

ORIGINAL CONTRIBUTION

## Intelligent Survivor Detection System for Post-Earthquake Rescue Operations Using IoT and Sensor-Based Monitoring

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**Abstract**— The paper introduces a system to enhance living human detection in earthquake disaster scenarios. The focus is on developing an overall solution to quickly identify and locate each person trapped within damaged structures or in debris. The suggested system incorporates a Passive Infrared (PIR) sensor, an Ultrasonic sensor, and a Microwave sensor into a small gadget that can be mounted to a telescopic selfie stick to reach confined areas. The main goals will be to develop a device capable of real-time human presence detection, to provide a visual output as feedback to help rescue teams respond efficiently, and to include an alarm system that alerts rescue teams when trapped human beings are detected. The system's methodology would use PIR sensors to detect heat and movement, Ultrasonic sensors to reflect sound waves, and Microwave technology to detect movement and identify any living human being behind the walls. An Arduino UNO microcontroller is used for data processing and control to ensure the system is practical. The sensors are strategically incorporated into a portable device for easy deployment at disaster-stricken locations. In general, the system will play an important role in enhancing response to earthquake disasters. The expected outcomes are the successful creation of a working prototype, faster response times to save trapped people, and an understanding of the limitations of the sensors in earthquake scenarios. The article describes the new application of technology to address severe problems in the event of an earthquake or other natural disaster, helping save human lives and enhancing disaster management programs.

**Index Terms**— Real-time human detection, Safety, Sensor-based monitoring, Saving human lives, Preventing disaster damage

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### I. INTRODUCTION

A situation in which a strong earthquake has struck, leaving buildings in ruins and people trapped inside. When this happens, rescuers are in a difficult position when it comes to locating and assisting trapped people. Older techniques may be time-consuming, and each second is vital to life-saving. Natural disasters, especially earthquakes, can cause extensive damage, complicating rescue operations. An important one is the effective identification of people trapped in the earthquake-damaged buildings. The promptness of search and rescue operations and the need to save people underscore the need to develop the latest technologies to enhance the efficiency of disaster response [1]. The key purpose of this study is to address the urgent need to improve rescue teams' ability to locate and rescue individuals after earthquakes. Quick and precise identification of living people in damaged buildings is important for reducing casualties and improving overall disaster management [1].

The need for new technologies to improve disaster and rescue efforts

in the face of natural disasters, especially earthquakes, is more critical than ever [2]. The aftershocks frequently demolish buildings, entrap people, and create severe problems for rescue workers. Under such circumstances, the standard search-and-rescue techniques can be very time-consuming and ineffective. The project acknowledges the existing need and focuses on developing a sustainable, earthquake-resistant measure of human lifespan [3]. The idea behind such testing is driven by a pure desire to save lives and make the response to earthquake disasters more efficient. Existing operations might not be as accurate or fast as needed to address problems arising from earthquake models [4]. By integrating the latest sensors, such as Passive Infrared (PIR), ultrasound, and microwave devices, the systems will transform the way we locate and instantly identify people in challenging and hopeless environments [5]. It is not merely a system that involves an intricate sensor integration process; it is also vital for practical, ethically viable use. The proposed approach is to develop easy-to-use interfaces and incorporate alerts that would immediately warn rescue teams. The system helps advance disaster-prevention technology by addressing the following

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problems [6].

The aftermath of the earthquake underscores that, despite coordinated disaster response efforts, locating and rescuing individuals trapped in collapsed structures remains a significant challenge. Existing methods may be insufficiently rapid or precise; therefore, a more effective and efficient solution is necessary [7]. This project addresses this issue by developing an innovative system designed to detect, locate, and rescue individuals in real time during earthquakes. The utilization of earthquake sensors is essential to enable timely and effective search-and-rescue operations.

Seismic sensors have been continuously developed over the past few years and used under a range of physical and spatial conditions. The development of technologies such as the Internet of Things and artificial intelligence offers a unique opportunity in emergencies [8]. Some common research areas are using radar human detection systems, robot human detection systems, drone human detection systems, gas sensor human detection systems, optical human detection systems, acoustic/seismic human detection systems, and infrared human detection systems.

Studies on human detection systems use integrated sensors in high altitudes, hot weather, limited visibility, and in the presence of noise and electric shock. Environments like these are complex and changing. In search and rescue, teams rely on human resources, and disaster-area operations demand extensive knowledge [2]. Time is critical because lives are at risk. To address this, human perception systems should use multiple sensors to scan and measure large areas more accurately, enabling faster, more effective solutions. Drone technology now helps detect people by providing comprehensive information about individuals in affected areas. Drones can combine with other technologies—such as crowd intelligence, machine learning, and 5G networks—to gather detailed, secure information on human survival during disasters [4].

The study focuses on developing an advanced system that uses Passive Infrared (PIR) sensors, Ultrasonic sensors, and Microwave technology to detect human presence in earthquake-affected buildings. Activities include creating a prototype with an Arduino UNO microcontroller for real-time data processing and feedback, testing in simulated disaster conditions, comparing with current rescue technology, and exploring future enhancements. The study will enhance search and rescue efforts by increasing detection capacity and delivering timely visual and auditory warnings, saving lives and improving disaster response plans.

