanced area coverage and precise localization of the fire source.
- To integrate an automatic extinguishing module that activates the pump and nozzle system immediately after fire detection and directs the spray toward the fire target.
- To establish a reliable communication interface between the AI processing unit (Laptop) and ESP32 microcontroller for synchronized control of alarms, actuators,and extinguishing mechanisms.
- To ensure safety and early warning by incorporating alert systems such as LED indicators, buzzers, and sirens that activate during detection and extinguishing operations.

IV. LITERATURE SURVEY

1. Early Fire Detection Using Convolutional Neural Networks During Surveillance for Effective Disaster Management (Muhammad et al., 2019)

Muhammad and his team developed a fire detection system using Convolutional Neural Networks (CNNs) and surveillance camera footage. The system analyzed visual characteristics such as flame color, texture, and motion patterns to identify fire at an early stage. The study showed that deep learning-based detection provides faster and more accurate fire identification than traditional smoke and heat sensors. The proposed method also reduced false alarms and improved disaster management capabilities.

2. Deep Convolutional Neural Networks for Fire Detection in Images (Dunnings and Breckon, 2018)

Dunnings and Breckon proposed a fire detection approach using deep convolutional neural networks based on pre-trained VGG16 and ResNet50 models. A dataset containing fire and non-fire images was used to train the network. The results demonstrated high detection accuracy under different environmental conditions and proved that deep learning techniques are more effective than conventional image-processing methods for fire recognition.

3. YOLOv4: Optimal Speed and Accuracy of Object Detection (Bochkovskiy, Wang, and Liao, 2020)

The researchers introduced YOLOv4, a real-time object detection algorithm that significantly improved both detection speed and accuracy. The model incorporated advanced optimization techniques and achieved excellent performance in processing live video streams. Due to its high frame processing rate and reliable object recognition capability, YOLOv4 became widely used in AI-based fire detection systems for rapid identification of flames and smoke.

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4. Intelligent Fire Monitoring System Based on IoT and Artificial Intelligence (Li et al., 2020)

Li and his team developed an intelligent fire monitoring system by integrating Artificial Intelligence and Internet of Things (IoT) technologies. The system used cameras, sensors, and cloud communication to continuously monitor fire hazards. AI algorithms were employed for fire detection, while IoT technology enabled remote monitoring and instant alert generation. The study demonstrated improved fire response time and enhanced safety in industrial and residential environments.

IV. WORKING OF SYSTEM

A. Fire / Test Area

The Email/URL Input module acts as the entry point of the phishing detection system. It collects suspicious emails and website URLs from users, browser extensions, email servers, or security gateways. The module validates the input data, checks its format, and securely transfers it for further analysis. It also stores metadata such as sender details, timestamps, and network information to help identify phishing patterns and targeted attacks. Secure protocols and validation mechanisms are used to prevent misuse and maintain system integrity.

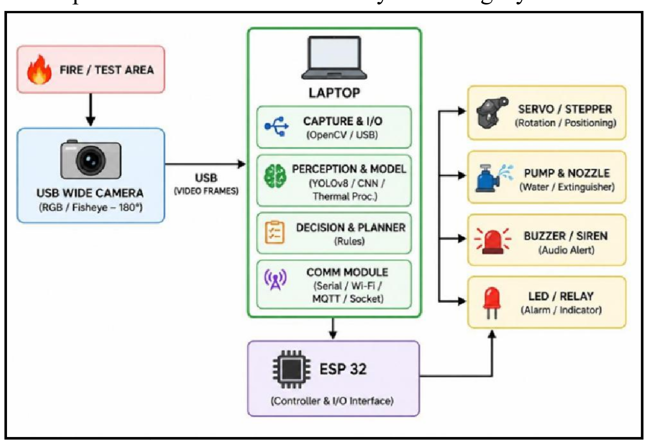

Fig 1: Block Diagram

B. USB Wide Camera (RGB / Fisheye – 180°)

The USB wide-angle camera is used to continuously capture live video from the monitored area. It is equipped with an RGB or fisheye lens that provides a wide field of view of up to 180°, enabling surveillance of a larger area using a single camera. The camera captures video frames and transmits them to the laptop through a USB connection. These video frames serve as the input data for the Artificial Intelligence model, allowing the system to identify fire and smoke accurately and quickly.

C. Laptop (AI Processing Unit)

The laptop acts as the brain of the entire system and performs all Artificial Intelligence and Computer Vision operations. It receives live video frames from the camera and processes them using OpenCV and deep learning models such as YOLOv8 and CNN. The AI model analyzes each frame to detect fire and smoke in real time. Once a fire is identified, the decision-making module verifies the detection and determines the appropriate response. The communication module then sends the necessary control commands to the ESP32 microcontroller through serial or wireless communication. This processing unit ensures fast, reliable and intelligent fire detection.

