A study on wireless recharging and wi-fi controlled domestic surveillance robot with automatic docking

S Bairavi, T Banu
Nehru Institute of Technology, Kaliyapuram,
Coimbatore 6411 05, Tamilnadu, India
***Correspondent Email: kambar99@gmail.com**

Abstract: A surveillance robot with automatic docking and recharging consists of two sections i.e., warfield section and the control room section, while the latter section consists of Passive IR motion detectors which are typically designed to send a signal to an alarm panel when they detect IR that indicates the object is moving. When the breach indication is received, the alarm panel responds by triggering an alarm condition. PIR motion detectors are normally used in conjunction with different parts of the war field when a person or motor vehicle enters a monitored area. When someone enters a secured area, it immediately sends a signal to the control room section via wireless communication and an alarm signal to the control room. At the same time, the camera continues to capture images at the host location, which are saved to the computer. When the on-board battery runs out, the robot can return to the docking station for recharging. The docking station includes a wireless power transmission induction unit.

Keywords: Docking station, PIR sensors, Induction unit, Warfield section, and control room section.

I. INTRODUCTION

With the rapid development of microelectronics and Wireless communication technologies, mobile robots are being widely used in various fields. In recent years, as the size and the cost of mobile robots have decreased significantly, they are finding increasing uses inhome environments. One of the major application is surveillance. Using the robots for surveillance have lots of benefits, it will increase the security and even more accuracy during dark too. In traditional home security systems, monitoring devices are usually mounted on fixed locations such as doors, windows and walls. A home surveillance system based on an embedded system with multiple ultrasonic sensor modules has been presented in [1]. If any intruder passes through the ultrasonic sensing area, the ultrasonic transmission will be blocked by the human body and made the user alert, by giving the alarm sound. The authors use a Majority Voting Mechanism (MVM) to process the output signals from multiple ultrasonic receivers. An automatic video-based human motion analyzer for consumer surveillance system has been proposed in [2]. Although most of the sensor networked 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 cannot be covered by the sensors. In view of these drawbacks, a more flexible and more efficient solution for home security is to deploy a mobile robot equipped with surveillance devices such as pyroelectric infrared sensors and cameras. The development of a mobile robot system for home security with some interaction functionalities has been presented in [3]. In mobile robot for home security have lots of merits even though it is having some demerits. One the demerit is battery, mobile robots are driven by the DC motors hence its consume more for patrolling process. Hence robots are designed to autonomously recharging its battery when it was low. There have been some successful attempts in implementing the docking capability on autonomous mobile robots. The first work on robot recharging has been done by W. Grey Walter [4]. He developed two mobile robots, Elsie and Elmer, which used light to find their way to a hutch where their power supplies were installed. More recently, Hada and Yuta presented a battery recharging system for long term activity of autonomous mobile robots [5]. This paper presents the design and implementation of Wi-Fi controlled home

surveillance robot with automatic docking and recharging capabilities. The proposed system is composed of a surveillance robot and a docking station. The surveillance robot is triangular structure. The wheel-based mobile robot with a USB camera is specifically designed for home security usage. It communicates with the general wireless home router through Wi-Fi. It communicates with the docking station through ZigBee and serves as a mobile wireless sensor network gateway. The docking station has a trapezoidal structure with an arc-shaped docking interface. The robot can return to the docking station for recharging operations when the on-board battery is too low. Docking station having wireless recharging hub, the transmission unit is connected to the induction coil and it will transfer the power form line to the coil. The robot having coil which is called as receiver coil, this will help to receive the power form the transmission unit. This both transmission unit and receiver units are coupled magnetically and the technology used to transfer power is Magnetic resonance coupled WPT (wireless power transmission).[6].

II. SYSTEM DESIGN

The home security robot will work in three mode of operation, they are remote control mode, patrolling mode and first response mode. In the remote control mode robot will be controlled by remotely through pc which is already connected with the home Wi-Fi network. In patrolling mode the robot will moves in pre-defined path autonomously. When security related information is acquired, it will be sent to home server for further analysis. In the first response mode the robot is connected with the other sensing device which is placed in the host area, when the device reports a security event to the pc and the surveillance robot will navigate to the target region to perform onsite inspection and also capturing the image using USB camera.

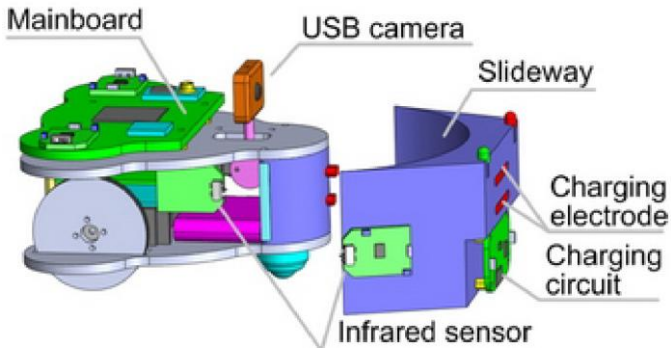

Fig. 1. HARDWARE ARCHITECTURE OF THE SURVEILLANCE ROBOT

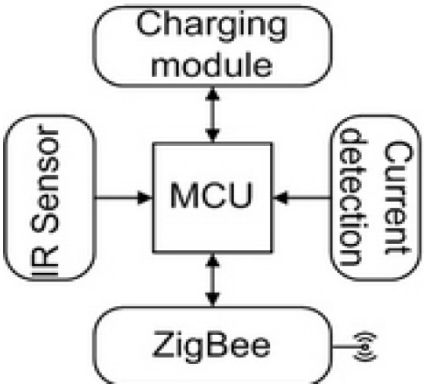

Fig. 2. HARDWARE COMPONENTS OF THE DOCKING STATION.

