ZigBee Controlled Rover for Human Search during Rescue Operations after an Earthquake Calamity

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by

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ABBREVIATIONS

NOTATION

Throughout this project, mathematical notations conform to ISO 80000-2 standard, e.g. variable names are printed in italics, the only exception being acronyms like e.g. SNR, which are printed in regular font. Constants are also set in regular font like j. Functions are also set in regular font, e.g. in $\sin(\cdot)$. Commonly used notations are t, f, $\mathrm{j} = \sqrt{-1}$, n and $\exp(\cdot)$, which refer to the time variable, frequency variable, imaginary unit, nth variable, and exponential function, respectively.

GLOSSARY

matrix a concise and useful way of uniquely representing and working with linear transformations; a rectangular table of elements 51

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Chapter 1

INTRODUCTION

Contents

1.1 Background of the Study

With the fast growing technology and the capacity of computers are getting bigger, there comes the opportunity to create robots and new research in controlling them. These robots are mechanical, controlled by computers, and perform their work with precision. In robotics, one major component of a robot will be its core or the brain. These droids move on their own using the technology of artificial intelligence. Without humans behind them, they cannot perform complicated instructions [Bharathi and Suchitha Samuel, 2013].

There are many ways to transfer data and control the mobile robot. Most use Bluetooth or wifi but these technologies fall short in coping up with the requirement of controlling sensors and control devices wirelessly. Zigbee has the fix for these control system. Zigbee is a technology based made for wireless communication. Some of its advantages are being low cost, low power consumption and low data rate [Bharathi and Suchitha Samuel, 2013]. This alternative can make new opportunities for the mobile robot.

Android platform used for devices such as smartphones and tablets can be used as a control interface for robots and it provides sufficient resources and integrates more sensors. In android, java language can be used to program the interface and it is easier because of its modern software engineering. The challenge is that of connecting the control interface of android to the parts of the robot.

1.2 Problem Statement

Nowadays many are having problems to go to certain locations due to harsh environment, life risking places etc. But still need to go due to certain conditions for example going for search and rescue during calamities. Many are trying to still do these but having their lives at risk as well is a very problematic problem. When a certain calamity arises in order to reach certain places many volunteers are needed or when you want to go to an expedition but you are not sure whether the terrain you are going to set foot on is safe you will need to have a volunteer to check the upcoming surrounding first. Especially when faced with natural calamities such as earthquake. With these in mind, robotic applications can be made in order to ease the tasks that are required also people can fully equip the robot with the technology needed to do certain tasks to ensure less risks and casualties.

By making use of a remote controlled robot people can avoid dangerous tasks or expeditions in areas that are hard to traverse.

1.3 Objectives

1.3.1 General Objectives

To design a remote controlled mobile robot for human search in inaccessible areas after an earthquake calamity

1.3.2 Specific Objectives

- To create a mobile robot that carries a camera and has a connection with the use of ZigBee.
- To develop an algorithm that can manually control a mobile robot using a computer.
- To implement the algorithm for controlling the robot in Android.
- To design a land mobile robot for flat city terrain.

- To implement human detection with optical and auditory alarms.
- To achieve 70% accuracy in detecting the human head.

1.4 Significance of the Study

It has been difficult for people to take safety precautions when going to unknown lands. It has been very harsh especially when going to narrow places and dangerous places especially when there are natural calamities such as earthquakes and typhoons, people cannot reach or justify whether the place is safe to proceed or not. But autonomous robots have limitations especially when it comes to specifics like controlling the robots precisely. Manual control bypasses this problem by shifting the controls to the user and also allows for a more direct approach on tasks. Controlling the robot using android to explore dangerous terrain and searching for humans is what this proposal is about.

This proposal aims to build a rover for earthquake purposes that can be further enhanced for search and rescue operations or discovering unexplored territory. The rover can be navigated on dangerous places such as destroyed land and small or narrow places such as the aftereffects of earthquakes, you can use the rover to explore the terrain without the risk of getting killed by aftershocks or other unforeseen events. It can also detect whether there are humans or not in the unexplored areas.

This robotic project also incorporates the ZigBee communication protocol to control the Robotic module. ZigBee communication provides another dimension to Robotic control, mainly applied to manure the robot in remote areas, where the security of humans is risky. ZigBee communication utilizes the efficiency of RF communication and substitutes the Bluetooth communication, making the communication possible up to 10001500 meters.

The robotic module may be effectively used to monitor a chaos situation using the wireless web cam mounted on the robot. The Robot is controlled by user friendly front end software developed in .NET. The project has a wide application in the security area. The module may be used to observe a hostage situation. The higher version of the robot may be used in areas where direct human approach is impossible.

1.5 Scope and Delimitation

1.5.1 Scope and Delimitation

- The mobile robot is designed to traverse flat solid terrain and not intended for steep inclines, sand/granulated ground, stepsand severely uneven roads.
- The mobile robot would relay the camera's findings to the android interface in real-time
- The human detection system detects the human head, hand or torso.
- Implement a human detection system that would trigger an alarm on the android's screen and a beeping sound upon successful detection and achieve at least 70% accuracy rate within 50 trial runs in various situations.

