Knowledge Management Framework for the Knowledge Distributed Robot System

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ABSTRACT

We propose the novel concept of the "Knowledge Distributed Robot System" for the autonomous robot operation in the complex environments such as a restaurant and office. Knowledge is distributed to the object itself and the database by using the radio frequency identification (RFID) tag and computer network. RFID tag is used as a mediator of the knowledge between the robot and the object. As a result, robot can autonomously manipulate the target object using the distributed knowledge. To verify the effectiveness of the proposed method, we constructed the experimental system. This knowledge distributed robot system and decentralization method of knowledge are introduced in this paper. The integrated knowledge management system for the collection and analysis of the distributed knowledge is also presented.

Keywords: knowledge distribution, robot system, knowledge management, RFID tags, Omniscient Organizer.

INTRODUCTION

Recently, we expect that the autonomous robot can work not only in the factory but the complex environment such as a restaurant and office. However, robots are still not common in these environments.

In the conventional research, "model based method" was generally used in the limited environment like a factory [1]. Some research showed that robot can navigate using the geometric model such as walls and doors [2]. But we are faced with a few difficulties in the complex environment. The reasons can be explained as follows:

1) It is difficult for a robot to acquire complex environmental information autonomously.
2) It is impossible to make all of models using the model based method in the complex environment.
3) It is difficult for the end user to make the model of the object whenever new objects come into being in the real environment.

To solve these problems, we used robot system based on RFID tag firstly [3]. And we proposed the "Knowledge Distributed Robot System" [4]. In the proposed environment, knowledge is distributed to the object itself and the database by using the RFID tag and computer network. Similar method was also proposed in the computer vision research which focuses on 3-D scene analysis using a machine vision system [5]. Figure 1 shows the proposed framework for our proposed method. Manufacturers share the object modeling data and operating knowledge for the robot manipulation as shown in this figure. Then, we will be able to solve these problems using the shared knowledge. Using the RFID tags, robot can easily coll-

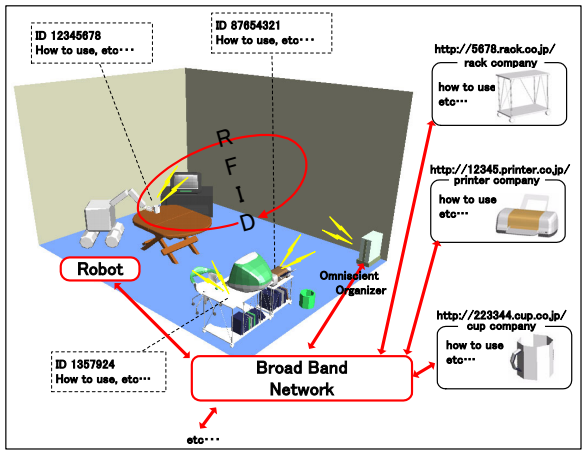


Figure 1. Proposed framework for the knowledge distributed robot system.

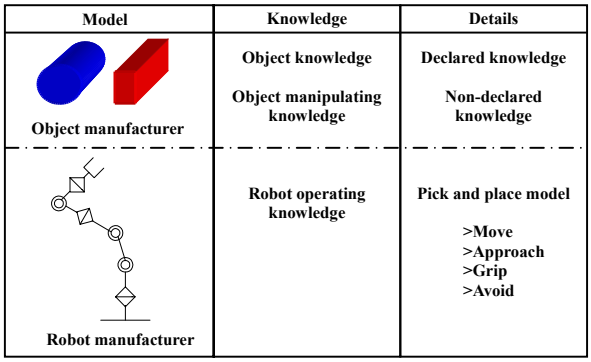


Figure 2. Knowledge for the object manipulation

ect the information about the environment and the object. The end user has no need to input the object model information into the robot controller. We can design the robot software more efficiently by dividing the knowledge for the robot system and the object. Therefore, in this paper, we present how to distribute and acquire knowledge, and introduce the integrated management system which can integrate and manage the distributed knowledge. Finally, the effectiveness of the proposed method is verified through experiments.