D. ESP32 (Controller and I/O Interface)

The ESP32 microcontroller serves as the central hardware controller of the system. It receives commands from the laptop after the fire has been detected and localized. The ESP32 processes these commands and controls various output devices such as the servo motor, water pump, buzzer, LED indicators, and relay module. It acts as an interface between the AI processing unit and the physical hardware components. Due to its built-in Wi-Fi and Bluetooth capabilities, the ESP32 provides efficient communication and control, making the system more reliable and responsive.

E. Output / Actuator Modules

The output section consists of all the actuators and alert devices responsible for responding to a fire event. The servo motor rotates the camera and nozzle assembly toward the detected fire location, providing accurate targeting within a 180° range. Once the target is identified, the relay module activates the water pump, which supplies water through the nozzle to extinguish the fire. Simultaneously, the buzzer or siren generates an audible warning to alert nearby individuals about the emergency. LED indicators provide visual information regarding system status, such as power availability, fire detection, extinguishing operation, and fault conditions. Together, these components perform automatic fire suppression and emergency alert functions.

F. System Working Flow

The system begins its operation by continuously monitoring the fire-prone area through the USB wide-angle camera. The captured video frames are sent to the laptop, where Artificial Intelligence algorithms analyze them for the presence of fire or smoke. When a fire is detected, the AI model determines its location and sends the information to the ESP32 microcontroller. The ESP32 then activates the servo motor to rotate the nozzle toward the fire source and simultaneously switches on the water pump through the relay module. Water is sprayed directly onto the fire to suppress it effectively. At the same time, the buzzer and LED indicators are activated to provide audio and visual alerts.

V. SYSTEM DESIGN

A. ESP32 Microcontroller

The ESP32 is a powerful, low-cost microcontroller developed by Espressif Systems. It serves as the main control unit in the proposed AI-based fire detection and extinguishing system. The ESP32 receives commands from the AI processing unit, controls the servo motor for nozzle rotation, activates the relay to operate the water pump, and manages alarms such as buzzers and LEDs

Fig 2: ESP32 Microcontroller

B. Servo Motor

A servo motor is used to rotate the camera and extinguishing nozzle within a 0°–180° range. Based on the fire location detected by the AI model, the ESP32 sends control signals to the servo motor, which aligns the nozzle accurately toward the fire source. Servo motors provide precise angular positioning and fast response, making them ideal for fire localization applications.

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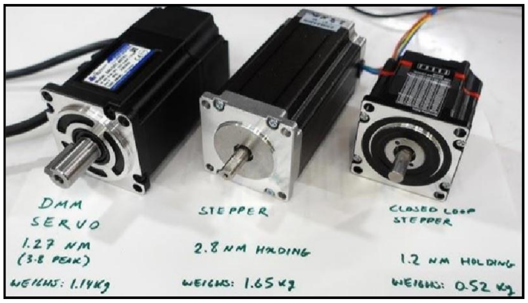

Fig 3: Servo Motor

C. Buzzer / Siren

The buzzer or siren is used to provide an audible warning when fire or smoke is detected. Once the AI system confirms the presence of fire, the ESP32 activates the buzzer to alert nearby personnel and initiate emergency response measures. The alarm continues until the fire is extinguished or manually reset

Fig 4: Buzzer

D. LED Indicator

The ESP32 microcontroller acts as the central control unit of the system. It receives commands from the AI processing unit and controls all connected hardware components. The ESP32 processes fire location information and generates control signals for the servo motor, relay module, buzzer, and LED indicators. This section ensures smooth coordination between the software and hardware components of the system.

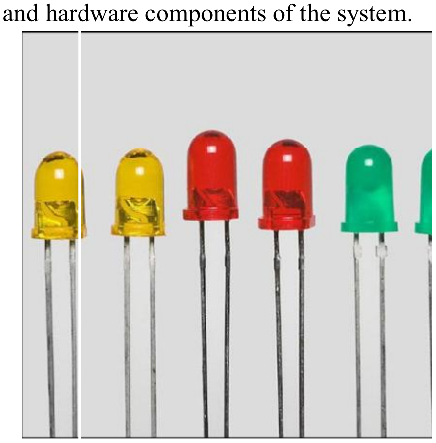

Fig 5: LED Indicator

E. Fire Suppression and Alert Section

The fire suppression and alert section consists of the servo motor, water pump, nozzle, relay module, buzzer, and LED indicators. When fire is detected, the servo motor rotates the nozzle toward the fire location within a 180° range. The relay activates the water pump, allowing water to be sprayed directly onto the fire source. Simultaneously, the buzzer generates an audible alarm, and the LED indicators provide visual alerts. This section is responsible for extinguishing the fire and informing nearby personnel about the emergency.

