Design of Location Management Module and Environment Server for Constructing of Intelligent Environment Space

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Abstract – In this paper, we propose location information service model of objects on the intelligent environment space. To achieve this, we design location management module for registering location information and environment server for providing location information. In addition, the specification of location information and the process of protocol for service providing is also defined. Finally, we test the designed system in a real environment which has many sensors such as RFID or Camera for registering location. The results of this study show that the proposed system can manage the location information of objects in real-time.

Keywords – Intelligent Environment Space, Location Management Module, Environment Server

1. Introduction

In the current robot system, it is difficult to conduct the desired work in the different environmental condition. For the practical use of the robot system, we must solve the problem about this issue. To accomplish the robot system which can manage work safely and certainly in the various environmental condition, the intelligent work modules[1] such as work planning module, interaction intelligent module, manipulation intelligent module, intelligent environment module and so on which are robust for the environment have been developed in Next Generation Robot Project[2]. Among these intelligent work modules, discussion in this paper will center around developing intelligent environment module for the service of the location information of the objects.

In an intelligent environment, for the robot to function robustly, it is important to know about the location information of the objects in the environment. To achieve this, we are developing the location management module and environment server for providing information on the location of objects such as humans and robots existing in the environment.

In this paper, we suggest the framework for the service of the location information, the communication protocol, the method of expressing information and constructing database to provide the location information effectively. Also, we define the procedure of using location information and the registration of constructed database. Also, this model is constructed in the real environment to verify the availability of the system.

2. System Structure

2.1 Overall Composition

The total system for location service is composed of the location management module and the environment server. The location management module takes charge of the registration of the location information and environment server takes charge of the providing the location information. A user can access the location information by designed common API(Application Program Interface) library for C or Java language. All communication processes are encapsulated in API. By this API, the registration and use of the object's location information is not only referred to the user but also to other the intelligent work modules. Figure 1. shows that overall system structure.

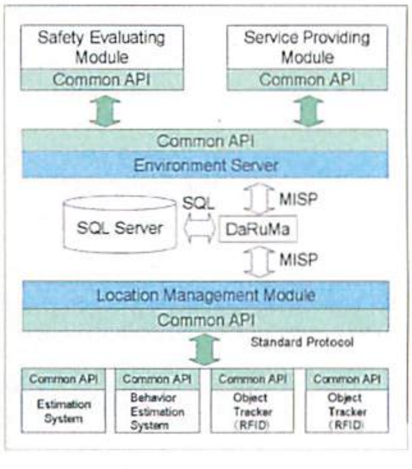

Figure 1. Overall system structure

In this system, the location management module and the environment server adopt DaRuMa(DAtabase for Rescue Utility MAnagement)[3,4] which was developed by AIST(Advanced Industrial Science and Technology) and NIED(National Research Institute for Earth Science and Disaster Prevention) in Japan for database server. The adopted DaRuMa is appropriate for database server in suggested system because it has flexible and extendable communication structure, DaRuMa/MISP(Mitigation Information Sharing Protocol) [5], for data storage and query which is based on XML. The communication messages from API for the location information are translated to DaRuMa/MISP in the location management module and the environment server in real-time.

2.2 Location Management Module

The location management module registers the location information from a robot with various sensors such as RF tag R/W and image sensor to the database. To describe location information properly, the expression of the coordination value of the location must be defined. Also, to describe not only the coordination value but existence of the object in a area, we can consider define coordination value as the existence flag in some coordination system. In addition, we put the time stamp to the location information for expressing the location of a movable object in real-time. Table 1. presents the specifications of the registration information. The history of transition on the object's ID and coordinates information is recorded by the registering objects on a time base. We can monitor that Plate A moves from outside of Hall to inside, and then moves to some table named Table01, and finally locates at coordinate value (10, 20, 0) in the local coordination system of the hall.

