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DEVELOPMENT OF SMART SHOWROOM

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ABSTRACT

We have been studying “Smart Robotics Building”. That is an idea of a building where robots can easily move and offer various services to us, using IT infrastructures around them. “Smart Showroom” is a part of “Smart Robotics Building”. In the showroom, a robot automatically gives us a grand tour around exhibitions. The system is composed of the following elements; a mobile robot, an area monitor server which detects people staying in predefined areas, a position server which detects robot positions with sensors on the ceiling, a navigation server which determines the robot routing and controls the robot to a destination, a service server which controls the robot voice and projector on the robot head, and a guidance client with which we can compose automatic guidance procedure. These servers and the client on the computers network are a distributed autonomous system. This paper shows the system and a result of a demonstration experiment.

KEYWORDS

Detecting Robot Position, Area Monitoring, Guidance Robot, Robotics Building

1. INTRODUCTION

In Japan, various kinds of service robots are required to resolve a serious problem of declining birthrate and aging society in our country. Major tasks of these service robots are helping human activities, carrying objects, and leading someone to destinations. Moving capability in living space will be one of the most important functions of all of these tasks. Installation of the moving systems including navigation, guidance, and control subsystems into a single mobile robot may not be the best solution to service operations of robots because such robots become too complicated and expensive. On the contrary, improvement of the surrounding infrastructures with IT equipments will be one of the practical ways to realize harmless and reliable robot services [1].

