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A Review of Wireless Technology Usage for Mobile Robot Controller

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Abstract. This paper presents a comparative study of different wireless technology usage for mobile robot controller such as Bluetooth, WiFi or Wireless LAN and 3G. In literature review, particularly discuss the flow of the application and transferring data or information to the mobile robot. Comparison of the frequency, data rate and range for each wireless technology used in this application are discussed. The advantage and disadvantage of each wireless technology are analyzed. At the end, selection of wireless technologies depends on the type of application to be developed considering the following; range, frequency and data rate.

Keywords: Wi-Fi, WLAN, Bluetooth, 3G, Mobile Robot Controller.

1. Introduction

In recent years, wireless technology has given rise to a large number of available mobile tools and their emerging applications are becoming more and more sophisticated by years. Therefore, many mobile robot platforms use wireless technology to communicate with off-line computing resources, human machine interfaces or others robots. Many mobile robots have equipped with wireless technology such as Bluetooth, Wi-Fi, Wireless LAN etc.

Numerous robotics institutes and universities are focusing on intelligent mobile robot systems [1-8]. Revolutionary new technology involving mobile robots in Mechanical Engineering, Electronic Engineering, Information Engineering, Automation Engineering and Artificial Intelligence, etc. Mobile robot is presented with a situation or a different form depending on the area of application usage. This robot can drive, walk, swim or fly. An appropriate sensor is required to design a mobile robot and know how to control it. Therefore, various mechanisms used to control this mobile robot. With the advancement of wireless communication technology in mobile robots, there is a great possibility that we shall have a cell-phone controlled the robot maid, wheel chair or an autonomous robot car as in [9]. Regardless of the method used either by using technology 1G, 2G or 3G owned by mobile device.

This paper is organized as follows. The literature review of wireless technology and briefly explain that the technologies used for mobile robot presented in Section 2. We include the review of recent researches. In Section 3, we discuss advantages and disadvantages for each wireless technology. We summarize the paper in Section 4.

2. Literature Review

2.1 Bluetooth

Most wireless technologies such as Bluetooth and IrDA standard provide the ability to strengthen the local wireless network. Bluetooth technology was created by Ericsson in 1994 and is used to replace the cables in the office, in laboratories or at home as in [11]. Bluetooth is a radio frequency cable with a short

distance to replace the unlicensed technology with 2.4GHz bandwidth in the scientific industry. Typically, Bluetooth devices have a range of approximately 10 meters and it can support both voice and data communications with broadband 1 MB per second as in [12]. Because of the advantages of Bluetooth, such as low costs and low power and nature can be pointed to different directions, parts of Bluetooth has been integrated into various types of mobile devices such as mobile phones, PDAs and other wireless set. Research from In-Stat / MDR and Frost & Sullivan has estimated the use of Bluetooth will be sold around 200 million units in 2001 and will increase to one billion in 2006. Therefore, currently the usage of Bluetooth technology was developed for mobile robot controller. With Bluetooth, mobile robots then can be easily handled with a push of button from our common electronics gadgets such as hand phones or PDA. Fig. 1 shows the architecture for a Bluetooth enabled autonomous mobile robot as in [9].

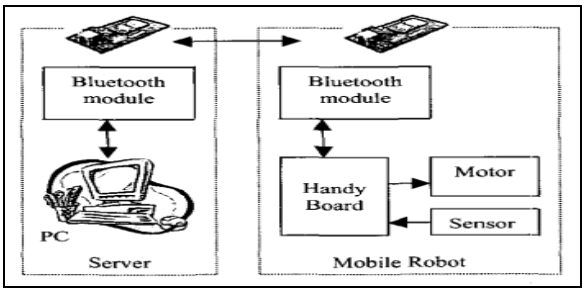

Figure 1 Hardware Architecture [9].

In this project, a Bluetooth device in the server connected to the serial port of the PC. Then, for the mobile robot, a Bluetooth device is connected to the RS232 of the Handy Board. During the navigation of the mobile robot, all the sensor readings can be viewed from server (PC). At the same time, PC can send direction command to the mobile robot.

2.2 Wi-Fi or Wireless LAN

Wi-Fi or WLAN (Wireless Local Area Networks) is a wireless network based on a series of specifications from the Institute of Electrical and Electronics Engineers (IEEE) called 802.11. Wi-Fi uses unlicensed radio frequency, mostly in the 2.4GHz band. It enables a person with a wireless-enabled computer or PDA to connect to the Internet via a wireless access point. The geographical region covered by one or several access points is called a hot spot. Wi-Fi was intended to be used for mobile devices and local-area networks, but it is now often used for Internet access outdoors. There are several types of Wi-Fi:

- 802.11a (offering transmission speeds of 24mbps to 54mbps)
- 802.11b (6mbps to 11mbps) and 802.11g (24mbps to 54 mbps)
- 802.11n (50mbps to 100mbps) is a proposed specification that will become a Wi-Fi standard once it's finalized by the IEEE, and the Wi-Fi Alliance completes its interoperability testing.

