Ubiquitous Spot Service for Robotic Environment

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Abstract: Recently, ubiquitous computing is a hot topic. And, ubiquitous computing brings big benefit for robotics. Distributed computers provide much information to robots. And, distributed sensors help the navigation and manipulation of robots based on the sensor network. Moreover, to distribute the actuators at the environment, environment becomes one of the robots as we call "Ubiquitous Robot", and physical services and informative services can be provided to the present robot that concentrates necessary functions for one body. Ubiquitous robot can provide some type of services that are not only space but also small area as we call "spot". In this paper, we propose ubiquitous spot service that is one of the services by ubiquitous robot. And, to realize proposed service, improved wireless sensor network node (UFAM) is introduced, and detail specification of the node is shown.

Keywords: Ubiquitous robot, Area sensing, Spot service, Wireless sensor network

1. INTRODUCTION

Recently, ubiquitous computing is one of the hot topics in the field of computer science, which allows humans to get information anywhere and anytime. However, ubiquitous computing is mainly focused on information service. The actual daily living environment requires not only information service but also physical service. To meet this end, we propose the "Ubiquitous Spot Service" that is flexible service for humans based on the specified spot of the robotic environment.

In the field of the robotics, there are many kinds of robots, but the objective of all these robots is to support humans physically. To do this, the robots should be programmed to have all information that is necessary to carry out the given mission. Actually, it is difficult to make this kind of robot. To cope with this problem, environmental support is very important.

In this sense, ubiquitous computing and intelligent robotics are good combination, because each field can assist each lacking point. Based on this discussion, we have proposed "Ubiquitous Robotics", which is the robotics combined to ubiquitous computing [1]. To realize the "Ubiquitous Robot", environment should provide the information and physical service to robots and humans. Moreover, this environment should become sensors for robots.

In the "Ubiquitous Robot", robot functions are distributed in human living environment. So, these robot functions must effectively collaborate to each other. To realize the collaboration of robot functions, communication and control functions are necessary.

The Ubiquitous Functions Activation Module (UFAM) that is a key device for Ubiquitous Robotics has been developed to meet these needs, because UFAM has wireless communication method and a few digital I/O port to control some devices. If we use UFAM, distributed robot functions can communicate each other of the robotic environment, and control sensors and actuators.

The robotic environment can provide several types of services. And, it is better for these services to change the service area. For example, when a person sits on a chair and watches a TV, environment detects the person's spot, and controls the sound direction of TV and light condition that is best for a person's spot. Moreover, this robotic environment can support a person at not only spot but also space. However, UFAM cannot support these flexible spot services. So, it is necessary to attach some functions for UFAM to realize the flexible area services in the robotic environment.

In this paper, UFAM is introduced as one of the key devices for "Ubiquitous Robotics". And, we propose the "Ubiquitous Spot Service" to realize the flexibility spot and space services in the robotic environment. To provide the spot service, the improvement version of UFAM is also introduced. Finally, an example case using UFAM is shown.

2. UBIQUITOUS ROBOT

In the ubiquitous computing environment, many computers and sensors are distributed to the environment. It is easy to get information at every time, everywhere based on the ubiquitous computing and the sensor network. These sensors and computers are very useful for robots, because information of environment is very important to control them. Robots have only actuated functions like manipulation and mobility using distributed computers and sensors. Robots are basically composed of sensors, actuators, and controllers. So, if we extend this concept for

