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Ambubot with Defibrillator for Medical Services in Smart Cities

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***Abstract* - A smart city is an urban development vision to integrate information and communication technology (ICT) and Internet of things (IoT) technology in a secure fashion to manage a city's assets. Through the use of sensors integrated with real-time monitoring systems, data are collected from citizens and devices – then processed and analyzed. The information and knowledge gathered are keys to tackling inefficiency. 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 External Defibrillator (AED) must be administered to the victim within a few minutes after collapsing. Hence, we have designed and developed the Ambulance Robot, shortened as Ambubot, which brings along an AED in a sudden event of cardiac arrest and facilitates various modes of operation from manual to autonomous functioning to save someone's lives in smart cities. Details of design and development of such robot is presented in this paper.**

***Index Terms*— Smart healthcare, smart cities, emergency management, robotics.**

1. INTRODUCTION

It can be seen with many of today's occupations have been replaced by automation in order to help prevent manual handling injuries in the workplace. The smart world is expected to involve ubiquitous sensing, computing, and communication to achieve comprehensive interconnections of physical perception, cyber interaction, social correlation, and cognitive thinking. Increasing population density in urban environments demands adequate provision of services and infrastructure.As an emerging platform for that domain, a mobile robot can be employed in order to facilitate the health care operation as a smart operating vehicle in smart cities. In contrast, a mobile robot would be able to travel through-out the environment and can put their position wherever its condition. Mobile robot is an autonomous or semiautonomous machine that capable to move around in their environment and also can perform various tasks either with direct or partial control by human supervision or completely autonomous. With using multiple sensors for navigation, this robot can navigate from a point to a given destination without losing the correct path or hitting obstacles. There are various sensor types used for autonomous navigation in mobile such as vision and range sensors. Mobile robots are mostly used to investigate hazardous and dangerous environments where the risks for human operation exist. This robot can also be used to interact with human such as take care the elderly and doing household chores. In future smart cities, mobile robots can take over some tedious and time-consuming tasks.

In the case of health emergency, it is common to call the emergency hotline to seek for assistance which often the ambulance will be dispatched to the scene in average of ten minutes time. Details of that information are depicted in Figure 1 for various territories. In practice, the advent time of ambulance is far above the ten minutes standard. This is owing to many obstructions during the process of dispatching an Ambulance and it may defer the patient from receiving the service on time. Substantially different factors prevail in this issue ranging from traffic congestion, difficulty to locate the address, long distance, and so forth. Any one of these delays can lead to increase response time.

Meanwhile, it is a very hard task for bystanders to locate the nearest Automated External Defibrillator (AED) in a situation where someone is suffering from sudden cardiac arrest. To tackle these problems, we have designed and developed an ambulance robot (AmbuBot), which can place a small package containing an AED to save lives of cardiac arrest victim. Our developed robot is presented in Figure 2.

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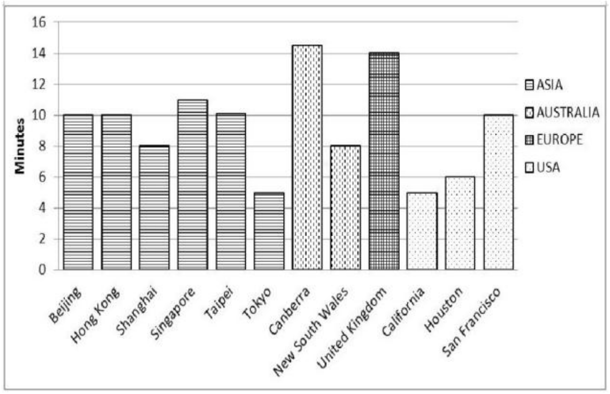

Fig. 1. Response times of ambulance services in various countries

Fig. 2. The developed Ambulance Robot.