WLAN has changed the interaction manner through wire line between operators and robots in the past. The work area of robots has not been influenced by the availability of lineate pavement anymore.

Reference [13] has shown a development of robot communication system. In this development, antenna used to operate in the control link of a mobile robot. The link will carry control signals for the robot movements and image frames taken from an infrared camera mounted in the robot. The link is set by means of commercial WiFi boards, an Access Point placed on the robot and another PCI board inserted on the desktop computer. Mobile robot moved according to the commands sent through the wireless channel by a desktop computer. Characteristic Wi-Fi systems used in this development are wideband is around 100MHz, with a center frequency of 2.45GHz, for the IEEE802.11b and IEEE802.11g. Fig. 2 shows the schematic of the mobile robot and the control office

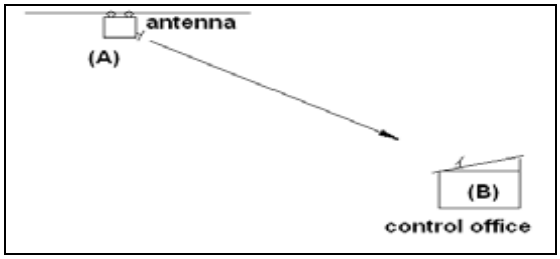

Figure 2 Schematic of the mobile robot and the control office[13]

Other wireless technology usage is developed teleoperation robots repairing the leaky chemical container as in [14]. This project used WLAN for transmitting every movement of the virtual robot to the real robot. This WLAN responsible for transmitting operators' commands, the position information of the robot and the leak, remote video from the real robot, and so on. On the spot, control center is far from the real robot, and several buildings are among them. Through using a high gain antenna and an amplifier communication distance of WLAN can extend to over 30km. Fig. 3 shows the WLAN of Bridge Connection Pattern used in this project.

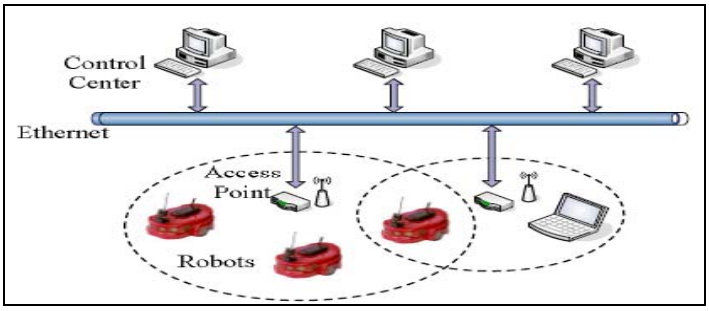

Figure 3 Bridge Connection Pattern WLAN[14]

2.3 3G

Third Generation (3G) mobile devices and services will transform wireless communications into on-line, real-time connectivity. 3G wireless technologies will allow an individual to have immediate access to location-specific services that offer information on demand. The concept of 3G wireless technologies represents a shift from voice-centric services to multimedia-oriented (voice, data, video, fax) services.

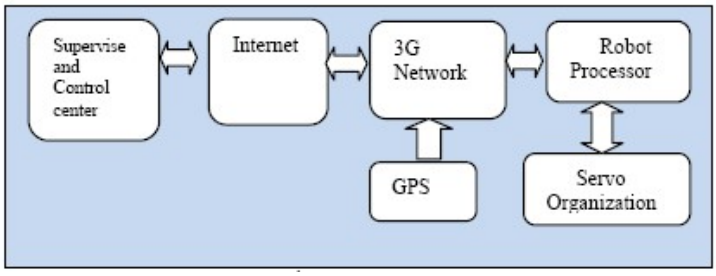

Figure 4 System Structures [15]

Reference [15] have proposed remote control system based on 3G technology and GPS (Global Positioning System) for rescue robots. The system modules contain the terminal, the monitor system and network for data transfer. It includes the correspondence technique, GIS (Geography Information System) technique, data processing technique, 3G technique; satellite fixed position, the robot control technique and a Streaming media application technique. Fig. 4 shows the structure of the system.
The workflow of processor is

i) The processor passes the plank of GPS OEM to deal with the GPS satellite signal and get the position current and some other information, such as the speed and the direction etc., and hand over ARM to process. Then send back the Monitor center though the 3G correspondence.
ii) The processor accept Monitor center control orders, open the camera, implement to collect the video frequency information, after the data processing, send back the information to Monitor center though the 3G correspondence, implement the video frequency contact between the terminal and the backstage.
iii) The monitor center send out various control orders to the robot processor, the processor controls the servo organization after processing the information,
iv) finally, the robot takes the long range control orders, and complete various rescue missions