1.5.2 Assumptions

- Battery life of the Android device may shorten due to the calculation load and the activated Bluetooth.

1.6 Description and Methodology

1.6.1 Description

1.6.1.1 Mechanical

Microcontroller PIC 16F877A the microcontroller acts like the brain of the wireless mobile robot system. The microcontroller chip that has been selected is PIC16F877A, manufactured by Microchip. The purpose of the IC among others is for controlling the speed of DC motor This chip is selected based on several reasons: first it is small in size and equipped with sufficient output ports without having to use a decoder or multiplexer. Second its portability and low current consumption. Third it has builtin PWM which allow us to vary the duty cycle of DC motor drive. Fourth it is a very simple but powerful microcontroller. Users would only need to learn 35 single word instructions in order to program the chip. Fifth it can be programmed and reprogrammed easily (up to 10,000,000 cycles) using the universal programmer in robotics lab.

1.6.1.2 Wireless Communication

The vehicle would be controlled by a wireless remote controller. This wireless remote controller would control the movement of the vehicle. The remote controller that will be used in this project will be ZigBee based which uses Radio Frequency, Commercially available Remote Control (RC) units use small microcontrollers in the transmitter and receiver to send, receive and interpret data sent via radio frequency (RF). The receiver box has a PCB (printed circuit board) which comprises the receiving unit and a small servo motor controller. RF communication requires either a transmitter matchedpaired with a receiver, or a transceiver (which can both send and receive data). RF does not require line of sight and can also offer significant range (transmission distance). Standard radio frequency devices can allow for data transfer between devices as far away as several kilometers and there is seemingly no limit to the range for more professional RF units. XBee and ZigBee modules use RF for communication, but allow the user to vary many of the communication parameters involved. These modules have a specific footprint (layout) and are only produced by certain companies. Their main advantage is that they provide a very robust easy to set up link and take care of all of the communication protocol details.

1.6.1.3 Human Recognition

The Human Recognition system will make use of a camera that will be interfaced through wireless communication to a computer that will have its own GUI (Graphical User Interface). The system will be able to detect Humans within the area based on a program that will allow the system to identify a person by comparing specific physical human attributes namely, the face, hand and torso, be it male or female. We will make use of the implementation of the Adaboost algorithm and Haarlike features, a common feature used for facial detection. The algorithm can be used specifically for training the database along with further applications on facial, hand and torso detection.

Fig. 1.1 System Model of the mobile robot

1.6.2 Methodology

1.6.2.1 Electrical and Mechanical Testing

In the mechanical design testing part, the prototype will be tested for its capability to traverse on land, the maximum speed that the system can attain when passing through different types of floor namely, Laminate, Stone, Tiles, Carpet, and Hardwood will be noted.

1.6.2.2 Communication and Human Recognition Testing

The systems capability to be controlled by a wireless remote controller around areas with and without obstruction and its capability to detect humans in different positions will be tested. The first test will be conducted on rooms or certain areas within a city. The system must be able to detect a human face, hand or torso at a distance of at least 4 meters in daylight and 2 meters in dark areas. There will be 23 different test subjects for every condition in this part of the experiment. The background of each test will be of white up to fairly decorated. Next, the recognition system will be tested in a simulated environment. The number of frames transmitted per second will be determined by the timestamp that is part of the captured frames. Lastly, is the capability of the system to detect within a dark environment, the system has LEDs that can be turned ON when the surrounding is dark. This will help the system to see in dark areas. The systems capability to be controlled by an RC controller around areas with and without obstruction will be tested. The environment where the system will be tested will consist of different types of floors such as Laminate, Stone, Tiles, Carpet, and Hardwood. The first test will be conducted to see if the system can be controlled over a minimum distance of 200m line of sight without obstructions. A test whether the system can handle 200m line of sight will be conducted. The second test will involve controlling or traversing the vehicle over a distance with obstruction. We will characterize the maximum distance that the system can traverse when obstruction such as concrete and wooden walls are present, we will also obtain the maximum distance that the camera can still transmit video feed when there is obstruction such as wooden wall and concrete.

1.7 Gantt chart

Fig. 1.2 Gantt chart

Chapter 2

LITERATURE REVIEW

Contents

2.1 Remote-controlled Home Robot Server with ZigBee Sensor Network

Recently, interest of general public toward ubiquitous home network has immensely increased and wireless PAN (personal area network) has attracted strong attentions as short-distance networking solution. Convenience of wireless PAN technology has attracted more attentions over traditional wired home network devices such as Ethernet, PLC and Home PNA since it requires no cabling work. In the future, home server will be combined with robot to provide functionalities identical to current home service robot as well as to implement more effective and spontaneous server. In this paper, embedded board has proposed as a home server for an efficient control of internal information and conditions of house from remote location and virtual home robot server to be implemented with ZigBee sensor network [m. Choi et al., 2006].