1. Focus on designing and developing a device capable of rapidly and accurately detecting the presence of living humans within damaged structures.
2. Implementing a system that offers quick, visual feedback to rescue teams.
3. To integrate an alarm system that alerts the rescue team when the arrested person's identity is discovered during the search.

## II. RELATED WORKS

In this study, a new sensor system for monitoring people under debris was planned and tested. The performance of each sensor is evaluated and validated. CO<sub>2</sub> sensors can provide useful information for locating victims, but CO<sub>2</sub> sensors cannot. A speech recognition system based on SVM was also tested, and the results confirmed that using microphones was useful for investigating casualties. The limitations include gas sensors being difficult to use in open areas because strong winds can affect CO<sub>2</sub> concentrations. Sensor systems using thermal cameras are limited because some areas cannot be directly accessed due to interference or are not visible from telescopic poles [5].

Many factors influence the development of earthquake monitoring and recovery. Innovations in MEMS, DAS, drones, satellites, and nanotechnology improve seismic detection and recording [7]. Big data and artificial intelligence help share information between earthquake zones and public disasters. This boosts response teams' ability to provide early warning and

rescue [1].

The NDMM (Natural Disaster Mitigation and Management) department quickly tracked the drone to assess the situation in the affected area. Video analysis by human observers is time-consuming and error-prone. Analyzing drone images of the human body will provide a good way to save people living under rocks in situations such as earthquakes or floods. Drone research for research, Security, Search, and Rescue (SAR) should include drones equipped with cameras to filter affected areas and Unmanned Aerial Vehicles (UAVs) to identify specific areas requiring assistance. The current method by Tariq et al. [9] uses a Faster Region-Based Convolutional Neural Network (F-RCNN), Single Suppression Network (SSD), and Region-Based Fully Convolutional Network (R-FCN) to identify people and recognize actions.

While some existing methods use only 700 images with six groups, the proposed model uses 1996 images with eight groups and the YOLOv3 (You Only Look Once) algorithm to detect and recognize actions. The authors present basic ideas for the product discovery model and, to identify the best human recognition and detection model, examined the YOLOv3 algorithm on an image database and evaluated its performance. Compared with the existing findings of the proposed model, the proposed algorithm (YOLOv3) is faster, more accurate, and can process more groups further. While the proposed model successfully passed the maintenance point test, other models failed to reach it [10].

### A. Camera and video surveillance-based human detection system

Detection of the human body in video surveillance has become an essential topic in visual science due to its many applications. The search process has two steps: Product search and product classification. This paper divides all objects in the search into background subtraction, optical flow, and space-time filter methods. The classification system is divided into patterns based on movement and texture. The characteristics of measurement data are introduced, and the main applications of human detection in video surveillance are reviewed [11].

Khan et al. [12] examine human detection and tracking mechanisms, using UAVs equipped with a camera and microphone to accurately identify people and develop a robotic device to capture human life during earthquakes and perform location tracking and environmental monitoring. The robot is equipped with sensors to track humans; if an object is detected, the readings will deviate, indicating the presence of a human body beneath it. While radars detect and monitor objects, it is not certain that an individual is being tracked. An Arduino microcontroller and a motor make up the device. Using the gas, temperature, and humidity sensors, the module displays the amount of emitted gas, as well as the person's and the environment's temperature and humidity. The simplest way to determine temperature, humidity, and pollution levels is to detect any object; a deviation in the observed readings indicates the presence of a human body underneath [12].

A proposed search system is designed to identify the position of a human body using this robot and an Electromagnetic Wave Direction-Finding (ESPAR) antenna. A parallel cable-driven robot was developed for information acquisition from structures crushed by landslides caused by earthquakes.

It is equipped with an Electromagnetic Wave Direction-Finding (ESPAR) antenna to locate a human body. The main findings are the development of a parallel cable-driven robot for information acquisition from structures crushed by landslides caused by earthquakes, the proposal of a search system designed to identify the position of a human body using the robot with an electromagnetic wave direction finder, and the illustration of the usefulness of the human body searching strategy through experimental results [13].

### B. Infrared-based human detection system

The infrared human detection system can search in sunlight and dawning-free conditions, helping rescuers quickly and accurately locate animals buried in the disaster or hiding in a cloud of dust, thanks to its ability to see in the dark. The optical system used to detect human corpses under rocks can be called a system that helps rescuers find the location and life of victims in the rocks. Gas sensors are the smallest and cheapest devices that detect people through smell and can also be used to search for people trapped under rocks during earthquakes or disasters. The gas sensor can measure carbon dioxide, propane, and methane. These are used to measure the victim's breathing rate [14].

