

Design and Implementation of a Social Robot-based Companion Animal Care Service

Kang-Hee Lee, Ho-Sun Shin

Abstract: Social robots are getting closer to life. Global companies such as Sony, Softbank, or Asus are launching various kinds of social robots and the market is getting bigger and bigger. Accordingly, we investigate the state-of-the-arts of companion animals and IT fields that include social robots toward companion animals-related market. Inspired by these trends, this paper designs and implements a companion animal care service that can be provided by a new service mean, social robot. First, the rule-based expert system is used to create objects, values, and rules to recommend food for companion animals. Second, the corresponding modularization is performed to mount on social robots. Third, a behavior service module is created and operated for communicating with the user. We experiment the proposed social robot-based companion animal care service using Java-based First-Order-Logic (FOL) reasoning system and Jibo SDK. It verifies the effectiveness through interaction with real social robot users.

Index Terms: social robot, companion animal, service, rule-based expert system, Jibo, food.

I. INTRODUCTION

A variety of social service models are emerging as the times change. This is caused by the huge flow of the fourth industrial revolution. With the increase of one person households, the market for companion animal services is also increasing and generated in various ways. According to this trend of the times, this paper proposes and implements a companion animal care service using social robots as a new service model. The purpose of this paper is to design and implement the companion animal care service provided by the social robot to show the operation between the user and the robot as a prototype.

This paper consists of the followings. Section 2 reviews the scale and status of companion animal-related markets. Social robot services are also reviewed for finding a contact point between companion animal services and social robots. Section 3 designs a social robot-based companion animal care service. To design the expert system for caring for companion animals and recommending their food, the rule-based system is employed. Objectives are defined and the rules are designed. Section 4 experiments the designed expert system and verifies its effectiveness using Jibo's SDK and simulator. Finally, concluding remarks are followed in Section 5.

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II. RELATED RESEARCH

A. State-of-the-Art of the Companion animal Market

This section reviews the scale and status of growing companion animal-related markets and then examines the flow of the markets in the IT sector.

According to a report of ministry of Agriculture and Food and Rural Affairs, the scale of companion animal-related market is growing globally [1]. The number of households raising companion animal increased by about 4% from 17.9% in 2012 to 21.8% in 2015. This is a sharp increase compared to the previous year's 0.5% increase [2]. Also, the scale of market has been reported to grow by more than double digits every year [3].

These facts are evidence that the demand for services and supplies for companion animals has increased and reflect that the industry is watching these changes carefully. In fact, it is a trend to actively produce and sell new services targeting households that raise companion animals in various industrial fields such as insurance, hotel industry.

the scale of companion animal-related market(Unit : billion won)

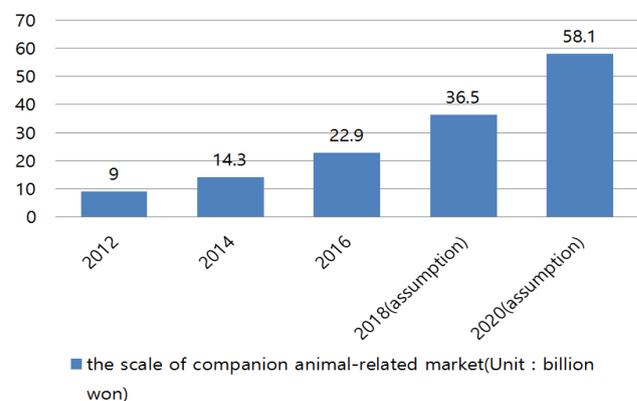


Fig. 1. Scale of companion animal-related market

To create and sell services for companion animals in diverse industries, the IT industry has begun to produce various goods and services. Its market size is getting bigger and bigger. For example, Ottawa Pet Expo in 2015 predicted that the companion animal wearable market would grow to about \$ 2.6 billion by 2026 [4].

As an example of companion animal services in the IT market, a company that created 'Perbo', IoT-based cameras and snack paying device, received six times as much as its expected investment through crowdfunding sites [5]. In



addition, movements are also being made to leap into the companion animal market in IT, such as the use of connected devices for companion animal, development of smartphone application for companion animal care [6], and companion animal personalization services [7].