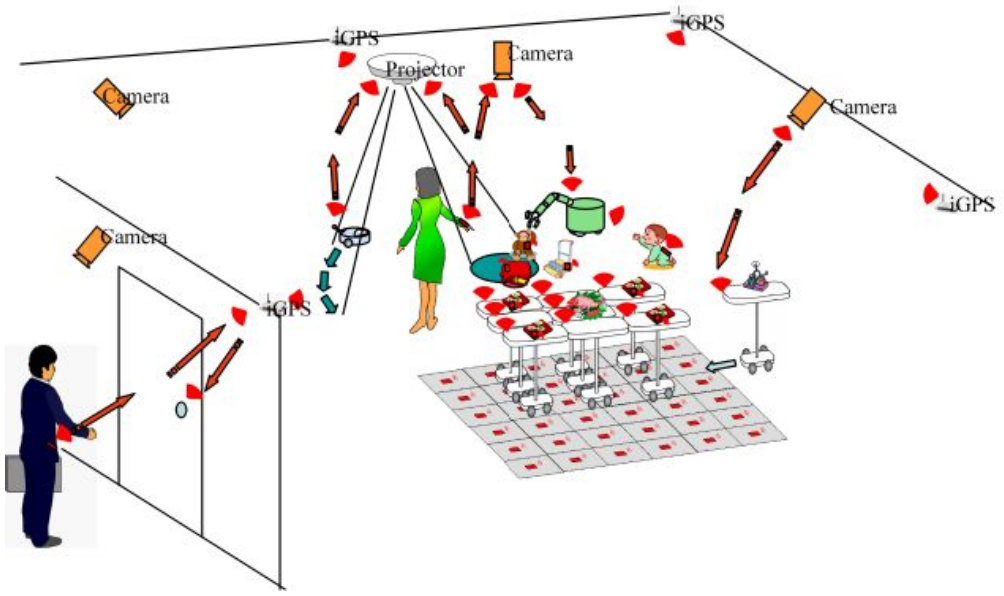

Fig.1 Concept Image of Ubiquitous Robots

physical environment which has sensors, actuators and controllers, we can define this environment as Ubiquitous Robot, which is shown in Fig. 1. Ubiquitous Robot can provide various functions, which are not only informative service but also physical service.

3. UBIQUITOUS SPOT SERVICE

3.1 Ubiquitous Functions Discovery Service

In the ubiquitous robot space, there are two types of users. One is the present robots that are concentrated with many sensors, actuators, and computers. The other one is human beings, who are living there. These users can be supported from the ubiquitous robot space. Users can control the ubiquitous robot functions to satisfy their objective. However, it is assumed that there are many robot functions. So, users have some trouble to control robot functions, because user must understand how to use these robot functions. It is very important things to use the ubiquitous robot functions.

It is better that abstract information, which is information of all robot functions in this space, is shown to the users. “Ubiquitous Functions Discovery Service” is proposed to realize this framework [2] [3]. In this service, user can get available service information from user’s space, and ubiquitous robot functions are basically invisible from users. So, users need not to consider the presence of ubiquitous robot functions.

The ubiquitous functions discovery service is consists of following three layer.

- Ubiquitous functions layer
- Management layer
- Knowledge database layer

The overview of the ubiquitous functions discovery service is shown in Fig.2. In this figure, ubiquitous functions layer is especially focused on. Each ubiquitous function attaches the ubiquitous functions activation module, which is described in next section.

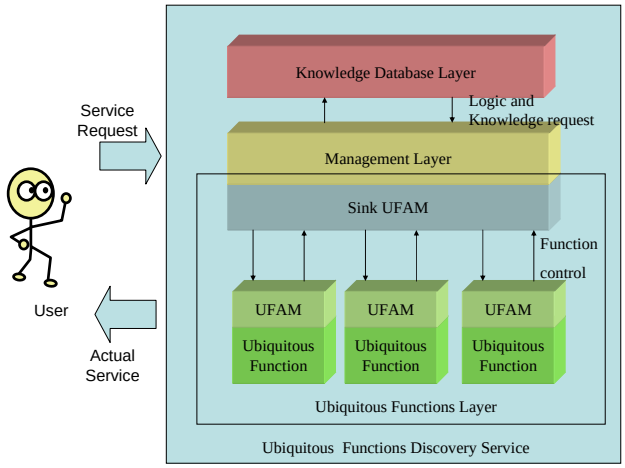

Fig. 2 Ubiquitous Functions Discovery Service

The ubiquitous functions discovery service is realized to the several methods. For example, ubiquitous functions activation module is supplied to services on the unit of a room. The size of service area is decided to the specification of the ubiquitous functions activation module.

In this paper, ubiquitous spot service is described. This service is focused on the spot oriented services. In the following subsection, ubiquitous spot service is proposed. And, new version of UFAM that is realized to this service is described to the next section.

3.2 Ubiquitous Spot Service

In this section, ubiquitous spot service is proposed. This service is focused on the spot oriented service.

In the office, when the user sits on his seat, user wants to obtain service information that can be supplied in the entire room but his seat. In the other case, when the robot stops in front of the door, robot want to get the information about door open. Such door open service is not space service but

spot service. To realize spot oriented service, ubiquitous spot service is necessary.

3.2.1 Related Works

RFID tag recognition system (ex. SUICA) is one of the examples. In the case of SUICA, RFID tag reader includes a ticket gate. And, users have a tag, which is included in the SUICA. To use this system, several spot services are proposed(ex. Cochira etc.). However, in the case of SUICA, communication distance is very short. So, when user wants to use this system, user must attach the SUICA to this reader.

CoBIT is realized to spot service in the ubiquitous robot space[4][5]. CoBIT can receive the voice information and power supply from LED or infrared camera. When the user wears this device, user can get the spot information of expected target. However, CoBIT can not directly control the ubiquitous functions. Moreover, CoBIT has directivity with the specification. So, when user comes from some direction that can not be supplied to the power energy, user can not received any services.