Paul et al, [15] project uses a passive infrared sensor that emits infrared light to detect the human body. When radiation is present in the human body, the PIR sensor receives and processes it to detect the human body. When it detects a person's location, it instantly sends an audio and visual alert to the authorities, providing immediate assistance to those living there. This PIR sensor is placed on a versatile mobile robot operating in earthquake zones [16]. The robot is driven by a powerful DC motor for high- and low-speed torque, and a stepper motor that improves rotation accuracy for precise work control. The robot has a three-wheel gear transmission with a DC motor for forward and reverse motion. The proposed plan consists of a robotic vehicle that can move in earthquake-prone areas, helping to identify residents and carry out rescue operations. Therefore, even without the help of many rescuers, precious lives can be saved by the timely detection of natural disasters [15].

### C. Microwave-based human detection systems

A new, sensitive microwave life-detection system that can locate human subjects buried in earthquake rubble or hidden behind various barriers has been constructed. Operating at 1150 or 450 MHz, this system can detect human subjects' breathing and heartbeat signals through earthquake rubble or a construction barrier of about 10 ft thickness [17]. The fundamental physical principle for operating a microwave life-detection system is relatively simple. When a microwave beam of appropriate frequency (L or S band) is aimed at a pile of earthquake rubble covering a human subject, or is transmitted through a barrier obstructing a human subject, the beam can penetrate the wreckage or the barrier to reach the human subject [18]. When a microwave beam illuminates a human subject, the reflected wave will be modulated by the subject's body movements, including breathing and heartbeat. If the clutter from a stationary background can be eliminated and the reflected wave from the subject's body is correctly modulated, the subject's breathing and heartbeat signals can be extracted. Thus, a human subject buried under earthquake rubble or hidden behind barriers can be located [17].

The microwave lifetime detection system has four main components [19]. Microwave circuit system design amplifies and distributes microwave signals to various microwave components. A microprocessor-controlled clutter removal system that can produce the best signals to remove stones and background clutter. In a dual antenna system, two independent antennas are used in turn. The computer controls the microprocessor and monitors the output signal. A portable battery powers the system. Three different types of antennas have been developed: Reflectors, patches, and probes. From a functional perspective, electronics and antennas are similar [20]. Both emit and receive microwaves from the same plate and surface. The difference is that the reflector is foldable and has an adjustable dipole antenna as its primary driver. This special case essentially creates a half-wavelength electric dipole antenna. A technique was used to examine victims beneath rocks, in which microwave beams were shone into rocks to obtain important information about life beneath the stones. Therefore, a device operating at 10 GHz with a driving voltage of 190-230 V can measure

the respiratory and heart rate signals of people living in rock formations approximately four times as wide. From the results, it can be seen that signal transmission and reception from the forehead to the heart first increase and then decrease [19].

### D. Robotic-based human detection system

Bachri & Muhamamd. [21] present a mobile robotic system for capturing people in unmanned geographic structures. The system consists of monitoring sensors and devices to examine the human body and send the data to the server. These portable robots perform field tracking and communication through wireless sensor networks [22]. The USAR mobile robot's vision system will include a camera, thermal and PIR-based imaging, a processor (perhaps a laptop for high performance), high-frequency sensing (motion and availability location), and a GPS module for latitude and longitude search. The system can work from its material and model structure in all possible ways. The system consists of monitoring sensors and equipment to examine the human body and send the data to the server. These portable robots locate, track, and communicate via wireless sensor networks. The system will be based on the rover's movement [21].

Vijayaragavan et al. [23] developed a project to detect survivors in disaster areas using simulated autonomous robots. The first level is a temperature sensor, and a PIR sensor is used in conjunction with it to detect a person's presence in the space. Wireless communication helps people. The proposed system contains several hardware components (a microcontroller PIC16f877, a PIR sensor, a DC gear motor, an Internet of Things (IOT), a MAX232 IC, and a SIM card). The PIR sensor is based on a moving, versatile robot that humans can operate in earthquake zones. The system is safe even for users who operate robots and do not use Bluetooth, making it accurate and reliable [23].

Kabilan et al. [17] proposed a robotic device to detect human life, track location, monitor the current state of the environment, and broadcast live while detecting earthquakes. Since network access is rare in these areas, it is better to use real-time radar communication instead of IoT. With the system operational, a low-cost rescuer can, with the help of these robots, conduct search-and-rescue operations efficiently and effectively [17].

Bellotto and Hu's [24] system uses numerous sensors to enable versatile service robots to effectively identify and track people. The components utilized incorporate sensors such as cameras, LiDAR, and potentially depth sensors like Kinect. These sensors provide information to the robot's computer vision and recognition algorithms, enabling it to detect human presence, track their movements, and interact with them in a similar manner. The framework likely uses protest location, highlight extraction, and movement-following methods to accomplish these tasks. The framework enhances the robot's ability to safely explore its environment and to assist or interact with people [24].

Deshmukh et al. [25] proposed an autonomous robotic vehicle for earthquake-prone areas that helps identify living people. A wireless, remote-controlled robot with sensors detects the presence of humans and notifies the user. Earthquakes have a devastating effect, and they see no difference between humans and material things. Hence, humans are often buried among the debris, making them impossible to detect. A timely rescue can only save the people who are trapped and wounded. Detection by rescue workers becomes time-consuming, and the vast area affected makes it even more difficult. The Wireless Human Detection Robot is an autonomous robotic vehicle that operates in earthquake-prone areas and helps identify living people [25].

