Ontology-based Service Model for Social Robot Service Description

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Abstract This paper presents an ontology-based service model to describe social human-robot interactions of service robots. The ontological description allows us to develop an open and extensible service model suitable to build social robots in the multi-agent framework. We use the Gaia Methodology as the foundation of the model to augment social human-robot interaction. Experimental results show that our ontology-based model can be extended towards an integration framework for social robots to utilize existing robotic systems.

Keywords Social Robot·Ontology·Service Model

1 Introduction

Rapid advances in artificial intelligence and robotic engineering technology give rise to the interests in social robots, which in turn bring about expansion of various social robot platforms such as Pepper of Japan, JIBO of USA, and Buddy of France. However, they provide services in a closed way, so that the development of robot services are limited unavoidably.
In this paper, we present an ontology-based service model to describe social human-robot interactions of service robots. The ontological description allows us to develop an open and extensible service model suitable to build social robots in the multi-agent framework. We use the Gaia Methodology as the foundation of the model to augment social human-robot interaction. Experimental results show that our ontology-based model can be extended towards an integration framework for social robots to utilize existing robotic systems
In the following sections, we first identify requirement for social robot platform, our approach toward an open ontology-based social robot platform, and experimental results with conclusions.

2 Requirements

2.1 Support for Multiple Actors

The social robot service is performed by multiple robots playing a given role as a member of a particular organization in society. So the service model should describe properties related with multiple actors [1].

2.2 Model-driven System

The social robot providing services should take into consideration social factors as contextual information such as personality of the robot, user characteristics, emotional aspects, privacy, safety, and so on. The social service description thus should be incorporate diverse models and the resultant services should be driven by the model to reflect all the aspects harmoniously

2.3 Support for Human-Robot Interaction

A social robot is an autonomous robot that interacts and communicates with humans or other autonomous physical agents. Human-robot interaction thus should be considered up front at the design of the service model [2].

2.4 Openness and Expandability

In order for the social robot service developers easily utilize and extend the social service models for diverse applications in various environments, the service model should be highly open and extensible.

3 Background

In order for a social robot to perform service intelligently, the environment for task execution considering both the knowledge and functionality for intelligence is crucial. In this paper, we assume the use of intelligent robot task management system that supports knowledge-based task execution by abstracting information from environment into ontological knowledge. Intelligent robot task management system should provide with 1) a general interface to interact with platforms for behavior management with sensors and actuators of the robot, 2) the capability to derive and maintain abstract knowledge from complex contextual information by applying inference rules and domain knowledge, 3) A knowledge management capability to manage and expand knowledge based on the ontologies related to robots and services, 4) A task management capability to manage intelligent service execution based on contextual information and task plans.
In addition, it is desired to have a modularized description of the domain-specific service and the required knowledge in order to provide seamless extension for new services in an importable package. The service package, what we call, may contain robot configuration information, context inference rules, knowledge related to user or service, and task model to

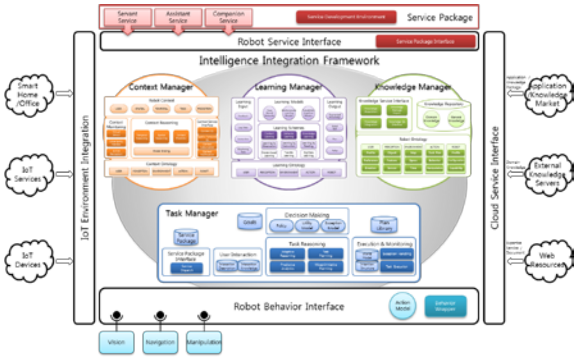

Figure 1 Robot Intelligence Platform

provide the service.

Our description of the service model is based on the robot intelligence platform that satisfies the aforementioned requirements as shown Figure 1. In this platform, the service model in the service package is imported dynamically and incorporated into the running services by the Robot Service Interface. Our social model takes advantage of this capability to provide an open and extensible services.

4 Service Model

The service model for social robots built on our robot intelligence platform is also designed to satisfy the requirements identified in Section 2.

Firstly, we adopt the properties from the Gaia Methodology to support multiple actors in terms of the role for the member of an organization in a multi-agent system. The developers then can describe each robot's role individually for the coordinated activities of social robots [3].

Secondly, it is possible to describe the instances of the ontological social model by broad expressions to specify well-define social contextual information such as personality of the robot, user characteristics, emotional aspects, privacy, safety, and so on.

