

How to Provide Service using Intention and Service Models

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Abstract— This paper is one of parts for providing intelligent services. To do so, we focus on user intentions. Lots of researches for human intentions focus on human actions because actions are followed by intentions. So they treat human actions as human intentions. But sometimes there are differences between actions and the intentions. Abraham Maslow, a psychologist, presented the theory of human motivations[1]. He said that all human actions were based on their own needs. Therefore, we think that if we describe human needs and make some proper models to contain them, we can catch human intentions and make devices provide good services. That's the main motive of this paper.

Keywords—intention, intention model, service model, proactive, intelligent service

I. INTRODUCTION

Under various circumstances, people do their actions with various intentions. Therefore, the outfit of some actions looks similar but intentions to lead their actions may be different. If a device, such as a service robot and a home appliance, could recognize the difference between intentions and if a device could provide its service based on the recognized results, it could provide much higher level of services. However, it is very hard for a device to identify person's intentions under a variety of external conditions. In the current level, it is necessary to set a goal to recognize specific situations not all kinds of cases.

As the HCI or HRI technology has been developing, service robots and home appliances have more powerful interactions with the outside world. They can do and give more works to users. Sooner or later, especially service robots would be regarded as consumer products. However, unlike usual home appliances, services robots can move and do services with and

without actions. In the future, a service robot would also be able to assist people physically in every daily life and live together like a member of family. In that time, users would expect robots to do different services from those of usual home appliances. It means that users would require much more suitable services at the right time not services that would provide with fixed rules.

To provide the right services, the proactiveness of services is one of the key aspects to make a service robot do proper services[4]. And the other key aspect is to interpret user's intentions before a service robot does its services. In this paper, we define the proactive service as a service that can be acted by understanding and predicting service recipient's situations or intentions, and served to a proper target recipient with or without any clear command.

This paper is for making user intention model and presents examples using those models. The intelligence in a device is necessary to make it provide much proper services to users. There would be a lot of ways to provide intelligent services. We think that good services are related to user status and user status can be described as user intentions. We can say that user intentions are directly related to human action. But sometime it is not correct. So we have to deal with the differences. We handle those gaps using basic human needs. We use Bayesian Networks and ontology to model user intentions. Each model describes user intentions based on sensor data for physical environment, user actions, and ontology for spatial, object, and user information. And we present some examples for how to represent human intentions and how to process them.

The rest of the paper is organized as follows. In Section II, we introduce the concept of Proactive Space and situational-awareness including user intention modelling. Section III explains prototype implementation. Finally section IV gives conclusions and the future works.

II. USER INTENTION MODEL

A. Models of User Intentions

People do their actions or movements with various their intentions. Although some situations look similar, the intentions to lead actions may be different. Therefore, if devices could catch user's intentions before doing their services and if they could distinguish or understand intention's differences between looking similar situations, they could have much powerful methods to do their services. However, in the real life, there is no way to bright those kinds of abilities to devices and there is a long way ahead to reach there. In the current level, target cases should be focused specifically rather than all possible cases. It is necessary to specify cases and handle them to model.

Many studies on the relationship between actions and intentions of person have been doing. According to these studies, person's intention can be inferred from person's behaviour. In other words, the actions could be regarded as one of the ways to express intentions. In psychology, human behaviour aims at fulfilling the needs which do not meet. It can be deduced that there is a relationship between person's desires and intentions; the intentions can be said to the expression of behaviour trying to satisfy the needs. Therefore, we can derive related need from intention.

People receive a lot of impact on the surrounding circumstances, so the current circumstances would affect their needs which people require.

The information surrounding human can be sensed through various sensors. However, sensors can sense environmental information, and the meaning of the situation may vary depending on interpretation. In addition, it is difficult to represent situations just using raw sensing data. Thus, it is important to give specific meanings to situations for representing the value of sensors.

The human intentions are various and the real-world's problems associated with them are much more difficult. User intention itself is not always a service but it could be related to service or be used as one of inputs for service models. Therefore, to provide a proper service based on reasoning intentions, we also get service models, which describe various services.

