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ROBOTIC AMBULANCE FOR EMEGENCY MEDICAL SERVICE

Dr.S.V. Naresh[1], P.Nagavenkata sai[2], R.Mohan Rao[3], M. Bindu Madhavi[4], Sk.Mahaboob Subhani[5]

[1]Professor, ECE, SMCE, Thummalapalem, Andhra Pradesh, India.

[1]svenkatanaresh@gmail.com

[2,3,4,5] Student, ECE, SMCE, Thummalapalem, Andhra Pradesh, India.

[2]naga19197@gmail.com[3]mohanraoronanki1@gmail.com

[4]binduradha91@gmail.com[5]subhanishaiks78690@gmail.com

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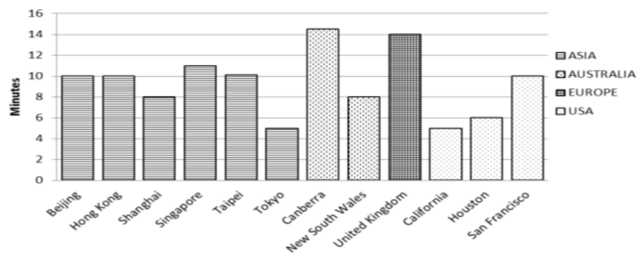
ABSTRACT: Smart cities essentially require the state-of-the-art technologies that can provide smart service in various aspects, and robotic systems are one of the key solutions for such requirements. Time is a critical issue when dealing with people who experience a sudden cardiac arrest that unfortunately could die due to inaccessibility of the emergency treatment. Therefore, an immediate treatment using automated Robotic Ambulance must be administered to the victim within a few minutes after collapsing. Hence, we have designed and developed the ambulance robot, which brings along an automated external de-brillator (AED) in a sudden event of cardiac arrest and facilitates various modes of operation from manual to autonomous functioning to save someones lives in smart cities. The details of the design and development of such robot are presented in this paper.

1. INTRODUCTION

Emergency situation refers to any unforeseen event that can jeopardize and bring significant injuries on a person's life. This situation can be broken down into two basic categories, natural and man made calamities. Natural calamity is the phenomena of nature caused by environmental factors that can bring catastrophic consequences. While the world population grows rapidly with increasing their concentration in hazardous environments without giving much consideration to the local Geo-climatic conditions have exacerbated the devastation caused by natural calamities. Therefore, different forms of natural calamities like drought, earthquake, extreme temperature, mass movement wet, typhoon, and volcano strike according to the vulnerability of the area in the globe. On the other hand, the catastrophe can also be caused as the consequence of technological or human hazards, including industrial accident and transport accident, where it is commonly known as man made calamity. Natural calamity is generally inevitable and biquitous worldwide that kills thousands of people and destroys billions of dollars of habitat and property each year. According to The International Disaster Database (EM-DAT)'s data, the number of deaths reported is getting less, however the number of people reported affected by natural calamity is increasing dramatically. It was due to global warming and the fact that the technology advancement makes the frequency of global calamity tends to be higher. Therefore, decreasing the rate of mortality is usually seen as the most effective way.

fig:1.1Response times of ambulance services in various countries



Meanwhile, it is a very hard task for bystanders to locate the nearest Automated External Debrillator (AED) in a situation where someone is suffering from sudden cardiac arrest. In order to tackle these problems, we have designed and developed an ambulance robot , which can place a small package containing an AED to save lives of cardiac arrest victim.

The rest of this paper is structured as follows. Important aspects of health care in smart cities and related background for AED, intelligent vehicle, rescue and medical robots are presented in Section II. The idea of ambulance robot for smart city is elaborated in Section III. The operation of the Robotic Ambulance is presented in Section IV.Finally discussion and future works are discussed in Section V.

2. BACKGROUND

Due the natural and manmade calamities, developments of medical and rescue robots are essential. This section will provide a brief description of rescue and medical robots in terms of both the size and function of robots in distinct environments. In addition, it will include how and which types of robots can be applied in various situations.