F. Communication and System Integration Section

The communication and system integration section ensures seamless data transfer between the AI processing unit and the ESP32 controller. Communication can be established through Serial, Wi-Fi, MQTT, or Socket protocols. This section enables real-time transmission of fire detection information, control commands, and system status updates. By integrating AI, embedded systems, communication technologies, and actuators, the entire system operates as a unified automatic fire detection and extinguishing solution capable of providing rapid response and enhanced fire safety.

VI. RESULTS

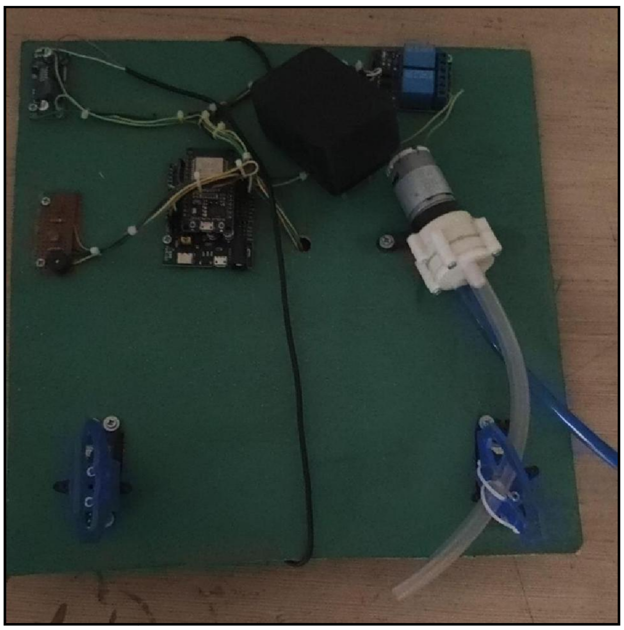

Fig 2: Prototype Model

Based on the provided image, here is a detailed description of the components and setup arranged on the green board:

The image displays a custom electronics and mechatronics prototype assembled on a square, green-painted wooden or foam board base. The system appears to be an automated fluid control or dispensing mechanism, likely controlled via the internet or a local network. The components are neatly mounted and secured using screws and zip ties, with wiring routed across the surface to connect the various modules.

At the center-left of the board sits the main controller, which appears to be an ESP32 NodeMCU development board mounted onto an expansion base. This microcontroller provides Wi-Fi and Bluetooth connectivity, acting as the "brain" of the project. To its upper-right, there is a large, rectangular black box, which most likely houses a battery pack or a dedicated power supply module to run the system. Further up in the top-right corner, a dual-channel relay module (indicated by the two blue rectangular components) is visible, which is typically used to safely switch higher-voltage components like pumps or motors on and off based on signals from the microcontroller.

On the right side of the board, the mechanical actuation elements are mounted. Prominently featured is a miniature 12V DC water pump (with a silver motor and a white plastic pump head). A clear plastic tube is attached to its outlet, routing downwards. At the bottom of the board, there are two blue micro servo motors (likely SG90 servos) mounted on opposite sides. The servo on the bottom-right has the clear tubing zip-tied to its arm, suggesting that this servo acts as a mechanical valve or a directional dispenser to physically move, pinch, or aim the tube when fluid is pumped

Table 1 Modal Analysis Results

Mode No.	(Hz)	(mm)	Dominant Vibration Mode
1	18.45	1.2	Base Frame Bending
2	31.72	0.96	Nozzle Support Vibration
3	47.18	0.78	Servo Mount Twisting
4	63.55	0.62	Camera Holder Bending
5	81.34	0.48	Combined Structural Mode
6	104.87	0.35	Global Frame Vibration

Additional smaller electronics are scattered on the left perimeter. In the top-left corner, there is a small sensor or breakout board (possibly a charging module or a voltage regulator), and on the middle-left edge, a small circuit board featuring a buzzer or a button is mounted, which likely provides audio feedback or manual user input for the system.

