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Smart Robot For Disaster Detection Using Zigbee Technology

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Abstract

Natural calamities are unstoppable and they do occur. But humans are becoming increasingly aware in the concept of intelligent rescue operations in such calamities so that precious life and material can be saved even though the they cannot be avoided. Still there are lots of disasters that occur all of a sudden and earthquake is one such thing. Earthquakes and building collapses produce a devastating effect and they see no difference between materials and humans. Hence at a lot of times humans are buried among the debris and it becomes very difficult and impossible to detect them. A quick rescue can only save the people who are buried and wounded. This paper aims to make the detection of victims and survivors more efficient by using robots and sensor systems. The objective of this paper is to introduce the use of robots as a risk detection tool for human rescuers

Keywords: Disaster detection, Robots, Sensor, ZIGBEE, ARM microcontroller, GSM,

Introduction

Disasters can rattle economic and social balance of the society as well as nature, because of high rise buildings, buildings under construction or any other manmade structures in urban and industrial areas which are prone to these calamities. These disasters can be divided into natural and human lured disasters. Natural disasters include cyclones, bushfires, floods, storms and earthquakes. Besides natural tragedy, the urban areas is also prone to human induced disasters such as industrial accidents, major fires and transportation accidents. During such calamities various essential services (like disaster rescue teams, medical, fire brigades and paramedical personnel, police) are employed in order to avert loss of life and property.

According to the field of Urban Search and Rescue (USAR), the odds of saving a victim is high within the first 48 hours of the rescue effort, after which the possibility becomes nearly zero. Generally, Rescue personnel cannot enter into some parts / places like earth quake affected or building collapsed areas. All of these tasks in very dangerous and risky situations are performed mostly by trained dogs and humans. At times, the rescuer may become a victim who needs to be rescued. This is the reason why for so many years autonomous robots have been proposed to help the personnel to implement tasks that neither humans dogs nor existing tools can do.

A relatively new field of research in search and rescue operations is the use of rescue robots, or basically the use of autonomous robots. It is a part of the broader aspect of regulating a group of mobile robots to accomplish a specific task. There is a need for effective (direct or indirect) communication methodologies that help to achieve cooperative behavior. Search and rescue operations have high priority in calamities like earthquakes or terrorist attacks or building collapses. The initial steps of larger operations in relief missions are search and exploration. However there exists all out ongoing research efforts for developing multi-robots search teams to be set up in such missions where traditionally these tasks had been performed by human teams.

The intention in designing a robot is to facilitate quick and easy detection of disasters and search of human beings by giving security and helping hand through reprieving. The robot consists of two sections namely, a control field section and a floor field section. The technology used in this disaster detection robot has a number of significant features such as robotic control by own, detecting disasters. It can also sense the vibrations and provide an alert through control room to the concerned authorities. The robot then detects a human, takes a snap from the area by using a high quality wireless camera equipped with a DC motor for the robot-directional view that is mounted on the mobile robot to send real video or images signals to the control section.

These snap or video stream acquired by the receiver unit can be primarily used to take appropriate steps according to the received data. This robot can also be used to reach places reach like hidden places or tunnels, small areas covered by rubble where humans cannot reach. The main focus of this system is to offer maximum possible safety of the human being.

Here, in this paper, we have high lightened the importance of developing a robot which can actually work in a real disaster site. This work is illustrated by using the entire sub modules involved in the development of robots for search and rescue task

Related Works

Earthquakes produce a mortifying effect and they see no difference between human and material lot of times humans are buried among the debris and it become impossible to detect them. In the existing system, there is no automatic control operations as the robot is operated manually and thus it offers low protection. The alert system is also not proper. The detection range of the robot is less. The communications between wireless robot and the control unit are extremely noisy and therefore more than 25% of them have no use. This eventually leads to loss of interactions between the robots and the personnel. As a result, the robots stop working totally. A very high processing cost is also incurred in capturing, transmitting , and storing a large number of images