A. Rescue Robots

Most rescuers occur shortly after the event of a calamity happens. In that event, human rescuers will organize the rescue planning to get out to the calamity areas, find victims, and help them as fast as possible. They have very short time to find victims in any calamity situation; otherwise the likelihood of finding victims still alive is nearly zero. In such a critical situation, technology can be used to support rescuers in different tasks. Intelligent mobile robots and cooperative multi-agent robotic systems are increasingly being used in many different ways to find and save victims in a faster and more efficient way. The robot that can do such tasks is well known as rescue robot. Rescue robot is a robot that has been precisely designed to do rescuing jobs in situations that are hazardous for mankind to handle it, for instance rainstorms, collapsed buildings, obstructions, and dangerous substances.

To be useful tools rescue robots have to be fairly small, not too heavy and maneuverable enough to enter into gaps and move through cracks or narrow spaces that are impossible for humans and even trained dogs. These robots must be capable of navigating in challenging situation both indoors and outdoor terrain to find victims. Typically, robots will be equipped with tele-operated so that they have a good communication with human rescuers to gather crucial information including the location of victims in a map and way that human rescuers can reach victims. It can also place a small package containing food, medication, and a communication device near the victim.

Rescue robots are broadly divided into four different categories depending on modality and model size. There are four different groups of the robot based on modalities namely UGVs (Unmanned Ground Vehicles), UAVs (Unmanned Aerial Vehicles), UUVs (Unmanned Underwater Vehicles), and USVs (Unmanned Surface Vehicles). UGVs are typically placed on the ground to help human rescuers to find victims in areas that too dangerous for human. UAVs are developed to transport medical treatments to victims. These robots can extract meaningful information about the surrounding conditions to the responders. Water-based robot also called as UUVs are designed to replace humans for working underwater where it is both dangerous and difficult for humans. USVs have ability to work on the water surface. These robots can help rescuers to locate and bring some equipment to victims.

Rescue robots can further be divided in three groups, depending on the model sizes, man-packable, man-portable, and maxi-sized. Man-

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packable robots are typically small and more likely to be used immediately after a calamity. These robots can also travel over debris and climb stairs into a calamity hot zone. The next larger size is man-portable robots that may need two people or a small terrain vehicle. Manportable robots are often used for logistics support both in the hot zone and outside the hot zone. Maxi-sized robots are robots with the biggest size and need trailer or other special transportation logistics.

Rescue robots had been used in the last few decades with the participation in the recent devastations, such as 2001 the World Trade Center (WTC) collapse, the 2004 Mid Niigata earthquake in Japan, the 2005 hurricanes Katrina in the United States, as well as the 2011 Tohoku earthquake and tsunami in Japan. Three species of small UGVs namely Inuktun micro-VGTV, Inuktun micro-Tracks, and Foter-Miller Solem were sent to find victims at the World Trade Center 9/11 disaster in New York City, United States. In theformer incident robots were used to explore and inspect the rubble of the twin towers.

On 23 October 2004 the largest earthquake hit the Niigata Chuetsu in Japan and thirty-nine people were reported dead. The first snake robot of the Soryu III has been developed to find victims at a calamity site and it had a length of 1.2m, a weight about 10 kg, and a maximum speed of 0.37m/s. There are three components mounted upon the robots namely a charge-coupled device (CCD) camera, an infrared camera (FLIR), and two-way audio as well as proprioceptive sensors. This robot is also supported with CO2 sensor to detect human breathing. The worst hurricane has been happened in the southern Gulf Coast of the United States in 2005 and the 2000 lives reported to have died. There were two UAVs used to get information about rural regions cut off by flash flooding in the aftermath of calamities.