Thirdly, we define a protocol model to describe human-robot interactions as well as interactions between robots by explicitly representing the interactions in terms of the roles specified the organization.

Finally, we construct the service model based on the ontology suitable for developer to easily utilize and extend the service model.

The properties of the service model that we propose are as follows.

Property	Subproperty	Description
Role		Role as a member of organization
Responsibility	Liveness	The Goal that the Role should perform
	Safety	The state that the Role should maintain
Permission	Read	Accessible resource for Role
	Write	Modifiable resource for Role
	Generate	Resource that can be created by Role
Activity		Primitive behavior that a Role can perform
Protocol		Interaction between Role
Agent		The Agent that subject of Role
Acquaintance		Relationships for interaction between roles

```
@base <http://ai.uos.ac.kr/ontology/> .
@prefix service-model : <http://ai.uos.ac.kr/ontology/#Social-robot-service> .
@prefix resource : <http://ai.uos.ac.kr/ontology/#Resource> .
@prefix fact : <http://ai.uos.ac.kr/ontology/#Fact> .
@prefix emotion : <http://purl.obolibrary.org/obo/EFOEM#> .

<#Reception-Manager>
        a service-model:Role;
        service-model:hasResponsibility <#Reception-Manager-Responsibility>
        service-model:performActivity <#Near> , <#Greeting> ;
        service-model:performProtocol <#AskIntention> , <#QuerySchedule> .
<#Reception-Manager-Responsibility>
        a service-model:Responsibility ;
        service-model:liveness (near, greeting, askIntention)* ;
        service-model:safety resource:VisitorEmotion ==
        emotion:MFOEM_000079 . //good
<#Reception-Manager-Permission>
        a service-model:Permission ;
        service-model:read resource:BuildingMap, resource:Schedule ;
        service-model:write resource:Schedule .
<#Near>
        a service-model:Activity ;
        service-model:input resource:HumanPosition , resource:MyPosition ;
        service-model:output fact:near ;
        service-model:precondition resource:true .
<#Greeting>
        a service-model:Activity ;
        service-model:input resource:null ;
        service-model:output fact:greeting ;
        service-model:precondition fact:near .
<#AskIntention>
        a service-model:Protocol ;
        service-model:to <#visitor> ;
        service-model:input resource:sentence ;
        service-model:output resource:Intention .
<#QuerySchedule>
        a service-model:Protocol ;
        service-model:to <#schedule-manager> ;
        service-model:input resource:Person ;
        service-model:output resource:Schedule .
<#Reception-Agent>
        a service-model:Agent ;
        service-model:hasRole <#reception-manager> , <#Schedule-Manager> ;
        service-model:knows <#schedule-manager> .
<#Visitor-Agent>
        a service-model:Agent ;
        service-model:hasRole <#visitor> .
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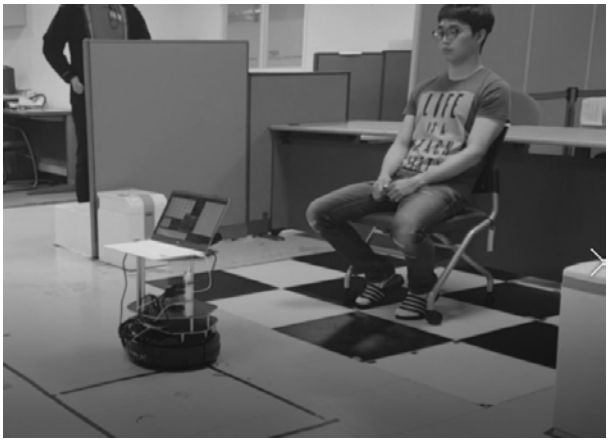

Figure 2 Experiments with a Turtle Robot

The effectiveness of our approach toward the ontology-based social model is being actively tested with a Turtle robot to execute reception service as shown in Figure 2. Even though it is at early stage to verify the effectiveness and completeness of the model, we are encouraged at the preliminary experimental results satisfying partially the requirements.

6 Conclusion

In this paper, we identified the basic requirements for the social robots and presented an ontological social service model based on Gaia Methodology. We believe that our ontological description allows us to develop an open and extensible service model suitable to build social robots in the multi-agent framework. Our preliminary experiments show promising results in part. Our next step is to test and verify fully the effectiveness of our social model by experimenting with more complex and diverse social behaviors that incorporate emotions and social dialogues.

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