Intention model itself is not the objective. The reason to make intention models is to provide suitable services to users. In this paper, we make intention models using Bayesian Networks and Ontology. The process of modeling user intentions consists of four parts:

1) **Defining problems and setting targets of model:** In this step, we define target problems and models. We confine target problems and draw user intentions. Through this step, the target basic intentions can be derived. Combining derived basic intentions, we could make more sophisticated intentions. Examples of basic intentions may be 'trying to drink water',

'going to sleep', 'trying to go out', 'trying to have a meal', and so on. Examples of combined intentions may be 'eating something before going out'.

2) **Describing related behaviours and environment:** This step finds behavioural and environmental factors related intentions defined in the prior step. Considering current available resources and using these factors, we express user intentions found in step 1. User actions from camera, environmental information from various sensors, and identities of objects and spaces from RFID could be considered. And this phase includes defining basic human needs, which are related to physiological and safety. Using behavioural and environmental information, defined basic needs are modelled and they seem to be sub-goals of user intentions.

3) **Building intention models:** In this step, intention modes are modelled using the results of prior steps. Considering correlation and causality between the results of the previous steps, each intention is to build a model based on user intentions. The final output of intention models is a kind of user intention but it's not the final result of services. The output of models could be an input of service models.

4) **Making Ontology:** In this step, we describe all the information into ontology. Behavioural and environmental information, intention models, service models, objects, which are included such as robot, sensors, camera, spaces, users and their preference, are all described in ontology.

B. Proactive Space

Homeostasis in the living creatures can be defined as maintaining creatures' internal systems according to changing outside circumstances and/or responding outer stimuli. Living creatures can take cognizance of external changes and stimuli and appropriately respond to changes to maintain their homeostasis. It's the big difference between the living things and the inanimate objects.

What if the homeostasis is applied to a robot? We use the concept of homeostasis to robotic spaces. This space is called proactive space. The proactive space can be defined as the confined area where a robot has to maintain the space stability. Whenever some factors break its stability, the robot takes cognizance of them and corresponds to some actions to recover the breaking stability. The robot can take cognizance of changing its outside circumstance and take some actions to maintain the space stable. That's why we use situational-aware [5] instead of context-aware. To apply this concept, the stabilities of the space must be described and we make some knowledge of the space stabilities using the ontology.

C. Situational-Aware Network

Unlike human beings who have the abilities to think, decide, and act according to their situations, robots haven't had those kinds of abilities by themselves. To make robots operate like

human beings, we have to let them know where they are and what they do. “Where they are” means that they know at least the time to do something and “what they do” means they can select the right action under a current situation. For the one, we use sensor network system and RFID system. Using the results of them, we can reason current situations and check the right time to do something. For the other, we choose service model which describes service situations, service goals, and so on.

“Situational-Aware Network (SAN)” gathers and processes sensor data for the situational-aware. The SAN consists of four components: sensor parts, processors for sensor data, situational knowledge, and situation board. Fig. 1 shows the SAN structure.

1) Sensor parts: The sensor parts include sensor network and RFID system. The sensor network system uses temperature sensors, humidity sensors, light sensors, IR moving detector sensors, and magnetic sensors for detecting the state of door open. We identify user and object identities using RFID system

2) Processors for sensor data: The processor has two types: primitive type and fusion type. The primitive processor (PP) transforms just one raw sensor datum into one symbol using situational knowledge. The fusion processor (FP) fuses multi-sensor data and/or symbols.

3) Situational Knowledge: User and object information are also described to the ontology. The situational knowledge is described using rule format and ontology. Using rule format, sensor data are transformed to symbols representing physical environments. The ontology represents information of sensors including what they describe, where they work, and etc. Interpreting meanings of sensor outputs, the processor generates facts for current environment.

4) Situation Board: The situation board (SA) maintains the results of the processors. The contents of the situation board change dynamically and are referred to other modules which use current situations.

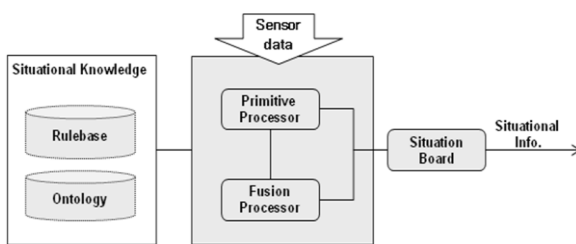


Figure 1. Situational-Aware Network Structure

D. Service Model

To make robots operate like human being, they have to have some behavior knowledge which is implemented by just

programming something in the codes or building up with knowledge-based type. In the paper, we use service models for the service knowledge.