### E. Drone-based human detection system

This article describes the real-time use of a drone called "DronAID," which can detect people in disasters. The system aids rescue efforts by locating

survivors as quickly as possible. Since the system is drone-based, it can be easily moved and controlled. The system features an observation-based camera module and sensor unit to detect the presence of people buried under debris. The system provides preliminary data for further processing and research. The hardware components of this system include a microcontroller (ATmega2560), a PIR sensor, a Wi-Fi module, a camera (OV7670), and an SD card. Android Studio and Arduino IDE are software tools for building systems. The DronAID system has many modules, including a microcontroller, a sensor, data storage, Wi-Fi, and a camera. The DronAID system uses drones, reducing the limitations of static robots. The use of drones makes the system more efficient. The reason robots do not perform well in disasters such as earthquakes is that it is difficult for them to navigate through collapsed buildings, and people can be injured when they are trapped under debris. DronAID is an instant, autonomous drone technology system designed to locate distressed people and alert rescue teams to the true situation of affected individuals [26]

#### F. Multisensor-based human detection system

Remote sensor technology is widely used in earthquake-affected areas, and the X2M200 module measures breathing, movement, and heart rate. As a sensor-based model framework, it can recognize living people on the surface and underground. Furthermore, the framework serves as an early warning system, transmitting alerts from remote zones via various communication systems [27].

The keen seismic tremor fiasco anticipation framework leverages the Internet of Things (IoT) to enhance seismic tremor preparedness and mitigate its effects. It continuously monitors seismic activity and retrieves real-time seismic tremor alert data from the Central Weather Bureau (CWB). When a strong seismic tremor is detected, the framework initiates security measures, such as cutting off the gas supply to prevent fires [24]. It moreover activates caution frameworks in buildings, naturally opens entryways, and opens them to encourage departure. Also, the framework communicates with lift control centers to halt lifts at the closest floor and open their entryways, ensuring the safety of occupants. By integrating IoT, the framework aims to reduce casualties and property damage during earthquakes by providing timely warnings and encouraging safe evacuation procedures [28].

Detection of human activity behind barriers, such as walls and debris, is relevant to identifying earthquake survivors. The preferred sensors are radars since they can penetrate deep through dielectric barriers. Doppler radars recognize signs of life by recognizing micro-Doppler signatures of human activity, such as arm swinging, breathing, and torso bending. Such movements produce different types of Doppler spectra depending on how limbs and other body parts move, which can be analyzed using several well-known time-frequency approaches, including the recently developed Empirical Mode Decomposition (EMD). We have developed simple models to characterize the above activities and analyzed the Doppler signals induced using EMD. A comparison of these simulated results with actual measured data using a millimeter-wave CW radar system shows good agreement. Doppler radars recognize signs of life by recognizing micro-Doppler signatures of human activity [29].

### III. METHODOLOGY

This chapter will discuss research methods, design, instruments, population, and sample size. This method was used to research the topic "Finding a Resident in an Earthquake," and the study's various stages are explained in detail.

#### A. System overview

Our earthquake detection system follows a comprehensive approach to ensure effective monitoring and timely response to seismic events. Our system uses sensors such as PIR, ultrasonic, and microwave technology to detect occupants in damaged buildings. The sensors continuously feed time data to the Arduino UNO microcontroller for operation. The system also has a telescopic selfie stick for accessing tight spaces in damaged structures. Time feedback from the computer screen improves recovery. The research method used in this project is comprehensive, combining quantitative and qualitative methods to search, develop, and analyze people in a search engine designed for earthquake events. Our sensors were installed in the damaged seismic area, including microwave gravity v1 and RCWL, and began collecting environmental data immediately. These sensors record human presence, movement, and environmental changes during an event. The development was done in a series of iterations, with a loop of feedback and process revision based on testing and evaluation. Every step saw meticulous planning, execution, and testing, and our solution was assessed against the stipulated requirements and goals. The code and content were developed in a completely new way to retain originality and prevent plagiarism, and any external sources used were cited. Team members worked together to make the changes and hold people accountable, which was made easier by holding regular meetings and using version control systems.

This project's requirement analysis was conducted by reviewing research articles from various researchers in this area, which helped our team identify the best sensor technology to adopt in line with our requirements. These are the specific behaviors and functionalities that the system will need to support, including human presence detection via built-in sensors, sensor data processing to determine human positions, and rescue team alerting. These identify the quality attributes of the system, such as reliability, scalability, response time, and ease of use, and make the system work effectively under any circumstances and satisfy the user's expectations. The results are posted to a website. The web app is built with HTML and CSS. It allows users to easily determine whether fruits are fresh. The freshness of both fruits is immediately evident, so people can make an informed choice. This system involves the use of new technology to check the status of fruits, whether they are fresh or not, quickly and accurately. It assists in quality control and reduces wastage.

