Indoor Orientation tracking method using ubiTrack*

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ABSTRACT

In this paper, we propose the indoor orientation tracking method using ubiTrack. In ubiquitous computing environment, the information of the location is one of the important contexts which are used to the context-aware service. But most of the indoor location tracking method causes the problem of the infringement on people's privacy. Necessity of orientation tracking is proposed in order to provide the more intelligent services with the location tracking. To know orientation of a user or device, we attach two infrared receiver modules to the ubiTrack receiver. Two IR receiver modules attached to the ubiTrack receiver track the location, the direction and size as well as the orientation from the location information of a user and device. As the ubiTrack receiver attached on the device informs the location information of a device to the environment every some terms, the proposed method can provide the user with the location and orientation in the condition that user's privacy problem is guaranteed. Experimental results show that the method recognizes orientation of a device in home environment with the errors below 15 degrees. The proposed method can be applied to many LBS gearing the context-aware services in ubiquitous computing environment.

Keywords: ubiquitous computing, context tracking, location, orientation, LBS

1. INTRODUCTION

In the ubiquitous computing environments, the environments recognize the users' context by themselves, and provide personalized services anywhere and any time. To realize these intelligent environments, many research organizations have studied the context awareness and developed various applications exploiting context [1-3]. Even though they deal with different context according to their services, they have the common factor that the location information has been utilized. In this sense, the location information has considered as the important information to realize ubiquitous computing environments. Recently, the studies on the orientation-aware as well as location-aware have grown increasingly.

Currently, various location tracking systems have been developed in order to track users indoor. Cricket compass [4] developed by MIT uses a RF and ultrasound signal,and added the some ultrasound receiver modules to the traditional Cricket. Thus, it can track the location and orientation of a user and device. But when tracking the location of a user and several devices at the same time, a server which manages the location information of devices is needed. It is a disadvantage that the ubiquitous computing aims the decentralized environments. Active Badge [5] developed by AT&T uses a RF and ultrasound such as Cricket but it has a privacy problem because it consists of an active sensor and several passive beacons. UbiTrack [6] which is infrared-based indoor location tracking system has advantages of simple operation and consideration of privacy problem. However, it is a difficult to recognize the specific contexts of a user and device because it cannot track the orientation of a user and device.

In this paper, we propose the orientation tracking method using ubiTrack. We connect two IR receiver modules using not only one but different ID each other to ubiTrack receiver. Two IR receiver modules can be attached to any place where the user wants because they are connected to each other with the long wire. And mobile device attached on a device broadcasts its information.

Proposed method has three advantages. First, ubiTrack receiver can recognize the orientation of a user and device by using two IR receiver modules which have each different ID. Second, we minimize inconvenience that a user always has to hold the mobile device through

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attaching two IR receiver modules on the shoulder. Lastly, a mobile device attached on a device broadcasts to the user's mobile device using wireless LAN (IEEE 802.11b). Thus, it can become aware of the location and orientation in the condition where the privacy of the user is not violated.

This paper is organized as follows. In chapter 2, we describe the architecture of proposed method and orientation tracking method. In chapter 3, we verify the accuracy and performance of proposed method. Various applications are explained in chapter 4. Finally, we mention conclusion and future works in chapter 5.

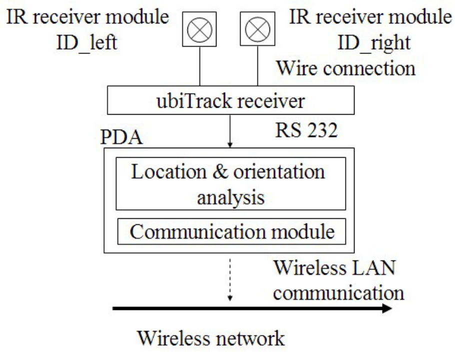

Figure 1 diagram of ubiTrack receiver

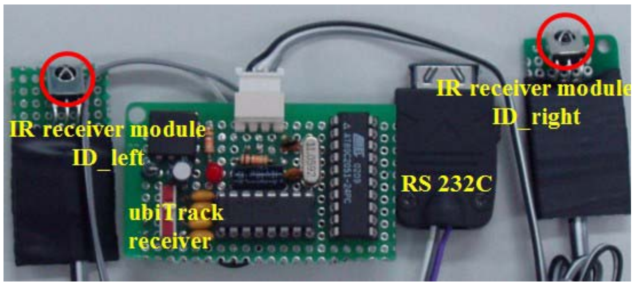

Figure 2 ubiTrack receiver

2. ORIENTATION TRACKING METHOD USING UBITRACK

We propose that the orientation tracking method using ubiTrack provides orientation information which is one of the important contexts to the context-aware application. This method can become aware of the orientation information as well as location by using two IR receiver modules. We can become aware of the location and orientation of not only a user but also a device at the same time by broadcasting a deivce's location and orientation information to the environment. We attached two IR receiver moduels on the shoulder by connecting with wire in order to become appropriate to the mobile environment.