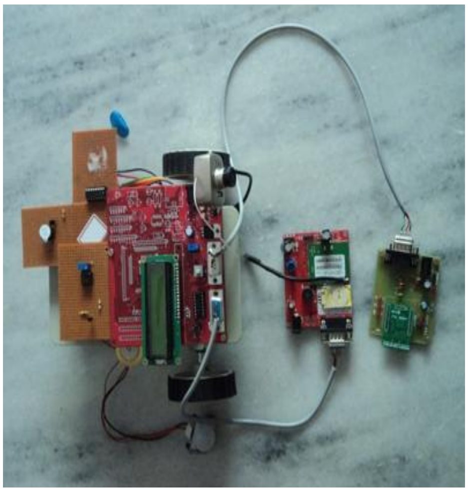

Figure 1: Proposed design of robot

Proposed System

The project proposes a robot assisted disaster detection system that provides support to the rescue personnel by providing automatic detection of causalities as and when they occur and sending alert messages to the concerned authorities (including rescue personnel, fire, ambulance, police). The robot also focuses on the detection of humans by using PIR sensors. The system uses ZIGBEE & this makes the system both accurate & reliable. It is an effective and safe system to ensure that the more lives can be saved

Design of Proposed Module

1. **ZIGBEE**
2. **GSM**

ZIGBEE

ZIGBEE is a specification for a suite of high-level communication protocols built from small, low-power digital radios and used to create personal area networks. ZIGBEE is based on an IEEE 802.15.4 standard.

Depending on its low power consumption limits the transmission distances are only 10–100 meters in the line-of-sight which is based on environmental Depending on its low power consumption limits the transmission distances are only 10–100 meters in the line-of-sight which is based on environmental characteristics and power output. ZIGBEE devices can broadcast data over long distances by passing the content through a mesh network of intermediate devices to reach more isolated ones. ZIGBEE is quite often used in low data rate applications that has the need of long battery life and secure networking.(ZIGBEE networks are secured by 128 bit symmetric encryption keys.) ZIGBEE has an intermittent data transmissions rate of 250 kbit/s, that is best suited for a sensor or input device.

Applications include electrical meters with in-home-displays, wireless light switches, traffic service management systems, and other consumer and industrial equipment that depends upon short-range low-rate wireless data transfer. In relation with other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi, the communication technology defined by ZIGBEE specification is designed to be simpler and less expensive.

Our proposed system uses ZIGBEE for communication between the control section and floor field section of the robot.

Figure 2: ZIGBEE Transmitter and Receiver

GSM

GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard developed by the European Telecommunications Standards Institute (ETSI) to represent and portray protocols for second-generation (2G) digital cellular networks used by mobile phones.

The GSM standard originally characterizes a digital, circuit-switched network optimized for full duplex voice telephony. This developed over time to comprise of data communications, first by circuit-switched transport, then by packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS). The architecture diagram of GSM module is shown below.

