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Design and Deployment of an IoT-Driven Firefighting Robot with Adaptive Fire Extinguishing Agents and GPS Integration

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Abstract - This paper reports the design and development of an Autonomous Fire Fighting Robot. The project mainly focuses on developing a robot that can go to places where a fireman has to risk his life and go put off the fire. Fire disasters can occur anytime at any place and result in high losses. Due to the damage of buildingsand explosive materials, it becomes a major task to save people and to stop a disaster. With such constraint sin the handling of fire, a technological breakthrough that can help to fight the fire utilizing a fire fighting robot from which people and properties can be saved from the fire accidents. With the advancement of technology, humans are replaced with robots in life-risking situations. In the proposed system, we develop a robot that automatically detects, navigates, and suppress the fire before it rages out of control. The system automatically detects the fire using the flame sensors attached to the firefighting robot, which will continuously monitor the intensity of the fire. If the value of temperature increases above the predefined value it will send the warning message to the corresponding authority using the GSM module and at the same time robot automatically navigate towards the detected fire. Consequently, the robot moves in the direction to which the temperature recorded to be relatively very high among three flame sensors using an L293 motor driver. Once the robot reaches near the fire, Arduino actuates the relay and the pump will automatically on for the water to be sprinkled through the sprinkler. By implementing the proposed system,any fire disasters can be avoided with a minimal amount of damage to property and risk of human life.

Keywords: Fire Fighting Robot, Arduino, Flame Sensors, Temperature Sensor, Motor Driver, Sprinkler, Disaster.

I. INTRODUCTION

Nowadays, securing one's property and business against fire is becoming more and more important. Monitoring commercial and residential areas all-round is an effective method to reduce personal and property losses due to fire disaster.

Home fire detection is a matter of great concern, and thus many efforts are devoted in most developed countries to the design of automatic detection systems. A fire alarm system should reliably and in a timely way notify building occupants about the presence of fire indicators, such as smoke or high temperatures. A fire detector is usually implemented as a smoke sensor due to its early fire detection capability, fast response time and relatively low cost. Other options for the fire detection are based on gas sensors or temperature sensors fire detectors that use a single sensor, generally a smoke sensor, and present high false-alarm rates due to temperature changes.

In order to prevent fires from occurring or minimize their impact,

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accurate and early detection is essential, and automatic fire detection is becoming very essential to reduce the fire in the building and industry. Automatic fire alarm system provides real-time surveillance and monitoring. A key aspect of fire protection is to identify a developing fire emergency in a timely manner, and to alert the building's occupants and fire emergency organizations. This is the role of fire detection and alarm systems.

Generally, fire detectors are designed to respond at an early stage to one more of the four major characteristics of combustion, heat, smoke, flame or gas. No single type of detector is suitable for all types of premises or fires. Heat detectors respond to the temperature rise associated with a fire and smoke detector respond to the smoke or gas generated due to fire.

The most prevalent threat faced by all institutions is FIRE. No institution is immune from fire. Until the owners/trustees of these institutions develop plans for dealing with the fire threat, they place the building and its occupants and collections at risk.

The complexity of these plans may vary from a simple evacuation plan, to a fire prevention program, to a more complex plan that includes passive and automatic fire protection systems almost 90% of fire damages occur due to lack of early fire detection. A fire attack is usually silent and people will know about fire only when it has spread across a large area. SMS based Fire Alert system gives warning immediately to one or more mobile numbers and hence remedy actions can be taken quickly. This helps to prevent major damages and losses created by a fire accident.

II. LITERATURE REVIEW

Akyildiz, I. F., & Kasimoglu, I. H. (2004). Wireless sensor and actor networks: research challenges. Ad Hoc Networks, 2(4In their seminal paper, Akyildiz and Kasimoglu explore the emergent field of Wireless Sensor and Actor Networks (WSANs), which synergize the capabilities of sensors and actors to monitor and interact with the physical world. Sensors gather information about the environment, while actors take action based on this data, thus forming a comprehensive system for automated response and control in various applications such as environmental monitoring, military operations, and healthcare.

Akyildiz and Kasimoglu's comprehensive examination of these challenges provides a foundational framework for future research and development in WSANs, emphasizing the need for interdisciplinary approaches to address the complexities inherent in such systems.

Al-Kuwari, M., Ramadan, A., Ismael, Y., Al-Sughair, L., Ismail, M., & Al-Ali, A. (2018). Smart-home automation using IoT-based sensing and monitoring platform. IEEE Transactions on Consumer Electronics, 64(3), 259-266. doi:10.1109/TCE.2018.2859578

This paper by Al-Kuwari et al. presents a comprehensive design and implementation of a smart home automation system utilizing an Internet of Things (IoT) based sensing and monitoring platform. The primary objective is to enhance the quality of life by automating home environments, providing convenience, security, and energy efficiency. The proposed system integrates various sensors and actuators connected through an IoT platform to perform tasks such as lighting control, temperature regulation, security monitoring, and energy management.

