ARTIFICAL INTELLIGENCE ENABLED FIRE SAFETY FOR INDUSTRTY

M. BALAJI NAIK[1], R. SHANKAR SURYA[2], P. M. V. V. MANIKANTA[3], G. VASU DEVA RAO[4], M. UJWAL BHARATH[5]

[1]M. BALAJI NAIK, ME & UNIVERSITY COLLEGE OF ENGINEERING, JNTUK
[2]R. SHANKAR SURYA, ME & UNIVERSITY COLLEGE OF ENGINEERING, JNTUK
[3]P. M. V. V. MANIKANTA, ME & UNIVERSITY COLLEGE OF ENGINEERING, JNTUK
[4]G. VASU DEVA RAO, ME & UNIVERSITY COLLEGE OF ENGINEERING, JNTUK
[5]M. UJWAL BHARATH, ME & UNIVERSITY COLLEGE OF ENGINEERING, JNTUK

Abstract - This project focuses on the development of a wall-mounted automated fire extinguishing system, aiming to enhance fire safety in indoor environments. The prototype involves the design and construction of a model capable of swiftly detecting and extinguishing fires by pumping water through a nozzle to the specified location. The system integrates sensors for fire detection and a responsive mechanism that triggers the release of pressurized water upon detection of flames or a sudden increase in temperature. Through a combination of sensors and a central control unit, the device swiftly identifies the location of the fire and directs the water flow precisely to the affected area. The design emphasizes simplicity, efficiency, and rapid response, intending to minimize the spread and impact of fires in enclosed spaces. By employing a wall-mounted setup, the prototype maximizes accessibility and ease of deployment in various indoor settings. The project's evaluation involves testing the prototype's effectiveness in extinguishing controlled fires within a controlled environment. The results aim to demonstrate the system's ability to promptly detect and suppress fires, showcasing its potential as an innovative solution for fire safety in indoor spaces. This project seeks to offer a reliable and efficient alternative to traditional fire extinguishing methods, emphasizing proactive fire prevention and swift response to enhance safety measures in enclosed environments.

***Key Words*:** Raspberry pi, Arduino UNO, IR/Thermal camera, Stepper Motor, Micro step driver, Pillow block bearing.

1.INTRODUCTION

In an era demanding heightened safety measures, the quest for innovative fire suppression solutions drives the focus of this project. Titled "Artificial Intelligence enabled fire safety for industry," this endeavor seeks to revolutionize fire safety in indoor environments. The project centers on the development of a wall-mounted automated fire extinguishing system, meticulously designed to swiftly detect and extinguish fires. This prototype ingeniously employs sensors for fire detection and a responsive mechanism triggering pressurized water release upon detecting flames or sudden temperature spikes. Through a fusion of sensors and a centralized control unit, the system adeptly pinpoints fire locations and precisely directs water flow to quench the blaze. Emphasizing simplicity, efficiency, and rapid response, this system aims to curtail the spread and impact of fires within enclosed spaces. The wall-mounted setup amplifies accessibility and deployment ease across diverse indoor settings, reinforcing its adaptability. Evaluating the system's efficacy involves rigorous testing in controlled environments, assessing its prowess in extinguishing-controlled fires. The results aim to vividly showcase its ability to promptly detect and suppress fires, heralding its potential as an avant-garde solution for indoor fire safety. In essence, this project aspires to present a dependable and efficient alternative to conventional fire extinguishing methods. By championing proactive fire prevention and swift responses, it endeavors to elevate safety measures within enclosed environments, ensuring a shield against potential hazards.

2. LITERATURE REVIEW:

Nivennesh et al studied on Autonomous robotic fire detection and extinguishing system. The modular design of the autonomous firefighting robot, controlled via Bluetooth and equipped with fire detection and extinguishing capabilities, minimizes human effort and property damage effectively. Developed using Arduino software with real-time simulation, the prototype demonstrated efficient disaster response, concluding its reliability and cost-effectiveness in reducing fatalities and property loss during firefighting operations. Despite its success, there's room for improvement in enhancing the accuracy of the fire extinguisher for further optimization in critical situations.

