Final Program & Digest Book

SICE-ICCAS 2006

SICE - ICASE International Joint Conference 2006

October 18 - 21, 2006

BEXCO(Busan Exhibition & Convention Center), Busan, KOREA

The Society of Instrument and Control Engineers (SICE), Japan (http://www.sice.or.jp)

The Institute of Control, Automation and Systems Engineers (ICASE), Korea (http://icase.or.kr)

SICE-ICASE International Joint Conference 2006
Oct. 18-21, 2006 in Bexco, Busan, Korea

Occlusion Avoidance of Information Display System in Intelligent Space

Yoshihisa TOSHIMA[1], Qinhe WANG[1], Noriaki ANDO[2] and Hideki HASHIMOTO[3]

[1] Department of Electrical Engineering, The University of Tokyo, Tokyo, Japan
(Tel : +81-03-5452-6258; E-mail: {toshima, qinhewang}@hlab.iis.u-toyko.ac.jp)
[2] Intelligent Systems Research Institute, Advanced Industrial Science and Technology, Tsukuba, Japan
(Tel : +81-029-861-5022; E-mail:n-ando@aist.go.jp)
[3] Institute of Industrial Science, The University of Tokyo, Tokyo, Japan
(Tel : +81-03-5452-6257; E-mail: hashimoto@iis.u-toyko.ac.jp)

Abstract: This paper presents occlusion avoidance of information display system in Intelligent Space using RT-Components. Intelligent Space is an environmental system realized by cooperation of RT components (robots, sensors or actuators) inside a space (room, corridor or street) and can gather various kinds of information, especially the position of human and objects. When Intelligent Space observes a human, it is able to provide interactive information to him. Occlusion problem is needed to be solved to provide interactive information according the human movement. We developed the occlusion avoidance algorithm for the active projector. And this paper proposes a system in Intelligent Space using RT-Components which is useful and easy to integrate for system user or developer.

Keywords: Information Display, Intelligent Space, RT-Middleware

1. INTRODUCTION

This paper presents information display system in Intelligent Space. Intelligent Space is an environmental system realized by cooperation of RT components (robots, sensors or actuators) inside a space (room, corridor or street) and is able to support human in informative and physical ways [1].

Information display support in Intelligent Space has realized providing interactive information based on the human movement using active projector, which is put in this space.

There is a problem occurs in a specific area where projection of the projector is obstructed by the human body, the method to solve this occlusion problem will also be discussed in this paper. Occlusion problem is needed to be solved to provide interactive information according the human movement.

To make the environment space or several applications easily to be applicable with our active projector system, RT-Middleware[2] is used (AIST, Japan) due to its features in flexibility and expansion of the system in the future.

2. INFORMATION DISPLAY SUPPORT IN INTELLIGENT SPACE

2.1 Interactive Information support

The concept of Information display support in Intelligent Space is shown in Fig. 1. This System is to realize the interactive information display according to the human movement by using Active Projector in the Space. The motivation is Intelligent Space can gather various kinds of information, especially the position of human and objects. That is to say, Intelligent Space can observe the state of human and obtain the embedded information. Therefore, using Active projector which is able to project toward any position, it is able to interactively provide information to human (user).

Using the information in the space to support the domestic ubiquitous environments, The project such as