2. BACKGROUND

A variety of the labels can be largely categorized into three dimensions: technology, people, and community. The conceptual variants are mutually connected with substantial confusion in definitions and complicated usages rather than independent on each other. In the process of providing better services to all citizens and improving the efficiency of administration processes, the concept of a smart city has been lauded as a promising solution for the coming challenge of global urbanization. The main challenges for the healthcare domain of smart cities are using ICT and remote assistance to prevent and diagnose diseases, and deliver the healthcare service in addition to providing all citizens with access to an efficient healthcare system characterized by adequate facilities and services. The Internet of Things revolution is redesigning modern healthcare with promising technological, economic, and social prospects. Hence it is required to develop new smart technologies to provide advanced healthcare service to the citizens of smart cities and in this paper, we aim to present one of feasible solutions for one of the critical problems of modern cities. Despite the very useful functionality of AED and even though this device is placed in various public areas nowadays, practical operation of AED still requires improvement which motivated us to develop a robot to perform such critical task in smart cities. Real case scenarios show that it is often difficult to find out the nearby AED when a panic situation occurs, bring and apply it to the victim. Several people are also required to get familiar with AED in advance.

2.1. Automated External Defibrillator

Sudden cardiac arrest is a condition in which the heart abruptly and unexpectedly stops beating due to a lack of oxygen getting to the brain and other organs. This is one of the leading causes of death in both men and women worldwide. It can happen anywhere at work, at home or anywhere else. Cardiac arrest commonly arises in individuals who have not had any heart problems or not in the well-recognized high risk for heart disease. Automated External Defibrillators or AEDs are designed to help someone in cardiac arrest. These devices should be applied to the victim as rapidly as possible to minimize any serious side effects while paramedics are enroute to the scene. 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 Ambubot as a platform to save someone's life during cardiac arrest.

An emergency could arise at any time with no warning. Meanwhile, the fate of patients cannot be influenced by waiting the ambulance but rather could be changed if some treatments could be given within a few minutes of the patients collapse. For instance, individuals suffering sudden cardiac arrest could be saved if the AED is applied within a few minutes after the occurrence of cardiac arrest. At the same time, someone who helps the patient must be able to perform CPR (Cardiopulmonary Resuscitation) and attaches an AED to a person in cardiac arrest. The AED is small electronic portable defibrillator designed for minimally trained or untrained non-medical personnel. This device can generate single-phase and double-phase waveforms. Single-phase waveforms generate a high-energy output. It may cause damage to the heart and skin. In contrary, double-phase waveforms produce a low energy output.

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In order to mitigate those problems and keep patient staying alive before the advent of ambulance, we utilize Ambulance Robot application to carry an AED and according to our long-term plan it would be able to perform CPR to a person in cardiac arrest. We believe that our application can mitigate the constraint of human ability to locate the AED at the nearest location of victim and increase the survival time of victim.

3.AMBULANCE ROBOT FOR SMART CITY

As mentioned earlier, we used Ambubot as a platform to save someone's life during cardiac arrest. There are two techniques that can be used to keep cardiac arrest victims alive either by body-attached sensor or mobile phone application, as pictured in the sectional view Figure 3. Whenever one of them is used, they will immediately send out warning message and Global Positioning System (GPS) information to Ambubot center. Ambubot center will convert the longitude and latitude coordinates into a street map location using a GPS and GIS parser. in the case of using the body-attached sensor acceptable as fall sensor, this location could be integrated with other basic information about the victim such as personal contacts and characteristics, blood type, height, weight, and photograph to generate the complete information needed for search and assistance tasks.

After Ambubot center processes this data packet, it will generate two commands namely a command for dispatching Ambubot from the station to the scene as precaution to save patient life before ambulance arrives and other command for delivering an emergency message to family members via Global System for Mobile Communication (GSM) so they can obtain relevant information concerning the falling person via mobile phone.