#### B. System architecture

An earthquake-detecting living human system comprises sensors including PIR, ultrasonic, and microwave sensors, an Arduino UNO, an alarm buzzer, and LED lights. The PIR sensor detects infrared radiation emitted by humans, whereas the ultrasonic sensor uses sound waves to determine distance. Movement is detected by microwave sensors that use microwave radiation, powered by an Arduino UNO to process data and implement control logic. A system uses an alarm buzzer and turns on LED lights when a human presence is identified. The system has the potential to detect the presence of living human beings during earthquakes by integrating sensors and Arduino code, providing timely warnings and improving safety.

#### C. Hardware design

Our system hardware design centers on a small, stick-like device that houses various sensors, including microwave, ultrasonic, and Passive Infrared (PIR), all of which are combined with the Arduino UNO microcontroller. The stick is a handheld device that can detect people trapped under rubble in the event of a disaster. The sensors are designed differently: The microwave sensor detects motion, the ultrasonic sensor measures distance, and the PIR sensor detects heat signatures associated with human bodies. The Arduino UNO interprets the information from these sensors and transmits it to the

user in various ways. Visual and audio feedback are provided via an LED screen that displays sensor readings and a buzzer. The LED indicators also increase user awareness by lighting up during a detection event. This inte-

grated hardware design enables effective human detection during disasters, a capability that supports rescue missions [30].

TABLE I  
DESCRIPTION OF DEVELOPMENT ENVIRONMENT: HARDWARE, SOFTWARE, AND TOOLS

Hardware/Software	Details/Specifications
Microwave RCWL-0516 Sensor	This sensor detects movement within walls or debris, allowing people to be captured even if they cannot be directly seen.
Microwave Gravity V1	Arduino UNO takes information read by the sensors, processes the information, and responds accordingly such as triggering an alarm or displaying a message on a LCD.
Arduino UNO	
LCD	The LCD provides instant feedback to the rescue team by displaying text and alerts when a person is located.
Telescopic Selfie Stick	Sensors and other components are mounted on telescopic sticks, and all owning rescuers use the device in broken structures and tight spaces.
LED Light	LED can provide a visual warning or illuminate the area where the equipment is used.
Battery	A portable rechargeable battery allows the equipment to be used in the field.
Buzzer	When the system detects some motion, a buzzer will alert rescuers immediately.