A. Surveillance Robot

The hardware architecture of the surveillance robot is shown in Fig.1. The robot having two DC motors which is connected to the rear wheels to derive the robot. The servo motors are used to tilting the camera for a wide field of view. The circular shaped coil is equipped in robot which is called as power receiver unit and robot gets power from the receiver unit and charges its batteries. The voltage detection module is mainly used for real-time detection of onboard battery status. The core will command the robot to return to the docking station when onboard battery is lower than the present working voltage. In similar when onboard battery is higher than the present working voltage core board will command the robot to start to work again. The surveillance robot having two sets of communication systems they are home Wi-Fi network and the ZigBee network. The basic command like controlling the

robot remotely through PC and video transmission are using the home Wi-Fi network. The docking and recharging behaviors are using ZigBee network.

B. The Docking Station

The docking station include a charging module, a current detection module, a wireless communication module and two IR sensors, as shown in Fig.2. The current detection module uses a comparator to compare the input voltage to determine the presence or absence of charging current. The wireless communication module exchanges data with surveillance robot through ZigBee network. The two IR sensors are used to precise docking of the robot when the robot entered into the docking area. 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. 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. The docking station having the induction unit is connect to the circular shaped transmission coil. The induction unit induce power from the power transmission line by a special current transformer, it belongs to charging dock fixed in magnetic field of the transmission line and outputs induction power for transmit unit. Transmitter unit and receiver unit could be conceived as LC resonance tanks and they transmit power wirelessly when they are tuned to oscillate at the same frequency. Then robot gets power from the receiver unit and charges its batteries.

III. SIMULATION RESULTS

In this simulation have done the remote control mode of operation of surveillance robot as shown in Fig.3. The IR sensors are used to avoid the obstacles while we are controlling the robot. And the USB camera can capturing images continuously and transmits to PC via home Wi-Fi network. The onboard battery level is spontaneously checked with the current detection module.The robot can be controlled by robot dash board which is having the analog control stick which is showed in Fig.4(A). While controlling the robot if there any obstacle detected the robot can pass through it without collide. Those functions can be done by set of Infra-Red sensors in the robot showed in Fig.4(B).

Fig. 3. SIMULATED OUTPUT WITH SURVEILLANCE ROBOT.

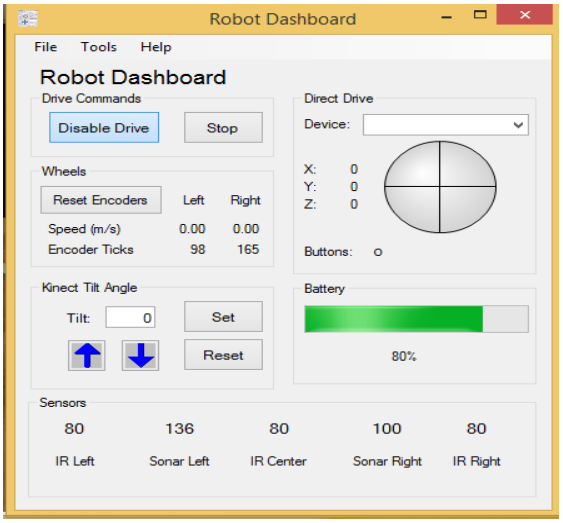

Fig. 4(A) REMOTE CONTROL PANEL

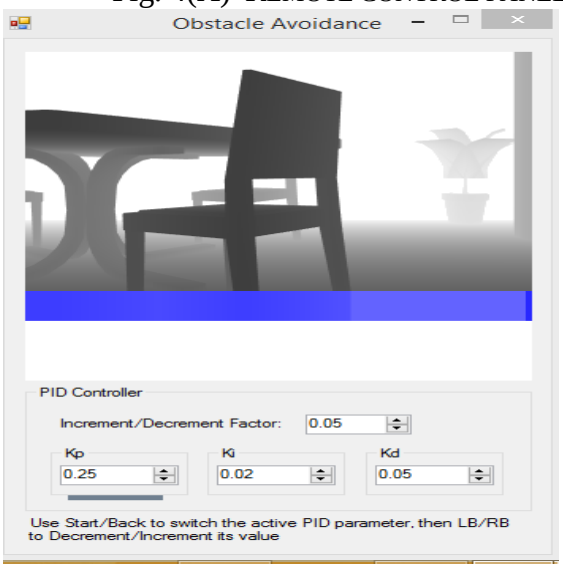

Fig. 4(B). OBSTACLE AVOIDANCE.

IV. FUTURE STUDY

In the future, the surveillance robot will also be simulated in other two mode of operations. Which is first response mode and the patrolling mode. The first response mode sensors are connected in a network and ZigBee gives the sensors network gateway. Then patrolling mode is the one which is robot will keep on moves in a pre-defined path.

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