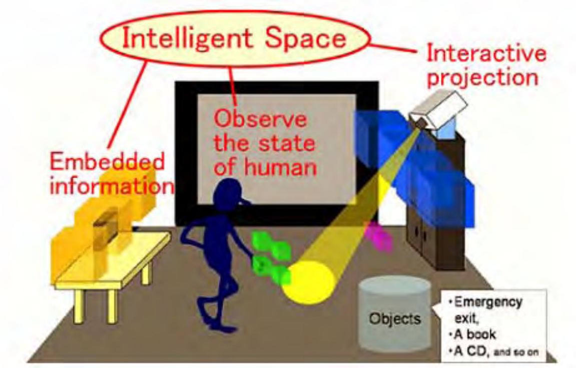


Fig. 1 Information Display System in Intelligent Space

Easy Living[3] and Sensing Room[4] are being researched. Active project also can be used in some specific spaces such as the art gallery to support visitor such as walking path guidance by utilizing the support visual information in the intelligent space. However in these researches, due to the limitation in projection of position area and human movement are previously established, the interactive information of human movement has not being considered yet. By utilizing the interactive information, many environments can be applicable, for example, the information or walking path guidance in the hotel lobby or exhibition hall, the sign or mark illustration in public space, the information service in daily life. Therefore it is feasible to implement this proposed framework to support the human activities in the space by providing the interactive information according to the human movement on the floor.

2.2 Occlusion problem

By using a single projector, human body may obstruct the desired position area of the projection which causes occlusion problem. For example, the problem occurs at the position where human is easy to see is the area in front of the human and when projector

89-950038-5-5 98560/06/$10 © 2006 ICASE

try to project at this area where the human body himself obstruct the projection in this area. The using of multiple projectors can solve this problem but this proposed method to solve occlusion problem may arise some problems.

1) More projectors more costs.

2) The establishment of the projector arrangement to avoid the occlusion is required.

3) In comparatively large space, it is very difficult to manage many projectors to display the information. For example, when many projectors are used to provide the information to people in the space, one projector should be used to provide information to one person or one group of the people.

4) It is not reasonable to use multiple projectors in some applications where it is necessary to provide the information at a specific position.

After all, each project itself may also arises problems. So it is quite necessary to find the solution of these problems. In another way, we introduce the occlusion avoidance by using information system to solve the occlusion problem.

3. INFORMATION DISPLAY SYSTEM USING RT-COMPONENT

3.1 RT-Component

RT-Middleware supports the system development method by using RT-Component and new framework to make composite component for RT-Component. Therefore, RT-Middleware realizes low level and real-time composition of independent RT-Components.

RT-Component contains mainly InPort/OutPort and Activity. InPort/OutPort as input/output of RT-Com ponent, and communicates data between other RT-Components. InPort receives data from OutPort and OutPort sends data to InPort on the contrary. Activity operates RT-Component and the state transition to contain coa logic of RT-Component itself.

On the system, RT-Middleware is able to make hardware such as sensors or actuators and software such as fuctions or applications into RT-Components and connecting those RT-Components to RT-Middleware network, it is able to composite the system flexiblity.

In case of an environmental system such as Intelligent Space, the system tends to be large-scale and complex. The flexible and expandable one in the change of the environment or scenario can be achieved by using RT-Component. The information display is also one of the above described systems. Information display system in Intelligent Space is also desirable to have the easy integration, cooperation among devices and simple addition, change and delete of application, devices or function on its system. Therefore, we implements this proposed system by using RT-Components, and use OpenRTM-aist (AIST, Japan) as RT-Middleware.

3.2 Information display system using RT-Component

The construction of information display system using RT-Component is shown in Fig. 2. The data type of InPort/OutPort which is common input/output interface between RT-Components on each RT-Components is shown in table.*. This system can be classified into 3 Component departments. Sensing Components department, Application Components department, and Device Components department, which are respectively described below.

3.2.1 Sensing Components depertment

Sensing Components department consists of ZPSOut Component and HumanState Component. This department obtains position and direction of human, and outputs its data to Application Components department.

