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Agent Mobility in Human Robot Interaction

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Abstract - In network human-robot interaction, human can access services of a robot system through the network The communication is done by interacting with the distributed sensors via voice, gestures or by using user network access device such as computer, PDA. The service organization and exploration is very important for this distributed system. In this paper we propose a new agent-based framework to integrate partners of this distributed system together and help users to explore the service effectively without complicated configuration. Our system consists of several robots, users and distributed sensors. These partners are connected in a decentralized but centralized control system using agent-based technology. Several experiments are conducted successfully using our framework The experiments show that this framework is good in term of increasing the availability of the system, reducing the time users and robots needs to connect to the network at the same time. The framework also provides some coordination methods for the human robot interaction system.

Keywords: Agent, HRI, mobile robots.

1. Introduction

Robots exist in the real world, sense the world through their sensors, and act correspondently. At the same time, these robotic agents exist in the cyber world, get requests from users or other robotic agents, interact with users, other robotic agents or with environment and cooperate when necessary. To successful cooperation among different partners, our system should be simple, fast and robust in wireless environment. It therefore should support knowledge level communication among agents to reduce communication burden. Abstract all partners in the system as agents, we canexplore the knowledge level communication and the coordination methods in agent technology. To create a system like that we should solve some problems. Firstly, we should agentify program for each partners. Secondly, we should make a framework where these agents can discover and interact with the others. A framework like that takes into account the special characters of each agent type and support the way to interact among them. In our approach, we use the multi-agent platform as the core. Then we classify the behaviors and services of each agent. With each type, we provide a corresponding coordination method. Agents will discover the other agent or service types via agent or service description and apply the corresponding cooperation protocol.

2. Related work

2.1 Software agent coordination

Agent coordination is an important topic in multi-agent fields. In [1], they classify the coordination in software agent into: Organizational structuring, contracting, multi-agent planning and negotiation approaches. Some researches try to use these approaches to solve multi-robot cooperation problem such as in [2], where an auction-based technique is used.

2.2 Service discovery and exploration

Service discovery methods may be categorized into non agent-based approach and agent-based approach. There are some common non-agent based protocols such as JINI [3]. Jini uses a centralized scheme where all types of services are registered to a lookup service. Users contact the lookup service to discover existing services. In the agent-based approach, in FIPA [4], service discovery is provided by a special agent in an agent platform (AP). Each agent can register to one AP or more. In this AP, there is a special agent named Directory Facilitator (DF). DF works as a center to collect service information of each agent.

2.3 Responsive environment and its application in dynamic path planning and localization

Turning an environment into a responsive environment by installing sensors around the environment is one approach that used in some human tracking systems. In [5], the camera array is installed around the workspace and it is used for human movement tracking. In our implementation, we try to combine the environment sensor and local sensor information by exploring a multi-agent architecture. Usingthis environment we can improve the probabilistic localization method such as Markov localization described in [6] by using an idea similar to [7] in view of combining external sensors and local sensors.

3. Proposed framework

3.1 Overall Framework

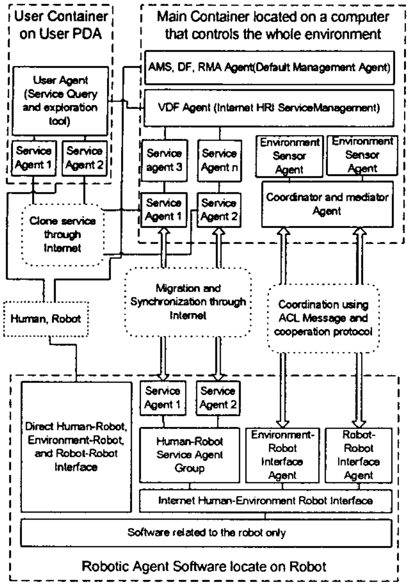

Figure 1. Overall framework

In our approach, multi-agent framework is used to control the interaction among robots, human and environment. The responsive environment is created with a main container and some environment agents that allow it to respond to the change in the environment. This environment interacts with the users even as robotic agents are offline. Users access to the system via a User Agent (UA) located on their PDA. On the PDA, there is no information about the robots. UA will query and get the available services from the main container and get a clone version of services or interact with the services via ACL communication. One problem is the offline situation, when a robot are temporally out of control due to battery charging, location changing or suffering from communication problems. It requires a lot of time to find when a robot is online to control it. We solve this using the slave service agent as in part B For the Internet-based environment-robot interface, the coordination is done by discovering services required by each agent, following a cooperation protocol and using the ACL message to transfer the required information. We solve it in part C We select FIPA standard to implement the system.