2.1 System architecture

Figure 1 is a diagram of ubiTrack receiver part. If ubiTrack transmitters emit IR signal with each ID, two IR receiver modules receive each different ID according to their locations. The signal which is received in the ubiTrack receiver is transferred to ubiTrack receiver, and in it, the signal is restored to the ID presenting each sensenig area [6]. The IDs of each sesnsing area received in the ubiTrack receiver are transferred to the PDA of a user or device by using serial communication (RS232C). The IDs are transformed to the coordinates, such as (x, y). By using this coordinates, the PDA of a user or device generates the middle point of each sesner location, width, and orientation in the orienetation analysis part. Lastlly the location, width, and orientation generated by the orientation analysis part are transferred by wirelss LAN (IEEE 802.11b) to the wireless network

2.2 direction recognition techniques

We use two IR receiver modules in order to become aware of the orientation. Two receiver modules have each different ID, such as right and left. Two receiver modules are aware of orientation of a device by using each location information of two IR receiver modules. Figure 3 shows the method of orientation tracking. Six circles are IR sensing areas generated by IR transmitters attached on the ceiling. We attach two IR receiver modules to the each side of a device of which we want to know the location and orientation. The device location is presented as the center point (x, y) between two IR receiver modules. 'ℓ ' is the measuring width of a device, which is a distance between two IR receiver modules as shown table 1. Proposed method can be aware of 2-dimensional location. It is realer than the conventional systems which can be aware of only 1-demensional location such as a point. Then, it can be aware of orientation (θ) by using each location of two IR receiver modules. If left and upside point is (0, 0), Θ is an angle between the north direction and the forward direction of a device. So, if the forward direction of a device is headed to the north, the orientation of this device is 0 degree.

The mobile device attached on the device of which we want to know the location broadcasts its location and the orientation information to the environment. The conventional systems caused the user's privacy problem because the environment managed information of a user and a device. The information of a user is recognized by

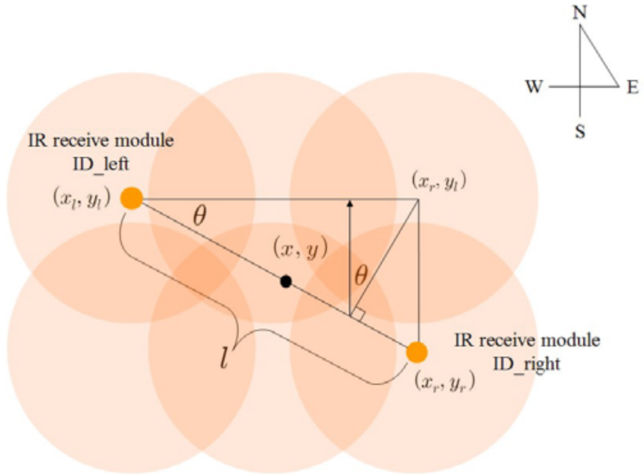

Figure 3 orientation tracking mothod

Location	$(x,y) = (\frac{x_l + x_r}{2}, \frac{y_l + y_r}{2})$
Length	$l = \sqrt{(x_l - x_r)^2 + (y_l - y_r)^2}$
Orientation	$\theta = \cos^{-1} \frac{\lvert x_l - x_r \rvert}{\sqrt{(x_l - x_r)^2 + (y_l - y_r)^2}}$

Table 1 computation of location, length, and orientation

the mobile device of a user. In the proposed method, the information of a user is recognized in the mobile device. The mobile device informs of the information to the environment every some minutes. And then, the mobile device recognizes a device's information with a user's information by directly receiving broadcasted information of the device without a server. Thus the propsed method can be aware of the location of a user and a device decreasing the user's privacy problem.

We divide the IR receiver modules from the ubiTrack receiver. In the case of the classical ubiTrack, to receive IR signals a user has to hold the ubiTRack receiver paralleled to the ceiling. However, we can be aware of the location and orientation even though we divide the IR receiver modules from the ubiTrack receiver, and attach them on the shoulders.