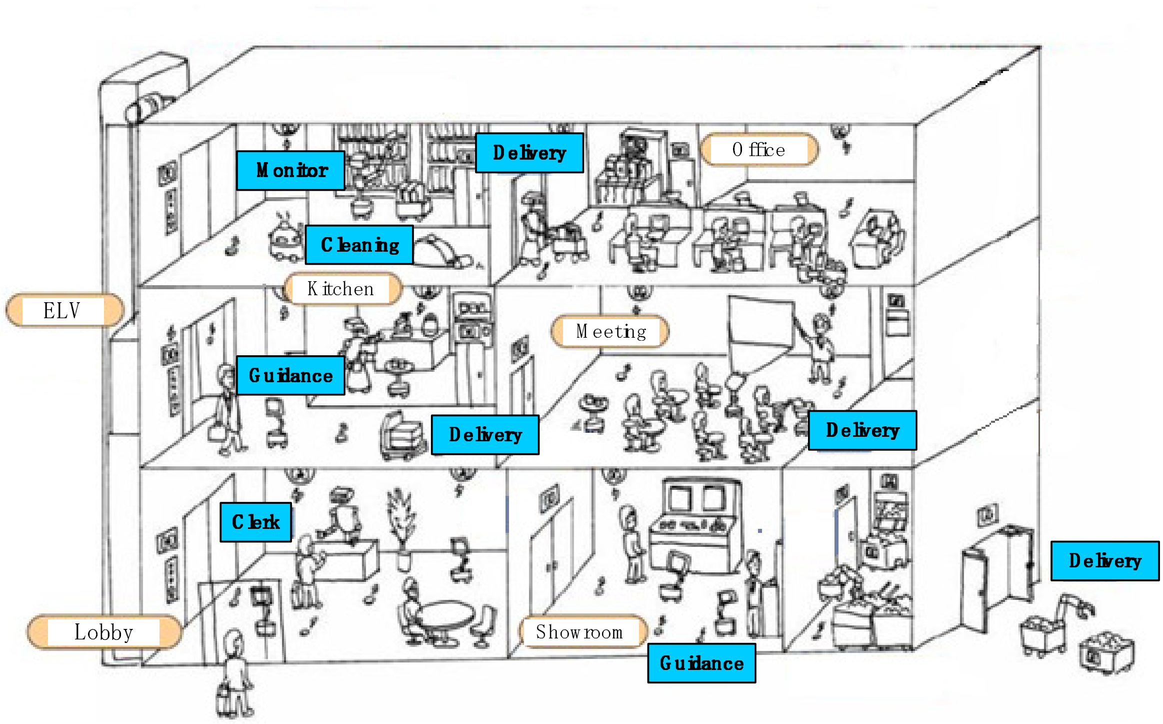

Figure 1.1. Smart Robotics Building

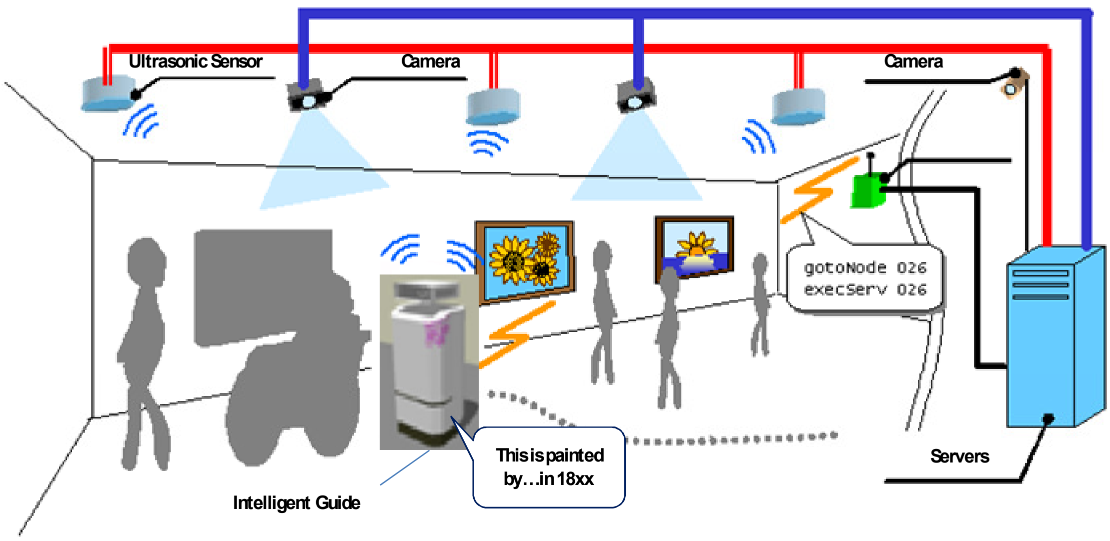

Figure 1.2. Smart Showroom

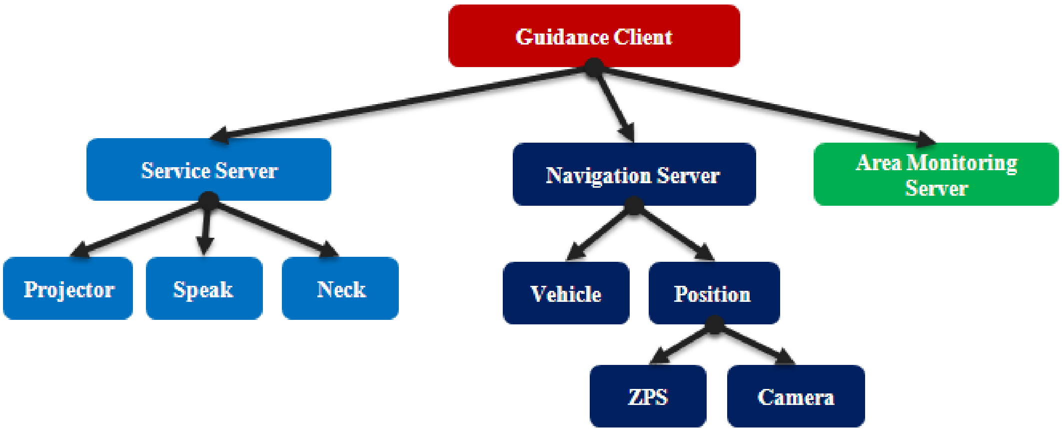

Figure 2.1. Smart Showroom Client-Servers

We have been studying "Smart Robotics Building" (Figure 1.1). That is an idea of a building where robots can easily move and offer various services to us, using IT infrastructures around them. For the first step, we developed "Smart Showroom" (Figure 1.2). That is a part of "Smart Robotics Building". In the showroom, a robot automatically gives us a grand tour around exhibition. This paper shows the developed Smart Showroom.

2. SMART SHOWROOM

2.1. Overview

When several people stay in the entrance of the showroom, a mobile robot approaches the people and starts guidance. The procedure of the guidance is written in a script file. The robot stops at an exhibition and explains it by voice or stops in front of a screen and show presentation with its voice.