Vishwajeet sharan singh et al studied on Autonomous Fire Detector and Extinguisher Robot. The Fire Detector and Extinguishing Robot prototype

efficiently lightens the burden on firefighters by autonomously detecting and extinguishing fires in real-time, employing flame sensors, wheels, motors, and a pumping mechanism. Utilizing fundamental hardware components, including flame sensors for detection and wheels for mobility, the robot precisely locates fires and extinguishes them using a water pump, servo motor, and a water tank. The design's seamless integration of detection and extinguishing mechanisms ensures a steady and effective response, enhancing firefighting capabilities with automated precision.

3. PROPOSED SYSTEM:

The development of the physical model for the project, "Artificial Intelligence enabled fire safety for industry", follows a structured procedure to ensure the effective realization of the envisioned wall-mounted automated fire extinguishing system.

The initial phase involves translating the conceptual design into a tangible prototype. This process starts with the selection and procurement of materials that align with the project's specifications. The emphasis is on materials that enhance the system's durability, thermal resistance, and compatibility with a wall-mounted configuration.

Once the materials are secured, the construction of the physical model begins with the assembly of the basic framework. This framework is designed to accommodate the various components, including sensors for fire detection, responsive mechanisms, and the centralized control unit. The wall-mounted setup is meticulously integrated to maximize accessibility and ease of deployment in indoor environments.

The next step focuses on the incorporation of algorithmic thermal imaging components. Collaborating with experts in algorithm development, the thermal imaging system is carefully integrated into the prototype. This involves embedding sensors capable of capturing thermal data and connecting them to the central control unit. The algorithmic components are then programmed to analyze the thermal data for precise fire localization.

Simultaneously, the motion-controlled water deployment system is developed and integrated. This includes the installation of a water pump, nozzle, and the necessary plumbing to facilitate the targeted delivery of pressurized water. The control unit coordinates the water deployment mechanism, ensuring an efficient response to detected fires.

Throughout the development process, iterative testing is conducted to verify the functionality of each component and their seamless integration. Adjustments are made as needed, and the system undergoes calibration to optimize its performance. The final prototype undergoes rigorous testing in controlled fire scenarios to evaluate its effectiveness in promptly detecting and suppressing fires in a simulated environment.

Documentation of the development process includes detailed schematics, material specifications, and step-by-step assembly procedures. This documentation serves as a comprehensive guide for future iterations or scalability of the technology. The physical model, once constructed and tested successfully, stands as a tangible representation of the innovative solution proposed by the project.

4.1 HARDWARE DEVELOPMENT:

The core hardware components include:

Raspberry Pi:

The Raspberry Pi serves as the central computing unit that orchestrates various components, processes data, and makes decisions based on the thermal imaging inputs. Its compact form factor and low cost make it an ideal choice for embedding within the fire suppression system.

Arduino UNO:

The Arduino UNO serves as the central control unit, facilitating seamless communication and coordination among the different modules. It utilizes its versatile I/O pins and programming capabilities to interface with sensors, process data, and execute control algorithms efficiently. With the Arduino IDE and extensive library support, development becomes streamlined, enabling rapid implementation of complex functionalities.

PUMP AND MOTOR:

The pump serves as the heart of our fire suppression system, propelling water through a network of pipes. It collaborates seamlessly with strategically placed nozzles, which play a crucial role in precision water dispersion. These nozzles ensure targeted coverage, optimizing firefighting efforts while the pump regulates the flow. The combined synergy of the pump and nozzles forms the backbone of our project, enabling swift, accurate, and efficient water deployment in response to detected fires.