B. Similar Social Robot Services: Zenbo and Jibo

This section examines the services of social robots offered to specific members of the family, similar to companion animal care services. In reality, social robots have already been released or are coming out. Instead, care services for children and the elderly are being built first. In this section, we focus on the concept of social robot and service of Zenbo as an example of specialized service for residents.

The discussion of the concept of social robot has been made so far and it is difficult to make a definite definition, but experts agree that the goal of social robot is interaction with users [8]. Unlike conventional robots, artificial intelligence, IoT, and cloud technologies are often combined with robots, which may be one of the reasons why social robots have begun to gain popularity again at the advent of the fourth industrial revolution. Current social robots function as home robots in most cases. Pepper, Jibo, Hub robot, Buddy and Zenbo are cases of them.



Fig. 2. Zenbo's wearable device based elderly specialized service

As shown in Fig. 2, Zenbo is a social robot released by ASUS. In the form of a mobile robot, it moves around the home and performs simple commands such as door lock, helping to purchase goods through user's voice recognition, searching food recipe, etc. This function can also be found in other social robots [9]. However, unlike other cases, Zenbo offers specialized services for elderly people. This service operates based on a wearable device. When the wearable device worn by the elderly detects an abnormal pattern, it sends a notification to other family members and displays the state of the user [10,13,14,15,16,17,18,19,20].



Fig. 3. Child-specific service of social robot case (left: Zenbo, right: Jibo)

This service is an increasingly demanding service type as it enters the aging society. And it can be predicted that it will become an indispensable service for those who can not reside in the elderly population. Likewise, there is a continuing

increase in the proportion of households which raise companion animals, so there is also a demand for services for companion animals.

Next, in the case of specialized services targeting these people, the entertainment is a main function. As shown in Fig. 3, Zenbo offers children a storybook story. The fairy tales story service is provided in the case of other social robots. The right side of Fig. 3 shows the storybook service provided by social robot Jibo [11]. In this paper, we try to implement a food recommendation service for companion animals using social robot Jibo and experiment to see how it works.

III. DESIGN OF SOCIAL ROBOT-BASED COMPANION ANIMAL CARE SERVICE

In order to design and implement the social robot -based companion animal care service, we narrow category range of service to be provided to the user. For this purpose, cats (showing rapid growth rate) among dogs and cats, which are the most abundant animals in Korea, were selected for the service [1]. Next, we designed a service that could help us select the feed for cat care. The design and implementation of the service reflects the needs of the companion animal owners as well as the size of the companion animal market [12]. Unlike the type of service that is purchased at a hospital or a related store, the proposed service allows the owner to select and purchase his or her own animal considering the circumstances of the companion animal. As a means of design, one of the types of artificial intelligence, the rule-based expert system is used. It employs First-Order-Logic. The knowledge base objects and permissible values are shown in Table 1.

Table 1. The objects and values of companion animal care social robot service

object	value
age	2 months old
	3 months old
	4 months old
	5 months old
	6 months old
	7 months old
	8 months old
	9 months old
	10 months old
	11 months old
	12 months old
	2 years old
	3 years old
	4 years old
5 years old	
6 years old	
7 years old	
8 years old	
over 9 years old	
feed type	wet feed
	kitten feed



	adult feed
	senior feed
priority	price
	between price and quality
	quality
feed grade	organic and holistic
	super premium
	premium
consideration	long hair
	hair ball
	neutralization
	abnormal weight gain
	pregnancy and lactation
	palatability
	sensitive digestive system
recommended ingredient	skin, hair care
	weight loss promotion
	high protein
	none
result	feed currently being fed
	ANF 6free indoor kitten
	premium edge-kitten
	royal canin kitten
	kitten chou
	probest cat blue
	catrang kitten
	nutro natural choice adult hair ball chicken and whole brown rice formula
	orijen6 cat&kitten
	proplan sterilised/weight loss
	total equilibrio adult hair ball
	royal canin sensible
	proplan neutralization&weight loss
	whiskas adult hair ball
	pronature holistic senior
	nutrena a little leon senior
	total equilibrio senior cast rated
	proplan longevis
	probest cat
	professional diagnosis
cannot provide recommendation	

The knowledge that constitutes the objects and values of the service are the things to consider when selecting cat food. The cat food is largely categorized into the age and the specific considerations according to user preferences. The user's preference value means the value that the user chooses between the quality of the food and the price. Object lists are 'age,' 'feed type,' 'priority,' 'feed grade,' 'consideration,' 'recommended ingredient,' and 'result.'