Since some incidents of the aforementioned have attacked in some part of the globe, rescue robots have been widely used to help victims at calamities site where human rescuers cannot enter. Such a situation was realized at the Fukushima nuclear reactors in Japan after the Higashi Nippon earthquake that occurred on 11 March 2011. The earthquake destroyed the interiors of buildings and causing some areas were highly contaminated by radiation. Several types of robots have been used to explore areas inside the reactor buildings where humans could not enter such as Packbot , and Quince .

B. Medical Robots

Nowadays, most of robots produced are typically created for industrial sectors. These robots have replaced human laborers involvement in hazardous and harmful tasks. The number of robots used in industrial production has grown strongly within the past few decades. On the other side, the development of robots in service sectors is still limited. These robots are often called as service robots that perform tasks for people instead of serving industrial manufacturer. Service robots are often mobile, capable of working independently, and interacting with humans. These robots are comprised of various types and one of them is a medical robot. In the recent years, application of robots in medicine has become a more interesting topic for both robotics researchers and the general public. They have been used to fundamentally change interventional medicine with robots and bring some new techniques to support physical therapy, rehabilitation, and even perform more difficult procedures.

Medical robots can be classified into two categories follow their utilization which are medical robots to assist people and medical robots to assist medical staffs. There are two distinct groups of robots that typically used for assisting people, such as rehabilitation and companion robots. Rehabilitation robots are dedicated to provide assistive equipment for those people with impairment following stroke. Hybrid Assistive Limb 5, Lokomat, and Bionic Limbs are most widely used in hospitals for rehabilitation. Companion robots offer tremendous potential for enhancing the quality of human lives in the future. There are a several examples of companion robotics, such as Lovotics, RIBA], and Paro Robot.

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In addition, there are three different groups of robots that typically used for assisting medical staffs, such as telerobotics, surgical, and pharmacy robots. Tele-robotics is enabling many participants to control the robot simultaneously that are situated in remote location or otherwise inaccessible. The list of tele-robotics that helps in medicine is including Remote Presence-Vita Robot andNursebot. Surgical robotics can be categorized into two classes, which are robots that perform surgery, e.g. Cyberknife Radiosurgery, and robots that assist the surgeon in the surgery, e.g. Da Vinci robot. Pharmacy robots can handle a wide range of tasks for preparing intravenous medications in a sterile environment such as packaging, and labeling of medications.

3. SYSTEM DESCRIPTION

Sudden cardiac arrest is the leading cause of death worldwide. It can happen anywhere at work, at home or anywhere else. AEDs are designed to help someone in cardiac arrest. However, it may take a long time to get an AED at nearest scene of victims because AEDs are not available everywhere. Therefore, we have proposed the Ambubot as a platform to save someone's life during cardiac arrest. This robot can be characterized by different degree of autonomy and it will execute different tasks as illustrated

TABLE 1.DIFFERENT TASKS OF ROBOTIC AMBULANCE

Task	Tele-control	Partially Autonomous	Autonomous
Autonomous Navigation	No	Yes	Yes
Execute the AED	No	No	Yes

BLOCK DIAGRAM:

