Personal Information Annotation on Wearable Computer Users with Hybrid Peer-to-Peer Communication

Koji Makita, Masayuki Kanbara, and Naokazu Yokoya

Nara Institute of Science and Technology,
8916–5 Takayama, Ikoma, Nara, 630–0192, Japan

Abstract. This paper proposes a wearable annotation overlay system which can correctly annotate dynamic users of wearable computers. To provide users with the newest annotation information, a network shared database system for wearable AR systems has been proposed. With the database, a wearable annotation overlay system which can dynamically annotate users of wearable systems has been investigated. In conventional systems, since dynamic users' position is transmitted to wearable AR systems via a shared database server, it is difficult to overlay annotations at a correct position because of low frequency of updating and delay of client-server communication. In this paper, we propose a new effective method for wearable AR systems to obtain dynamic users' positions by using hybrid peer-to-peer(P2P). In experiments, annotations on dynamic users have been proven to be overlaid correctly enough to show where users are.

1 Introduction

With an advancement in computing technologies, a wearable computer can be realized[1]. Therefore, many wearable augmented reality(AR) systems have been investigated for displaying location-dependent annotation information[2-7]. At the same time, the concept of network shared database system for wearable AR systems has been proposed[8] in order to efficiently provide users with newest information. Furthermore, a wearable annotation overlay system which can annotate dynamic users of wearable systems has been developed with the network shared database[9].

Fig.1 shows an example of wearable annotation overlay system which can annotate dynamic users of wearable computers. The system has possibilities of new effective applications. Some examples are mentioned in the following.

– When we want to find our acquaintances in a crowd of people, wearable AR systems can show us where our acquaintances are.
– In case of emergency, we can easily and fastly find a policeman or a medical doctor around us by using wearable AR systems.

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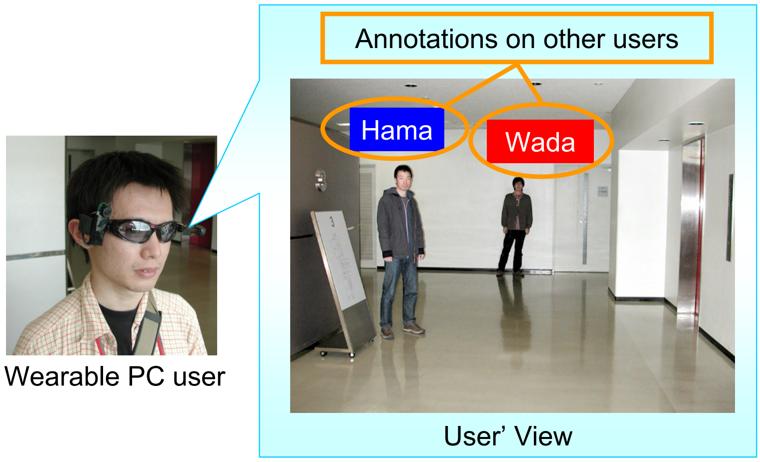

Fig. 1. An example of annotation overlay system which can annotate dynamic users of wearable systems

To annotate dynamic users of wearable systems in a multi-user environment, a user's computer needs to obtain annotation information of other users in real-time. At present, a network-shared annotation database via a wireless network is usually prepared and annotation information of users is managed by the annotation database in a server. Thus wearable annotation overlay systems obtain annotation information and position of users from the database. Therefore, it is difficult to overlay annotations of dynamic users on the correct position in AR images because of the low frequency of updating information and communication delay. In the case that there are displacements of annotations, it is difficult for users to recognize correspondences between annotations and dynamic users of wearable systems. Therefore, the conventional framework works well only when there are a limited number of clients around.

High frequency of updating and low communication delay make it possible for annotation overlay systems to overlay annotations of dynamic users at correct position. If the system can correctly overlay annotations of dynamic users, the system might be suitable for much broader range of applications because the system can work well in the crowds of people. The purpose of the present study is to construct a new effective method for wearable AR systems to obtain dynamic users' positions. To realize high frequency of updating and low communication delay, we use both client-server communication and hybrid P2P. In the method, a client system transmits its position to the server at some intervals. The client system also transmits its position using P2P to other client systems by request from the server.