Table 2 shows the rules of the rule-based expert system based on this base knowledge. There are 40 rules and 4 groups. Group A is related to 'feed type.' Group B is related to 'feed grade.' Group C is related to 'recommended ingredient.' Especially, D is the final rule group to recommend cat food from rule 12 to rule 40. Its conditional statements are based on Groups A, B, and C. For the detail, refer to Table 2 and Fig. 4.

Table 2. Rule-based expert system rules for companion animal feed recommendation

Group	Rule	Condition	Conclusion	
A	1	If age is "2months old"	Then feed type is "wet type"	
		or age is "3months old"		
		or age is "4months old"		
	2	2	If age is "5months old"	Then feed type is "kitten type"
			or age is "6months old"	
			or age is "7months old"	
			or age is "8months old"	
			or age is "9months old"	
			or age is "10months old"	
	3	3	If age is "11months old"	Then feed type is "adult type"
			or age is "12months old"	
			If age is "2years old"	
or age is "3years old"				
4	4	or age is "4years old"	Then feed type is "senior type"	
		or age is "5years old"		
B	5	If age is "6years old"	Then feed type is "holistic and organic"	
		or age is "7years old"		
		If user's priority is "quality"		
6	6	If user's priority is "between quality and price"	Then feed grade is "super premium"	
		If user's priority is "price"		
C	8	If consideration is "long hair"	Then recommended ingredient is "skin, hair care"	
		or consideration is "hair ball"		
	9	9	If consideration is "neutralization"	Then recommended ingredient is "weight loss promotion"
			or consideration is "abnormal weight gain"	
	10	10	If consideration is "pregnancy and lactation"	Then recommended ingredient is "high protein"
			or consideration is "palatability"	
			or consideration is "sensitive digestive system"	
11	11	If consideration is "none"	Then recommended ingredient is "none"	

D	12	If	feed type is "wet type"	Then	output is "sorry, we cannot provide recommendation"
	13	If	feed type is "kitten type"	Then	output is "your cat needs professional diagnosis"
		and	recommended ingredient is "weight loss promotion"		
	14	If	feed type is "kitten type"	Then	output is "feed currently being fed"
		and	recommended ingredient is "none"		
	15	If	feed type is "adult type"	Then	output is "feed currently being fed"
		and	recommended ingredient is "none"		
	16	If	feed type is "senior type"	Then	output is "feed currently being fed"
		and	recommended ingredient is "none"		
	17	If	feed type is "kitten type"	Then	output is ANF 6free indoor kitten
		and	recommended ingredient is "skin, hair care"		
		and	feed grade is "holistic and organic"		
	18	If	feed type is kitten feed	Then	output is premium edge - kitten
		and	recommended ingredient is high protein		
		and	feed grade are holistic and organic		
	19	If	feed type is kitten feed	Then	output is royal canin kitten
		and	recommended ingredient is skin,hair care		
		and	feed grade is super premium		
	20	If	feed type is kitten feed	Then	output is kitten chow
		and	recommended ingredient is high protein		
		and	feed grade is super premium		
	21	If	feed type is kitten feed	Then	output is probest cat blue
		and	recommended ingredient is skin,hair care		
		and	feed grade is premium		
	22	If	feed type is kitten feed	Then	output is catrang kitten
		and	recommended ingredient is high protein		
		and	feed grade is premium		
23	If	feed type is adult feed	Then	output is nutro natural choice adult hair ball chicken and whole brown rice formula	
	and	recommended ingredient is weight loss promotion			
	and	feed grade are holistic and organic			
24	If	feed type is adult feed	Then	output is nutro natural choice adult hair ball chicken and whole brown rice formula	
	and	recommended ingredient is skin,hair care			
	and	feed grade are holistic and organic			
25	If	feed type is adult feed	Then	output is orijen6 cat&kitten	
	and	recommended ingredient is high protein			
	and	feed grade are holistic and organic			
26	If	feed type is adult feed	Then	output is proplan cat - sterilised/weight loss	
	and	recommended ingredient is weight loss promotion			
	and	feed grade is super premium			
27	If	feed type is adult feed	Then	output is total equilibrio adult hair ball	
	and	recommended ingredient is skin,hair care			