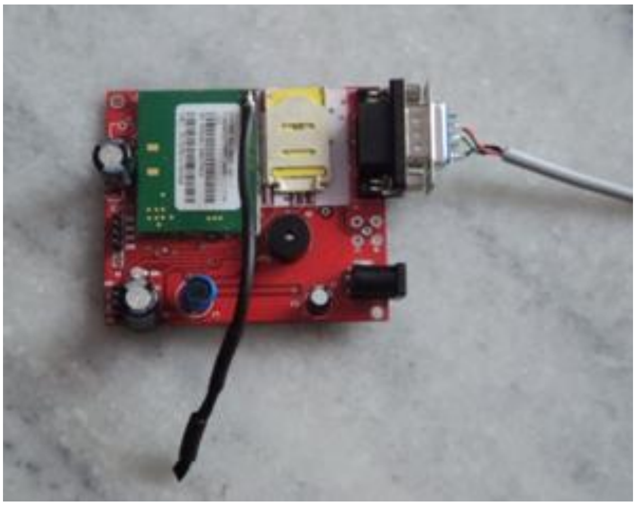

Figure 3: GSM module

GSM operates on four different frequencies: 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. The frequencies most commonly used are the 900 MHz and 1800 MHz bands. To minimize common types of interference, GSM combines TDMA with frequency hopping and wideband transmission. GSM uses block code as well as convolutional code. GSM provides only 9.6 kbps data connection. The protocols and access methods for GSM may be from X.25 or X.32. The various GSM security mechanisms are authentication, confidentiality, anonymity. Telephony, fax, SMS, call forwarding and call waiting are few of the services supported by GSM.

Our proposed system uses GSM module for sending an alert message to the concerned authorities when the building collapses

Sensors Used

The following list of sensors used are:

1. PIR Sensor
2. Piezoelectric crystal sensor

PIR Sensor

Passive Infrareds sensors (PIRs) used in some security alarm systems are nothing but electronic devices that are used to detect a human body by motion of an infrared emitting source. The pyroelectric sensor is made up of a crystalline material which develops a surface electric charge when exposed to heat in the form of infrared radiation.

The amount of radiation striking the crystal influences the change in the amount of charge that can be measured with a perceptive FET device built into the sensor. This radiation (energy) is identified by electronic devices designed for such a purpose since it is invisible to the human eye. The actual sensor on the chip is made out of gallium nitride in the form of a thin film, usually from natural or artificial pyroelectric materials.

Piezoelectric Crystal Sensor

Piezoelectric crystal sensor is a sensor made of quartz that produces potential difference across its opposite faces when under mechanical stress. These crystals when deformed or subjected to vibration they generate a small voltage known as piezoelectricity. This deformation though only in nanometers, has useful applications such as production and detection of sound. It has been found that piezoelectric crystal when embedded in motors can yield a small amount of energy with each step.

This sensor helps in increasing efficiency and reducing pollution. They also generate a voltage that is proportional to the velocity of the crystal when it is deformed and thus requires no power source.

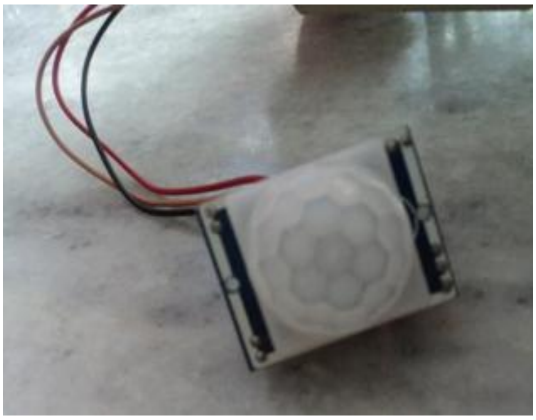

Figure 5: PIR Sensor

The sensor buffers a piezoelectric transducer. As the transducer is moved from the mechanical neutral axis, bending creates stress within the piezoelectric element and generates voltages. The sensor is ratiometric. The sensor is design to be used with 1018 Phidget interface kit 8/8/8.

