Control of mobile robot system with wireless transmission of image information.

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Abstract: There are various researches on mobile robot systems. Connection method between server and client of mobile robot system is one of them. In the case of mobile robot system, when connection method between server and client is wireless than wire, applications may be expanded. Also in remote monitoring environment using mobile robot system, we are interested in an effective transmission of the image information between server and client.

In this paper, Bluetooth is used for connection method between server and client. One of the major applications of Bluetooth is the cable replacement for mobile and peripheral devices. Using Bluetooth, we propose the control method of mobile robot system. Bluetooth offers fast and reliable transmissions of both voice and data over the globally available 2.4GHz ISM (Industrial, Scientific and Medical) band. It has the advantage of small size, low power and low cost. It has the disadvantage of limited range and limited bandwidth. Also in order to transfer effectively image information between remote site(server) and mobile robot system(client) using Bluetooth, we applied to MPEG-2 and MPEG-4 image compression techniques and the results are compared with each other.

Keywords : Mobile Robot System, Bluetooth, Wireless Transmission, MPEG

1. INTRODUCTION

Bluetooth, WLAN(Wireless LAN), HomeRF(Home Radio Frequency), IrDA(Infrared Data Association) and UWB(Ultra Wideband) are generally used for a short-range wireless data communication. Bluetooth is an emerging wireless technology for voice and data transmission within 2.4GHz ISM band. Also Bluetooth provides a short-range ad hoc connection.

Bluetooth consists of one master and one more slaves up to 7. This is called piconet. The devices within a piconet play two roles : that of master or slave. The master is the device within a piconet whose clock and hopping sequence are used to synchronize all other devices (i.e., slaves) in a piconet. The slaves are the devices within a piconet that are synchronized to the master via its clock and hopping sequence.

Two types of links have been defined for the Bluetooth specification in support of voice and data applications. : An Asynchronous Connectionless (ACL) link and a Synchronous Connection-Oriented (SCO) link[5]. ACL links provide data traffic on a best-effort basis. The information carried can be user data or control data. ACL links provide asynchronous and isochronous services. SCO links provide real-time voice and multimedia traffic using reserved bandwidth. Both voice and data are carried in the form of packets and the Bluetooth specification can support ACL and SCO links at the same time. ACL links provide packet switching communication and SCO links provide circuit switching communication with all slaves participated in a piconet. Bluetooth provides an ACL link and one more SCO links up to 3. Bluetooth provides both point-to-point connection and point-to-multipoint connection.

Bluetooth uses TDD(Time Division Duplexing) and FHSS(Frequency Hopping Spread Spectrum). Bluetooth works each spread-spectrum device hops 1,600 times a second among 79 frequencies. Bluetooth uses frequency hopping for low interference and fading.

A compressed image information is transferred by using ACL link and voice information is transferred by using SCO link. In order to transfer effectively image information using Bluetooth, we use MPEG-2 and MPEG-4 image compression techniques. MPEG-2 technique includes compression of image information, encoding and decoding. MPEG-4 technique includes very high compression rates. Image and voice information is transferred to server from client. They are displayed in each application programs.

An overall system is composed of both server and client. Server system is composed for user. Client system is composed to control mobile robot and image information of camera adhered to mobile robot. Control packet can be setup velocity, turning angle and moving distance in order to control of mobile robot. Control packets are of several bytes size and can control kinds of 8 devices.

Using Bluetooth, we have performed experiments on data transmission rates between a master and a slave. We have performed experiments on mobile robot system in order to control in remote environments using image information of camera adhered to mobile robot. Also we have transferred decompressed images and compressed images by using MPEG-2 and MPEG-4 image compression techniques from client to server using Bluetooth.

In this paper, in order to control mobile robot system, we define control packets. Also it is shown that the mobile robot system is controlled by wireless using image information of camera adhered to mobile robot of client in remote environments. Using Bluetooth, we have performed experiments on data transmission rates and image transmission rates between server and client.

This paper is organized as follows. Section 2 introduces general system organization. Section 3 introduces MPEG-2 and MPEG-4. Section 4 presents control packet construction. Section 5 presents our experiments and results. Finally, Section 6 concludes this paper.

2. GENERAL SYSTEM ORGANIZATION

2.1 Wireless Data Communication Module

Figure 1 shows wireless data communication module is used for Bluetooth module of CSR (class 2).

