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Automatic Battery Replacement of Home Surveillance Robot using WSN

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Abstract – Wireless Sensor Networks (WSNs) can be defined as a self-configured and infrastructure-less wireless networks to monitor physical or environmental conditions, such as temperature, sound, etc. Here, It is used for the automatic battery replacement of home surveillance robot. The proposed system is composed of the surveillance robot and the docking section for the automatic battery replacement of the surveillance robot. The palm-sized surveillance robot communicates with the general wireless home router through Wi-Fi. It communicates with the docking section through Zigbee and serves as a mobile sensor network gateway. The time duration capability is a critical function for the surveillance robots and it is relied on the power supply. The charging duration of the battery mounted in the robot is an important issue. Battery replacement of the surveillance robot is the best solution to increase the long term activity of robots. The robot can return to the docking section for battery replacement when the battery is too low. So the robot need not to be turned off for long duration of time while replacing the battery. MATLAB is used to implement this battery replacement process of surveillance robot.

Index Terms – Surveillance robot, docking. Battery replacement

I. INTRODUCTION

The next great computing paradigm shift to pervasive computing is already well under way and it refers to the emerging trend toward numerous, easily accessible computing devices connected to an increasingly ubiquitous network infrastructure. With the rapid development of microelectronics and wireless communication technologies, the range of potential applications of mobile robots are enormous. Various mobile robots have proposed for the housework such as cleaning, cooking, pet feeding, house plant watereing and taking care of children [1][2]. Mobile robots are widely used in industrial automation, home automation, hospital automation, entertainment and military applications, etc [3]. Most of the mobile robots are now working around us and also they will help us a lot in our daily lives [4][5].

Most of the mobile robots are used in security applications. Home security is one of the typical applications of mobile robots. With cheaper production techniques, surveillance cameras are simple and inexpensive enough to be used in home security systems, and for everyday surveillance. An automatic video-based human motion analyzer for consumer surveillance system has been developed in [6]. A home surveillance system based on an embedded system with multiple ultrasonic sensor modules has been presented in [7]. If any intruder passes through the ultrasonic sensing area, the ultrasonic transmission will be blocked by the human body. The development and characterization of a surveillance robot with hopping capabilities for home security has been discussed in [8]. The surveillance robot is 9cm in height and 250g in weight and it can leap over obstacles more than 4 times its own size. The development and characterization of a surveillance robot with automatic docking and recharging capabilities for home security has been proposed in [9]. The development of automatic docking system with recharging and battery replacement process for home surveillance robot has been discussed in [10]. A hybrid wireless sensor network contains both mobile and fixed nodes, which enables the monitoring of chronic patients and their home environment has been proposed in [11]. The design and implementation of a low cost GSM/GPRS based on wireless home security system has been proposed in earlier days. The system can response rapidly to alarm incidents and has a friendly user interface including a LCD and a capacitive sensor keyboard. A wireless access monitoring and control system based on digital door lock which includes the Zigbee network protocol.

Even though most of the current home security systems can work normally, it is inconvenient to deploy and maintain a lot of sensors and accessories everywhere in the rooms. Due to irregular room structures and various physical limitations of sensors, there often exist some regions that can not be covered by the sensors. In view of these drawbacks, a more flexible and more efficient solution for home security is to deploy mobile robot equipped with surveillance devices such as pyroelectric infrared sensors and cameras. Many researchers worldwide are now engaged in designing various mobile surveillance robots for home security applications. The design and implementation of an intelligent home security is to implement a low cost and small home security robot that is suitable for patrolling tasks in narrow indoor environments.

This paper presents a wireless sensor network gateway system for automatic battery replacement of home surveillance robot. The proposed system is composed of a surveillance robot and a docking section. The surveillance robot is palm-sized one and it communicates with the docking section through Zigbee and IR sensors and also it serves as a mobile sensor network gateway system. The wheel-based mobile robot with a USB camera is specifically designed for home security usage. It can communicate with the general wireless home router through Zigbee and IR sensors.

The rest of this paper is organized as follows. Section II introduces the overall design of the home security system based on the proposed surveillance robot and the docking station. The docking performance are presented in Section III. Conclusion is given in Section IV .