2.2 Remote power OnOff control and current measurement for home electric outlets based on a lowpower embedded board and ZigBee communication

Zigbee is a wireless network that any device can connect to and interact with other devices that is also connected to it. Zigbee is known for being security assistance for residences and the future of smart homes. An example of that is came up with an idea to remotely control on and off switches and at the same time measure the current for electric outlets at home [Bai and Hung, 2008]. They used two modules which are the server and zigbee control modules. For their interface they have used visual basic to generate a simple GUI for the user.

2.3 Design of Intelligent Mobile Monitor System Based on ZigBee and Android

Aside from zigbee another significant component the group planned to work with is android. Android can be used as our interface to communicate with the zigbee controlled car. Chang-qing & Hai-liang introduced a design for an intelligent car that uses bluetooth as to connect with any smartphone [Chang-qing and Hai-liang, 2012]. The only difference is the medium used for the interaction of the car and the user. Zigbee working together with android is not new. Dao designed an intelligent mobile monitor system using zigbee network and android platform. The mobile monitor system has high stability and high reliability and also flexible because it can be used in any environment whether in the agriculture, industry or for service business [Dao et al., 2012].

2.4 SMaRTCaR: an integrated smartphone-based platform to support traffic management applications

A research conducted by Campolo uses a smartphone as a platform to control a car and support traffic management [Campolo et al., 2012]. This is to add new services for the passengers and drivers. They have studied that with the growing technology and that smartphone is one of the most useful for experiment. Also they recognized that cars can be the most efficient way to collect data through surroundings. Sensors are installed in the cars to monitor parameters like temperature and amount of pollution.

2.5 Design and Construction of Rescue Robot and Pipeline Inspection Using Zigbee

Finding a technique to help, a robot was used to rescue a trapped baby in a bore well. The robot was also controlled by human and acts by the instruction given to it. By using just pc and the technology of wireless called zigbee, they are able to manipulate the mobile robot. They also use a camera for monitoring the audio and video [Bharathi and Suchitha Samuel, 2013].

2.6 Mobile robots in mine rescue and recovery

In other areas such as in mining, accidents also occur. Accidents like being trap underground are some usual cases in the United States. The country provides rescue teams that are trained for dangerous rescue missions. Using robots, they gather data from the hazardous areas and at the same time search for missing humans. Using robotics as a solution prevents other accidents to happen like detonating explosives and also suffer from heavy smokes and unstable ground [Murphy et al., 2009].

2.7 Multi-robot exploration under the constraints of wireless networking

Some other benefits of monitoring robot are for surveillance, planetary explorations and some rescue missions. Using robotics can make dangerous jobs easy by being much faster and robust. The approach to create multi-robot exploration takes away limitations of the wireless networking. The built algorithm is based on a population that makes samples of all the movement of robots. Also this algorithm selects the best one every step. The created team of robots explores the field maintaining the connection of the ad hoc network within each robot as well in their base located at a fixed point [Rooker and Birk, 2007].

2.8 ROBHAZ-rescue: rough-terrain negotiable tele-operated mobile robot for rescue mission

A designed a robot for rescue operations named ROBHAZ-DT3 operated with chained doubletrack mechanisms. The main purpose is to work for military and civilian missions located in hazardous and dangerous environments. They build the algorithm based on effectiveness of the robot on the field and how will it perform the rescue operation [Kang et al., 2005].

2.9 Remote control realization of distributed rescue robots via the wireless network

The wireless sensor network (WSN) is quickly being developed and it can result to many possibilities. Integrating the new wireless technology zigbee to mobile robots is their focus. Some achievements are being remotely controlled and monitoring different sensing devices with 802.11g and zigbee. Communication between human and robot is very significant. With the use of 802.11 g the voice signals and transmitting video are further enhanced to effectively detect the victims [Yeh et al., 2008].

2.10 Design and implementation of user-friendly remote controllers for rescue robots used at fire sites

Many conducted and developed robots for rescue operations during catastrophe and these generated different types of robots like firefighting robots, surveillance and the rescue robots. They propose a similar only a more user-friendly type of robot that is used for gathering information about like videos and concentration of temperature and gas data [Kim et al., 2010].

Chapter 3

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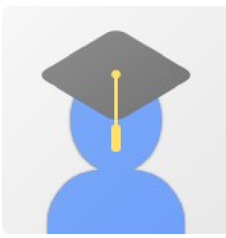
Appendix A
ANSWERS TO QUESTIONS TO THIS PROJECT

Contents

Appendix B
USAGE EXAMPLES

Appendix D
VITA



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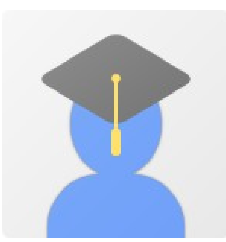

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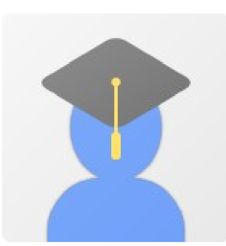

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