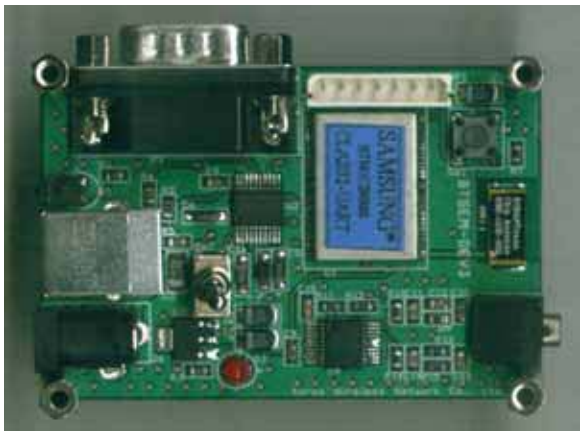


Fig. 1 Bluetooth Module (class 2).

Generally transmission distance of class 2 is about 10m. Maximum data rate is known to be 1Mbps[5]. But actual experiment result presents about 100m[6].

Figure 2 shows standard packet format for Bluetooth.

Fig. 2 Standard Packet Format for Bluetooth.

Bluetooth packet is composed of access code, header, payload. Access code is used for synchronization, DC offset compensation, partition of packets. Header includes low level link control information. Payload is used to transfer user data and control data. It has variable length of maximum 2745 bits.

Serial communication between mobile robot and Note PC is about 9.6Kbps. This is enough to transfer control packet to control the mobile robot. Image information of camera adhered to the mobile robot can be transferred by serial communication between camera and Note PC.

2.2 Mobile Robot System

Figure 3 shows the mobile robot used for experiment. This contains encoder and minimum control distance is 0.001m. Also, maximum velocity is 1m/s.

Fig. 3 Mobile Robot.

2.3 General System Organization

System accomplished by both server and client consists of server for user and client in order to control mobile robot and visual information of camera. Figure 4 shows organization of general system.

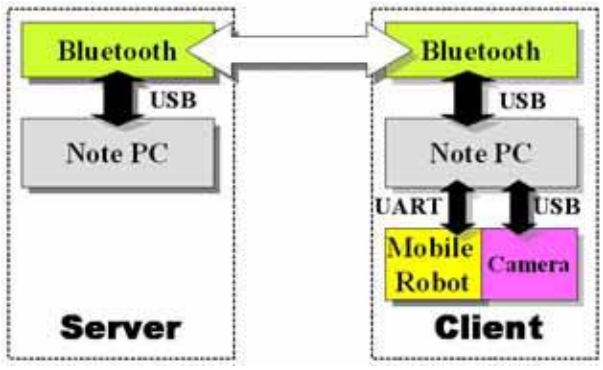
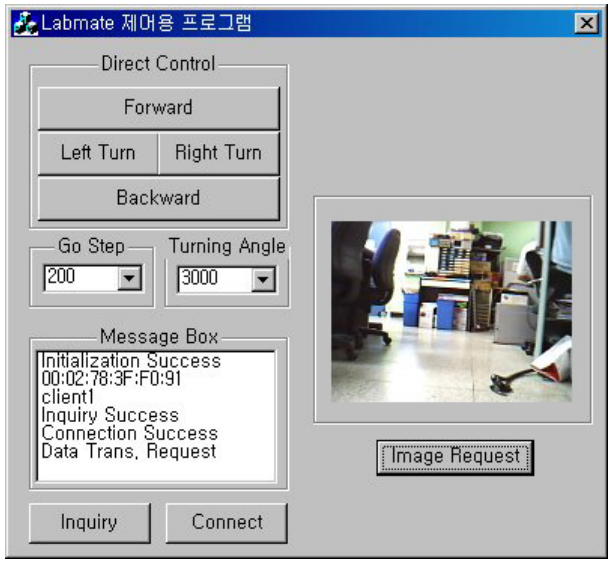


Fig. 4 System Organization.

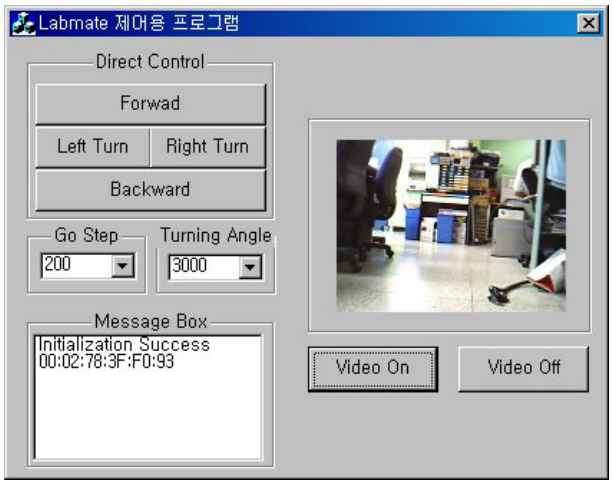
As shown Figure 4, ACL(Asynchronous Connectionless) link is connection between server and client. Communication between Bluetooth and User, between Bluetooth and mobile robot accomplishes using the special User Interface like Figure 5.