The hardware design of the body-attached sensor mainly consists of a GPS satellite location module, a gyro sensor, a microprocessor, and a GSM communication module. The body-attached sensor could be integrated in the objects that a person frequently uses (e.g., glasses frames, belts, and watches) as a wearable device to give a convenience without disturbing the person daily lives. The dimension of the body-attached sensor is suitable for the fixation on the human body and produces low power consumption. The GPS satellite location module is used to provide satellite location information needed to find the shortest path of victims, such as longitude/latitude coordinates, time, and direction. Information and personal health history will be generated by Ambubot center to help ensure the patients safety. The microprocessor is in charge of computation and command execution as the main intelligent hardware module. When the gyro sensor sensed that the patient collapse, the microprocessor will transmit a short message to notify family members. The GSM communication module is used to provide a communication channel to transmit emergency rescue messages concerning the patient to Ambubot center and receive commands from the server. Since the body-attached sensor requires a certain amount of power to function properly, it is important to have a power supply that can provide the right amount. When 10 % of the power is left, this function sends a message to family members to replace the battery so as to ensure the normal operation of the system.

There are various ways of dispatching Ambubot to reach a destination, such as tele-control, partially autonomous and fully autonomous.

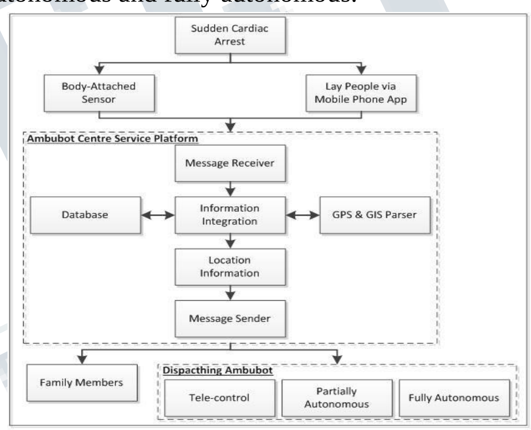

Fig. 3. Overview of the system workflow.

3.1. Tele-control

Tele-control assists human operator to direct maneuvering Ambubot using a visual display and a control pad. In general, the main function of tele-control system is to assist human operator to perform and accomplish complex, uncertain tasks in hazardous, and less structured environments. In this mode, an Ambubot needs a people like driver who in charge to control the robot with using a remote-control device, which resembles a controller panel, and watch the real-time video stream from two surveillance cameras on Ambubot to navigate, locate, and approach the victim. In this scenario, when Ambubot approaches the victim, human operators from the control center provide detailed

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instructions to people near victim to operate the AED device carried by Ambubot.

5.ROBOT OPERATION

In the process of developing Ambubot, we first focused on the first mode namely tele-control to take complete control over the Ambubot operation due to the difficulty of implementing other mode in real health care environment mostly because of safety issues. These various sensors play a vital role to adjust the behavior of the robot according to its surrounding situation. Aside from that the recognition and decision capability of a human is much better than an intelligent robot because human can easily identify objects and its geometric features while it is extremely difficult to be done by the robot. Because of these reasons tele-control technique has been suggested as a useful scheme to operate the robot in the harsh environment. We aim to improve this system from remote control, to semi-autonomous and later fully autonomous behavior.

