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ROBOTS IN DISASTER RESPONSE: INNOVATIONS AND CHALLENGES

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Abstract
A disaster management robot is an autonomous or remotely operated apparatus that supports emergency response efforts. These robots can be employed to: provide and aid persons in need; assess and track the extent of a disaster's destruction; search for survivors in dangerous areas; and search for survivors themselves. One of the key benefits of disaster management robots is their capacity to perform tasks that are too dangerous or difficult for humans. For example, sensors can be added to robots to detect radiation, gas leaks, and other hazardous materials. This allows the robots to safely investigate disaster areas and provide vital information to rescue teams. An autonomous or remotely operated device that aids in disaster response activities is called a disaster management robot. These robots have the ability to help those in need by providing supplies and medical attention, tracking and analyzing the damage caused by a disaster, looking for survivors in hazardous locations, and even going in search of survivors. One of disaster management robots' primary benefits is their capacity to perform tasks that humans might find too hazardous or difficult. Robots can safely investigate disaster zones and give rescue crews crucial information by being fitted with sensors that can identify radiation, gas leaks, and other dangerous materials.
Keywords: Fire fighting, Robotics, hazardous gas detection.

Introduction
A Humanitarian Assistance Approach with Promise. Natural disasters can strike at any time and are unpredictable. Natural disasters like floods, earthquakes, and storms as well as man-made ones like industrial accidents and terrorist attacks can have catastrophic results. Though they work tirelessly, first responders and those offering humanitarian aid to victims often encounter challenges that could make their work more challenging. In these situations, disaster management robots can be an effective tool to support and supplement human efforts. When a disaster strikes, a specially designed robot known as a disaster management robot aid in rescue and relief operations. Explains how their ability to navigate difficult terrain makes them ideal for use in emergency situations. For disaster management, a variety of robot types with various functions are available. For instance, there are robots that can sift through rubble to find people who may be buried beneath buildings. In addition, real-time information about disaster areas can be delivered by aerial drones, which helps rescue teams organize and prioritize their operations. Another advantage of disaster management robots is their ability to perform tasks that humans would deem too hazardous. For example, they can enter hazardous areas like chemical factories and nuclear power plants that would be too risky for human workers. They are able to accomplish tasks that would be unfeasible otherwise, and the chance of harm or death to rescue workers is greatly reduced. Disaster management robots have already been used in several real-world scenarios, despite the fact that research into them is still in its early stages. In the Fukushima nuclear accident in 2011, for example, robots were used to inspect and clean up the damaged reactors. In addition, during the 2015 Nepalese earthquake, robots were used to look for survivors among the debris of fallen buildings. Notwithstanding their promise, disaster management robots still face several challenges. One of the main challenges is their cost, as they are often costly to produce and run. They also require specialized knowledge and training in order to operate effectively, which can be challenging for organizations without the necessary funding. This robot has two systems: a hazardous gas detection system and a firefighting system. This system's main objective is to keep an eye on and respond to environmental catastrophes brought on by the release of harmful gases. It is essential to have a trustworthy monitoring system because these disasters can have serious effects on the

environment and human health. Which system (ELPWSN, MATLAB, WISENET, or TELOS) is best suited for tracking and responding to man-made environmental disasters brought on by toxic gas emissions will probably be revealed by the comparison's findings.