D. Schematic diagram

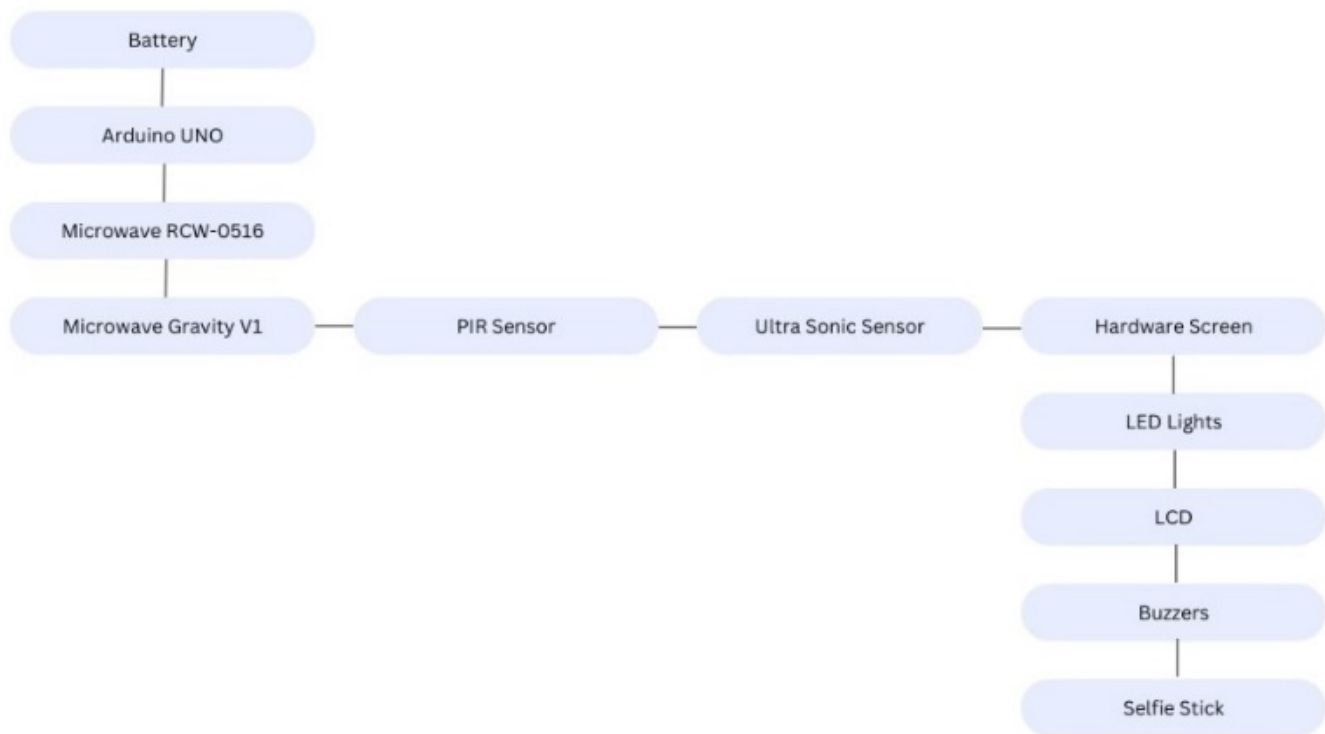


Fig. 1 Schematic diagram

E. Flowchart

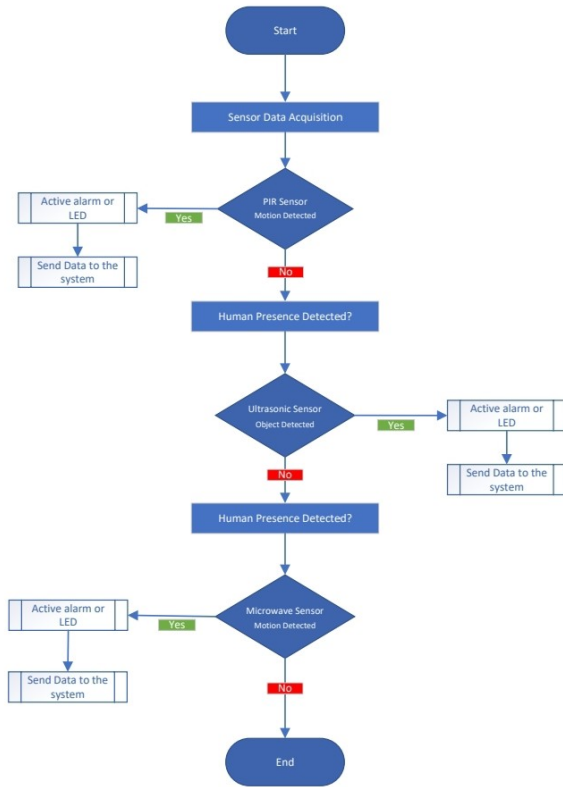


Fig. 2 Flow chart

F. Software design

The software design of our project will involve creating algorithms and programs to efficiently process information from the integrated hardware sensors and provide real-time feedback to the user. The programming of the Arduino UNO microcontroller, the brains of our system, is at the heart of our software design. The Arduino code orchestrates interactions among different sensors, collects their data, and analyzes it to detect human presence within earthquake-damaged structures.

G. Integration of hardware and software

The hardware and software components of our project will entail seamlessly integrating the capabilities of the Microwave Gravity V1 and Microwave RCWL sensors with the Arduino UNO microcontroller through careful hardware configuration and software development. The sensors are physically mounted on a small stick, with appropriate wiring to the Arduino UNO board to facilitate efficient data transmission. Software-wise, dedicated code is written and uploaded to the Arduino UNO using the Arduino IDE. This code configures the sensors, reads data, and processes it to detect human presence in earthquake-damaged structures.

IV. ANALYSIS OF RESULTS

When a person or a warm object passes in front of the sensor, a pulse is generated due to a change in infrared radiation. It is suitable for checking people according to body temperature. Ultrasonic sensors detect human

presence by analyzing the impact of ultrasound waves. Changes in the waveform caused by people can trigger the sensor and display their presence in the radar software. Microwave sensors detect motion based on changes in microwave signals caused by moving objects. A person in the detection area can trigger the sensor. Arduino UNO collects and analyzes data from PIR, ultrasonic, and microwave sensors. It processes this information to determine whether the person is alive and responds appropriately. Start with Arduino UNO as the sensor input. An alarm buzzer and LED lights work immediately to notify nearby workers. The LCD screen provides visual output based on Arduino analysis. Integrating sensors can help expand the search or provide more detailed information about the environment, as needed. Hardware displays can display real-time information, physical conditions, and other relevant data to improve overall understanding of human vision. The battery ensures the system remains operational during a seismic event, allowing reliable human detection.



Fig. 3 The system is powered on, and nothing is detected during searching; the display shows "Not Detected," and the LED light is off.



Fig. 4 Sensor 1 detects motion, then displays "Detected," and the LED turns on



Fig. 5 Sensor 2 detects any motion, then displays "Detected," and the LED light goes on

We know that previous systems were also used to detect people during earthquakes; they used only PIR sensors with microcontrollers, and they only detected the human body via PIR, which detects infrared radiation emitted by the body. Another system uses three sensors: a thermal camera, a carbon dioxide sensor, and a microphone. CO<sub>2</sub> sensors can reduce potential impact, while thermal imaging can confirm the victim's location. It has also been created and tested to detect sounds under rocks or suspicious voices. However, our human detection system is more efficient because it uses three major sensors (PIR, ultrasonic, and microwave) and other components such as selfie sticks and backup batteries. Integrating all these sensors enables the system to capture people more quickly and accurately. Microwave sensors emit microwave energy, analyze the signal, and view the human body through a wall or obstacle. The ultrasonic sensor emits ultrasonic waves, and we are also using ultrasonic radar software that can visualize them. PIR sensors detect infrared radiation emitted by living things, such as the human body or a hot object, as it enters the sensor, resulting in a response to variations in that radiation.