This paper is structured as follows. Section 2 describes the proposed method for wearable AR systems to obtain dynamic users' positions. In Section 3, experimental results with a prototype system are described. Finally, Section 4 describes summary and future work.

2 Annotation Overlay to Dynamic Users with Hybrid P2P

2.1 Overview of the Framework

To overlay annotation information of dynamic users, two types of data below are usually needed.

1. Users' personal information
2. Users' positions

For example, in Fig.1, users' names are needed as personal information and users' positions are needed to overlay annotations on correct positions. Since these data are updated successively, client systems have to obtain the latest data in order to annotate to dynamic users. Users' personal information is acquired once in a while. On the other hand, users' positions are updated in real time. Thereby, client systems can overlay annotations by obtaining users' personal information at regular intervals. However, users' positions must be consecutively obtained with a small communication delay. If a server provides client users' positions, time lag which arises from a delay of client-server communication is not small. Furthermore, the server must send and receive all of the users' positions continuously in real-time. In this case, loads of the server and the network are generally high. To solve these problems, we employ hybrid P2P communication for obtaining users' position from other clients. However, since we have to consider a network limit and marginal performance of user's system, it is difficult to send and receive multiple users' positions by only using P2P.

Because of this situation, we install a database server which can be accessed with a wireless network and the database manages annotation information. The server is shared by multiple users of AR systems and has two functions below.

1. Providing multiple users' personal information and positions
2. Management of timing of starting and stopping P2P communication

Since the database contains personal data of multiple users, we have to carefully consider the security and privacy issue. In this study, we apply existing network-shared database design[8] to the database which manages multiple users' personal information and positions. Moreover, the database manages user's ID and IP address to control P2P communication. In Section 2.2, the outline of the proposed system is described. Section 2.3 describes how to update and obtain annotation information by client-server communication. Section 2.4 describes how to obtain dynamic users' positions.

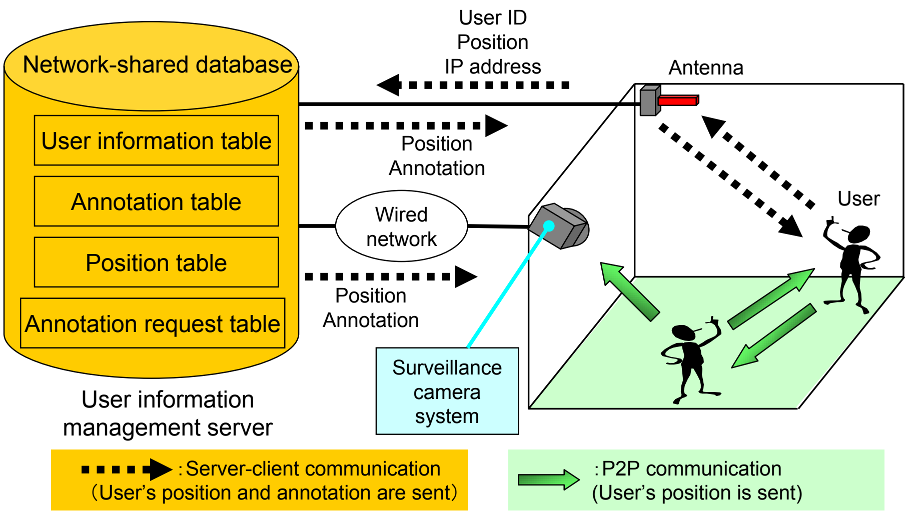

Fig. 2. Outline of proposed annotation overlay system

2.2 Outline of the Proposed System

Fig.2 shows an outline of the proposed annotation overlay system. The proposed system consists of a user information management server and two types of client systems. Components of client systems and the database in the server are described in detail in the following.

- Client systems
  In this study, we assume an environment where there are multiple users of wearable AR systems which can access network and obtain the position and orientation of the user's viewpoint. We assume two types of client AR systems; wearable AR system and fixed surveillance camera system. Wearable AR system can be applied into a communication tool between multiple users. On the other hand, fixed camera system can be applied into a security camera system.