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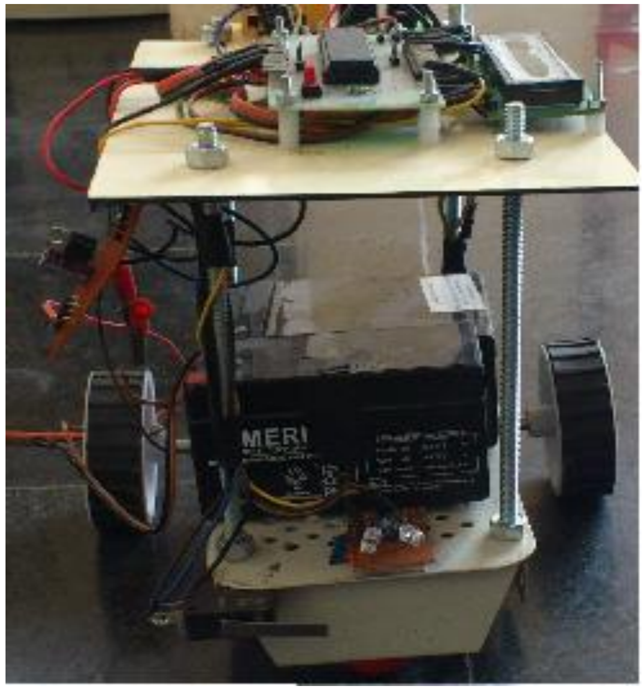

Fig. 1. A prototype of the Surveillance Robot.

II. SYSTEM DESIGN

The overall design of the home security system has been discussed in this section. The conceptual architecture of a home security system based on the proposed surveillance robot is shown in Fig. 1. The surveillance robot wanders around in the rooms or follows predefined routes autonomously. It overcomes obstacles on its routes by making a detour. The robot can return to the docking section for replacement of battery when the on-board battery is too low.

+

Motor -

+

Motor -

Fig. 2. Overall System design of the Surveillance robot and Docking section.

The overall system design of the surveillance robot and the docking section is shown in Fig. 2. It shows how the system can be work. The input video image is given from the camera to the system. Using Max 232 port , the image can be converted into signal and it has been transmitted and received by zigbee.

1. The Surveillance Robot

The hardware design parts of the surveillance robot is shown in the figure 2. The DC motors are used to provide power to rotate the wheel of the surveillance robot. Battery charge detector is used to detect the real-time charging status of the battery. In the normal working status, when detecting that the battery voltage is lower than the preset charging voltage, the core board will command the robot to return to the docking station for recharging. In the charging status, when detecting that the battery voltage is higher than the preset working voltage, the core board will command the robot to start to work again. The robot depends on two infrared sensors and two incremental encoders to perform obstacle avoidance, autonomous navigation and other locomotion tasks.

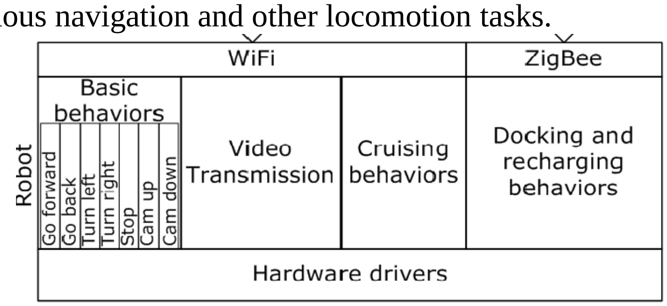

Fig. 3. Software design of the surveillance robot.

The software design of the surveillance robot is shown in Fig.3. The embedded program in the robot can implement basic locomotion behaviors and other high-level behaviors such as video transmission, cruising, docking and battery replacement. The robot communicates with the docking station through ZigBee and serves as a mobile wireless sensor network gateway. Matlab process is used to find the position of the docking section, to replace the battery of the surveillance robot.

2. The Docking Section

The hardware components of the docking section include a charging module, a current detection module, a wireless communication module and two IR sensors, and two DC servo motor. The current detection module uses comparator to compare the input voltages to determine the presence or absence of charging current. The DC servo motors are used to replace the battery of the surveillance robot. The wireless communication module exchanges data with the surveillance robot through the ZigBee network. The IR sensors are used for precise docking when the robot is in the docking area.

The outline of the docking area is shown in Fig. 4 . Each side of the docking station has an IR sensor to detect obstacles ahead. According to the outputs of the IR sensors, the relative position between the robot and the docking station can be determined. Therefore the robot will connect to the docking station automatically. During the docking process, the IR sensors on the robot will temporarily stop working to avoid interfering with the IR sensors on the docking station.