It is used Ultrasound 3D Location system (Furukawa Co. Ltd) as human sensor. This sensor system consists of ultrasound receiver and transmitter (tag). A lot of receiver is installed in area 5m × 5m, obtain 3D position of transmitter. Consequently, by fixing transmitter to

Table. 1 InPort/OutPort data type of RTComponents on the system

Component name	InPort	OutPort
ZPSOut	—	Float × 3 (Position) Float × 3 (Position)
HumanState	Float × 3 (Position) Float × 3 (Position)	Float × 4 (Position, direction)
FrontProjection	Float × 4 (Position, direction)	Float × 3 (Position)
Revision	Float × 4 (Position, direction) Float × 3 (Position)	Float × 3 (Position)
Converter	Float × 3 (Position) Float × 3 (Position)	Float × 2 (Angle)
RTCLUnitCtrl	Float × 2 (Angle)	Float × 2 (Angle)

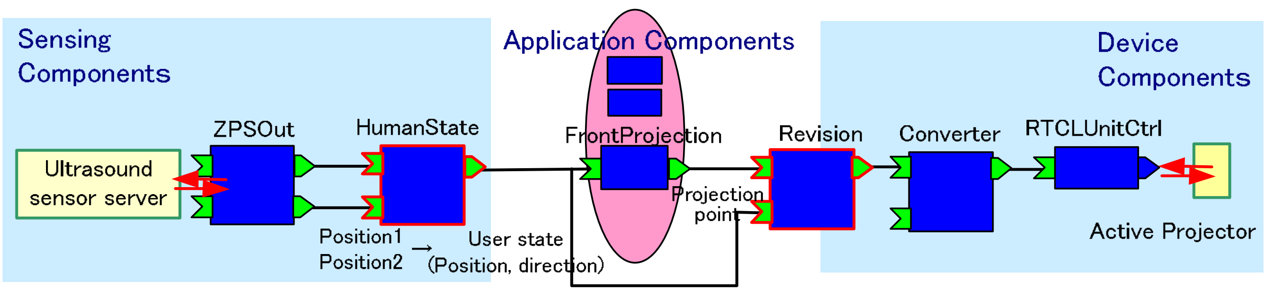


Fig. 2 Construction figure of this system using RT-Component

human, this sensor system is able to measure 3D position of human. ZPSOut Component respectively receives positions of two tags from ultrasound sensor server. HumanState Component sends the human movement to Appliction Components department. In this case, the human movement is position and direction of human. HumanState Component calculates vector of its two tags and sends position and direction of human to Appication Components department. Experimental environment installed Ultrasound 3D Location System is shown in Fig. 3.

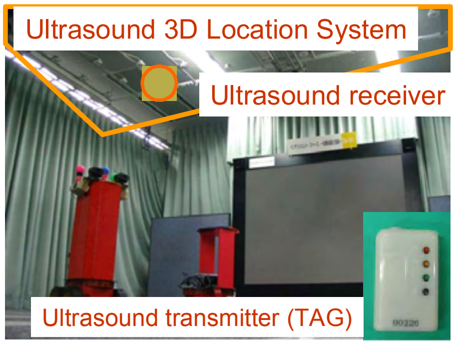


Fig. 3 Experimental environment installed Ultrasound 3D Location System

3.2.2 Application Components department

Application Components department receives the human movement from HumanState Component in Sensing Components department, outputs projection point which is reference position. FrontProjection Component gives projection to the front of human. This Component receives data of human's position and direction from InPort, find the projection point to front of human and outputs it.

3.2.3 Device Components department

Device Component department receives reference data from Application Component department, actuates adapted application. As projection device on this system, we have developed Active Projector using RT Component-Lite embedded micro controller[5]. Active Projector is shown in Fig. 4. Active Projector is a projector located on the pan-tilt enable stand. Converter Components converts projection point into reference pan-tilt angle. Finally, RTCLCtrl Component operates Active Projector through LAN cable. Also by GUI control panel, the activity control of Active Projector is realized in RTCLCtrl Component.

Fig. 4 Active Projector

3.2.4 Revision Component

Revision Component performs occlusion avoidance. InPort of this Component receives projection point and the human movement (position and direction of user). This Component revises toward occlusion problem, and outputs revised projection point. If occlusion don't occurs, OutPort's projection point is the same as InPort's one. This Component is connected between Application Components department and Device Components department. It is easy to switch the system function in RT-Components, Revision Component is used to send the data from InPort to OutPort when the RT-Component is in ready condition.