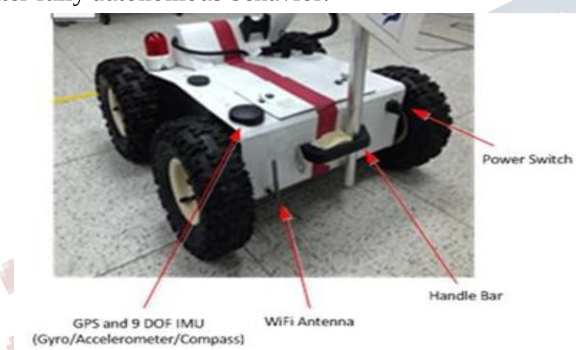

Fig. 4. System structure of Ambulance Robot

Fig.5.c.Active and resistive forces of the Ambubo
In tele-control scheme, the operators must continuously operate and monitor Ambubot. Subsequently,Ambubot accepts command tasks from human operator to move the robot from its initial position to its prescribed goal, and this task planning relies mostly on the human supervision. Nevertheless, the interaction between human operator and Ambubot allow the operator to feel the remote environment and can control the motion of the robot intuitively. With using two surveillance cameras mounted on the robot, one in front of the body and the other one on the arm, Ambubot will report the current situation to operators and display the motion through streaming video.
The tele-control mode includes the robot located in the station and the control server equipped with computer. Ambubot center service platform consists of three servers, which are implemented on three independent server systems namely database server, message controller, and GIS server as illustrated in Figure 6. All servers are located within a firewall to enhance the system security. Database server is designed for data storage and management. A message controller server is connected to the telecoms short message server for enhancing the efficiency of message processing including the acceptance and transmission of a larger volume of short messages via network packets.

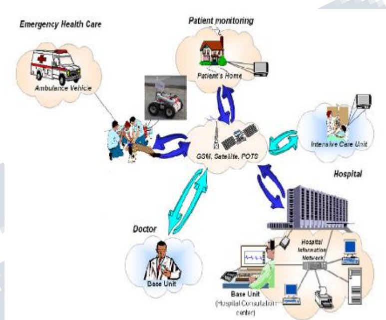

Fig. 6. System architecture of Ambubot center.

The other server is Geographic Information Server (GIS) used to convert the GPS longitude/latitude coordinates to location information in terms of street address and important landmarks, allowing family members and Ambubot to efficiently acquire geographical spatial information concerning the falling patient and dispatch Ambubot more effectively. In addition, this server is solely responsible to assist Ambubot to find the possible shortest path between Ambubot and victim.
The block diagram in Figure 7 shows the gradual implementation of dispatching Ambubot that will arrive to the premises within ten minutes of collapse. With using telepresence, it allows an operator to remotely control the movement of Ambubot to the scene. The control is given to the operator not only in the case of non-critical environment but also in a critical situation or bad visual feedback thus the operator can rapidly control Ambubot. An emergency message and current position of victim will be generated these data will be evaluated and thereupon transmitted automatically to Ambubot center immediately after a sudden cardiac arrest happens. The majority of people use smart mobile phone. Therefore, the development of mobile phone application connected to Ambubot center is convenient because it can provide on-time medical care to the victim.

Alternative method in the case of lack of smart phone would be to call the Ambubot center.

Fig. 8. Remote operations of Ambubot in Ambubot center.

As delineated in Figure 8 two operators in Ambubot center use a suitable input device such as a control pad and a computer to control the movement of the robot. The two surveillance cameras on the Ambubot enable the human operator to assess the remote situation and make a safe and continuous operation possible.

Fig. 9. Ambubot controller interfaces.

In order to generate a street map location of victim, Ambubot used GPS and GIS parser to convert the longitude and latitude coordinates to location information concerning place of victim with cardiac arrest history and location information of victim will be integrated with message controller server. This message combines with other basic information of victim such as personal contacts and characteristics, blood type, height, weight, photograph, and health history of victim in cardiac arrest, while also will inform family members of the shortest path to reach the victim.

As shown in Figure 9, the high-resolution video and audio integrated in our robot is used to visually provide human operators with information of the surrounding so they can guide Ambubot to avoid any obstacles on the way of dispatching the robot to the scene. Moreover, the integration of the operator with video streaming in the Ambubot's controller provides an opportunity to interactively communicate with the lay rescuers on the premises. When Ambubot arrives in the location of victim, human operator instructs lay rescuers to apply the pads of AED to victims chest.