The velocity and turning angle of mobile robot is controlled by the user interface. User interface of server is implemented Initialize, Inquiry, Connection Process, Image information display of camera transferred from client for use Bluetooth. User interface can be setup velocity, turning angle and moving distance. Also, it can be transfer command for movement to client.

User interface of client is similar to server. Image information of camera displays it in real time. Also, on/off of camera is controlled by the user interface of client.



(a) User Interface of Server.



(b) User Interface of Client.
Fig. 5 User Interface.

3. IMAGE COMPRESSION TECHNIQUES

In this paper, in order to implement image transmission of wireless communication, we transfer image signal from MPEG Encoder using Bluetooth. Received image signal to server decodes to original image signal thru MPEG Decoder.

Through this work, we implement transmission of image information using Bluetooth and show transmission rate of image information in experiments. Two types of experiments are performed. One uses decompressed image information and the other uses MPEG-2 and MPEG-4 image compression techniques. Then, the results are compared with each other. Image size is 160*120.

3.1 MPEG-2

MPEG-2 is standard to compress digital video and audio data. MPEG-2 is generally used for DVD and HDTV. Also, it includes Interoperability, Scalability, Extensibility.

3.2 MPEG-4

MPEG-4 could transfer image with very low bit rates by getting high compression rates within the limits of the possible. MPEG-4 is generally used for Videophone, Mobile and Internet. Also, it includes Low Bit Rates (2~64Kbps), Scaleable Coding, Error Resilience, Object Oriented[7].

3.3 Image Processing Organization

Figure 6 shows organization of general image processing. An overall image processing system is composed of server system and client system.

Client system compresses image information from camera and transfers to server system by using Bluetooth. Client system is composed of user interface, mobile robot, software and camera. User interface appreciates camera and provides stores and transmission of image. Software compresses image information from camera and transfers to use Bluetooth. Camera connects PC to USB and transfers image information to User Interface.

Server system decodes compressed image information transferred by client system and displays.

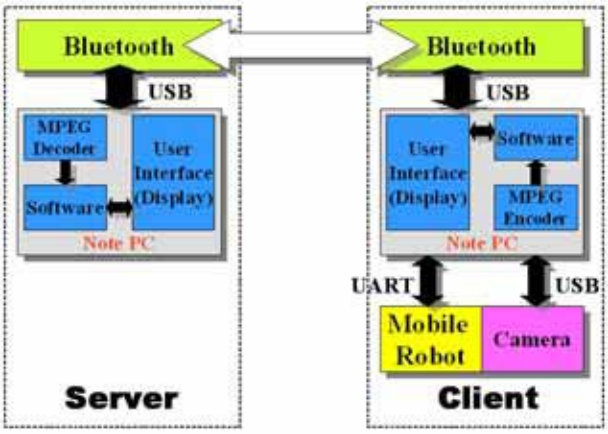


Fig. 6 Image Processing Organization.

4. CONTROL PACKET CONSTRUCTION

4.1 Control Packet

Control packet considering expansion is packet for control the mobile robot. Figure 7 shows construction of control packet.

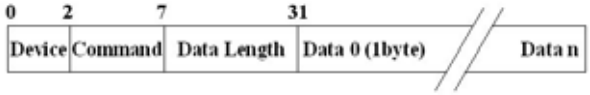


Fig. 7 Control Packet.

Control packet is several bytes size and can be controlled kinds of 8 devices. It can be sent kinds of 32 commands.

Table 1 shows the defined command used for experiment.

Table 1. Defined Command

Device	Command
Mobile Robot	0 – Reset
	1 – Go Forward
	2 – Go Backward
	3 – Turn Right
	4 – Turn Left
	5 – Emergency Stop

In this experiments, we define commands to control the mobile robot, that is, Forward, Backward, Left/Right Turning, Emergency Stop and Reset command.