  Client systems request annotation information by transmitting request packet to the server. After obtaining annotation information, the systems create AR images.
- User information management server
  Personal information and position of users are managed by network-shared database in the user information management server. The server has a user information table, an annotation table, and a position table. Tables 1, 2, and 3 show sample lists of information. The server also has an annotation request table. Table 4 shows a sample list of data. The data in Table 4 means that there are five users in an area, and client A has requested annotation information of clients B and D.

Table 1. User information table

ID	Password	Group	IP adress
User A	aaa	Group A	163.221.・・・
User B	BBBB	Group D	163.221.・・・
User C	cCcC	- - -	163.221.・・・

Table 2. Annotation table

ID	Annotation ID	Authorization
User A	A001	User B, C
User B	B001	User C
User C	C001	Group A

2.3 Updating and Obtaining Annotation Information by Client-Server Communication

Each client system has specific ID and communicates with the server in a certain interval. Each wearable AR system automatically sends its specific ID, IP address, and position to the server via a wireless network. On the contrary, the fixed camera system only sends its ID and IP address because its position is fixed in the real world. Position table is updated by the positions sent from wearable AR systems. In the case that a user of wearable AR system wants annotation information, the system sends a request to the server. Annotation request table is updated by request of client systems.

User information management server generates the P2P transmission list as shown in Table 5. The P2P transmission list is generated for each system. Destination addresses of client systems are included in the P2P transmission list. The P2P transmission list is updated by using data of table 1, 2, 3, and 4. Each client system automatically obtains the P2P transmission list in a certain interval and

Table 3. Position table

ID	X	Y	Z	Updated time
User A	0.2	1.0	1.1	19:00:00
User B	-3.2	15.3	1.2	19:39:11
User C	3.6	8.8	1.0	19:54:53

Table 4. Annotation request table

R. S(**) \ Dst(*) ID	A	B	C	D	E
Client A		○	×	○	×
Client B	○		×	×	○
Client C	○	×		○	×
Client D	○	○	×		×
Client E	○	×	×	×	

Table 5. P2P destination list

Dst(*) ID	Dst(*) address
User B	163.221.···
User D	163.221.···
User E	163.221.···

Dst(*) : Destination

R. S(**) : Request sender

refers to the list in order to transmit its position to other clients. For example, if the list shown in Table 5 is for client A, the system of client A continuously transmits its position to systems of clients B, D, and E.

2.4 Obtaining Dynamic User's Position

This section describes a procedure of obtaining users' positions. The procedure consists of nine processes as shown in Fig.3, which shows an example of the case client A requests annotation information of client B. Each process in Fig.3 is described in detail in the following.

1. Request-transmission for users' positions
   First, client A requests annotation information of client B. Every client system is always able to transmit a request to the server. The request is transmitted with an user ID as well as a password of request sender(client A).
2. Client authentication
   The server checks the user ID and the password to authenticate the validity of the client system. Only if the ID and the password are successfully authenticated by the server, we go to the next step.
3. Checking of obtaining annotation authorization
   The server checks that client A is given permission for obtaining annotation information of client B. Only if client A is given permission by client B, we go to the next step.
4. Update of annotation request table
   The annotation request table is updated by the server with the request. Table 4 shows that client A has requested annotation information of clients B and D.
5. Generation of P2P transmission list
   The server generates a P2P transmission list for each client system. Table 5 indicates that client A has to transmit its position to clients B, D, and E by P2P communication. The server generates the P2P transmission list considering the specification of client systems and network environment.