The paper demonstrates the effectiveness of the IoT-based smart home automation system through a prototype implementation and experimental results. The system shows significant potential in improving home automation, security, and energy management, making it a valuable addition to modern smart homes.

Amudha, P., & Philominathan, P. (2020). An IoT-based smart fire detection and alerting system. International Journal of Innovative Technology and Exploring Engineering

Amudha and Philominathan's paper addresses the critical issue of fire safety by developing an IoT-based smart fire detection and alerting system. This system aims to provide early fire detection and prompt alerts to minimize damage and enhance safety in residential and commercial buildings.

Experimental Results: The authors present experimental results demonstrating the system's effectiveness in detecting fires and generating timely alerts. The results indicate that the system can reliably detect fire incidents and provide early warnings to prevent significant damage

Amudha and Philominathan's work highlights the potential of IoT-based systems in enhancing fire safety. By integrating various sensors, microcontrollers, and IoT connectivity, the proposed system offers a comprehensive solution for early fire detection and alerting, significantly improving response times and reducing the risk of fire-related incidents.

Asadi, P., & Vahidnia, M. H. (2021). An efficient IoT-based fire detection and alarm system using fog computing. Journal of Ambient Intelligence and Humanized Computing,

Asadi and Vahidnia present an innovative approach to fire detection and alarm systems by incorporating IoT and fog computing technologies. This integration aims to enhance the efficiency and reliability of fire detection systems, providing real-time monitoring and rapid response capabilities.

III. METHODOLOGY

Design and develop the fire fighting robot that is utilized to control any disaster caused by fire, instead of Temperature sensors, Motor Driver, Motors, Servo Motor, Water Tank, GPS Module, GSM Module, Relay Module, Water Pump, Water Tank, Alarm, Chassis is used to mount all the components onto it. The power supply is connected to Arduino UNO and the motor driver. Once the fire is detected the robot will approach the fire and extinguish it.

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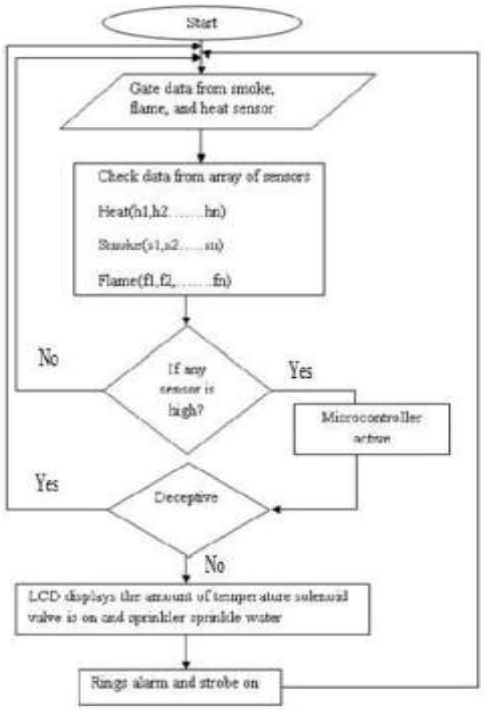

Figure.1 Flowchart of proposed system

Here's the block diagram of our Microcontroller Based Integration of Renewable Energy system. We can clearly describe the working process through this block diagram. Firstly we have two energy sources to supply electricity. One is the Solar and the other is the Wind. Generally Solar is the first priority of supplying the electricity. Our control system continuously monitors the voltage and the current of both sources. If any unwanted situation occurs such as under voltage of a sources, or power failure of any of those sources, our system immediately switches the supply line to another sources that has no problem and vice versa. If both of the sources lose their voltage to the minimum threshold voltage, it combines the two sources. A voltage stabilizer keeps the output load voltage always stable as the loads need. All processes, voltages, current and current source is shown in a LCD display.

Circuit Description

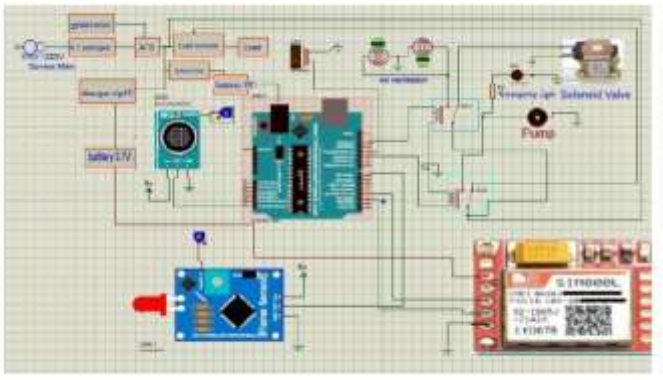

Figure 2 : Circuit diagram of the Project

As we can see there are two input sources which are connected to ATS (Automatic Transfer Switch). ATS is used to give an output which will switch the lines between mains and generator from the ATS. Our connection will be connected to the main load through the load controller and we will be connecting another line Form ATS to a converter which will be giving us 12 volt dc.