3. EXPERIMENT

To know the characteristic and error of proposed method, we meausered the location and orientation of the TV and the sofa in ubiHome [7] which is a smart home test bed. Figure 4 shows the method of experiment. As seen figure 4, we attached two IR receiver modules on both sides of a safa. We changed the orientation of a sofa from 0 degree to 90 degree. The physical width of a sofa is 180cm. To increase the trustness, we used 100 IR signals received from the IR transmitters per each orientation on the experiments. And like a sofa, we also attached two IR receiver moidules on the both-side of a TV, fixed left side, and changed the orientation of a TV from 0 degree to 90 degree. Then we measured the location, width, and orientation of a TV. Also in the case of TV, we used 100 IR samples per each orientation on the experiments. Figure 5(a) is a picture of ubiHome test bed, where ubiTrack is established, and figure 5(b) shows that ubiTrack receiver is attached on the sofa.

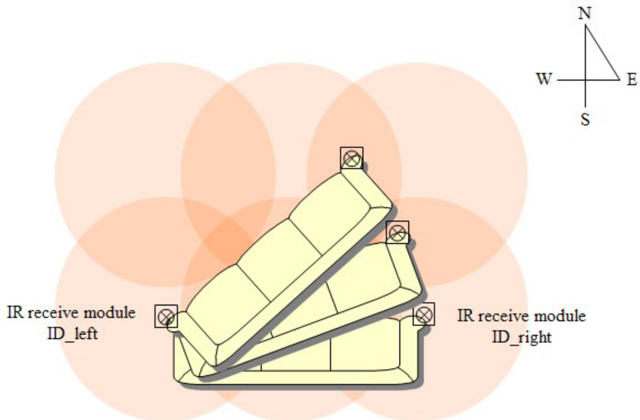

Figure 4 measurement method of a sofa's orientation

Figure 5 experimental set-up

Table 2 shows the width and orientation which are measured by changing 10 degrees as shown in figure 4. Figure 6 shows errors of TV and sofa orientation. As shown in figure 6, the measured orientation has errors within 15 degrees. Figure 7 shows errors of measuered width of a TV and a sofa. In this experiment, the TV shows the error rate of maximum 24% and the sofa shows the error rate of maximnum 10%. However, in this experiment we can not find some rules because the cause of errors is difference between each sensing area generated by ubiTrack transmitters.

Figure 8 shows the cause of errors. The casue of errors is that ubiTrack used proximity method in location tracking. Although two IR receiver moduels' location is different, if two IR receiver modules exist in a same sensing area, two

Orienataion (degree)	TV orientation (degree)	sofa orientation (degree)	TVlength (cm)	Sofa lenght (cm)
0	0	0	135	180
10	0	0	135	180
20	17.70	13.76	142.2	185.4
30	44.70	33.25	127.35	162
40	44.70	33.25	127.35	162
50	44.70	56.17	127.35	162
60	56.17	56.17	162.45	162
70	63.62	75.66	100.8	185.4
80	71.08	75.66	142.2	185.4
90	90	90	135	180

Table 2 measurement of orientation and legth

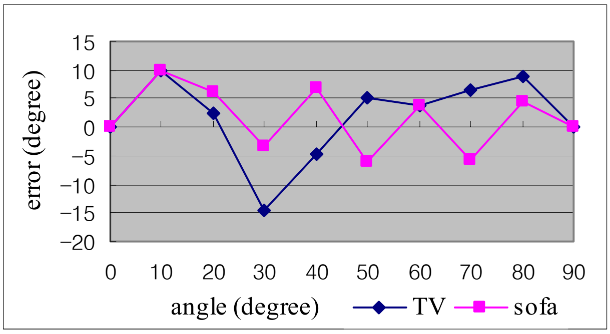

Figure 6 orientation errors of TV and sofa

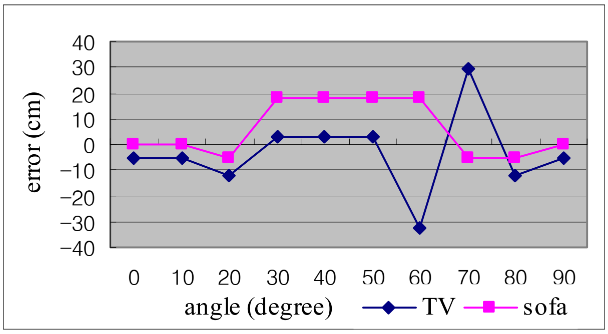

Figure 7 length errors of TV and sofa

IR receiver modules are recognized as if they are in the same area. For example, in figure 8, the locations of two IR receiver modules, which are a and b, are not same. But because two IR receiver modules are in the same sensing area, both of two IR receiver modules' locations are c. This means that meauserd locations of a and b are same. In this sequence there are errors about location. The width and orientation informations have errors because the location information having errors is used in calculcation.