Registration Time	Object ID	Coordinates System	Coordinate Value
10:00:00	Plate A	inHall	0(outside)
10:08:12	Plate A	inHall	1(inside)
10:33:57	Plate A	inTable01	1(inside)
10:35:41	Plate A	inHall	(10,20,0)
...	...	...	...

Table 1. Location lists by location management schema

In this sense, Figure 2. shows the example of coordinate system. For expansibility, the relation of coordinate system is described assuming information of object's existence as coordinate value in a coordinate system. Moreover, this is also applied in local coordinate system. Based on using the real-time system, the objects for location management were classified as dynamic objects and static objects and the schema was designed for the standard protocol.

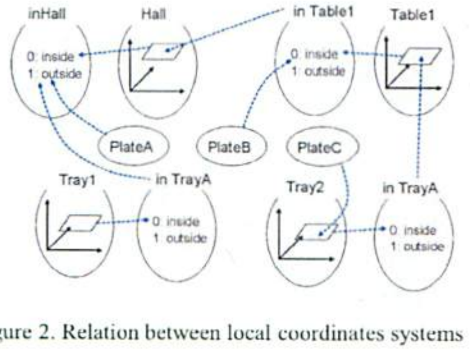

Figure 2. Relation between local coordinates systems

Figure 3. presents the flow of the registering the location information. The user can register the location information by designed API to database. The registration message from the user is sent to the location management module. The location module converts the communication message to XML based on location management schema which is derived from DaRuMa/MISP and sends to DaRuMa for registering database system.

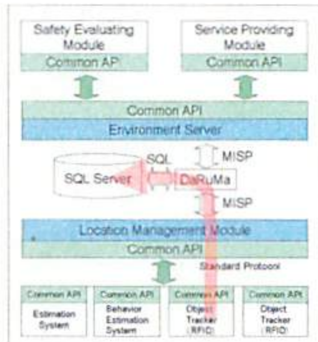

Figure 3. Flow of registering the location information

Figure 4. shows the example of XML code for registering the location information based on location management schema. The request of registering location of tray01 is conducted between the location management module and the DaRuMa.

```
<misp:Transaction xmlns:misp="http://www.infosharp.org/misp">
 <misp:Insert>

   <time>2008-02-28T15:00:00+09:00</time>
   <objectID>tray01</objectID>
   <location>
       <gml:Point srsName="#la-la-port-dining-shop01">
        <gml:coordinates>-1.8,+0.8</gml:coordinates>
       </gml:Point>
   </location>
   <locationNoise>
       <gml:Point srsName="urn:IntelliRobotProject:Noise">
        <gml:coordinates>0,0</gml:coordinates>
       </gml:Point>
   </locationNoise>

 </misp:Insert>
</misp:Transaction>
```

Figure 4. XML code for registering the location information

Also, to consider of the deviation of the location information, user can insert noise parameter into the communication message. This can helps to guarantee the safety margin in the robot system.

2.3 Environment Server

The environment server receives the location information request from the user, safety evaluating module and service providing module to provide the location information from database. We suggest the structured interface which is combined to a common API of the location management module. Like as the location management module, the environment server also communicates by XML based on location management schema.

Figure 5. shows the flow of the providing the location information. The user can request the location information

by designed API to the environment server. The request message from the user is sent to the environment server. The environment server converts the communication message to XML for inquiring the location information to database system. After that, the environment server receives the result from database system and sends that result to the designated user which requested the location information.