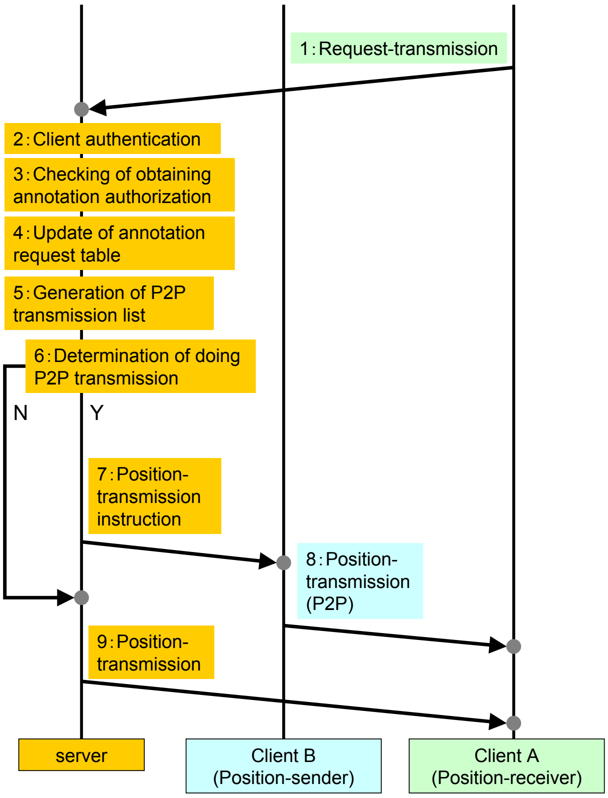

Fig. 3. A procedure of obtaining user's position via P2P communication

6. Determination of doing P2P transmission
   The server checks the P2P transmission list for client B. If client A is in the list, we go to Step 7. Otherwise, we go to Step 9.
7. Position-transmission instruction
   In this step, the server orders client B to send its position to client A by P2P communication.
8. Position-transmission by client system
   Client B is ordered to transmit its position by receiving a P2P transmission list. In this case, since client A is included in the list, client B starts transmitting its position to the system of client A by P2P communication.
9. Position-transmission from server
   If client A is not included in a P2P transmission list, the server starts transmitting the position of client B to the system of client A.

When client A wants to stop obtaining annotation information, client A requests the server to stop transmission. This stop-transmission is implemented in a similar way of obtaining user's position.

3 Experiments

3.1 Experimental Environment

We have carried out some experiments using the proposed method in our campus where users of wearable AR systems can use a wireless LAN. Fig.4 illustrates the experimental environment. We have developed a network-shared database of annotation information in a user information management server and set up one fixed camera system on the ceiling. The fixed camera system consists of a video camera and a standard PC. The user information management server and the video camera system use a wired LAN. We have also set up invisible visual markers on the ceiling for wearable computer users to estimate their position and orientation[7]. The area where user's wearable system can estimate its position and orientation is about 15m 3.5m. In experiments, three wearable system users exist in the environment. Users' positions are estimated by their wearable systems and are transmitted to the location server every 1 second. Wearable systems and the video camera system obtained the annotation information and users' positions and generated annotation overlay images. Fig.5 illustrates a hardware configuration of the wearable augmented reality system which is used in these experiments. Table 6 shows hardware configurations of the location server and the video camera system.

To generate annotation overlay images, position and orientation of the camera are needed. In experiments, the wearable system estimates the position and orientation of the user's viewpoint by using the conventional marker-based registration method[7]. On the contrary, the position and orientation of the video camera is estimated in advance.