On robot PCs and environment PCs, these functions are distributed. And these PCs are connected with TCP/IP network. (Figure 2.1)

2.2. Intelligent Guide

Table 2.1 shows a specification of the guidance robot. And Figure 2.2 shows an appearance. The following are several particular features of the robot.

– The movement mechanism is an omnidirectional wheel.

– A projector is on the robot neck with two degree-of-freedom.

– The robot speaks in accordance with ASCII characters strings.

– The computers on the robot are connected to wireless TCP/IP network.

– Two ultrasonic tags and a mark for detecting position are put on its head (Figure 2.4).

Table 2.1. Specification

Item	Specification
Height	1100mm
Width	500mm
Length	570mm
Weight	80kg
D.O.F	5-axes
Velocity	max3.6km/h
Sensors	Range Sensor×1
I/F	Voice Synthesis Projector
Communication	Wireless LAN(IEEE802.11g)
Running Time	1hours (Running Continuously)

2.3. Guidance Client

We write the procedures of commands to service server, navigation server and area monitoring server in a script. According to the script, the Guidance Client sends commands to those servers in series.

2.4. Service Server

According to a command sent from the Guidance Client, Service Server controls the robot voice, the projector on the robot or the robot's neck axes.

Figure 2.2. Intelligent Guide

2.5. Navigation Server

According to a command sent from the Guidance Client, the server navigates the robot to a specified location. The server requests Position Server for the robot's current location. According to the current location and the specified location, the server selects a path. In line with the path, the server sends the vehicle server the commands "go straight" or "turn" commands to the vehicle server. Two controlling methods are applied. One is a feedback control. With this method, the Navigation Server gets a location of the robot in real time and corrects the moving direction continuously. The other is an open loop control. With that one, at each node of the path, Navigation Server gets a current robot location, calculates a distance and direction to the next node and sends a command for the distance and rotation.

2.6. Position Server

Several cameras and ultrasonic receivers are put on the ceiling of the showroom. These cameras and receivers monitor a mark and tags on the robot from the ceiling consistently. (Figures 2.3–2.6)

For detecting robot position, we used a ZPS, Zone Positioning System, made by Furukawa corporation [2]. A controller of the ZPS sends the tags on the robot a command of sounding an ultrasonic sound. The receiver counts the interval between the time sending a command and the time listening to the sound and calculates the distance from tag to each receiver. We know the relational position of each receiver, then we can determine the position of the tag. From the difference of the positions of two tags on the robot, we can calculate the robot position and direction.

Sounds reflection on walls or columns and electromagnetic disturbance make the measurement with the ZPS unstable. Several cameras are put on several parts of the room where the measurement with the ZPS is unstable or the robot needs to move exactly. Using image processing, the mark on the robot is matched with an edge pattern model, and the position and direction of the robot is detected. In order to narrow the range of searching the mark image, the tag position detected with the ZPS is used, and the response time of finding the mark and the miss matching are decreasing.

Figure 2.3. Ultra Sonic Receiver

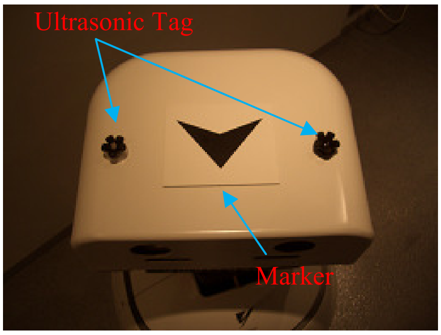

Figure 2.4. Ultrasonic Tag and Mark

Figure 2.5. Camera

Figure 2.6. Captured Image

2.7. Area Monitoring Server

Several wide angle cameras are put on the ceiling. At first, we determine the area of people staying in the camera image and the length of time that we consider as people staying. The cameras consistently detect people staying in the areas (Figure 2.7).

Figure 2.7. Captured Image

3. DEMONSTRATION

3.1. Showroom

We had a demonstration experiment at a showroom (Figure 3.1). The area of the robot movement is approximately 90[m^2]. In order to cover the area, we allocated 16 ZPS receivers and 10 cameras on the ceiling. The ceiling is approximately 3[m] high. The room has blinds that cut off all outside light. The light condition is stable in the room. Several exhibitions are arranged around the room and an open space around the center.