In the ubiquitous spot services, user can obtain the service information from any direction. So, wireless communication method is realized to non-directivity communication.

In this paper, ubiquitous functions activation module is proposed that is one of a key device to realize this service. In the next section, ubiquitous functions activation module is introduced.

4. UBIQUITOUS FUNCTIONS ACTIVATION MODULE (UFAM)

4.1 Introduction of UFAM

To realize the ubiquitous robot, communication method is important thing, because ubiquitous robot functions are distributed in the environment. There are two way of the communication method. One is the wired, the other is the wireless. However, wireless communication is better than wired communication, because of plug and play functions of new ubiquitous robot functions. For example, when user wants to add the sensor at the environment, ubiquitous robot can easily recognize one, and it is possible to use it immediately. To attach the wireless communication and processing method for ubiquitous function, we develop the “Ubiquitous Functions Activation Module (UFAM)” [1] as shown in Fig.3. Table.1 shows specification of UFAM. UFAM is superior to the general sensor network node [6]-[10] in the point of power consumption. For example, when UFAM communicates in five seconds, this module can act among a year. Moreover, UFAM has some digital I/O port. To use this port, UFAM can control the ubiquitous robot functions.

UFAM equips the helical antenna. Characteristic of this antenna is shown in Fig.4. Generally, helical antenna does not have directivity to the X-Y plane. In the case of UFAM, characteristic of the antenna is same.

UFAM can be communicated even by the distance of 10m or more. So, to apply the UFAM to ubiquitous robot, it is

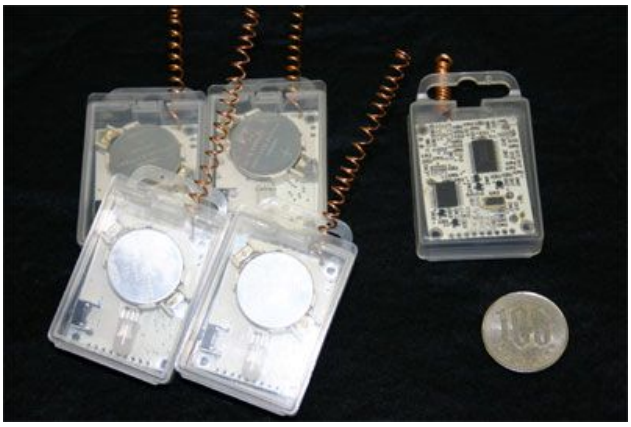

Fig.3 Ubiquitous functions activation module (UFAM)

Table.1 Specification of UFAM

CPU	PIC16F627A
CPU Clock	4MHz
Program memory	1Kbyte
Transmission/Reception IC	TA32305FN
Frequency Band	303.2MHz
Distance	About 10m
Baud rate	4800bps
I/O Device	Switch, LED (7color)
Free I/O port	I/O(4bit)
Battery	3V(Button Type)

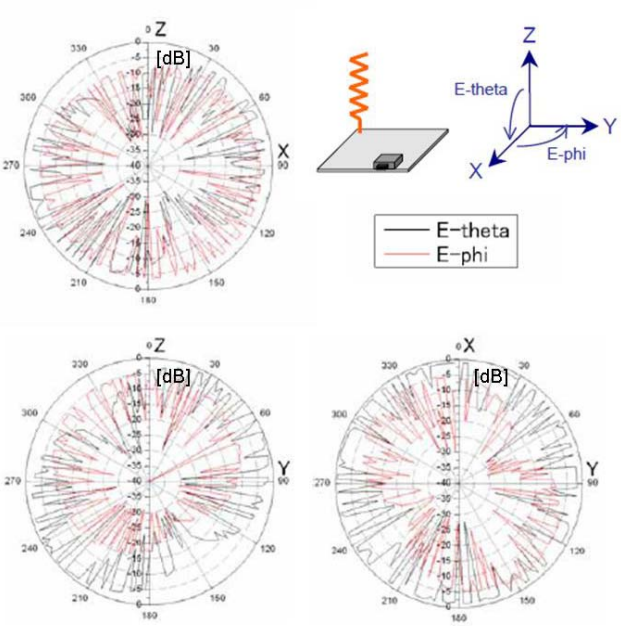

Fig. 4 Characteristics of the UFAM’s antenna

expected that users can get all function’s information in the space. So, this device is necessary to realize the ubiquitous functions discovery services. However, UFAM cannot control the communication distance. So, original UFAM can not apply the ubiquitous spot service.