	28	and	feed grade is super premium	Then	output is royal canin sensible
		If	feed type is adult feed		
		and	recommended ingredient is high protein		
	29	If	feed type is adult feed	Then	output is proplan cat - sterilised/weight loss
		and	recommended ingredient is weight loss promotion		
		and	feed grade is premium		
	30	If	feed type is adult feed	Then	output is whiskas adult hair ball
		and	recommended ingredient is skin,hair care		
		and	feed grade is premium		
	31	If	feed type is adult feed	Then	sorry, we cannot provide recommendation
		and	recommended ingredient is high protein		
		and	feed grade is premium		
	32	If	feed type is senior feed	Then	your cat needs professional diagnosis
		and	recommended ingredient is weight loss promotion		
		and	feed grade are holistic and organic		
	33	If	feed type is senior feed	Then	output is pronature holistic senior
		and	recommended ingredient is skin, hair care		
		and	feed grade are holistic and organic		
	34	If	feed type is senior feed	Then	output is nutrena a little lion senior
		and	recommended ingredient is high protein		
		and	feed grade are holistic and organic		
	35	If	feed type is senior feed	Then	output is total equilibrio senior cast rated
		and	recommended ingredient is weight loss promotion		
		and	feed grade is super premium		
	36	If	feed type is senior feed	Then	output is total equilibrio senior cast rated
		and	recommended ingredient is skin, hair care		
		and	feed grade is super premium		
37	If	feed type is senior feed	Then	output is proplan longevis	
	and	recommended ingredient is high protein			
	and	feed grade is super premium			
38	If	feed type is senior feed	Then	your cat needs professional diagnosis	
	and	recommended ingredient is weight loss promotion			
	and	feed grade is premium			
39	If	feed type is senior feed	Then	output is probest cat	
	and	recommended ingredient is skin, hair care			
	and	feed grade is premium			
40	If	feed type is senior feed	Then	your cat needs professional diagnosis	
	and	recommended ingredient is high protein			
	and	feed grade is premium			

The process of deriving the result value is the same as the following diagram. The fact of the database to trigger



the rules is the user's answer that occurs during the interaction with the user and the final result value is transmitted to the user through a rule trigger that occurs in a sequential query response.

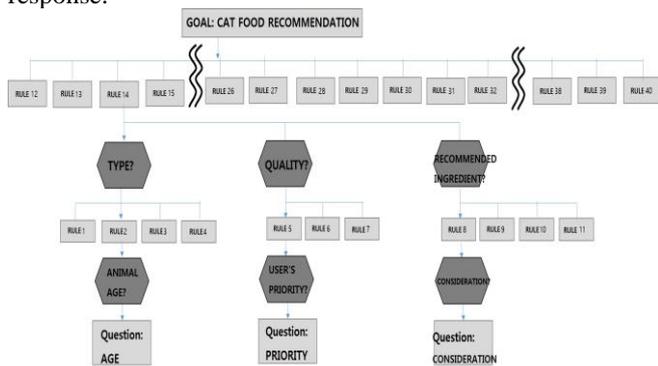


Fig. 4. Diagram of rule-based expert system of the service

IV. IMPLEMENTATION OF SOCIAL ROBOT-BASED COMPANION ANIMAL CARE SERVICE

This paper aims to employ Jibo robot as shown in Fig. 5. We joined in mailing list at Jibo website to purchase it. But we could not buy Jibo because of company problems. Anyway, in order to use actual Jibo or simulated Jibo, we had to develop using the Jibo SDK.



Fig. 5. Jibo's appearance

The Jibo SDK is used as a means for implementing the animal care social robot service (refer to Fig. 6). In order to load the rules of the designed expert system into the robot, we installed a module that acts as a forward reasoning engine called jools and implemented rules based on javascript language. The Fig. 7 below is a part of the implemented rule.