Other examples as in [16] are developed and present the performance analysis of an end-to-end mObile Tele-Echography using an ultra-Light rObot (OTELO), over the third-generation (3G) mobile communications network. Fig. 5 shows the OTELO Mobile Robotic System. In this system, various network protocols are used mainly for sending streaming data. The transport protocol family for media streaming includes User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Real-Time Protocol (RTP), and Real-Time Transport Control Protocol (RTCP). Since TCP retransmission introduces delays that are not

acceptable for real-time streaming applications with stringent delay requirements, especially for transmission over fading wireless links, UDP is typically employed as the transport protocol for video streams over such fading channels. RTP is an Internet standard protocol designed to provide end-to-end transport functions for supporting real-time applications. RTCP is a companion control protocol with RTP and is designed to provide QoS feedback to the participants of an RTP session; therefore, the RTP/UDP/IP protocol is applied in our work. The UDP/IP protocol is used for the robot data that is transmitted in both directions.

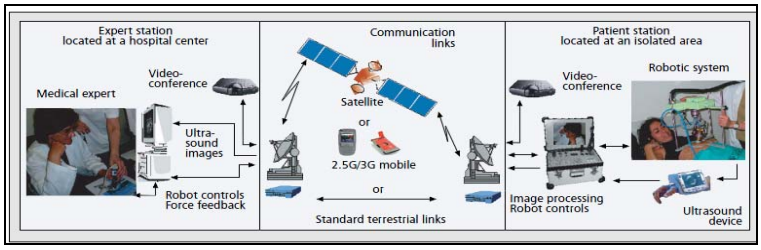

Figure 5 OTELO Mobile Robotic Systems[16]

3. Discussion

Although there are many wireless technologies that are used to control the mobile robot, but each technology have the advantages and disadvantages. For Bluetooth, mobile robots can be easily handled with a push button from any electronic gadget such as mobile phone and can used to control many other Bluetooth enabled devices such as printers, personal computer etc. This scenario makes the mobile robot useful and marketable for real time applications. Besides, the cost of implementation on small scale is relatively cheap. But developer for this application face a bound rate problem which is both micro controller and Bluetooth devices are running at different bound rate. Vice versa with Bluetooth, Wi-Fi uses of existing IEEE 802.11 infrastructure. So this is one of the advantages in reducing cost. However, a reduced performance is noticed in multi-floor and dense indoor environments because signal reflections and dynamic network conditions can result in undependable signal readings. In indoor communications, the path loss is also dependent upon the size and the geometry of the room, materials used, and the distance from transmitter.

Meanwhile, 3G is used for long range supervises and control of mobile robot. This generation combines wireless communication and multimedia technology. In addition, 3G have high speed transmission, fast connection, the expenses is cheap etc.. The 3G module effectively solved the bottleneck problem that the control and the transmission in rescue robot adoption with wired or wireless. Make the great deal of data deliver possible and make the function of the rescue robot stronger. Table 1 summarizes the comparison between wireless technologies for mobile robot controller.

Fig. 6 shows the comparison of wireless technologies in detailed as in [17].

Table 1, Comparison wireless technologies

Types of Wireless Technology	**Range**	**Frequency Band(s)**	**Data Rate**
Bluetooth	33 feet	2.4Ghz	1.5Mbps
Wi-Fi IEEE802.11b IEEE802.11g	100-150 feet	2.4Ghz	11Mbps 54Mbps
3G CDMA	Global	800 Mhz – 1900 Mhz	2Mbps

4. Conclusion

This has been a brief review of several wireless technology usages that might be used to control mobile robots. It is important to compare this technology and the bandwidth, frequency, data rate to transfer data among the devices for better development for mobile robot controller. All we need to do is to focus on how to bring the different characteristics of all the wireless technologies together in one portable application. Selection of wireless technologies depends on the type of application to be developed considering the following; range, frequency and data rate.

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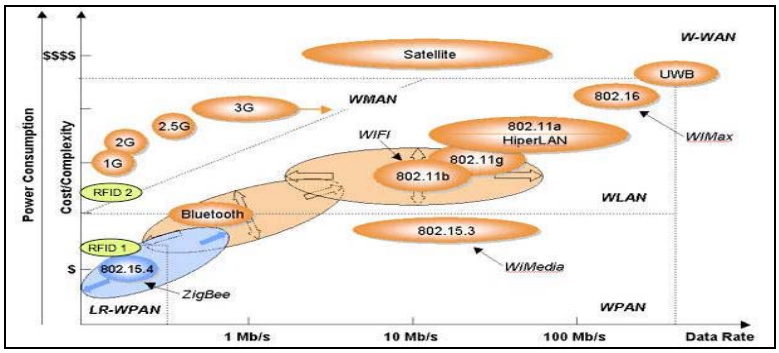

Fig. 6 Comparisons of Wireless Technologies

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