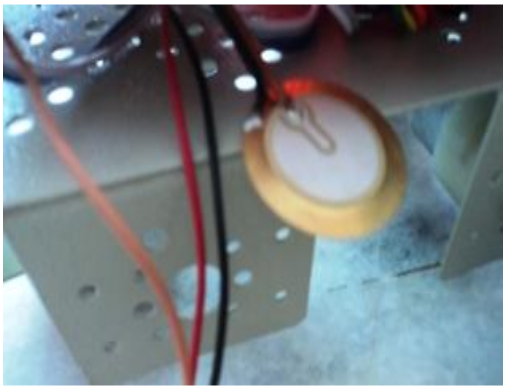

Figure 6: Piezoelectric crystal sensor used to detect vibrations

Overview of The system

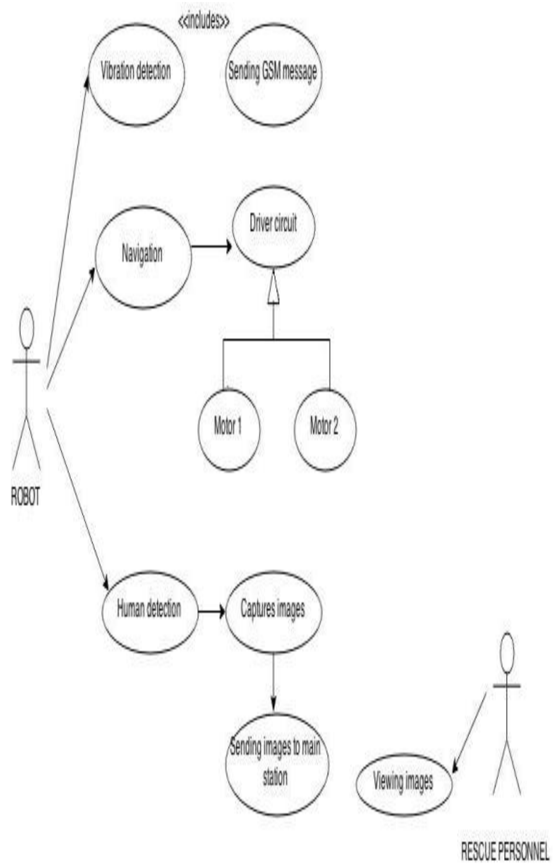

Figure 7: Use case diagram of the proposed system

Here, the system contains two actors namely robot and rescue personnel. It is these two actors who are mainly involved in the system. The use cases represent the various operations performed by the actor. For instance the robot performs vibration detection, navigation and human detection, while the rescue personnel perform the operation of viewing the images. The vibration detection use case includes sending a message using GSM to the concerned authorities. The navigation use case contains a driver circuit. This driver circuit use case is a generalized use case for the various motors used in the system. The human detection use case involves capturing the images and sending the images to the main station use cases.

Layout of The System

The heart of our system is the ARM 7 Microcontroller. This microcontroller acts as the core interface for all the modules and components of the system. The various sensors are directly connected to ARM microcontroller and the ARM microcontroller is directly connected to the ZIGBEE module, wireless camera and the driver circuits that are used for moving of the robot. ZIGBEE is connected to the interface in the computer known as the RS232. The vibration sensor (piezoelectric crystal sensor) when reaches its threshold value uses the GSM system to send an alert message to the concerned authorities. All of the coding is done by using Keil compiler since the robot is based on embedded systems