6 .SENSOR FUSION AND NAVIGATION

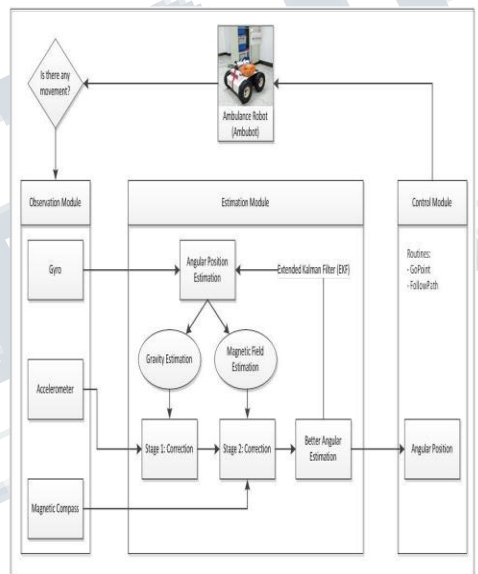

Fig. 10. Sensor fusion architecture of ambulance robot.

Our map which shows the experience environment of the proposed ambulance robot. Figure 12. The navigation planner of Ambubot modified that map as illustrated in Figure 13 for path planning as presented in Figure 14. It can be seen that the trajectory is planned for the robot to move from the main entrance of the campus to the dormitory. In the real case the AED is located in the main entrance of the campus at the security office.

The map is represented as an occupancy grid map using imported binary data. When sampling nodes in the free space of a map, PRM uses this binary occupancy grid representation to deduce free space. Furthermore, PRM does not take into account the robot dimension while computing an obstacle free path on a map. So, the map should be inflated by the dimension of the robot, in order to allow computation of an obstacle free path that accounts for the robot's size and ensures collision avoidance for the actual robot. By having the start point as the initial location of the robot in Ambubot center and the end location as the victims location the PRM path planner finds an obstacle free path

Time (Second)		1	2	3	4	5	6	7	8	9	10
Angular Position (Radian)		1.8	4.3	8.6	12.7	20	28.8	39.4	50.2	62.1	77.5
Moving Average	Estimated	4.8	4.3	8.6	17.4	19.5	30.9	38.2	50.2	63.9	77.8
	Error	3	0	0	4.7	0.5	2.1	1.2	0	1.8	0.3
EKF	Estimated	1.78	4.28	8.65	12.7	20.18	28.8	39.46	50.3	62.1	76.8
	Error	0.02	0.02	0.05	0	0.18	0	0.06	0.1	0	0.7
EKF (Bias: 2.05)	Estimated	1.8	4.35	10	12.71	20	27.9	39.5	51.1	62.4	76.5
	Error	0	0.05	1.4	0.01	0	0.9	0.1	0.9	0.3	1

Fig. 11. Comparison of the angular displacement errors in different approaches.

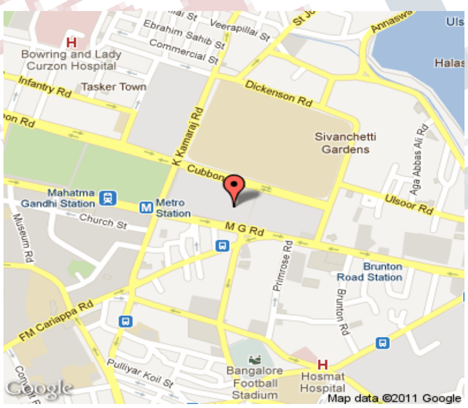

Fig. 12. The map which shows the experience environment of the proposed ambulance robot.

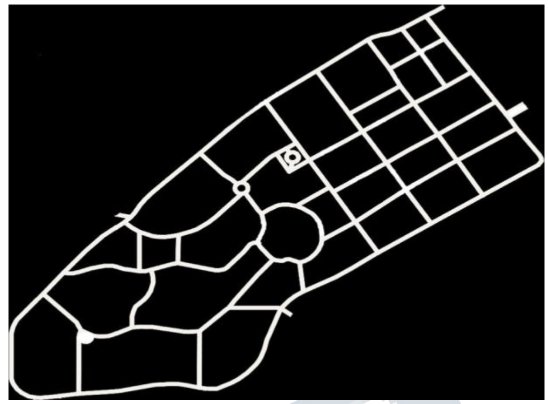

Fig. 13. The modified map in Ambubot navigation planning unit.