Lower power consumption and longer battery life are typically advantageous for remote monitoring applications, while timely information updates are crucial for rapid response to changing conditions [1] A potent method for comprehending and analyzing the electrical response of systems is impedance spectroscopy (EIS), which is applied in many domains, including sensor technology. Regarding sensors that identify harmful gases on electrode surfaces made of graphene-based composites, doped metal oxides, and semiconducting metal oxides, EIS plays a significant role. Here's an overview of the key points mentioned in your statement [2] The development of a robot with the capability to sense hazardous gases and perform real-time global navigation is a significant advancement in the field of robotics and environmental monitoring. Let's break down the key aspects of this robot and its functionalities [3] the effectiveness of electrochemical sensors for harmful gases, especially NO_2, SO_2, and H_2S. It highlights the importance of selecting appropriate sensing materials and considers key performance parameters to assess sensor effectiveness. Additionally, it introduces a novel metric for comparing sensor performance and discusses recent advancements in sensor technology for these gases.[4] The review's framework for smart gas sensing technology combines machine learning, signal processing, and sensor arrays to provide precise gas detection and identification. It addresses challenges and provides insights into future directions, including potential inspiration from brain-like sensing for further advancements in gas sensing technology [5]. choice of semiconductor material is a critical factor in designing effective gas sensors. Each material has its advantages and limitations, and researchers continue to explore innovative materials like 2D materials to address current challenges and expand the capabilities of gas sensing technology [6]. system provides a multi-layered safety approach to gas leak emergencies, with immediate alerts, gas removal, fire suppression, and remote notifications. Such systems are crucial in industrial settings, commercial spaces, and even residential areas where gas leaks can pose serious risks to safety. Regular maintenance and testing of such systems are essential to ensure their reliability [7] indoor firefighting robot concept offers the potential to save lives, reduce risks to first responders, and improve the overall effectiveness of firefighting operations in challenging indoor environments. It combines advanced technology, mobility, and communication capabilities to enhance situational awareness and response coordination during fire emergencies. Continuous development, testing, and integration into firefighting protocols are essential steps to ensure the successful deployment of such robots in real-world scenarios.[8] goal of the system is to provide a rapid and efficient response to major disasters, ensuring the safety of both rescue personnel and those in distress. By combining advanced technology with real-time communication and data acquisition, the system offers a feasible solution for disaster response and rescue operations.

It has the potential to minimize loss of life and property and reduce the impact on the health and safety of emergency responders. Thorough testing and integration into disaster response protocols will be essential for successful deployment [9]. a valuable addition to firefighting technology, particularly in scenarios where safety is a concern, and access to fire-affected areas is limited. Its compact size, autonomous capabilities, and remote operation make it a versatile tool for fire-fighting teams, potentially reducing the risks associated with battling fires and improving the overall effectiveness of firefighting efforts [10]. Fire Extinguishing Robot offers several advantages, including the ability to operate in hazardous conditions, such as fires, without exposing human responders to unnecessary risks. It can quickly respond to fire incidents and provide an effective means of extinguishing flames. Additionally, its mobility and flexibility in targeting the fire source make it a valuable tool in firefighting efforts. Continuous testing and refinement will be crucial to ensure its reliability and effectiveness in real-world fire scenarios [11]. Fire-fighting robot represents a significant advancement in firefighting technology. It leverages robotics, sensors, and cameras to autonomously detect and suppress fires while providing live video footage for monitoring and analysis. The robot's mobility and programmable control system make it a valuable tool in firefighting efforts, enhancing both safety and

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effectiveness. Continuous testing, refinement, and integration into firefighting protocols are essential to ensure its successful deployment in real-world fire scenarios [12]. System is to enhance security and safety by providing an intelligent robot that can detect and respond to fire emergencies while navigating obstacles. The inclusion of remote supervision allows for real-time monitoring and control from a distance, adding an extra layer of flexibility and security [13]. addressing the shortcomings of existing firefighting robots by developing an intelligent system that can operate autonomously, make decisions based on sensor data fusion, and navigate effectively in complex environments. Additionally, the proposed improvements in path planning and sensor calibration contribute to the robot's overall performance and reliability [14]. leverages technology to create a more efficient and automated irrigation system, benefiting farmers by simplifying control and optimizing water usage.