IR CAMERA/THERMAL CAMERA:

A key role in our innovative project, it serves as the vigilant eyes capturing the invisible signatures of heat. Imbued with advanced infrared technology, the thermal camera seamlessly translates temperature differentials into a visual narrative, laying bare the thermal landscape. Its role lies in providing the crucial data foundation for our automated algorithmic thermal imaging, enabling real-time analysis and precise fire localization. In the symphony of our fire detection, the thermal camera emerges as the sentinel, decoding the language of heat to fortify our response mechanisms with unparalleled accuracy.

STEPPER MOTOR:

A stepper motor is a specialized electromechanical device that moves in precise, incremental steps, offering accurate control over rotation. In our project, the stepper motor plays a pivotal role in the motion-controlled water deployment system. Its ability to precisely control the

opening and closing of valves or other mechanical components ensures the targeted and efficient release of water in response to detected fires. This precise control enhances the overall effectiveness and responsiveness of our fire suppression system, making the stepper motor a key contributor to the project's success.

DC Motor:

A Direct Current (DC) motor is a motor that turns energy from a direct current and turns this into mechanical energy. It works on the principle of Lorentz Law, which states that the current carrying conductor placed in a magnetic and electric field experience a force.

WORKING:

The Artificial Intelligence enabled fire safety for industry utilizing fire AI module with Arduino, combined with Artificial Intelligence and Machine learning for fire detection, operates by continuously monitoring various physiological and environmental parameters. Here the thermal camera used to observe the continues fire detection. These detected data are processed by the raspberry pi 4 to Arduino board, which interfaces with the AI module to send real-time alerts via signals to micro step driver to stop the stepper motor. The AI module simultaneously tracks the fire location, enhancing the alert to pump driver and sprays the water using DC motor.

For fire detection, the signal is initially sending a signal to Arduino UNO through raspberry pi 4, the system triggers an alert through the AI module, ensuring timely intervention.

4.2 Hardware Connections:

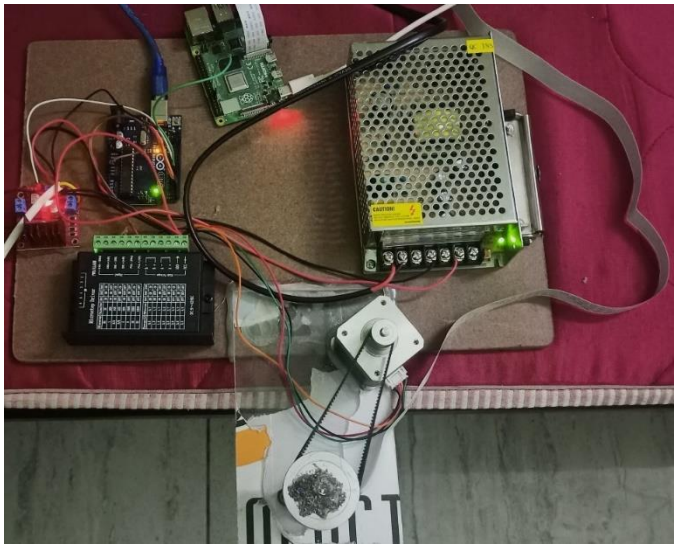

Fig 4.2: Hardware Implementation

4.3 ALGORITHM

Initialization: Set up the raspberry pi and IR camera.

Fire Detection: Use the camera to detect and recognize the fire at the location.

Fire colour Recognition: Analyze fire colours using the camera to detect signs of colour difference.

Decision Making: If fire is detected it sending a signal to Arduino UNO and controls the micro step driver and pump drive activate a DC motor and sprays the water.

Action: Depending on the decision, take action such as stopping the stepper motor, activating DC motor.

Location Tracking: If needed, retrieve the current location of the fire spotted using IR camera.