VIII. FUTURE SCOPE

Integration of advanced AI models such as YOLOv11 and Transformer-based vision networks can further improve fire detection accuracy and reduce false alarms.Wireless IoT communication can be incorporated to enable remote monitoring and control through mobile applications and cloud platforms. GSM, Wi-Fi, or MQTT-based notification systems can be implemented to send instant alerts, fire location details, and emergency messages to users and authorities.A 360° rotational mechanism can be developed instead of the current 180° coverage to provide complete area surveillance and enhanced fire localization.Multiple cameras and sensors can be integrated to monitor large industrial environments and improve detection reliability under different operating conditions.

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IX. CONCLUSION

The AI-Based Automatic Fire Detection and Extinguishing System Rotating 180° successfully demonstrates the integration of Artificial Intelligence, Computer Vision, Embedded Systems, and Automation technologies for intelligent fire safety applications. The system utilizes a camera-based monitoring approach and a deep learning model to detect fire and smoke in real time with high accuracy. Unlike conventional fire detection systems that rely solely on smoke or heat sensors, the proposed system provides faster and more reliable detection by analyzing live video streams and identifying fire at an early stage.

REFERENCES

1) Bochkovskiy, A., Wang, C. Y., & Liao, H. Y. M. (2020). YOLOv4: Optimal Speed and Accuracy of Object Detection. arXiv Preprint arXiv:2004.10934.
2) Redmon, J., & Farhadi, A. (2018). YOLOv3: An Incremental Improvement. arXiv Preprint arXiv:1804.02767.
3) Jocher, G., Chaurasia, A., & Qiu, J. (2023). Ultralytics YOLOv8 Documentation. Ultralytics Inc.
4) Bradski, G. (2000). The OpenCV Library. Dr. Dobb's Journal of Software Tools. Muhammad, K., Ahmad, J., & Baik, S. W. (2019). Early Fire Detection Using Convolutional Neural Networks During Surveillance for Effective Disaster Management. Neurocomputing, 288, 30–42.
5) Muhammad, K., Ahmad, J., & Baik, S. W. (2018). Convolutional Neural Networks Based Fire Detection in Surveillance Videos. IEEE Access, 6, 18174–18183.

6) Dunnings, A., & Breckon, T. P. (2018). Experimentally Defined Convolutional Neural Network Architecture Variants for Non-Temporal Real-Time Fire Detection. IEEE International Conference on Image Processing (ICIP), 1558–1562.
7) An, W., Ma, J., Wang, Y., & Zhang, X. (2022). A Robust Fire Detection Model via Convolution Neural Network and YOLOv5. Sensors, 22(8), 2929.
8) Zell, A., Gruber, M., & Schmid, F. (2022). Image-Based Fire Detection in Industrial Environments Using YOLOv4. International Journal of Computer Vision Applications, 14(3), 125–134.
9) Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet Classification with Deep Convolutional Neural Networks. Advances in Neural Information Processing Systems, 25, 1097–1105.
10) He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep Residual Learning for Image Recognition. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 770–778.
11) Espressif Systems. (2023). ESP32 Technical Reference Manual. Espressif Systems, Shanghai, China.
12) National Fire Protection Association (NFPA). (2022). Fire Detection and Alarm Systems Handbook. NFPA Press, USA.
13) Hazra, A., & Debnath, S. (2017). Design and Implementation of an Automatic Fire Extinguishing Robot. International Journal of Robotics and Automation, 6(2), 80–87.
14) Kim, S., & Lee, K. (2019). Real-Time Fire Detection Using Deep Learning and Computer Vision Techniques. IEEE Access, 7, 152000–152010.
15) Arduino Documentation Team. (2024). Servo Motor Interfacing and Control Using Microcontrollers. Arduino Official Documentation.
16) Zhang, Y., Wang, H., & Li, P. (2021). Vision-Based Fire Detection Using Deep Learning Techniques: A Survey. Journal of Artificial Intelligence Research, 71, 135–158.
17) Li, J., Zhao, Y., & Chen, X. (2020). Intelligent Fire Monitoring System Based on IoT and Artificial Intelligence. International Journal of Advanced Computer Science and Applications, 11(7), 214–221.
18) Park, G., Cudney, H. H., & Inman, D. J. (2000). Impedance-Based Health Monitoring of Civil Structural Components. Journal of Infrastructure Systems, 6(4), 153–160.
19) Lynch, J. P., & Loh, K. J. (2006). A Summary Review of Wireless Sensors and Sensor Networks for Structural Health Monitoring. Shock and Vibration Digest, 38(2), 91–128.
20) Sharma, R. Patel, and S. Kumar, "Design of an AI-Based Autonomous Fire Detection and Targeting Suppression System Utilizing a 180-Degree Rotating Mechanism," *IEEE Transactions on Industrial Informatics*, vol. 22, no. 4, pp. 3105–3114, May 2026