Additionally, it contributes to more sustainable and environmentally friendly farming practices [15]. A smart firefighting robot system has the potential to significantly enhance fire safety and emergency response capabilities. However, its success depends on robust design, testing, and integration with existing firefighting infrastructure and procedures [16]. owns the capacity to greatly enhance the quality of life and communication skills of those who are deaf and mute.. By translating sign language into audible speech, it can enhance their ability to interact with the broader community. It's an excellent example of technology being used for social inclusion and accessibility [17]. appears to be designed to improve fire response and extinguishing capabilities on ships. The use of misting technology is often more effective than traditional sprinkler systems because it can rapidly suppress fires while minimizing water damage to sensitive cargo or equipment [18]. By implementing a PID controller, the DC motor can maintain a consistent speed despite varying loads or external factors, making it a valuable component in various automation and control systems. The Arduino Uno, with its ability to interface with sensors and control outputs, is a popular choice for such applications [19]. mobile robot platform appears to be a well-rounded and cost-effective solution for a range of applications, including automation, surveillance, and logistics. Its combination of line following, mapping, navigation, obstacle avoidance, and a robotic arm allows it to perform tasks that require both mobility and manipulation capabilities. The integration of Raspberry Pi and Arduino Uno interfaces also provides the flexibility needed to develop custom control and sensing solutions, making it suitable for research, education, and practical applications [20]. the development of smart firefighting robots represents an innovative approach to addressing fire hazards and enhancing safety. These robots can work alongside human firefighters, making firefighting operations more effective and safer for everyone involved. While traditional firefighting tools remain important, technology advancements like these robots have the potential to revolutionize how we respond to fires and mitigate their devastating effects on society

DESIGN AND WORKING PROCESS:

A well-known microcontroller board built on the ATmega328P is the Arduino UNO. 2010 saw the release of this Arduino.cc creation. The board has a 16 MHz quartz crystal, 6 analog inputs, 14 digital input/output pins, a USB port for power and programming, and a power jack. Even for novices, the Arduino UNO board is made to be simple to use. It is programmed using the arduino programming language, which is based on C/C++. The board can be connected to a computer via USB, and the programming environment can be downloaded for free from the arduino website. The arduino UNO is widely used for a variety of projects, including robotics, home automation, and Internet of Things (IoT) applications. It is also popular in education, as it provides an easy way for Students to learn about electronics and programming.

Figure. 1 Arduino UNO

Owing to its widespread popularity, there are a tonne of online resources for learning about and utilizing the Arduino UNO. The term "UNO," which is Italian for "one," was selected to signify a significant redesign of the Arduino hardware and software. There are sets of digital and analog input/output (I/O) pins on the board. One of the best methods for controlling DC, Servo, and Stepper motors on a single board is to use the L293D Motor Driver Shield. Two Servo motors, two Stepper motors, and four DC motors can all have their rotational direction and speed controlled by it. Connecting an Arduino UNO or Mega is simple. In particular, this shield is used with Arduino robotics and CNC projects. Two L293d dual-channel H-Bridge motor driver integrated circuits and a 74HC595 shift register integrated circuit make up this module. Two L293D motor driver ICs are present on the motor driver shield. Thus, four DC motors or one stepper motor can be controlled by the L293d shield. One such integrated circuit is the 74HC595. With three state parallel outputs, this integrated circuit features an 8-bit D-type latch and an 8-bit shift 24 register. Both a serial input and a serial output are available from this shift register. It can also supply the 8-bit latch with parallel data. There are separate clock inputs for the shift register and latch.

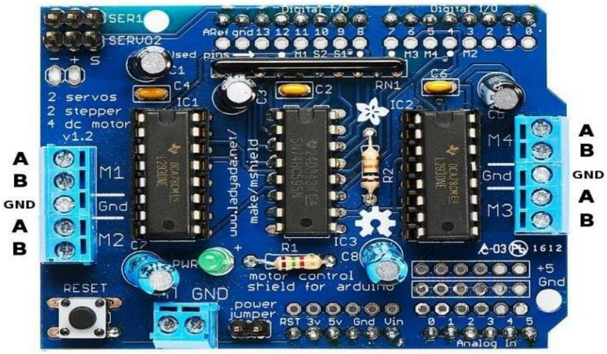

Figure. 2 Motor Driver L293D

A gas sensor, sometimes referred to as a smoke or gas detector, is an apparatus used to identify the presence of smoke or gases in the atmosphere. Monitoring for the presence of toxic or flammable gases is a common application in both industrial and residential settings, as well as smoke that may indicate the presence of a fire. Gas smoke sensors typically work by detecting the presence of specific gases or particles in the air. They use a variety of sensing technologies, including electrochemical sensors, infrared sensors, and catalytic sensors, among others.