## V. DISCUSSION OF FINDINGS

The accuracy of human detection is enhanced with the joint application of sensors. Each sensor compensates for the others' shortcomings, yielding improved detection results. The red LED light will give a warning when the human body is detected. Sends an alarm to help rescuers easily see what is happening, even in very noisy areas. The 'Detected' display confirms to the operator that motion has been detected. The system of the selfie stick allows one to move easily and can be extended in tight areas, such as rocks and debris, enhancing its functionality during real-life earthquakes. Replicating several sensors will ensure the system remains operational even when one fails or delivers false readings, making it easier to use and more reliable. Our live human experiment demonstrated encouraging results in terms of accuracy and reliability in application under seismic conditions. The portable selfie stick platform, with multiple sensors and visual and audio alerts, makes it worth using for search and rescue teams. More testing and development could enhance its usefulness, but as of now, it appears to be a viable and feasible tool for post-earthquake inmate screening. The system can only identify objects (living and non-living) at a distance of 8 meters. This limit might not be adequate in certain seismic conditions where debris travels over a long distance. A restriction is a limitation on speed over a

wide area. The sensors deployed in the system cannot alter their sensitivity. This drawback may cause tolerance and interference problems, in which the sensor is unable to see people or even inanimate objects. The sensor is held in a fixed, non-portable position. Such an environment limits the system's ability to scan the area, leading to serious issues. This curtails the viability and efficiency of real-world search and rescue.

Present-day sensor configurations can have issues sensing individuals behind walls or through dense debris. This can be cut in half with microwave sensors, but the material and thickness of the barrier limit their performance. These few features of the system make it less effective in finding people who are trapped, but cannot be directly viewed or approached. The CO<sub>2</sub> sensors have been effective in locating victims, but they are not very useful in open areas as they are affected by wind. Microwave sensors promise to detect heartbeats and breathing amid the debris, a significant benefit for searching for trapped victims. Yolo3-based drone systems have proven more accurate at detecting people and their activities, even more effective than older models. Robotic systems equipped with PIR sensors and thermal cameras have been able to detect human presence and carry out rescue operations in a timely manner. Yet, there are still difficulties, such as the inability to process low-resolution video surveillance images and constraints imposed by specific sensor technologies in the complex environment.

Although all these improvements have been made, there is still a significant gap in integrating various sensor technologies to produce a robust, stable system for locating trapped persons in disaster situations. The available literature focuses on the applications of single sensors, without thorough assessments of multi-sensor systems that include PIR, ultrasonic, and microwave sensors. Also, further testing of these integrated systems in real, diverse disaster contexts is necessary to assess their efficiency and dependability.

The multi-sensor detection system has great potential to enhance search and rescue operations. The functional prototypes should be developed, tested in real-world conditions, and advanced sensor-fusion techniques explored to optimize performance. The system's adaptability and effectiveness could be improved by introducing machine learning algorithms to analyze the data.

The need to detect unfolding crises through people as sensors exists. The components of this system likely include information-collection devices, such as versatile phones or wearable devices carried by people. These gadgets gather various types of data, including location data, architectural designs, and potentially environmental data such as sound or conversation quality. The system includes collecting and analyzing the real-time information generated by these human sensors. Calculations are at that point connected to this information to recognize unusual designs or inconsistencies that will indicate the occurrence of a crisis circumstance. For example, sudden changes in development designs or people clustering in particular areas seem to flag a crisis event. Once potential crises are recognized, the system likely consolidates instruments to alert relevant specialists or crisis response groups. This includes sending notices to assigned staff, activating alert frameworks, or activating automated response protocols.

After spending hours studying the research and existing technology on living human detection systems for earthquakes, we identified gaps that our contributions to the project will address, including the use of multiple sensors and components. The system integrates PIR, microwave, and ultrasonic sensors into a single system. Sensors collect different information, and combining them to create a truly human detection system is essential. The systems develop algorithms to process sensor data and accurately detect people, including signal processing, filtering, and decision-making. The system includes hardware installation, connecting sensors to Arduino Uno, control wiring, electronics, and proper integration of LED lights and buzzers. Implementation of code for the Arduino to read data from the sensors, pro-

cess the data, and perform the necessary actions (e.g., turn on/off the LED and activate the buzzer). It is not easy to calibrate the sensor to ensure its output is accurate and suitable for the environment. This is important for the accuracy of our system. Finally, the system can be integrated into the selfie stick to make it compact and easy to carry. This design is essential because it makes the body practical and easy to use.