The Service modeling process is as follows. The service modeling starts describing a scenario of target situations. In this stage, we sketch what the service is: causes of services, a situation and main goal of each service, and so on. After making the scenario, we divide situations as small as possible to make their complexity simple and maintain their relations using the ontology. The ontology for the model contains every model’s attribute, such as nodes, states of each node, service motivations, hierarchy and relationship between models, and so on. And it also gives information about when each model is triggered, how models are related to each other, and what they represent. Fig. 2 shows the problem simplification and relationships between models. We use an inference engine, Bossam Rule/OWL reasoner [3], to reason and interpret the ontology. After finding the main goal, we start detailed modeling which consists of two ways: downward from the goal and upward from sensor’s input. The downward way focuses on all possible causes which are affected by goals and used when drawing results. This method makes the model flourish and improve the readability of the model because it is based on cause and effect. And the upward way just concentrates on current possible resources and makes the modeling easy because it just considers tangible resources. After two processes, we connect results of each process.

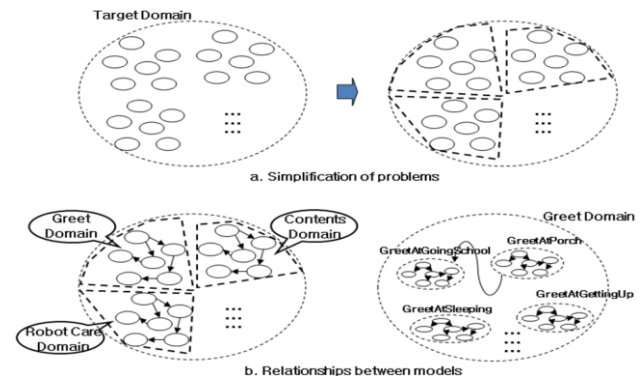


Figure 2. Simplification of Problems and Relationships between models

III. PROACTIVE SERVICE

We implement proactive services using intention and service models and experiment in home test bed, which have two bedrooms, a kitchen, and a living room. As shown in Fig. 3, the implementation environments include a PC-based mobile robot, PLC (Power Line Communication) controller and PLC-controlled devices such as air conditioner and a motorized window blind. In addition, there are RFID readers in each place to sense location of a user who carries a tag. The implementation system consists of a robot agent and robot task

engine mounded on the mobile robot, SAN (Situational-Aware Network) host, a knowledge-base server which contains various models and knowledge. They are connected to each other via wired or wireless LAN.

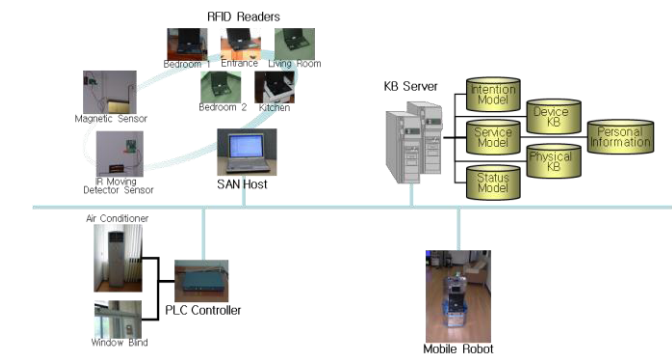


Figure 3. Implementation Environment

A. Process of Reasoning User Intention

The process of reasoning user intentions consists of 4 parts: environmental, action, needs, and intention analysis. Fig. 4 shows the brief overview of the process.

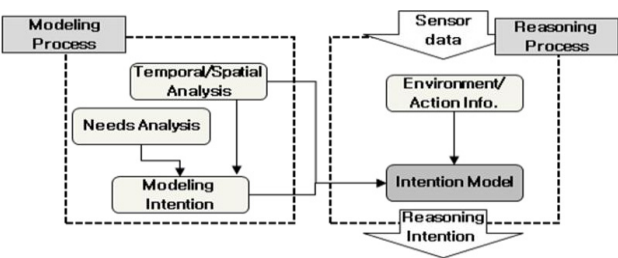


Figure 4. The process of the user intention

The environmental analysis is to analyze environmental factors. This can be divided into two parts: sensor data analysis and time/spatial analysis. In the part, all data from sensor and related knowledge are used.

Action analysis is to check what a user does or did. From this kind of information, this phase could draw what the user is doing.