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Figure. 3 Gas Sensor

An electronic gadget that measures and picks up infrared radiation in its surroundings is called an infrared (IR) sensor. William Herchel, an astronomer, made the unintentional discovery of infrared radiation in 1800. He discovered that the temperature was highest just beyond the red light when he was measuring the temperatures of each color of light (separated by a prism). Despite remaining within the same electromagnetic spectrum, infrared light has a longer wavelength than visible light, making it invisible to the human eye. Infrared radiation is released by anything that emits heat, or anything with a temperature higher than roughly five degrees Kelvin. In electronics, a breadboard is a prototyping tool used to create and test circuit designs. It's made up of a plastic board with holes arranged in rows and columns where wires and electronic parts can be inserted to build a circuit. Because they are reusable, breadboards make it simple to experiment with and alter circuit designs. A breadboard's holes are usually placed in groups of five, each of which forms a continuous strip The strips themselves are isolated from one another, but the holes within each group are electrically connected. Electrochemical devices, such as batteries, transform chemical energy stored in them into electrical energy. A vast array of electronic devices, ranging from compact handheld gadgets like laptops and smartphones to massive machines like electric cars and industrial equipment, are powered by them. Here, we were using 12V lithium-ion rechargeable batteries, which are a kind of rechargeable battery that has a maximum energy storage capacity of 12V. These are a common kind of battery that are used in many different electronic devices, such as laptops. A Bluetooth module allows wireless communication between the control system and the robot. This module allows the user to control the robot with a smartphone or tablet. It sends output signals to motors and other devices after receiving input from a variety of sensors. This mechanism may take the form of a foam dispenser, water pump, or other fire-fighting apparatus The Arduino board detects a flame and turns it on. Robots used in firefighting are made to put out fires through a variety of methods. The tank holds the water used in the extinguishing system, and the tank's capacity to hold water is determined by the robot's travel capability. The robot's motor drivers are used to control the motors' direction and speed. They use the signals that come from the Arduino board to control the motors. This system uses a foam dispenser, water pump, or other extinguishing techniques to put out thirty fires. The Arduino board activates it upon detecting a flame.

METHODOLOGY:

When it is unsafe for people to enter, such as in a burning building or when there are hazardous gases present, the firefighting and gas detection robot's job is to help. With the help of water, foam, or other firefighting agents, the robot can detect and put out fires as well as identify hazardous gases, smoke, and other types of incidents. It is equipped with a diversity of sensors and instruments. A robust, fireproof chassis may protect the robot's internal components from heat and flames, and the base may be tracked or wheeled for mobility. It could also have cameras and other sensors installed so that operators in the remote can watch the action from a safe distance. The process of creating an Arduino-

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powered disaster management robot involves setting requirements, selecting parts, designing and constructing the robot, programming the Arduino board, and testing the robot. entails determining the robot's dimensions, form, and capabilities in addition to choosing the parts it needs, like motors, sensors, and an Arduino board. There are several ways to break down the process of creating an Arduino disaster management robot. In order to assemble the robot, one must first determine its dimensions, form, and functionality. Next, one must choose the necessary parts, including motors, sensors, and an Arduino board, and wire them all together.

A chassis is also constructed to hold the components in place writing the necessary code to control the robot's movement and sensing capabilities.This includes programming the robot to detect hazardous gases and navigate around obstacles while searching for the source of a fire. By running various tests to ensure that the robot is functioning properly . This includes testing the robot's movement, sensing, and fire-fighting capabilities. Once the robot has been tested and is functioning properly, it can be deployed to various locations to assist in fire-fighting and gas detection. building a fire-fighting and hazardous gas detection robot using arduino involves planning and designing the robot, building and assembling the necessary components, programming the robot's movement and sensing capabilities, testing the robot's functionality, and deploying the robot to locations where it can be used to assist in fire-fighting and gas detection efforts.