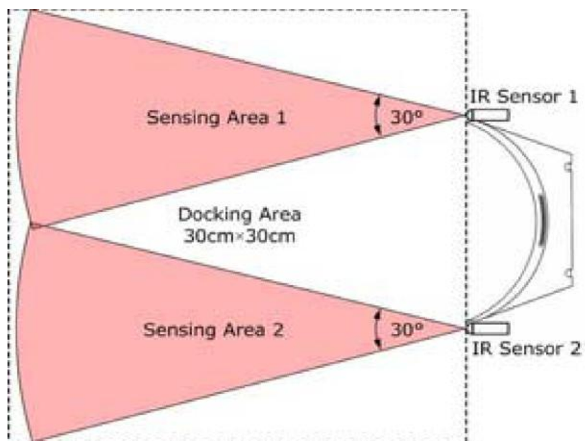

Fig. 4. Outline of the Docking area.

III DOCKING PERFORMANCE

This section deals with docking performance of the surveillance robot. The robot first runs its wireless senor network gateway and initiates a ZigBee network. It waits for the wireless end node of the docking station to join the network. Once the end node joins the network, the gateway sends the docking-start command. Then the end node will send back the IR sensor data of the docking station. The robot chooses its next-step actions according to the received IR sensor data types. If neither of the IR sensors detects the robot, it means that the robot fails to reach the docking area at the end of the navigation process. If the robot fails to find the docking station after two searching steps, it means that the cumulative localization error in the navigation process is too big. The robot must stop the automatic searching actions at once and send requests to the human operator for assistance.

IV CONCLUSION

A wireless sensor network gateway system for automatic battery replacement of home surveillance robot has been presented. A docking method based on the self-localization of the robot and the infrared detectors of the docking section has been proposed.

The robot can navigate back to the docking station for replacement of battery when the on-board battery is too low. Future work will focus on improving the current prototype robot to enable more functions.

REFERENCES

[1] C. D. Nugent, D. D. Finlay, P. Fiorini, Y. Tsumaki and E. Prassler, “Home automation as a means of independent living,” *IEEE Trans. utom. Sci. Eng.*, Vol. 5, No. 1, pp. 1-8, Jan 2008.

[2] Yoo Oh, Jae Yoon, Ji Park, Mina Kim and Hong Kim, “A name recognition based call-and-come service for home robots”, *IEEE Trans Consum Electron*, Vol. 54, No. 2, pp. 247-253, 2008.

[3] G. Song, Z. Wei, W. Zhang and A. Song, “A hybrid sensor network system for home monitoring applications”, *IEEE Trans Consum Electron*, Vol. 53, No. 4, pp. 1434-1439, 2007.

[4] G. Song, Y. Zhou, Z. Wei and A. Song, “A smart node architecture for adding mobility to wireless sensor networks,” *Sens Actuators A Phys*, vol. 147, no. 1, pp. 216–221, 2008.

[5] G. Song, K. Yin, Y. Zhou and X. Cheng, “A Surveillance Robot with Hopping Capabilities for Home Security,” IEEE Trans Consum Electron, Vol. 55, No. 4, pp. 2034-2039, 2009.

[6] W. Lao, J. Han and Peter H.N. de With, “Automatic video-based human motion analyzer for consumer surveillance system”, *IEEE Trans Consum Electron*, Vol. 55, No. 2, pp. 591-598, 2009.

[7] Y. W. Bai, L. S. Shen and Z. H. Li, “Design and implementation of an embedded home surveillance system by use of multiple ultrasonic sensors”, *IEEE Trans Consum Electron*, Vol. 56, No. 1, pp. 119-124, 2010.

[8] G. Song, K. Yin, Y. Zhou and X. Cheng, “A Surveillance Robot with Hopping Capabilities for Home Security,” IEEE Transactions Consumer Electron, Vol. 55, No. 4,pp. 2034-2039, 2009.

[9] I.K. Hwang and J.W. Baek, “Wireless access monitoring and control system based on digital door lock”, *IEEE Trans Consum Electron*, Vol. 53, No. 4, pp.1724-1730, 2007.

[10] M.Meena, P.Thilagavathi , “Automatic Docking System with Recharging and Battery Replacement for Surveillance robot” International Journal of Electronics and Computer Science Engineering, IJECSE,Volume1,Number 3.

[11]Radu Dobrescu, Dan Popescu, Maximilian Nicolae, and Stefan Mocanu “Hybird wireless sensor network for homecare monitoring of chronic patients” International Journal of Biology and Biomedical Engineering, Issue 2, Volume 3, 2009.