This 12 volt dc is connected to a 9 volt rechargeable battery and this battery provides power to the arduino UNO and another 220 volt line which is parallelly connected to the converter. This line will be used for a charger this charger, charges the 3.7 volt battery which is used for GSM module sim800L. Now coming back to our Arduino UNO there are two inputs, one is smoke sensor which is connected in pin number A5 in arduino UNO and another is flame sensor which is connected in pin number D7. Smoke and Flame sensors are powered from arduino and now comes the GSM module sim800L, as we described it early at that it takes power from 3.7 volt lithium ion battery it has two point first one is RX which is for receiving and second one is TX which is for transmitting RX is connected to pin number 3 and tx is connected to pin number 2. Buzzer is connected to Pin Number 11. Next there are two relay numbers: one relay coil is connected with pin number 13 and number two relay coil is connected to pin number 10. As we know there are three points nc, no and common. Common pin is parallelly connected to ATS output line. NC point is connected to solenoid valve and another point is connected to air ventilation system now comes the second relay. Its common pin is also parallel connected to the

ATS output line and its NC is connected with a load controller. Load controller is used for controlling the load and another point is connected to pump and emergency lights parallelly

IV. WORKING PRINCIPLE

Automated fire proction system is a service which can be very useful in our life. Now lets describe the working process :

The full system runs in Auxilary power source.

At first, if there is any kind of smoke detection in the building, the smoke sensor will be acitivated if the smoke is in range (ADJUSTABLE). Then it will pass the signal to Arduino UNO. Arduino UNO will provide the output to buzzer, solenoid gas valve, also to air ventilation system. After getting the signal buzzer & air ventilation will be turned on and the solenoide gas valve will cut the gas services throughout the building.

Now if there is any kind of fire detection in the building the flame sensor (ADJUSTABLE) will pass the signal to Arduino UNO.

Again Arduino UNO will provide the output to relay to cut the main electicity line and will give power to the emergency service light. For extra support the GSM module will inform the nearest fire service through sms & phone call. And it will be sending sms frequently after 10 mins (ADJUSTABLE). At the same time sprinkler will be trigerd, it will be supported by a pump for better water supply and pressure

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V.RESULT DISCUSSION

The aim of the project was to implement and design automatic fire alarming and

monitoring for factories, a smart home system aviation industries and the goal was met. Themicrocontroller unit responds to the instructions sent by the mobile phone according to thenecessity of the application as well as triggers the alarm upon a critical situation. The aim of theapplication to manage the electronic devices remotely was also achieved.

In our first approach we were faced with individual testing each of the components in

order they are working accordingly.so we started with the detection then headed to sms exchangeand the configuring the motors and finally combing all the components in to one set operationaltools.

Discussion

The development of technology has been affecting the life style of people. They are

dependent on technology even to carry out daily activities and technology has made the lifestylemore sophisticated and relaxing. It seems as if it was impossible to live without technology inthis century. Advanced technology has replaced the traditional lifestyle of people. For example, acoffee machine has replaced the traditional way of coffee making, finger-print and voicecontrolled electronic lock have replaced traditional locks, electronic news and media havereplaced the traditional paper news and media, bank cards and online shopping have replaced thetraditional cash and shopping. The examples mentioned above are a few least advanced technologies replacing the traditional lifestyle.

Besides these, there are many advanced technologies used by people for differentpurposes, they are playing significant roles in changing the lifestyle of people. With the development of technology, the concept of simple home has also been changing into smart homeand the concept of home has changed drastically during the last decade. The advancement oftechnology has not only played a significant role in the development of positive aspects but hasalso played an important role in the development of negative aspects. It has increased the risk ofburglary and intrusion using the latest modern technologies available. The busy lifestyle of human beings along with the increasing risk has led to the necessity of remote surveillance ofhomes.

VI.CONCLUSION

The overall aim of this project was to develop a Microcontroller base fire detector with automatic Adaptive Fire Extinguishing Agents for industrial application, by following the methodology proposed at the beginning we meet the objective planned. We made the study for the proposed hardware requirements. We also identified the required software along with their specification and make the analysis with them. Then we conquer a meaningful simulation and prototype result. During the study of the project we were able to design the general structure successfully, write the C langue and compile it using Ardiuno IDC effectively and achieve the required result by simulating the system using proteus tools. After the simulation we write Arduino code for proto type and we make the connection to gate the desired result.

In general, our system can check continuously the occurrence of fire in all suspected places of industry and take action within a short time around 10s to extinguish it.

Finally, depending on the availability of farther advance technologies, this type of project for automatic fire protection could be further improved to save materials from damage and reduce time taken to protect industries from fire.

It is recommended to UOG workshop and labs, chemical industries, production industries and other industries to implement and use this system which can solve and avoid many accidents and materials losses due to the fire. Each working place needs to have one or more systems, depends on the size of that place

In the future, increasing the range of specifications of the components used makes it more compact and reliable which can be implemented effectively in the place such as malls, industries, houses, building complexes, schools, colleges, etc

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