3.1 CODE AND ITS WORKING PROCESS

The code for the robot has been developed in arduino IDE software, which is an open-source software development environment used to program arduino boards. arduino IDE is written in Java and is available for Windows, Mac OS X, and Linux operating systems. It allows users to write and upload programs (sketches) to an arduino board using a simple programming language based on C/C++. A user-friendly interface: The IDE has a clean and simple interface that makes it easy to write, compile, and upload code to an arduino board. Integrated code editor: The IDE comes with a code editor that has features like syntax highlighting, auto-indentation, and code completion to help users write code efficiently. The IDE has a built-in library manager that allows users to easily download and install libraries for their projects. Serial monitor: The IDE has a serial monitor that allows users to communicate with the arduino board and view the data being sent and received. Board manager: The IDE has a board manager that allows users to select the type of arduino board they are using and configure the necessary settings. Cross-platform support: The IDE is available for multiple platforms, making it easy for users to develop code on their preferred operating system. Overall, the arduino IDE is a powerful tool for developing projects with arduino boards, and its user-friendly interface and features make it an excellent choice for both beginners and experienced developers.

3.2 ALGORITHM

Include the Software Serial library to create a new software serial port instance. Define variables for motor pins, sensor pins, and data received via Bluetooth. In the setup function, initialize the serial port with a baud rate of 9600.Initialize the software serial port with the same baud rate and the RX and TX pins. Set the sensor pins as input pins and motor and LED pins as output pins. Print the message "ROBOT" to the serial monitor. Set the motor pins to LOW to stop the robot .In the loop function Check if data is available on the software serial port. If yes, read it and print it to the serial monitor. Set the LED pins to HIGH to indicate the robot is in normal mode. Set the motor pin to HIGH to start the robot. Read values from the sensor pins and print them to the serial monitor. If the data received via Bluetooth is '1', move the robot forward by setting the appropriate motor pins to HIGH and LOW. If the data received via Bluetooth is '2', move the robot in reverse by setting the appropriate motor pins to LOW and HIGH. If the data received via Bluetooth is '3', turn the robot right by setting the appropriate motor pins to LOW and HIGH. If the data received via Bluetooth is '4', turn the robot left by setting the appropriate motor pins to HIGH and LOW. If the data received via Bluetooth is '5', stop the robot by setting all the motor pins to LOW. If the fire sensor 1 detects a fire, stop the robot, set the LED pins to indicate the fire's location, and wait for 5 seconds.

If the fire sensor 2 detects a fire, stop the robot, set the LED pins to indicate the fire's location, and wait for 5 seconds. If the smoke sensor 1 detects smoke, stop the robot, set the LED pins to indicate the smoke's location, and wait for 5 seconds. If the smoke sensor 2 detects smoke, stop the robot, set the LED pins to indicate the smoke's location, and wait for 5 seconds, end the loop function.

3.3 CODE EXPLANATION

The code sets up pins for various components like motors, sensors, and Bluetooth module. It reads data from the Bluetooth module and prints it on the serial monitor. It then checks the received character and based on the character it performs various actions like moving the robot in different directions or stopping the robot. The code also checks the sensors for fire and smoke and stops the robot if it detects fire or smoke. When fire or smoke is detected, it turns on a fan to stop the fire or smoke. The delay function is used to pause the execution of the program for a specified amount of time.