OBJECT MANIPULATION KNOWLEDGE

Knowledge Division for Object Manipulation

We made knowledge database for object manipulation. Figure 2 shows the structure of this knowledge database. From this point of view, the knowledge can be divided into two parts. One is for the object and another is for the robot. The knowledge for the object also can be divided into two parts. One is the knowledge of the object itself such as shape, weight, width, depth. And another is for the object manipulation knowledge. One example of the object manipulation knowledge is how to grip the target cup's handle and how to carry it parallel to the floor. One example of knowledge for the robot is such as pick and place algorithm. As a result, knowledge division makes it possible for a robot to manipulate the target object without a highly developed planning function.

Manufacturer's and User's Knowledge

Table 1 shows the example of the knowledge, which is shared with object manufactures, robot manufactures, and robot users.
One of the Knowledge on the robot side is a low level motion library like a point to point, a kind of end effecter and workspace. And the manufacturer offers

Table 1. Example of the distributed knowledge.

Manufacturer		User
Robot	Object	
Type of robot	Product name	Task
End-effecter	object model	
Shutting limit	Physical information	
margin of weight	Holding position and posture	
Motion library	Holding method	

the declared knowledge. Even if the robot system is different, knowledge of the object side is still useful.
As a result, robot can move autonomously based on the knowledge offered by manufacturer and user.
In the experiment, robot system performs common tasks such as clearing the table after dinner. To manipulate the target object, robot system uses the knowledge of the object manufacturer. Figure 3 shows the task of clearing the table based on manufacturer's and user's knowledge.

DISTRIBUTION AND ACQUIREMENT OF KNOWLEDGE

A few research results of the object oriented robot manipulation system have been published. The QR code based approach is a good example [6]. The robot manipulates the object by reading the handling knowledge written in the QR code. The model enhanced intelligent and skillful teleoperational robot system (MEISTER) is also a good example [7]. MEISTER makes it possible to describe the knowledge structure by general handling model and specified models. In this section, we consider the distribution and acquirement of knowledge based on these researches.

The Problem of Knowledge Distribution

Knowledge is not invariable and it can be changed if necessary. For example, the distributed knowledge for the object can be updated if a better handling method is found. In the proposed method, the knowledge is distributed on each object and computer network. The problem of the knowledge distribution is as follows:

1) How can we distribute knowledge to each object and database?
2) If the knowledge embedded in each object is change, how can we update the distributed knowledge of the RFID tag data?
3) Because the operating knowledge is different in ea-

Figure 3. The task of clearing the table based on manufacturer's and user's knowledge.

ch object, how can we describe the knowledge in general form?

We consider these problems in the knowledge structure.

Knowledge Structure

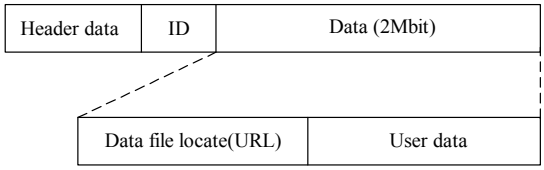
Figure 4 shows the knowledge structure of the proposed method, which is composed of the knowledge database on the computer network and URL information written in RFID tag. RFID tag also has the area for the original user's information. Therefore, the proposed knowledge structure has the following advantages:

1) Thanks to the URL, the knowledge can be directly collected from the database.

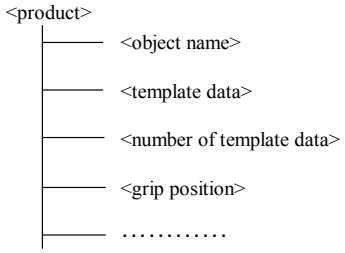
2) The object handling algorithm can be easily updated through the knowledge database which exists on the computer network. This increases all the more the effectiveness of the knowledge distribution and management.