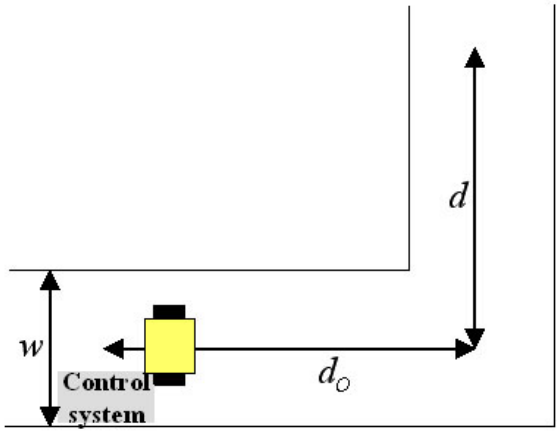
We define commands “GiveMeMessage” command from server to client and “CompleteMessage” command from client to server. Server sends control packet and “GiveMeMessage” command to client, then the client analyze control packet and accomplishes the work. After accomplished the work, client sends “CompleteMessage” command to server. Through this work, connection existence between server and client is confirmed.

5. EXPERIMENTAL RESULTS

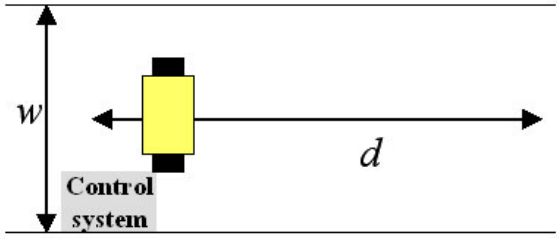
5.1 Data Transmission Rates

The above mentioned using Bluetooth, we perform an experiment on data transmission rates.

Figure 8 shows experiment environments.



(a) In case 1 : Corridor.



(a) In case 1 : Corridor.
Fig. 8 Experiment Environment.

Figure 9 shows results of data transmission rates. As shown Figure 9, average data transmission rate is about 452Kbps.

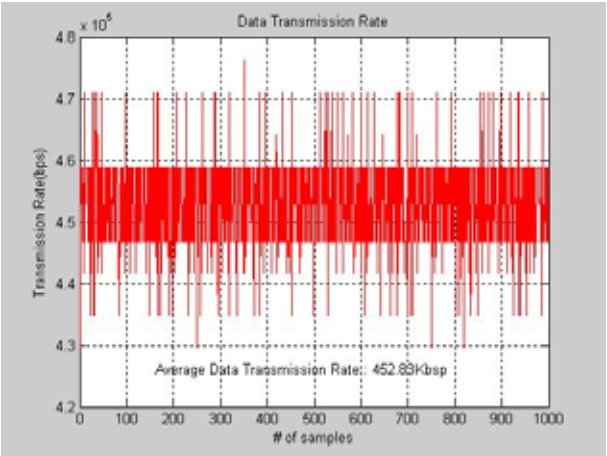


Fig. 9 Data Transmission Rates.

5.2 Image Transmission Rates

The above mentioned using Bluetooth, we perform an experiment on mobile robot system in order to control in remote environments using image information of camera adhered to mobile robot. The mobile robot is controlled by the server using image information sent by client. Also, we measured image transmission rates between server and client. Figure 10 shows image transmission rates. Image transmission rates are 0.5 frame/sec in the case of decompressed image, 2 frames/sec in the case of MPEG-2 and 6 frames/sec in the case of MPEG-4.

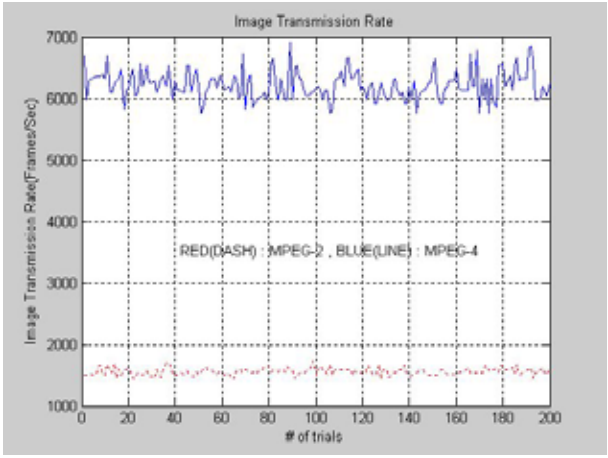


Fig. 10 Image Transmission Rates.

6. CONCLUSION

In this paper, in order to control mobile robot, we define control packet. Using Bluetooth, we measured data transmission rates between server and client. Also, it is shown that the mobile robot system may be control in remote environments with wireless using image information of camera adhered to mobile robot of client. In order to transfer effectively image information between remote site(server) and mobile robot system(client) using Bluetooth, we applied to MPEG-2 and MPEG-4 image compression techniques and the results are compared with each other. As shown the results, developed MPEG-4 technique for mobile and internet is more useful image transmission method of mobile robot system using Bluetooth.

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