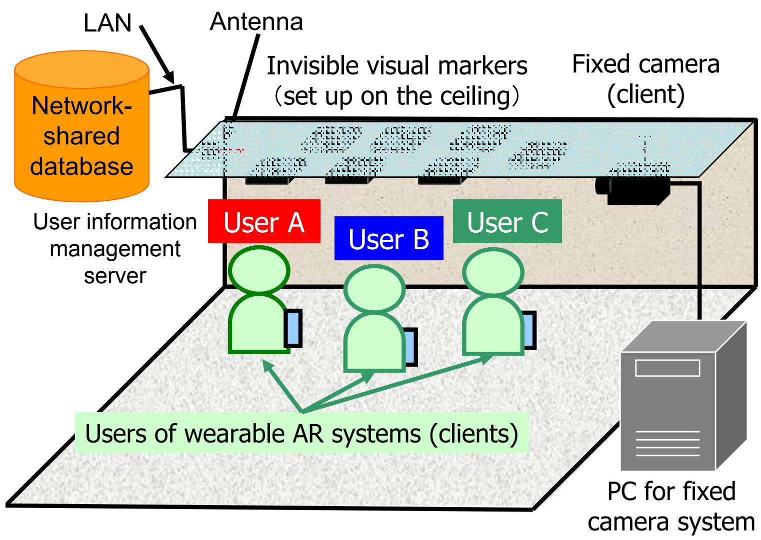

Fig. 4. Experimental environment

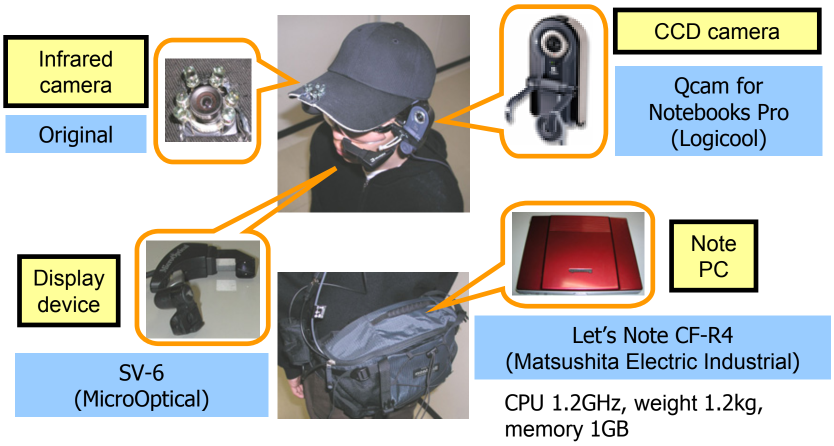

Fig. 5. Hardware configuration of wearable AR system

Table 6. Hardware configuration of server and fixed camera system

	Hardware	specification
Server	PC	CPU : Pentium 3 1.2GHz 512MB memory 100Mbps Ethernet
Fixed camera system	PC	CPU : Pentium D 3.0GHz 3.25GB memory 1Gbps Ethernet
	camera	DCR-TRV900 (Sony) 640 × 480 pixels

3.2 Annotation Overlay by Fixed Camera System

Fig.6 shows examples of annotation overlay images generated by the fixed video camera system. In the augmented images, translucent circles are overlaid on wearable system users' infrared cameras to indicate the positions of annotated users. The size of the circle is proportional to the distance of the fixed video camera system to a user. Users' personal information are also shown on the corners of the images. Figs.6 (a) through (c) show the annotation overlay images when the users' positions are obtained from the user information management server. Figs.6 (d) through (i) show the annotation overlay images when the users' positions are directly transmitted from users by using P2P communication. From Figs.6 (a) through (c), it is clear that the translucent circles are misaligned. This is because users' position table in the server is updated at approximately every second. On the other hand, the translucent circles in Figs.6 (d) through (i) are correctly overlaid on users' infrared cameras. In this case, users' positions are directly transmitted from users at about 10 times per second.

Fig. 6. Overlay images generated by fixed camera system

3.3 Annotation Overlay by Wearable Computer Systems

Fig.7 shows the annotation overlay images generated by a wearable computer system. In this experiment, three wearable computer users are walking in the area and their position and orientation are transmitted to one another at about 10 times per second. The method of showing annotations is same as the previous

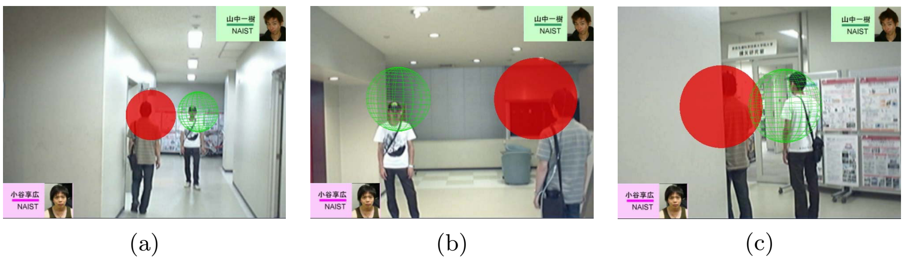

Fig. 7. Overlay images generated by wearable AR system

experiment. As shown in Fig.7, the translucent circles are correctly overlaid on users' infrared cameras. Through this experiment, we have confirmed that wearable computer systems can generate appropriate annotation overlay images by using P2P communication and show where other users are.

4 Summary

This paper has proposed a new method for annotating dynamic users of wearable AR systems to intuitively indicate other users' positions in user's view. Users of this annotation overlay system can see annotations on dynamic users and can correctly recognize where other users are. We have shown the feasibility of the method through the demonstration with experiments in our campus. In the future, we should further investigate the optimal management of P2P communication considering the specification of wearable computers and wireless network.

Acknowledgments

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