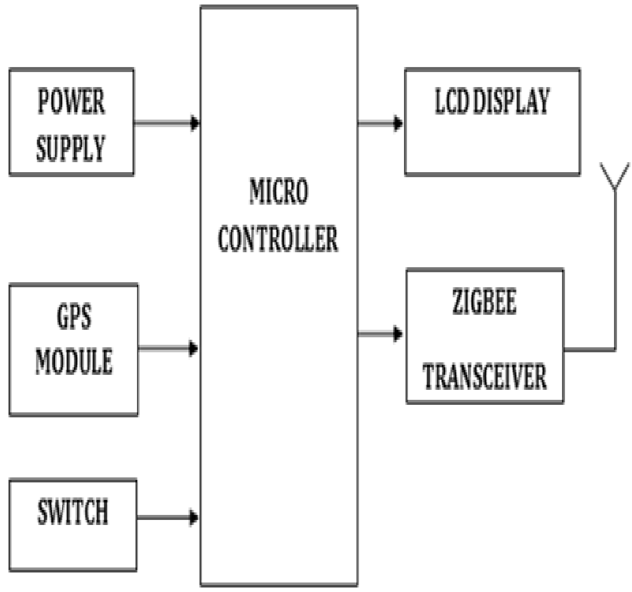

Fig 3.1: person section

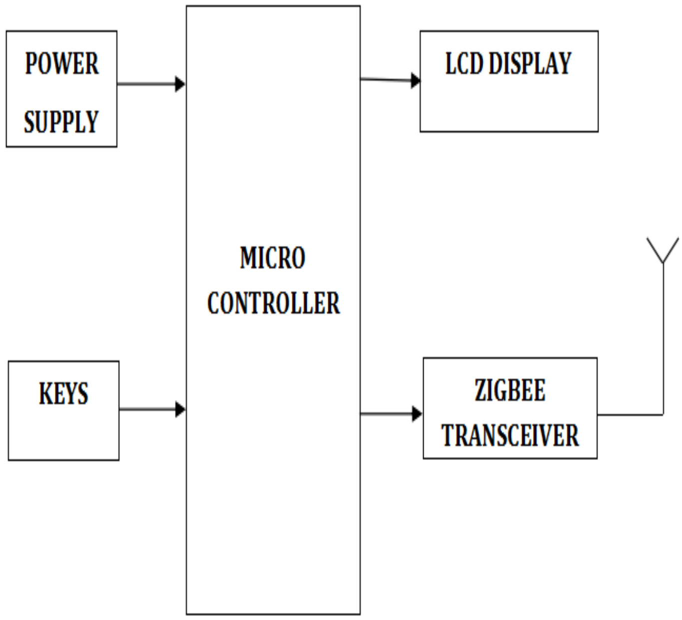

Fig 3.2:Control section

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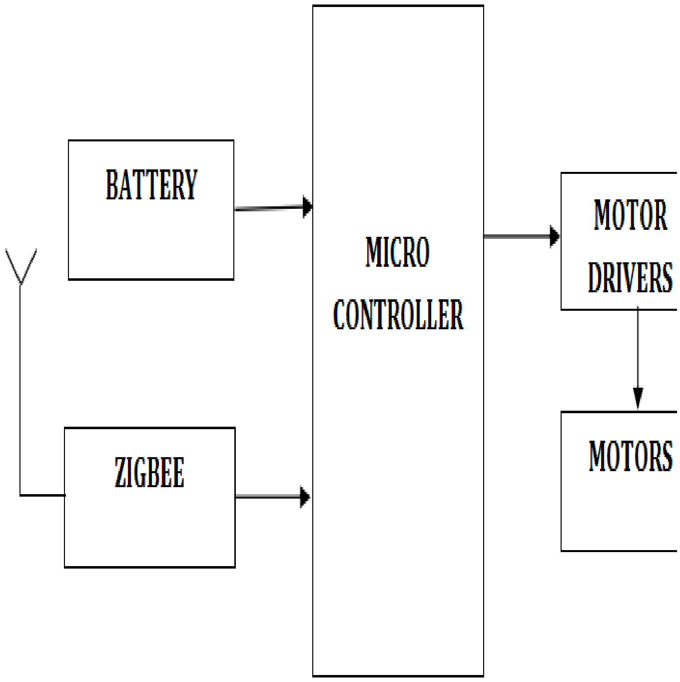

Fig 3.3:Robot section

This system consist of following component which are listed below.

1. Arduino (ATMEGA 328P)
2. LCD Display (16×2)
3. zigbee
4. GPS Module(SIM28ML)
5. Power supply
6. Motor drivers

3.1 Arduino:

This development board provides small plate with the same powerful microcontroller like Arduino Uno. The Arduino Nano is small in size that uses ATMEGA328P Microcontroller. It operates on 5V DC supply. Remaining all component interface with this device. The RX and TX pin of this device is connected to the TX and RX of the GSM modem of SIM800 Module. D10 Pin is connected to the TX of The GPS module.D2 to D7 Pin is connected to the LCD Display.