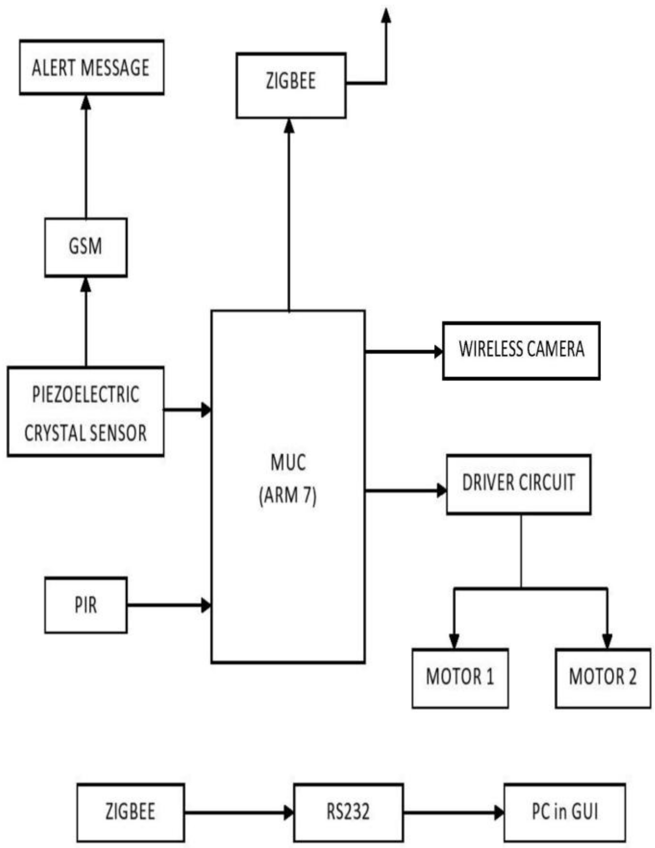

Figure 8: Internal layout of robot detection system

Software Implementation

First step in the implementation of our system is positioning of the robot at a proper distance from the building, where the robot has a proper coverage and visualization. Next, the robot monitors the building for any vibrations using piezoelectric crystal senor. If the threshold of vibration is high then the robot sends an alert message to the concerned authorities (rescue personnel, fire, ambulance, police) through the GSM module of the system. Then the robot moves from its standard location by means of motor present in the driver circuit. It then determines the presence of human beings by using PIR sensor. If a human is detected then the robot captures the image of the area by using a wireless camera and then sends the image to the control unit thereby helping the rescue personnel to act more quickly.

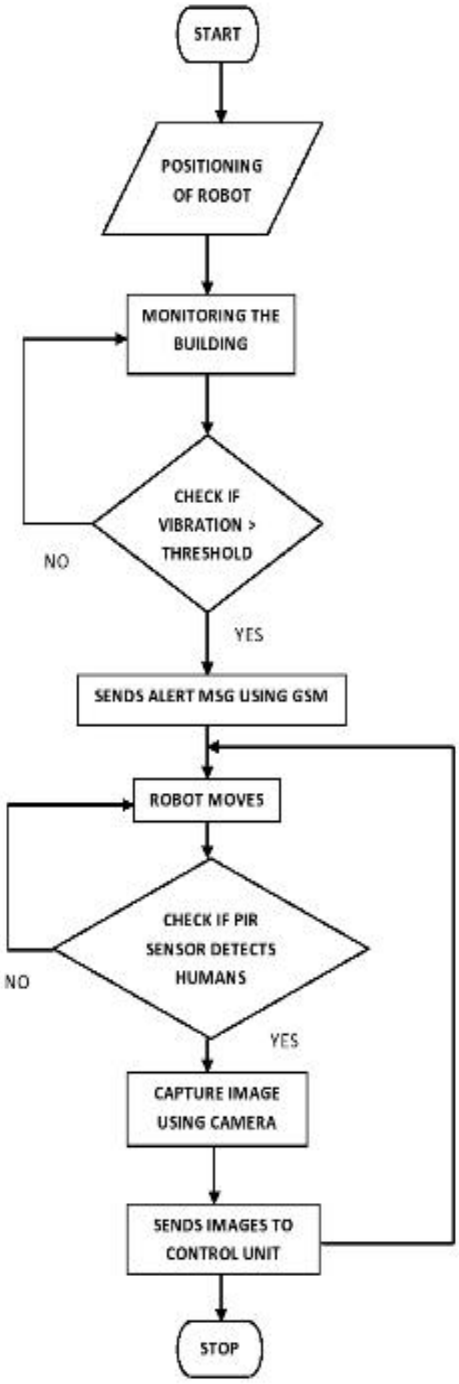

Figure 9: Process flow of operations in the robot

Conclusion

In this work of ours we have presented a robot system that enables quick and easy detection of disasters as and when they occur. Thus, acting as an element of immediate support to the rescue personnel by enabling detection of victims at significantly a more faster rate.

There is a wide scope of future development because the system developed is a low cost system. The robot can be enhanced by providing improvements in the various sensors used. It can also be equipped to handle hazard sources as well for instance gas or fire detection

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