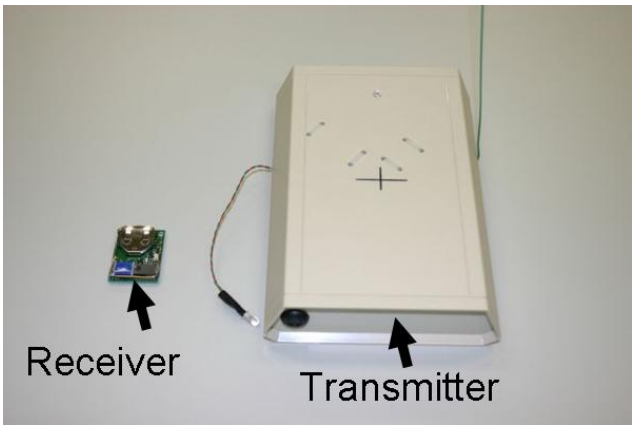

Fig. 5 UFAM version 2

Table. 2 Specification difference

	UFAM	UFAM2	
		Transmitter	Receiver
CPU	PIC16F627 A	PIC16F88	
Program memory	1K	4K	
Frequency	303.2MHz	303.2MHz	303.2MHz
		125kHz (Send only)	125kHz (Receive Only)
Communication Distance	about 10m	about 10m (303.2MHz)	
		about 2m (125kHz)	
Function	Degital I/O	Degital I/O RSSI Measurement	
Size	40*30*1	180*129.5*40	46.5*33*11

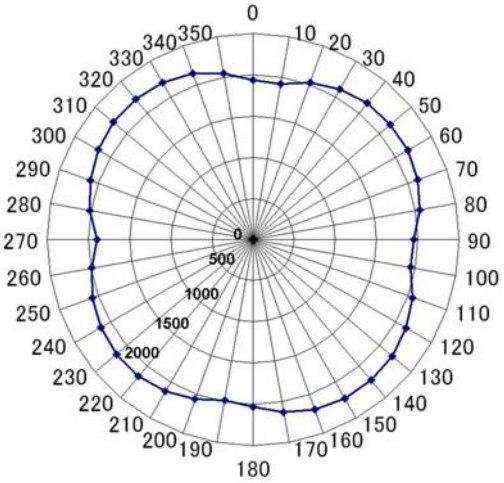

Fig. 6 Response distance between the transmitter and the receiver

4.2 Improvement of UFAM for ubiquitous spot service

In the ubiquitous spot service, approach detection method is very important. UFAM do not satisfy this method. To satisfy this method, UFAM is improved, which is called as UFAM Version 2 (UFAM2). UFAM2 is shown in Fig.5. UFAM2 is composed of two kinds of nodes. One is the receiver node as shown in left side on Fig.5. The other one is transmitter node as shown in right side on Fig.5. In the Tbl. 2, the changed part from original UFAM is shown.

Table.3 Statistics of measured data

Average Distance[mm]	2097
Standard Division[mm]	96
Maximum Distance[mm]	2253
Minimum Distance[mm]	1883

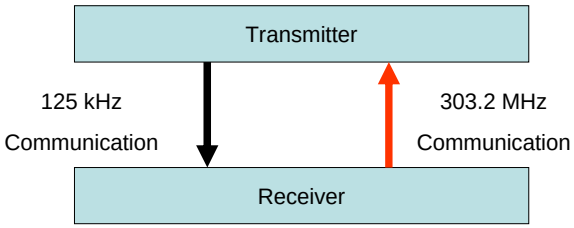

Fig. 7 Position detection between the transmitter and the receiver

Transmitter has two way communication methods. One is the radio wave of 303.2 MHz (HF) as same as original UFAM. This method can communicate more than 10m. The other one is electromagnetic induction that is used to passive type RFID tag like SUICA. In this communication method, UFAM2 use the radio wave of 125 kHz.(LF) In the specification, transmitter can detect the receiver about 2m. However, there are not data translations with the communication of the LF. Transmitter has three dimension diversity antennas to realize no directivity. Response distance with LF communication between UFAM2 transmitter and receiver is shown in Fig. 6. The unit of this figure is mm. And, statistical data is shown in Tbl.3. In these data, UFAM is satisfied with expected specification, which is about 2m.

UFAM2 receiver is equipped to the detection circuit of the LF communication. So, receiver cannot use LF communication to the transmitter. To use the detecting function of the LF communication, receiver can recognize presence position from the transmitter.

Transmitter can recognize receiver position to use two way communication methods as shown in Fig. 7. Transmitter sends the detection signal to use the LF. And, when the receiver receive this signal, receiver send acknowledge message to the transmitter using HF communication method.