Thus, on the system using RT-Component, the development of function is independently possible as a RT-Component. And the integration into this system becomes flexible.

4. OCCULUSION AVOIDANCE

Fig. 5 shows the situation that the desired projection position is obstructed by the human body. This situation occurs when the direction that human faces is the same as the direction of the projection. It disturbs providing correct information. Providing path avoidance or guiding path is a significant solution. As described section 2.2, the using of multiple projectors can solve this problem but it may also arise some problem. The development of the RT-Component is one of the proposed methods to avoid this problem as described below.

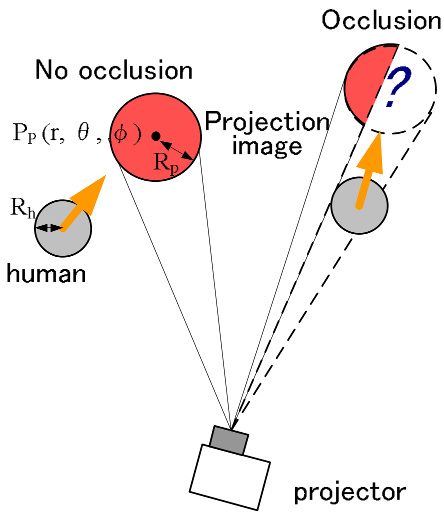


Fig. 5 Occlusion related human and projection point

4.1 Occlusion detect – Occlusion area and human model

Occlusion occurs when human enter into the area where human himself obstruct the projection. Therefore, creating occlusion area and human model and judging overlap those each other, occlusion can be detected.

Projector position P_m is considered as origin point and converse of the polar coordinate. Projector projects its image at any position area by a circle of radius R_p . The position P_P represents the center of the circular area projected by the projector whose radius is R_p. R_h and H_h present the radius and height of cylindrical human model while P_h is the center position of it. Projection point P_p is considered as the center of base of the cone generated by the projector. However as the Fig. 6 shown, occlusion does not occur when the projection is projected overhead human body. In another word, occlusion area occurs at area under the human's height. The margin of occlusion area is estimated as following formula Eq. (1) where $R_1 < r < R_2$, $\theta_1<\theta<\theta_2$ shows the fan shape.

$$\begin{cases} R_1 = (M_Z - H_h)\cdot\tan(\phi+\alpha) \\ R_2 = r + R_P \\ \theta_1 = \theta - \alpha \\ \theta_2 = \theta + \alpha \end{cases} \tag{1}$$

Where M_z: the component of projector position, α: the projection diffusion angle of projector with the approximation $\alpha = \tan^{-1}(R_P / d)$, and d :a distance from projector to the projection point P.

And overlap judgement of human model on occlusion area is shown in Eq. (2). In Fig. 7, the figure of occlusion area and human model is shown.

$$\begin{cases} R_1 < r_h + R_h \\ r_h - R_h < R_2 \\ \theta_1 < \theta_h + \sin^{-1}(R_h / d) \\ \theta_h - \sin^{-1}(R_h / d) < \theta_2 \end{cases} \tag{2}$$

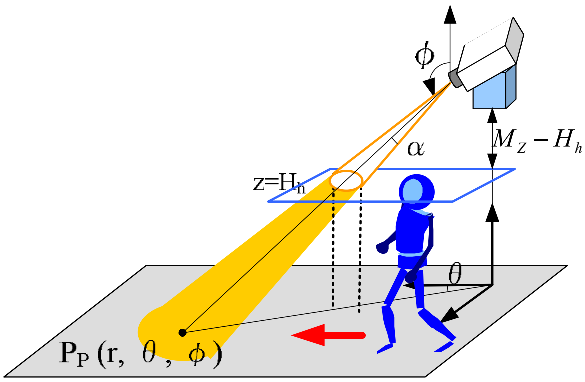


Fig. 6 Projection over head human body

4.2 Occlusion avoidance

Next, the method to avoid the occlusion will be described. Based on the direction that human enter into the occlusion area, the direction angle that human enter the occlusion area is detected. Human's side vision range is approximately 120 degrees but the awareness of side vision range is about 60 degrees [6]. However, in practice, human usually recognize awareness of side vision range after he entered into the awareness range, therefore the detection limit is set at 80 degrees.