3) In addition to the URL information only for the object handling, more information can be saved in the RFID according to the end user's liking.

Moreover, the proposed method uses XML for the description of the database. This makes it possible to structurize the physical and knowledge data. The XML database is extensible, exchangeable, and enables explanation of the data by itself.



(a) RFID TAG data structure



(b) Database structure using XML

Figure 4. Data structure.

INTEGRATED MANAGEMENT SYSTEM

Our experiment system is composed of the TAG system for object recognition, the vision system for object localization, the robot system for object handling, the web server for database, and the integrated management system. These systems are connected to each other through the computer network.

In this structure, the roles of the integrated management system are to collect and analyze the distributed knowledge and environmental information, and also to manage the flow of the information. Figure 5 shows the flow of the information in the integrated management system. We call this "Omniscient Organizer" (OO), which is constructed by EusLisp [8]. EusLisp is an object oriented Lisp language for the development of robot software.

The flow of information management in OO is as follows:

1) The user orders the task of clearing the table to OO.

2) The TAG system reads all knowledge of RFID tag on the table. (The table is equipped with a set of RFID reader/writer.)

3) RFID tag offers ID, URL and user information of the target object.

4), 5) Then, OO downloads necessary knowledge from the database.

6) OO sends this model and ID to the vision system and asks the information about the position of the obj-

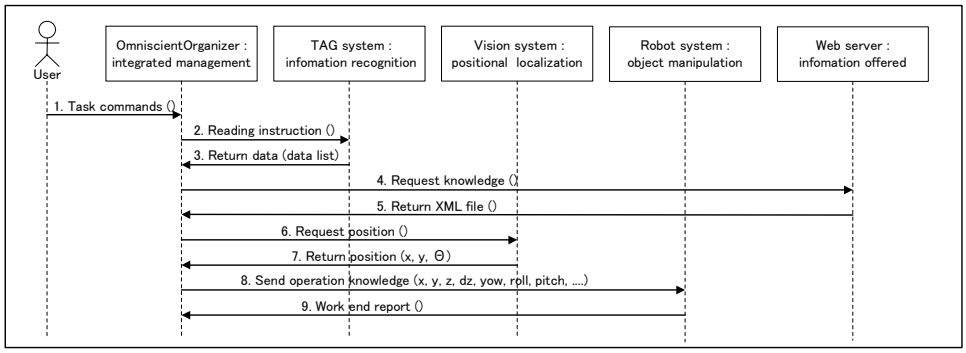


Figure 5. Command sequence of Omniscient Organizer.

ect to the vision system.

7) The vision system returns position information.

8) OO sends ID, operation knowledge, position information and user information to the robot system. The robot system converts this knowledge into command such as "move", "approach" and "grip" and operates the object using the pick-and-place algorithm.

9) The robot system reports the work end to OO.

10) The 2)-9) is carried out repetitively until the table is cleared.

The knowledge once downloaded from the web server is saved in OO as cash data. URL information is checked before accessing Web server. We improve the efficiency of the entire operation by this work. Moreover, by comparing ID, OO can know the grasped object and do the best handling even if it is impossible to distinguish by vision system.

CONCLUSION

In this paper, the knowledge distributed robot system which makes it possible to work in the complex environment was presented. We examined the object manipulation knowledge, and proposed distributed knowledge structure using RFID tag and XML for the description of the database. By using proposed knowledge structure, we also constructed the system which integrates and manages the distributed knowledge, which is essential in the proposed method. Through experiment, we verified distribution method and the acquirement method of knowledge for the robot operation and showed that the robot can operate the object easily using the integrated knowledge.

FUTURE WORK

In the experiment, target object was simple model. Therefore, the robot can be operated by the simple knowledge like handling position. In the next system, we will use the object manipulation knowledge in the experimental system for the generality of the task.

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