In order to decrease the errors, we should make each IR sensing area equal and small. The Errors of the proposed method are generated because the sizes of each IR senging are different and the sizes of some of IR sensing areas are bigger, approximately 2500cm^2. Thus if we make the IR sensing areas smaller and equaler than now, we can decrease the errors of measured location, width, and orientation of a user and a device. To change sizes of IR sensing areas, we have to change the arrangement of transmitters attached on the ceiling.

Figure 8 cause of error

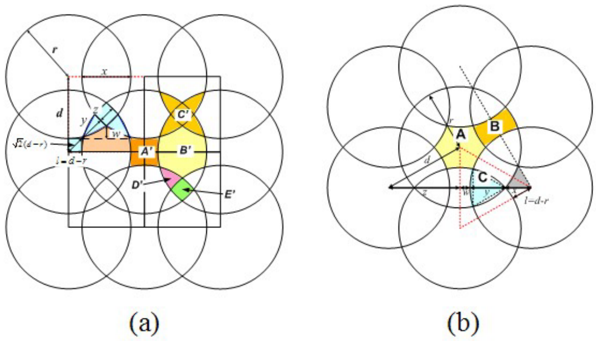

Figure 9 sensing area according to arrangement of IR transmitters

Figure 9 shows IR sensing areas according to each arrangement. Figure 9(a) is the current arrangement of ubiTrack transmitters. The current arrangement is a grid shape. We expressed the each sensing area according to the distance of each transmitter in figure 10. In figure 10, the most short and equal distance among the sensing areas, A, B, and C, is 90cm. Figure 9(b) shows the triangle shaped arrangement of transmitters. The change of each sensing area according to distance of transmitters is shown in figure 11. In figure 11, we can know that most short and equal distance of each sesing area, A, B, and C, is 94cm. In this point, each sensing area is about 1500cm^2, 1500 cm^2, and 1000 cm^2. This means that the triangle-shaped arrangement of the ubiTrack ttracnmitters has more accurate than the grid-shaped arrangement. Accordingly, we can decrease errors by changing the arrangement of transmitters to triangle-shaped it.

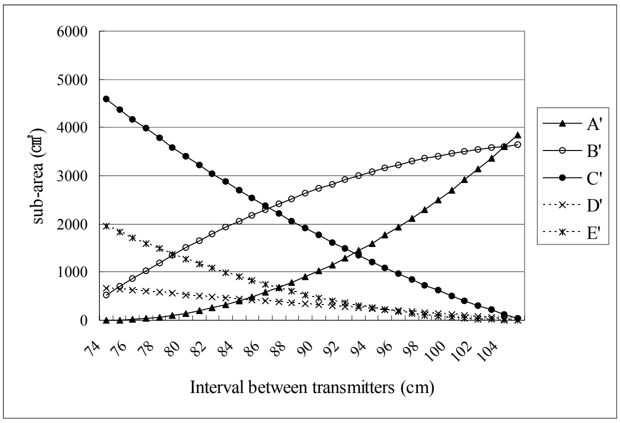

Figure 10 when the arrangement of transmitters is a gird-shape, IR sesning area according to distance of transmitters

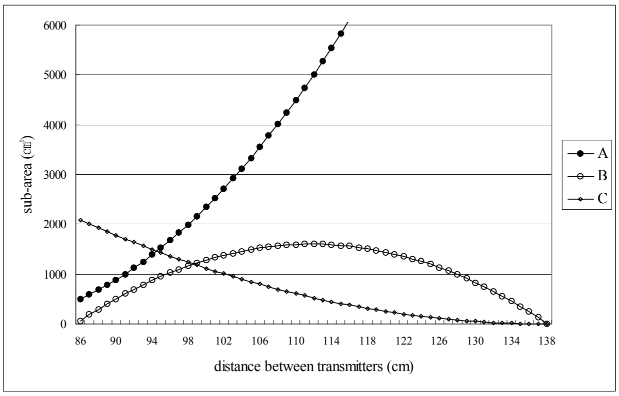

Figure 11 when the arrangement of transmitters is a triangle-shape, IR sesning area according to distance of transmitters

4. APPLICATION

The proposed method can be used in many location-based services. First, we applied it to the context-aware media service [8]. The context-awaer media service provides user with music, TV, and movie according to location of a user. If the direction of a user is face to the TV, the media service assumes that the user will watch TV. So if the direction of a user'eye is face to the ubiTV, TV service is provided the user with because the context-aware media service assumes that the user has the intention of watching TV. Although the user is near the TV, if the user is beside or back of the TV, the context-aware media service assumes that the user doesn't have an intention of watching TV. So in that case, the TV service would not be provided the user with. The second application is a viewfinder. The viewfiner shows not only the location of devices but also the location of the user. This application is user-centric system. If a user's view direction changes, the map is changed according to the user's view direction. Consequently, the viewfinder can track the location of devices easily.