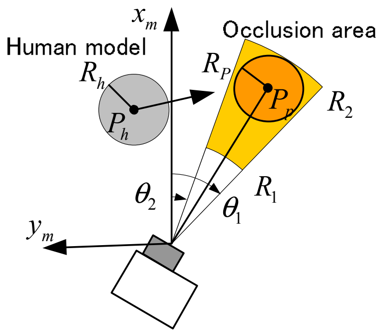


Fig. 7 Occlusion area and human model

When the limited angle is reached, the radius direction to the projection point is kept away to avoid the occlusion.

Fig. 8 shows the simulation result when front direction of the human is projected by a distance of 1 m. Human model's height H_h is 1.7m, radius is 0.25m, projection image radius R_p is 0.4m, and x direction at three different positions. Once occlusion avoidance is performed, occlusion does not occur at the left part of the figure but occurs at the other 2 areas. The angle should be detected as rapidly as possible. Next the radius avoidance is performed. The avoidance finished when angle is detected at the center part. In the right part of the figure, when the radius direction is detected, correct projection point can be generated. By following this procedure, the achievement of the occlusion detection and avoidance direction is confirmed.

Over more, not only human himself but also other objects such as chair and table cause occlusion problem, our proposed method can treat those objects as the human model and perform the occlusion avoidance algorithm.

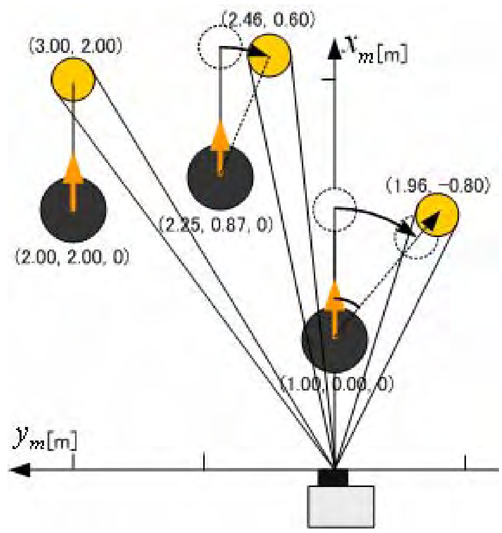
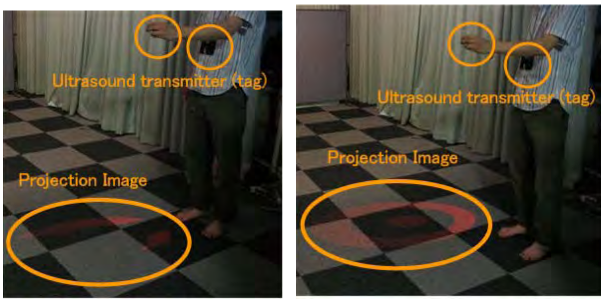


Fig. 8 Simulation of occlusion avoidance

5. EXPERIMENT

5.1 Confirmation of occlusion avoidance

In this chapter, occlusion avoidance based on the information display system is proved its validity by the experiment. The configuration of the system using RT-Components is shown in Fig. 3 on section 3.2. Two ultrasound transmitters (tags) are used, one is hanged over the human's neck and another one is held on the hand. Fig. 9 shows the system (a) without occlusion avoidance and (b) with occlusion avoidance. In (a) when occlusion avoidance is not activated, occlusion occurs and the system can not provide the correct information to user. In (b) when occlusion avoidance is activated, occlusion occurs and user can obtain the correct information.