3.2 Human Robot Interaction using slave agent and Virtual Directory Facilitator VDF :

In our framework, we separate the implementation part and the interface part of a service so that we can move the interface part around the network by migrating and cloning. Each robot appears in the system as an agent. Each time this agent registers to the AP, it will create its service slave agents. Using the mobility feature of the AP, slave agents migrate to locate on the main container. It is created at the time the robotic agents appear in the system and remains after a period of time that specifies by the robotic agents. The slave agents collect information when the robotic agents are offline, get the requirement or interact with users and other robotic agents. Then the slave agents synchronize with the robotic agent when it is online. To control such a slave agent groups, we create a special agent in the agent platform. This is VDF agent. VDF is responsible for synchronizing the slave agent and robotic agent. On the user's PDA, the UA is located. The UA simply works as a service query and display tool. UA can query all the services currently existed on a system and then select the service user wants to use. After a service is selected, VDF will clone a copy of the service interface, move it to the container in PDA. User interacts with the interface, and then all data will be synchronized among interface agent. Instead of only giving the name of service, the real interface of the services is given. Users can save time because they can access the system at any time, works with the interface they finds in the VDF and explores this service by invoking the interface.

3.3 Robot Environment interaction using a mediator agent and responsive environment:

By installing sensor around the workspace, connecting these sensors by a multi-agent platform, the environment information can be provided. Using this information the responsive environment can discover or change the behavior of a robot. From that, we would like to propose a complete intelligent environment framework, where environment play a more active role. It provides services, information, and even controlling algorithm. Normally, it is hard for robots to work and cooperate in an unknown environment because it does not know the changing in the environment beyond its sensors' range and the existence of the other robotic agents. This multi-agent system helps to overcome all these problems.

4. Implementation result

4.1 Robotic agents and service discovery testing

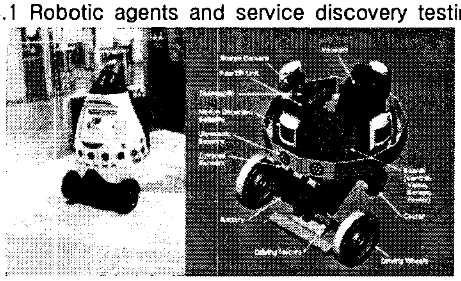

Figure 2. Issac Robot

We do the experiments on our robotic agent Issac. ISSAC, which stands for Intelligent, Sweeping Security Assistant companion, is a mobile robot developed at the our center. Users can customize a lot of Issac's features including move speed, turn speed, camera speed, vacuum position and working mode. The first service to be evaluated is the property-customized service. That type of service is different from a robot to robot because each robot has its own features. In the experiments, we select four options to customize. The working mode option is used to select the working mode of Issac. Issac has three working modes: Man following, wall following and manual mode. The second service to test is the cleaning service. Many users want to use this cleaning service at any time. If we use the conventional system, to make the high availability of the system to all users, Issac should have a permanent wireless connection.

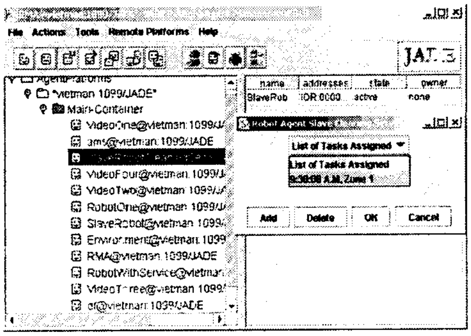

Figure 3. Cleaning service graphical interface

4.2 User interface agent UA

Different from a client on one conventional robotic system, our multi-agent framework uses a special UA. This UA does not have any particular information about robot or environment. However, this UA can search for the existing VDF, query the VDF on available services, clone the necessary service interface from the main container and run the interface on the user PDA. After register to the AP, UA can check the VDF. VDF contains the services of robotic agents that are currently online and offline.

4.3 Results

After evaluating the conventional system and the multi-agent system, we find some initial results that show the advantages of the proposal. The following tables show the main differences with the conventional system. The comparison also shows some unique features of the system such as the environment awareness feature and the ability to work directly with the services of some robots when they are offline by interacting with their slave agent.

Table 1. Comparison with Conventional system

Properties	Conventional tele-robotic control system	Multi agent environment with VDF and slave agent
Manual control	Yes	Yes (Using direct agent communication)
Offline scheduler	Yes (Use a server as the mediator)	Yes (depend on the VDF, Slave Agent)
Offline service interface	No (Service interface is defined on the server)	Yes (Users work with the service interface through slave agent)
Audio/video information	Yes (using Java Media Framework)	Possible (However, streaming data in FIPA is not standard)
Environment awareness	No (Robot should store all system information)	Yes (Robot interface with the system via Agent Platform)
Requirement of network access	Long time, Permanent	Short time, not necessary continuously

5. Conclusion

The interaction framework with a responsive environment and a service management system is a promising idea for autonomous robot working long-term in dynamic environments with dynamic assigning tasks. To explore this type of environments and robots, we propose the use of VDF, slave agents and EMA. Through experiments, this framework is proved to be good with some advantages in comparison with the conventional controlling system. It provides a dynamic interface among robots, environment and users. Users can access services of the system without prior knowledge Total time for agent migration and synchronization is small enough to give the system the ability to be available all times and save a lot of time for user to control the system. This method also reduces the time that robotic agents need to be connected to the network and can tolerate some levels of connection disruption. In this paper, service discovery with robot Issac is solved using our proposal framework

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