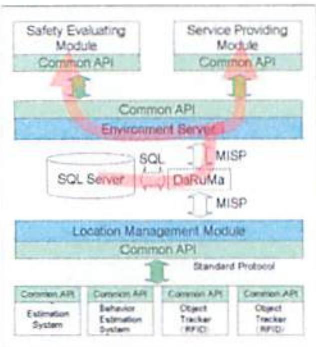

Figure 5. Flow of providing the location information

Figure 6. presents the example of XML code for providing the location information based on location management schema. The request of obtaining the location of trayA is conducted between the environment server and the DaRuMa.

```
<GetFeature xmlns="http://www.infosharp.org/misp"
    xmlns:gml="http://www.opengis.net/gml"
    xmlns:foo="http://...">
        <Query typeName="ObjectInfo">
            <Filter>
            <misp:PropertyIsEqualTo>
                <misp:PropertyName>objectID</misp:PropertyName>
                <misp:Literal>trayA</misp:Literal>
            </misp:PropertyIsEqualTo>
            </Filter>
        </Query>
</GetFeature>
```

Figure 6. XML code for providing the location information

Although the Pull-type method is a basic function for the obtaining of information, the Push-type method is also available when it is on the linked module condition. The Pull-type method for communication is based on the request of the information. The Pull-type method is used to normal operation such as occasional information query. However, periodic or mass queries of the information need the push-type method.

Especially, in the case of safety evaluation module, we designed the communication method which can be changed into the Push-type method for guaranteeing real-time.

3. Experiment

To verify the availability of the designed system, a demonstration was tested assuming that table clean up is made in a commercial facility. With this demonstration, we could verify the function of each module by testing the registering and obtaining the object's location information.

3.1 Experimental Condition

Each module was constructed on a lap-top computer. For the visual expression of location information, DaRuMa Earth[6] was adopted and tested. DaRuMa Earth is the client program for displaying of the registered location of the objects which is also developed by AIST and NIED for the monitoring of the DaRuMa system. We used the RFID system for sensing the location of the object. MySQL and JVM were also installed for the DaRuMa on Windows XP of the lap-top computer. The location management module and the environment server were located on the lap-top computer. Table 2. shows detailed test environment.

Item	Contents	Spec.	Etc
System H/W	Note PC	Intel U2400 1.06GHz 1.5GB RAM	
O/S	Windows XP	SE Service Pack 3	
Database Server	DaRuMa	Ver.2007-12	MySQL5.0 JVM5.1
Display S/W	DaRuMa-Earth	Ver.20071204	
Sensor	RFID R/W	Passive Type 13.56MHz	

Table 2. Test equipments and specifications

3.2 Demonstration Scenario

We assumed that the demonstration environment was the LaLaport in Kashiwa-shi Chiba-ken Japan. Thus, the map of the food court in the LaLlaport was modeled and embedded in DaRuMa Earth. After a user placed an order, the movement of the dish's location was tracked by sensors and was registered to the location management module. From the procedure above, we could verify the function of the system. RFID was used to recognize the ID of the dish. The RF Tag was assigned to each dish for distinction and the RF Tag R/W was installed in counter, table, and return dish tray of the store. Figure 7. presents the demonstration scenario mentioned above.

Figure 7. Demonstration scenario

3.3 Function Test

In the demonstration, the registration of the location information was conducted when the dish was on the order desk and on the table. Each step, the installed sensing module which has RF R/W tried to communicate with the location management module by designed API for registering location. We could verify the registration of location by receiving return message from the DaRuMa. The result of transient dish's location was also displayed like as shown in Figure 8.. Even though there was some display delay for monitoring caused by DaRuMa Earth, we could confirm the location information by each step in real-time with checking location lists like as Table 1. which was made by the location management server. We could findout the registration time, the coordinate system and the coordinate value in the location lists.

Figure 8. Demonstration screen of tracking the location of object

4. Conclusion

In this paper, we suggested the location management module and the environment server for the registering and providing the object's location for service in the intelligent environment. In addition, we designed the method of interaction with database, the communication protocol, coordinates system and the expression of object's location information.

For the future works, we would guarantee the safety of the system by an interface test with other modules in the intelligent environment project and concentrate on conversion method of coordination system and real-time tracking the location of moving objects. Also, the designed system would be made to embedded modules for miniaturization and to RT M/W components supporting the RLS(Robotic Localization Service)[7] standards for the system flexibility.

Acknowledgements

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