(a) (b)

Fig. 9 The system (a) without occlusion avoidance and (b) with occlusion avoidance

5.2 Experimental result

As assumed scenario location, areas such as gallery or entrance hall, when user (guest) stop at a specific area, the projection system will provide the information based on human's position and direction, also occlusion avoidance information is included. In this experiment, we tested the system in five cases which each case the position and direction of human is different. In each case, the area one meter away from the front of human is projected. And there are some errors on ultrasound sensor. Swing of human and error of ultrasound sensor causes the error of measuring human's direction. Therefore, ultrasound transmitters are fixed on table instead of holding on the hand.

As shown in Fig. 10, the validity of the occlusion avoidance and correct projection is confirmed. The purpose of proposed method is occlusion avoidance by human, but the method can substitute other objects as the human model, and perform the occlusion avoidance algorithm. By expanding it, Occlusion avoidance to projection-enable area will be realized on various areas.

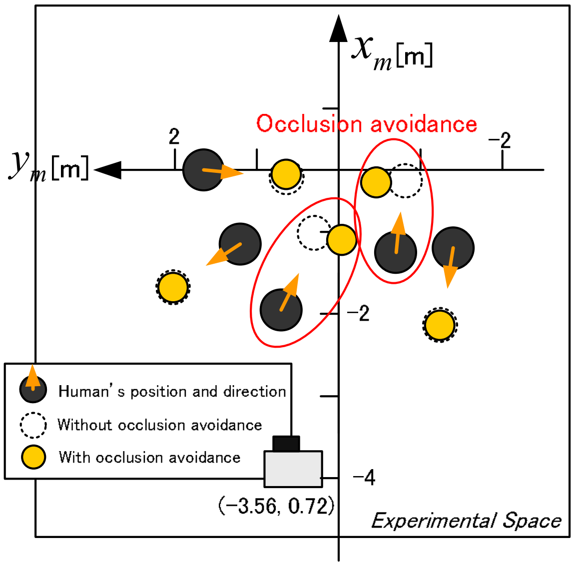


Fig. 10 Experimental result

5. CONCLUSION

This paper presents occlusion avoidance of information display system in the Intelligent Space. We proposed occlusion avoidance system by using RT-Components. As the experiment result is shown, although data is taken under the fixed condition, the system still operated well.

In future work, we plan to develop the projection image system. Concretely, occlusion avoidance is utilized to avoid the distortion of the image as well as improve the smoothness of the tracking projection by combining with this occlusion avoidance.

We also plan to detect the Human's movement speed and make a prediction for a better tracking walk guidance by creating new RT-Components and add to existed system.

REFERENCES

[1] J.-H. Lee and H. Hashimoto, "Intelligent Space – concept and contents", Advanced Robotics, Vol.16, No.3, pp.265-280, 2002.

[2] N Ando, T Suehiro, K Kitagaki, T Kotoku and W.-K. Yoon, "RT-Middleware: Distributed Co mponent Middleware for RT (Robot Technolog-y)", IROS2005, pp.3555-3560, 2005.

[3] B.Brumitt, B.Meyers, J.Krumm, A.Kern and S. Shafer, "EasyLiving: Technologies for Intelligen t Environments", Proc. of the Intl. Conf. on H andheld and Ubiquitous Computing, pp.12-27, 2 000.

[4] T. Mori, N. Hayama, H. Noguchi and T. Sato, "Informational Support in Distributed Sensor Environment Sensing Room", Proc. of the 2004 IEEE International Workshop on Robot and H uman Interactive Communication, pp.353-358, 2 004.

[5] Y. Toshima, Q. Wang, N Ando, T Suzuki and H Hashimoto, "Network based Display System for Intelligent Space", ROBOMEC2006, 2P1-E 19, 2006 (in Japanese).

[6] K. Noro, "Illustrated Ergonomics", JSA, 1990 (in Japanese).