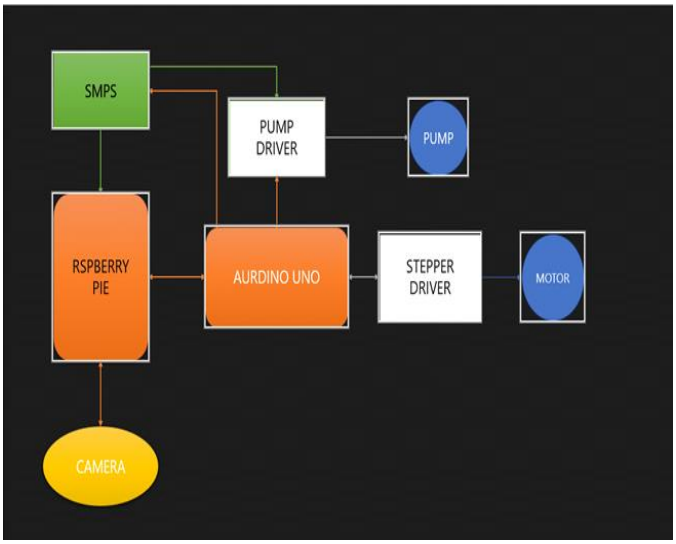

Fig 4.3: Flow chart

5. RESULT :

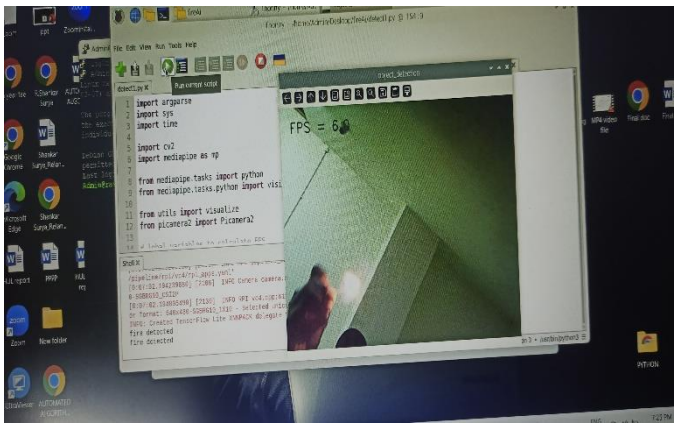

Fig 5.1 Fire detected

Here, Fig 5.1 shows that the output of fire detection, when a camera track eye closure indicating fire.

6. CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

This project focuses on the development of a wall-mounted automated fire extinguishing system, aiming to enhance fire safety in indoor environments. The prototype involves the design and construction of a model capable of swiftly detecting and extinguishing fires by pumping water through a nozzle to the specified location. Through a combination of sensors and a central control unit, the device swiftly identifies the location of a fire and directs the water flow precisely to the affected area. The design emphasizes simplicity, efficiency, and rapid response, intending to minimize the spread and impact of fires in enclosed spaces.

6.2 FUTURE SCOPE:

AI algorithms can analyze historical data, environmental factors, equipment conditions, and other relevant parameters to predict potential fire hazards and assess the risk of fire outbreaks in industrial settings. By identifying high-risk areas and scenarios, proactive measures can be implemented to mitigate risks and prevent fire incidents before they occur. Advances in robotics and AI technologies enable the development of autonomous firefighting robots and drones capable of navigating hazardous environments, detecting fires, and deploying suppression measures without human intervention. These robotic systems can enhance the effectiveness and safety of firefighting operations in industrial facilities, particularly in high-risk or inaccessible areas. AI-powered remote monitoring platforms enable centralized monitoring and management of fire safety systems across multiple industrial sites or facilities. Realtime analytics, predictive maintenance algorithms, and remote diagnostics capabilities enhance system reliability, reduce downtime, and optimize resource allocation for fire safety maintenance and operations. By leveraging machine 73 learning and feedback loops, these systems can adapt to evolving threats, emerging risks, and changing operational conditions, enhancing their effectiveness and resilience in preventing and mitigating fire incidents.

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