Needs analysis is to find proper needs. In this phase, we can find sub-goals. User intentions' models are made based on basic human needs. In ahead steps, we could get information for time, spatial and actions of the user. In this phase, the prior information acts like inputs and find human needs.

Intention analysis is to reason user intention. All the information and analytic results we get are used as inputs in this phase. Through this phase, we can get the final goal, user intention.

In Table 1, we show simple examples of reasoning process.

TABLE 1. SIMPLE EXAMPLE OF REASONING PROCESS

Step	Referential Information	Analytic Result
Environmental Analysis	Season(Summer) Current Time(Noon) Temperature(28) Humidity(70%)	Hot Summer Afternoon
Action Analysis	Previous Act(Going out) Current Act(Standing) Location(In Front of Fridge) Door of Fridge(Open)	Looking for Something in the Fridge
Needs Analysis	Thirst Hunger	Thirst
Intention Analysis	Finding a Cold Finding a Something to Eat	Finding a Cold

B. Providing Proactive Service

We show several example services using intention models. We implement prototype system in the test bed.

In the beginning of the experiment, a user is carrying a RFID tag. Magnetic sensors are attached at each door. IR moving detection sensors are also attached at each space to check points or objects, such as fridge, sofa at living room, each windows, and so on. RFID readers for detecting user's identity are located each space, such as entrance, kitchen, living room, and two bedrooms. In the living room, a temperature sensor and a humidity sensor are installed. There are one air conditioner, one TV, two motor blind, and one fridge, which are all controlled by a PLC controller.

Through reasoning user intentions, we can get proper user intention. User intention itself is not always a service but it could be related to a service or be used as one of inputs for service models. Therefore, to provide a proper service based on reasoning intentions, we also get service models, which describe various services.

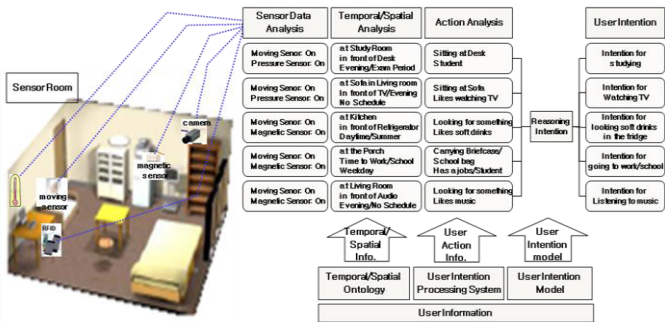


Figure 5. Examples of how to reasoning user intention

At the summer afternoon, the living room should be cool to make the user feel good. When a user enters his home, he wants his house cool. If the robot knows the time the user comes home, the robot will make the house cool before he comes home. But if the robot doesn't know about the time, the robot

does service to make spaces cool at that time that one of users is coming home.

When the user comes home, the robot is checking the identity of the user and greeting him or her with a suitable greeting. If the user is a student and is coming back from school, the robot could say "how was your school?". If a office worker, the greeting is changed, "how was your work?"

After entering home, the user comes to kitchen and is in front of the fridge. The RFID reader detects who's in kitchen and the camera monitors what the user is doing. If he opens the door of the fridge, the robot reasons what happens at that time. Identity(User A, student), time(summer, afternoon), space(kitchen, in front of the fridge), sensor(fridge door open, standing, temperature: 29, humidity: 70%), preference(likes Soft Drinks). From above information, the robot reasons that the user is 'thirsty' and looking something to relieve thirst. And then the robot proposes some recommendations for the user: recommending which drink is good for the user and asking the user to turn on the air conditioner.

IV. CONCLUSIONS

In this paper, we propose how to provide proactive services using intention and service models. We employ situation aware technique using sensor networks, RFID system and AI-based probabilistic inference technique. Home devices, such as home service robots, are enabled to be intelligent and enhance their service capability. Therefore, they could have an operational automaticity.

We also use the concept of Proactive Space. In this concept, devices and their environment are considered as single connected system. And robot services in the proactive space are internal processes to maintain the system. This concept makes devices, which are inanimate objects, act like living things.

In this paper, we don't consider emotion and complex user intention and we just handle physiological and safety needs when we design models. However, to flourish much more real services models and make devices provide real intelligent services, those things must be considered and modeled with details. Our future research direction would include user emotion and complex intentions and research how to build up models with them.

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