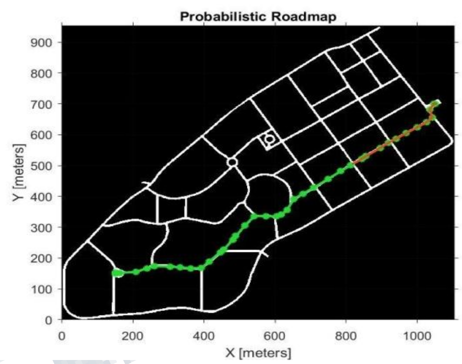

Fig. 14. The Probabilistic Roadmap calculated by Ambubot

REFERENCES

[1] H. Ning, H. Liu, J. Ma, L. Yang, Y. Wan, X. Ye, and R. Huang, "From internet to smart world," Access, IEEE, vol. 3, pp. 1994–1999, 2015.

[2] R. Jalali, K. El-khatib, and C. McGregor, "Smart city architecture for community level services through the internet of things," in Intelligence in Next Generation Networks (ICIN), 2015 18th International Conference on. IEEE, 2015, pp. 108–113.

[3] M. Arif, H. Samani, C.-Y. Yang, and Y.-Y. Chen, "Adaptation of mobile robots to intelligent vehicles," in Software Engineering and Service Science (ICSESS), 2013 4th IEEE International Conference on. IEEE, 2013, pp. 550–553.

[4] Y.-C. Lin, S.-T. Wei, S.-A. Yang, and L.-C. Fu, "Planning on searching occluded target object with a mobile robot manipulator," in Robotics and Automation (ICRA), 2015 IEEE International Conference on. IEEE, 2015, pp. 3110–3115.

[5] C.-P. Lam, C.-T. Chou, K.-H. Chiang, and L.C. Fu, "Human-centered robot navigation towards a harmoniously human–robot coexisting environment," Robotics, IEEE Transactions on, vol. 27, no. 1, pp. 99–112, 2011.

[6] T. Yonezawa, I. Matranga, J. A. Galache, H. Maeomichi, L. Gurgen, and T. Shibuya, "A citizen-centric approach towards global-scale smart city platform," in Recent Advances in Internet of Things (RIoT), 2015 International Conference on. IEEE, 2015, pp. 1–6.

[7] K. Nagatani, S. Kiribayashi, Y. Okada, S. Tadokoro, T. Nishimura, T. Yoshida, E. Koyanagi, and Y. Hada, "Redesign of rescue mobile robot quince," in Safety, Security, and Rescue Robotics (SSRR), 2011 IEEE International Symposium on. IEEE, 2011, pp. 13–18.

[8] E. Liu, L.-c. Wong, and L. C. Secretariat, Emergency Ambulance Services. Research and Library Services Division, Legislative Council Secretariat, 1996.

[9] H. A. Samani, J. T. K. V. Koh, E. Saadatian, and D. Polydorou, "Towards robotics leadership: An analysis of leadership characteristics and the roles robots will inherit in future human society," in Intelligent Information and Database Systems. Springer, 2012, pp. 158–165.

[10] T. Nam and T. A. Pardo, "Conceptualizing smart city with dimensions of technology, people, and institutions," in Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times. ACM, 2011, pp. 282– 291.

[11] R. Wenge, X. Zhang, C. Dave, L. Chao, and S. Hao, "Smart city architecture: A technology guide for implementation and design challenges," Communications, China, vol. 11, no. 3, pp. 56–69, 2014.

[12] P. Neirotti, A. De Marco, A. C. Cagliano, G. Mangano, and F. Scorrano, "Current trends in smart city initiatives: Some stylised facts," Cities, vol. 38, pp. 25–36,
2014