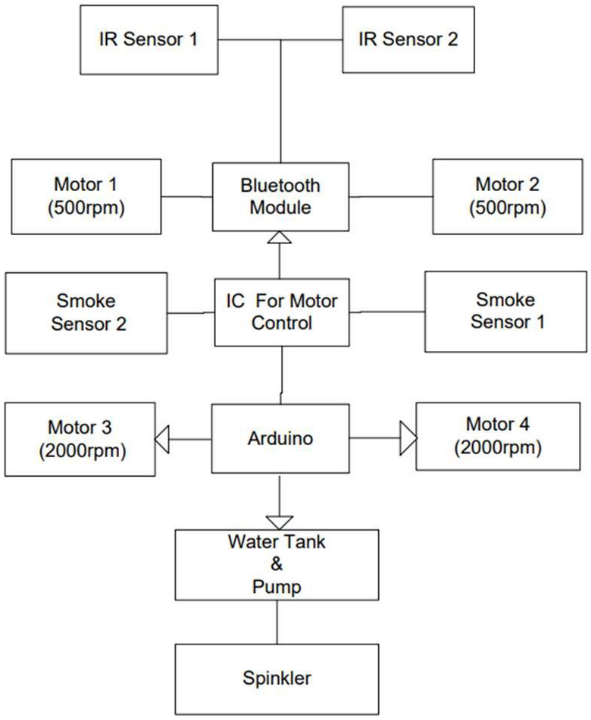

Figure. 4 Block Diagram of Disaster Management Robot

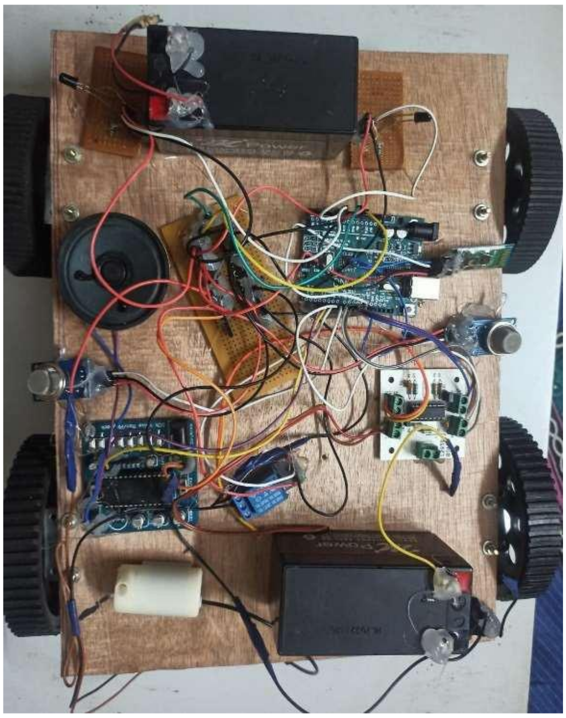

Figure. 5 Disaster Management Robot

RESULTS AND DISCUSSIONS:

The purpose of robotic firefighters is to assist human firefighters in extinguishing fires. They can navigate hazardous environments on their own or with remote control, such as tunnels, burning buildings, and chemical plants. These robots can be equipped with cameras, sensors, and foam or water spraying systems to locate and extinguish flames. Robotic firefighting can reduce the risk of human firefighter injury while speeding up response times to fires in difficult-to-reach areas. Hazardous gas detection and identification robots are being developed for use in laboratories, industrial settings, and other places where gases may pose a threat to human health and safety. These robots are equipped with sensors that are able to recognize a wide variety of gases, including explosive, flammable, and hazardous gases. Rapid reactions to gas leaks and spills are made possible by the robots' capacity to operate in dangerous environments and their real-time data delivery capabilities regarding gas concentrations and locations. Robotic firefighting and hazard gas systems could enhance the precision, efficacy, and security of emergency response. Since these robots are still in the development stage, issues like the need for more potent sensors, power sources, and communication systems still need to be resolved. Furthermore, some businesses may find the cost of these robots prohibitive, which could hinder their widespread adoption. To summarize, the development of robots with firefighting and gas detection capabilities could enhance emergency response capacities and reduce the likelihood of human casualties among first responders. As these technologies continue to be developed and improved, future reactions to fires and hazardous gas situations will likely be more effective and efficient. Conclusion:

Conclusion:

To sum up, firefighting and gas detection robots have shown to be highly valuable in a range of industries and environments. With their state-of-the-art sensors and technologies, these robots can quickly detect potentially dangerous fires and gas leaks and take prompt action to lessen the risks. When human fire fighters are unable to assist, such as in hazardous environments or high-rise buildings, robotic firefighting systems are extremely useful. They are able to spray firefighting agents or water into cramped areas and rubble-filled areas.

Additionally, they can be controlled remotely, reducing the possibility of injuries to fire fighters. Similarly, hazardous gas-detecting robots are helpful in identifying toxic and dangerous gases in industrial environments or other locations where gas leaks might occur. When these robots sense the presence of gas, they can detect it instantly and send operators real-time data and alarms so they can respond appropriately to contain the issue.

Hazard gas detection systems and robotic firefighting are helpful tools that can help avoid accidents, reduce the possibility of worker injuries, and minimize property damage. The necessity of these robots for maintaining safety in hazardous environments will only grow as technology advances and their sophistication rises.

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