UFAM2 is equipped to the function of the Received Signal Strength Indicator (RSSI). So, distance between transmitter and receiver is also measured to use these functions [11] [12]. To use these modules, ubiquitous spot service is realized.

5. EXAMPLE OF UBIQUITOUS SPOT SERVICE WITH UFAM2

To use UFAM2, ubiquitous spot service is realized. UFAM2 have sphere response area. So, when the user has receiver and transmitter is embedded in the space,

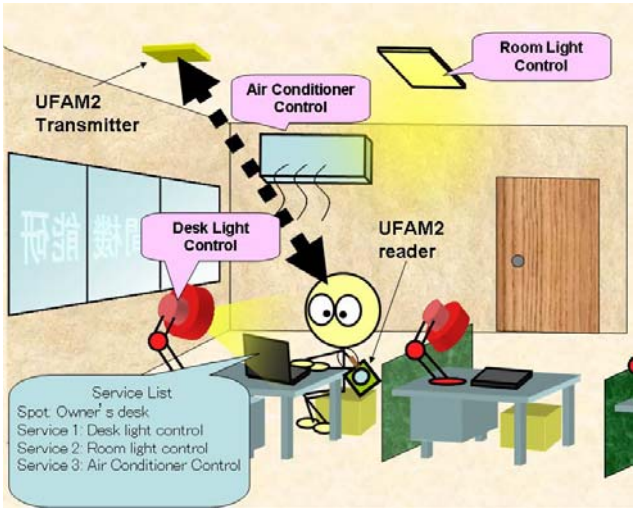

Fig. 8 Ubiquitous spot service for office scene

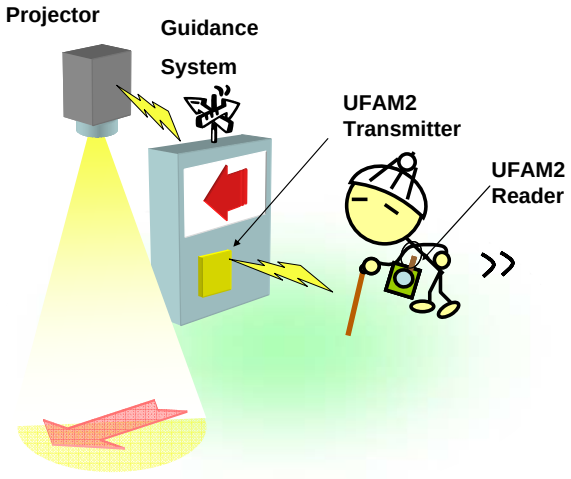

Fig.9 Ubiquitous spot guide system

transmitter can detect the approach of users. In this section, some examples are shown to apply this scheme.

5.1 Spot service in the office

In the section 2, spot service in the office is simply described. In this section, more detail process is shown. In the Fig. 8, several functions are set at the desk. In this case, user has a UFAM2 receiver. And, UFAM2 transmitter is set at the ceiling over the desk.

When the user approach to the desk, transmitter is detected the user's receiver. And, transmitter sends the detected information to the ubiquitous function discovery service. In this case, transmitter's message is added to the spot information. Ubiquitous functions discovery service makes service list of this spot, and send this list to the user's interface, which is mobile phone and PDA etc., when the user want to be supplied to some of the services. In the case of the UFAM, user can get the all service list of a space. This list is included on extract information. So, ubiquitous spot service makes the limitation based on the spot for service list.

5.2 Guidance Application

When guidance system is set at several points in a building , user can supply the guidance from this system. In this case, user has a UFAM2 reader include some ID, and UFAM2 transmitter is included in the guidance system as shown in Fig. 9. When a user approaches this guidance system, guidance system detects the presence of a user. And, guidance system request user's ID to ubiquitous functions discovery service. Ubiquitous functions discovery service teaches this user where to go thorough the guidance system. And, if a projector embedded the space, ubiquitous functions discovery service can select a projector, and this service shows user same action of above example.

6. CONCLUSION

In this paper, ubiquitous spot service has been proposed. This service makes the limitation based on the spot in the ubiquitous functions discovery service. To use this service, ubiquitous functions discovery service has been provided to spot service list for a user.

To realize this service, improvement version of the Ubiquitous functions Activation Module (UFAM2) is introduced. Detection area of the UFAM2 has non-directivity antenna, which is applied to three dimensional diversity antennas. To use UFAM2, the optimal list of each spot is made by ubiquitous functions discovery service.

UFAM2 can detect the area, which is sphere of 2m radius. To use this function, safety guarding service is expected to be contained to the ubiquitous spot services as a future work. The application of a building site etc. can be expected of this spot service.

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