3.2 LCD Display (16×2):

This display contains two internal byte wise resisters, One for the commands (RS=0) and second for character to be displayed (RS=1). It also contains a user programmed RAM area (the character RAM) that can be programmed to generate any desired character that can form using a dot matrix. To distinguish between these two data areas. The display takes varying amounts of time to accomplish the functions. D4-D7 pin is connected to the D2-D5 Pin of Arduino. RS and EN Pin of display is connected to the D6, D7 Pin Respectively also by giving a proper supply and system ground LCD is ready to display the data.

3.3 Zigbee:

XBee radio family consist of various XBee RF modules. Each having different specification. Generally, XBee modules operate within ISM 2.4 GHz (Unlicensed) frequency band. XBee modules support ZigBee protocol which is based on IEEE 802.15.4 standard.

XBee modules have source/destination addressing feature with unicast and broadcast communication support. They support point to point, point to multipoint, peer to peer etc. communication typologies.

XBee modules uses DSSS (Direct Sequence Spread Spectrum) modulation technique for communication. XBee has on board features like Digital I/O pins, analog ADC (10-bit) input pins, PWM output etc. It has serial UART pins for communication with PC and Microcontrollers serially. Some XBee modules (e.g. S2C) has support for SPI interface too.

3.4 GPS Model:

It consists of six wires out of which three wires are used for connection. The TX pin of this module which is connected to the D10 pin of the microcontroller. Voltage supply is about 3.3V to 5V.When Push button is pressed, GPS starts receiving signals from 4 satellites out of the 24 satellites in the orbit. Once if the connection is established the latitude and longitude values of the current location are obtained. The GPS acts as a transmitter. The 5V supply is given to the GPS from the controller.

3.5 Power Supply:

To make the DC power supply of 5volt we used step down transformer, bridge circuit, filter circuit and finally fixed voltage regulator. In this system we used step down transformer in which primary voltage is greater than secondary voltage.in this system we used 9-0-9 step down transformer.so at the transformer output we got 9volt AC. Then we used bridge circuit whose job to perform to convert AC into pulsating DC. Then filter is used to remove the noisy pulses and convert pulsating DC into pure DC. Then IC7805. Regulator is used which provides fixed positive 5V DC Output.

3.6 DC Motors

DC motor uses Direct Current (electrical energy) to produce mechanical movement i.e. rotational movement. When it converts electrical energy into mechanical energy then it is called as DC motor and when it converts mechanical energy into electrical energy then it is called as DC generator. The working principle of DC motor is based on the fact that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force and starts rotating. Its direction of rotation depends upon Fleming's Left Hand Rule.