3.2. Area of Detecting Position

8 cameras detecting robot's position are allocated on the ceiling. In the green shaded areas, we can detect the mark on robot by the cameras. In the orange shaded areas, we can detect the ultrasonic tags on the robot by the ZPS. These two areas are complementary allocated. Several chairs are arranged in order to watch a presentation. In this area robot has to move exactly. At P4 the robot run a presentation with the projector. Around P4, several chairs are arranged. Above there the cameras are allocated in order to move the robot exactly.

3.3. Guidance Procedure

P0->P1: Detecting more than three people staying, the robot goes P0 to P1 and says welcome messages.

P1->P4: The robot goes to P4 via P2 and P3, and runes projector and makes a presentation.

P4->P5: The robot goes to P5 and explains a exhibition.

P5->... : Sequentially the robot goes to next node and explains a exhibition.

P9->P10: The robot goes to final node and says goodbye messages.

P10->P0: The robot goes back to initial node.

In order to run these procedures, we edit a script file.

3.4. Results of Detecting Position

In some areas, reflection of the sound or absorption of the sound were occurred and detecting the position with the ZPS was unstable. The sampling rate of the ZPS detecting position was 90[msec] and that of Camera detecting position was 200[msec]. We observed detecting disturbance in the ZPS detecting position. Then we applied a digital low pass filter to the output data.

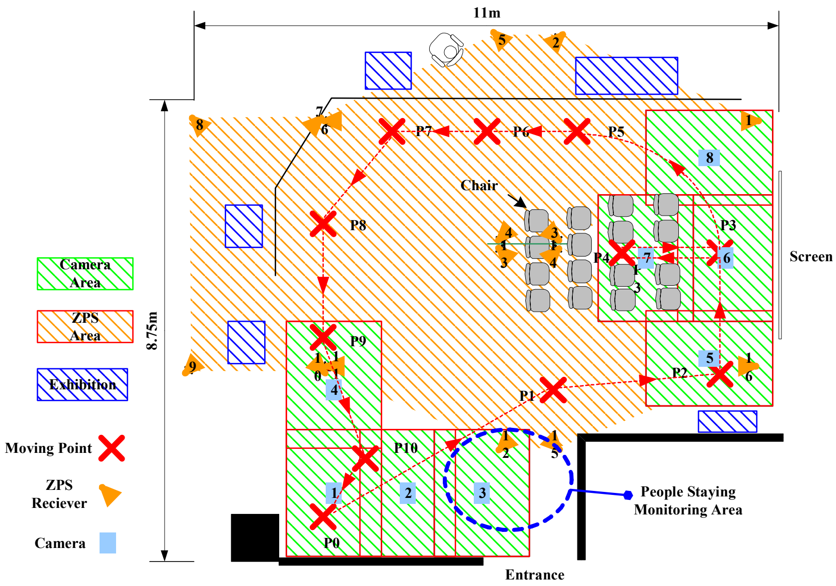

Figure 3.1. Showroom

3.5. Results of Controlling Robot

We conducted the robot' s locomotion control at a speed of 200[mm/sec] by the feedback control through P2→P3→P4 and P4→P3→P5 routes. There were few problems, however the movement of the robot ceased when communications system was not well. In the area where we used the ZPS, in order to obtain stable measurements, the robot stays for a second at each node. Next, we detected direction and distance to the next node and used one move command for one movement, which is called open roof control. The speed of the movement was 500 [mm/sec].

3.6. Summery

This time, we tried to detect the robot's position from the building and move the robot using the direct locomotion control through wireless LAN also from the building. Though there were some instability concerning to the robot's position detection, we were able to make the robot go along the predetermined route, show exhibits, and give presentation by devising control technique.

4. CONCLUSION

As part of the study of "Smart Robotics Building", we have worked on the development of "Smart Showroom". We have succeeded in demonstration the robot showed us around the showroom automatically by integrating three functions of the robots as a system; a function for detecting people's staying, a function for speaking and explaining by running a projector, and a function for detecting her own position and moving to the destination automatically. There are some problems to be resolved as to stability and velocity of locomotion control from the robot's positioning detection and environment through wireless LAN. We will continue to address these problems. Furthermore, we have planned to build Smart Robotics Building by expanding the technology of the "Smart Showroom" to "Smart Delivery System" in the building.

REFERENCES

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[2] URL Zone Positioning System, Furukawa Co. http://www.furukawakk.jp/products/ZPS_1.ht