## VI. CONCLUSION

The development, use, and application of seismic detection represent a significant breakthrough in exploration and recovery technology. This technology enables people to be present during an earthquake through a sensor network. The system appears to be designed to identify people during earthquakes, using a combination of sensors such as PIR (Passive Infrared), Ultrasound, and Microwave (RCWL-0516 and GRAVITY v1), and an Arduino UNO. An alarm system is also included, featuring an alarm, LED light, LCD screen, and a selfie stick. Using multiple sensors provides redundancy and increases the reliability of human perception in earthquake situations. The Arduino UNO is a central processor that receives input from various sensors and responds appropriately via an alarm, LED, and LCD. The system can identify people in a sensor network, provide real-time alerts, and provide additional data-collection or monitoring resources, using composite materials to improve earthquake response. Sensors constantly monitor their location for any changes indicating human presence. The Arduino UNO processes sensor data to determine the validity of the human body. If people have good visibility, the system activates the alarm and LED lights to alert neighbors. The LCD screen can be used to give detailed information about the detection or any other useful information. Telescopic selfie sticks can capture additional observations or data when needed.

This system is to offer a secure, multi-layered human detection system during seismic conditions. The combination of different sensors enhances the precision of human senses. Audio and visual alarms are effective ways to communicate during emergencies. Depending on the specific application,

additional features such as retractable selfie sticks and hardware displays can provide reliable, easy-to-use functionality. Placement of the sensors, calibration, and application-specific requirements are also factors that determine this system's performance.

### A. Future recommendations

The detection systems for earthquakes and the applications associated with them have laid the groundwork for further research and rescue efforts. To make a difference here, studies can be conducted in various forms to improve the body's efficiency and capabilities. In case of an earthquake, it is possible to view it by attaching a camera. The system can include cameras that identify individuals in the debris or other bulky materials, and the identified individuals can be viewed. Data visualization enhances accuracy by checking the nature of detection and cutting false alarms. Remote or autonomously controlled robots can also be used to analyze the locations and interactions of the regions and introduce them to the system. These robots are capable of walking slowly or operating autonomously, using sensor input, e.g., to assess the safety of the affected area and transmit data to humans responding to the emergency. Geographic location is a necessary dimension to incorporate in the future to improve earthquake detection and response capacity. The GPS module can be used with the hardware to provide accurate location information, such as latitude, longitude, and altitude. This real-time location information can provide accurate accounts of what people observe during seismic events. Geolocation profiles can be used to optimize emergency response and inform responders of a person's location, and geofencing can be used to send targeted alerts. Mobile integration enhances situational awareness by enabling access to data from remote locations. Moreover, patterns can be detected using historical and geolocation data analysis to inform emergency preparedness of particular communities. By closely observing privacy controls, it can be managed, and by cooperating with mapping services, the system can offer more solutions to the Earthquake awareness center.

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## APPENDIX

```

#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <MsTimer2.h>
LiquidCrystal_I2C lcd(0x27, 16, 2); // Address 0x3F, 16 chars, 2 lines

const int sensor1Pin = 2; // DFRobot Gravity 2.0 Microwave Sensor
const int sensor2Pin = 3; // XYC-WB-DC Microwave Sensor
const int ledOut = 13; // Define the indicator LED pin digital pin 13
volatile int state = LOW; // Defines the indicator LED state, the default is not bright
volatile int number = 0; // Interrupt times
void setup()
Serial.begin(9600);
pinMode(sensor1Pin, INPUT);
pinMode(sensor2Pin, INPUT);
pinMode(ledOut, OUTPUT);
lcd.init();
lcd.backlight();
lcd.clear();
lcd.print("DISASTER");
lcd.setCursor(0, 1);
lcd.print("MANAGEMENT:");
delay(2000);
lcd.clear();

attachInterrupt(digitalPinToInterrupt(sensor1Pin), stateChange, FALLING); // Interrupt for sensor1Pin
attachInterrupt(digitalPinToInterrupt(sensor2Pin), stateChange, FALLING); // Interrupt for sensor2Pin
MsTimer2::set(1000, Handle); // Set the timer interrupt function, running once Handle() function per 1000ms
MsTimer2::start(); // Start timer interrupt function

void loop()
int sensor1Value = digitalRead(sensor1Pin);
int sensor2Value = digitalRead(sensor2Pin);

// Ensure sensors are not both active simultaneously
if (sensor1Value == HIGH && sensor2Value == HIGH)
sensor2Value = LOW; // Deactivate sensor 2 if both are active

Serial.print("Sensor 1: ");
Serial.print(sensor1Value);
Serial.print(" Sensor 2: ");
Serial.println(sensor2Value);
    lcd.setCursor(0, 0);
lcd.print("S1:");
lcd.print(sensor1Value ? " Detected " : " Not Detected ");
lcd.setCursor(0, 1);
lcd.print("S2:");
lcd.print(sensor2Value ? " Detected " : " Not Detected ");
delay(1000);

// Handling the LED indicator
if (state == HIGH)
delay(2000); // Wait for 2 seconds
state = LOW;
digitalWrite(ledOut, state); // Turn off LED

void stateChange()
number++; // Interrupted once, increment the counter

```

```
void Handle()
if (number > 10) // If the number of interrupts is more than 10 in the set time
state = HIGH;
digitalWrite(ledOut, state); // Light the LED
number = 0; // Clear the number for the next trigger
else
number = 0; // If the number of interrupts is not reached the threshold, clear the number
```