4. OPERATION OF ROBOTIC AMBULANCE

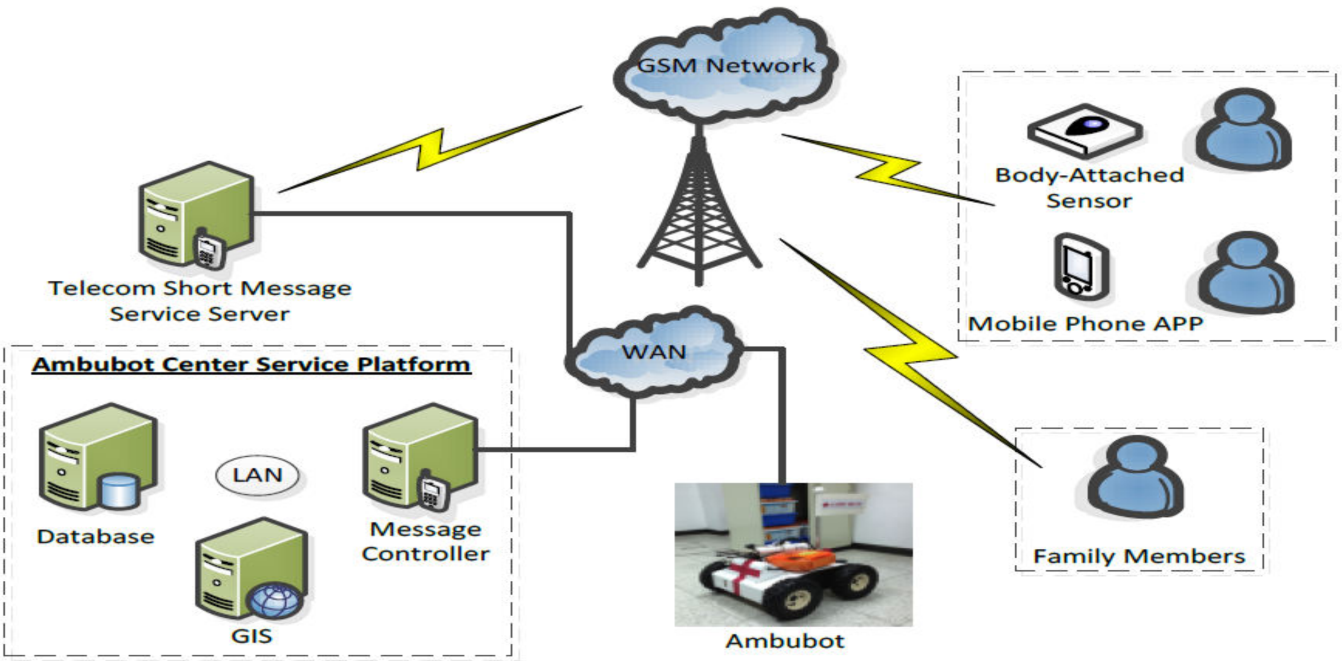

Fig :4.1 Architecture of Robotic Ambulance

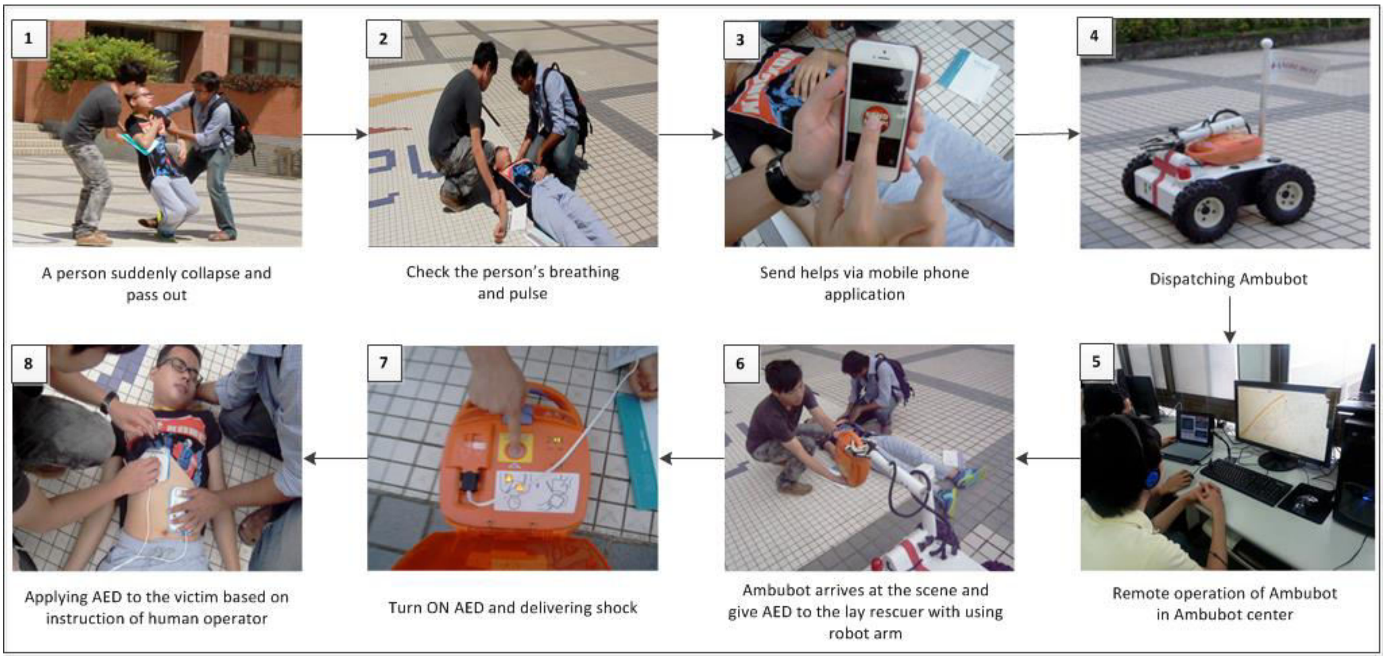

Fig :4.2 System Architecture of Ambubot center

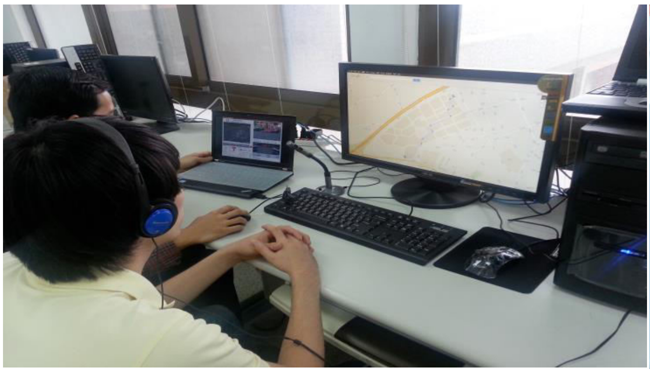

Fig: 4.3 Remote operation of robotic ambulance

fig:4.4 Robotic ambul controller interface

5. CONCLUSION AND FUTURE SCOPE

In this paper a novel ambulance robot called Robotic ambulance was presented which provides the service of an ambulance with AED and focus on a tele-operation. Sudden cardiac arrest occurs when the heart has stopped beating effectively due to an electrical malfunction of the heart. It occurs instantly or shortly after symptoms appear. Early access to the AED can be a life saving measure in the event of a person suffering in cardiac arrest. To have the absolute best chance of survival, immediate treatment must be carried out in the first few minutes after a person suffer a sudden cardiac arrest. In this paper, the Ambulance robot is intended to improve on manual search assistance of finding AED with the help of the information technology so that an immediate treatment can be delivered to help victims in cardiac arrest. There are three dispatching methods of Ambulance robot to reach location of victim namely telecontrol, partially autonomous, and fully autonomous. However, tele-control robot is a major focus of our current research due to the difficulty of implementing other methods in real health care environment. Such issue is practical where the accident occurs near the control station. The Ambulance robot operator guides a lay first responder through the entire process to apply AED before the ambulance arrives. To help keep the cardiac arrest victims alive, the body-attached sensor and mobile phone application can be used to prevent the victim from suffering any misfortune. For data management, an control center service platform consisting of database server, message controller, and H-GIS server is constructed to let robotic ambulance and family

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members acquire the relevant information about the victim.

Our future efforts will primarily focus on increasing the autonomous operation of the robot while working on two extra aspects. One is adding the ability of the body-attached sensor to monitor condition of the patient and then transmits some helpful information to specialists who would evaluate the patients' health conditions. Moreover, we have also considered the possibility of adding more advanced features such as integrating the body-attached sensor with portal service so that external user can monitor the patient wherever they are. The system will prompt the user to key in a username and password before the user can connect to the system. We believe that this research will result in better way to save someone's life during cardiac arrest and reduce the burden of lay rescuers to find an AED so that it can bring more practical and commercial value to our society.

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