5. CONCLUSION AND FUTURE WORKS

In this paper, we are proposing the indoor orientation-aware method using ubiTrack which can track the orientation as well as location of a user and a deivce. We use two IR receiver modules in order to become aware of the orientation. The mobile device of an objection broadcasts information about its location, width, and orientation. We divided the IR receiver modules from the ubiTrack receiver by connecting the wire. Thus, proposed method has advantages of as followings. First, the proposed method can be aware of the orientation and width as well as the location of a user and device by using two IR receiver modules. Secondly, it can keep a user's privacy by broadcasting its information to the environment every some minutes. Lastly we can set free two hands by dividing IR receiver modules from the ubiTrack receiver and attaching them on the shoulder.

The propoed method has an advantage that the device needs low conputing power because we use the proximity method. However, on the other hand due to this reason it is aware of only the approximate location. So we will increase the accuracy of this method through the probability approach.

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Paper Session 8 (uT Technology)

Session Chair : Hee Yong Youn (SungKyunkwan University)

1) WindowActive : An Interactive House Window On Demand
   Jae-Seon Lee, Kyoung-Shin Park, Min-Soo Hahn (Information and Communication University.)

2) Indoor Orientation tracking method using ubiTrack
   Woojin Jung and Woontack Woo (GIST)

3) Proposal of Secure Easy Remote Access Technology: Softwire
   Nobuyuki Enomoto, Hideo Yoshimi, Youichi Hidaka, Kazuo Takagi, Atsushi IWATA (NEC Corporation)

4) Double-Decker RFID Tags -- Basic Structures and Applications
   Shin-ichi Minato, Masaharu Yoshioka (Hokkaido University)

Paper Session 9 (uT Technology)

Session Chair : Japanese participant

1) Design and Application of GIS/LBS Technology for Developing Ubiquitous Environment
   Sang-Hoon Lee, Tae-Hoon Kim and Jee-Hee Koo (Korea Institute of Construction Technology)

2) Case with ubiquitous house designed from aspect of interior
   Hiroyuki Yoshida (Daiwahouse Industry Co. LTD R&D division), Nobuhiko Nishio (Ritsumeikan University)

3) Extended FACE Routing Protocol for Mobile Ad-Hoc Networks Author(s), Hideaki TAKAHASHI and Hiroaki HIGAKI
   Hideaki Takahashi, Hiroaki Higaki (Tokyo Denki University)

4) Development The UHF RFID Reader Platform Based on RISC Processor
   Jong-Ho Kim (Digitalsys), We-Duke Cho (Center of Excellence in Ubiquitous Computing & Networking),
   Ho-Sung Choo (Hongik University) and Young-Kil Kim (Ajou University)

[POSTER SESSION]

Poster Session 1 (Community Computing Technology)

Session Chair : Jai-Hoon Kim (Ajou University)

1) SSR (Smart Sleep Recognizer) : Making Decision Based on Probability of User's Intension
   Dong-Wook Lee, Soung-Hun You, We-Duke Cho, and Jai-Hoon Kim (Ajou University)

2) Implementation of PLC Home Network System based on Embedded Linux
   Kyung-Hwan Cha, Yu-Seok Hyun, Jong-Jin Yoon (Dongseo University)

3) An Inter-working Processing System for heterogeneous hierarchical wireless sensor networks
   Sea-Young Ahn (Korea University), Kang-Ho Woon, Seong-Dong Kim (Korea Electronics Technology Institute),
   We-Duke Cho (Center of Excellence in Ubiquitous Computing & Network-CUCN), and Sun-Shin An (Korea University)

4) A Zone Networking Architecture based on Zone Masters for Mobile Ad-Hoc Wireless Networks
   Namhi Kang, Ilkyun Park and Younghan Kim (Soongsil University)

5) Ontology-based High Level Event Subscription Method for RFID Middleware
   Jong-Yun Jung, Ki-Yeol Ryu, Jung-Tae Lee (Ajou University)

6) A Middleware Architecture for Community Computing with Intelligent Agents
   Seungwok Han and Hee Yong Youn (Sungkyunkwan University)