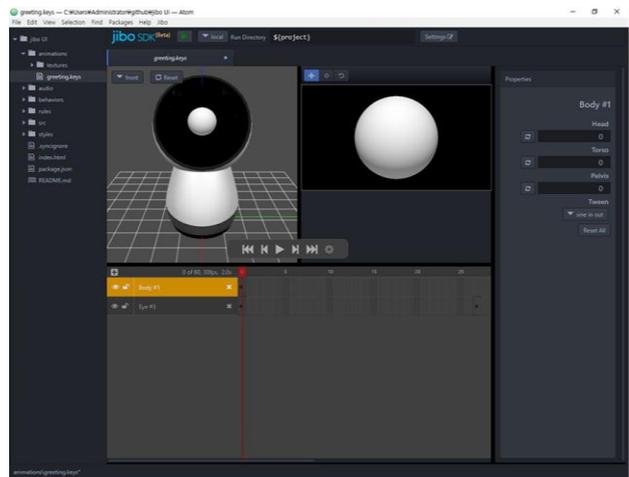


Fig. 6. Jibo SDK

```
{
  "name": "living_rule24",
  "condition":
    function(feedtype,recommendedIngredient,feedgrade) {
      return ((feedtype == "adult type") && (recommendedIngredient == "skin,hair care")&&(feedgrade == "holistic and organic"));
    }
  "consequence":
    function() {
      this.output = "nutro natural choice adult hair ball chicken and whole brown rice formula";
    }
},
```

Fig. 7. Implemented example code: 4th rule of feed recommendation service

Based on the implemented rules as shown in Fig. 7, we generated a robot reasoning module and produced a behavior module that generates the reaction with the user while generating the result through the inference module. Fig. 8 shows the operation of the service provided to the user through the combination of the produced behavior module and the inference module. The user who requests the service is asked about the age of the companion animal and the priority value and consideration of the user in sequence. The user creates the facts of the database by answering the questions. The fact is stored inside the robot and activates the inference module. At the same time, the robot responds appropriately to the user, terminates the service by carrying out the service and delivering the final result to the user.

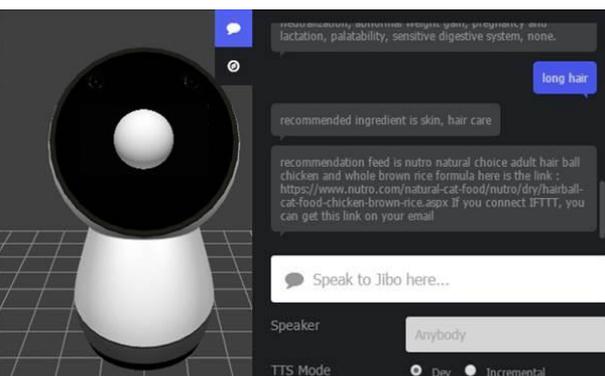
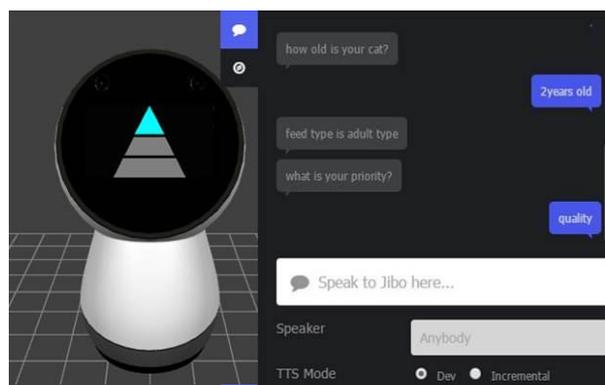
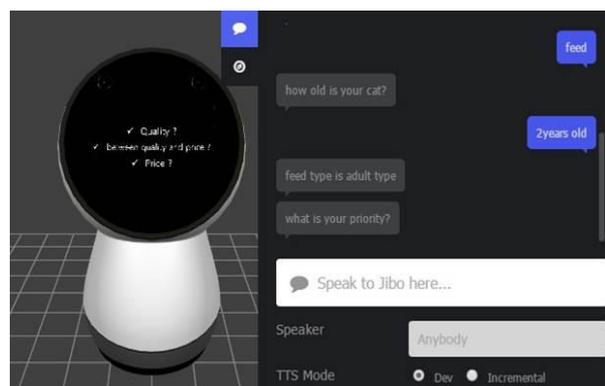
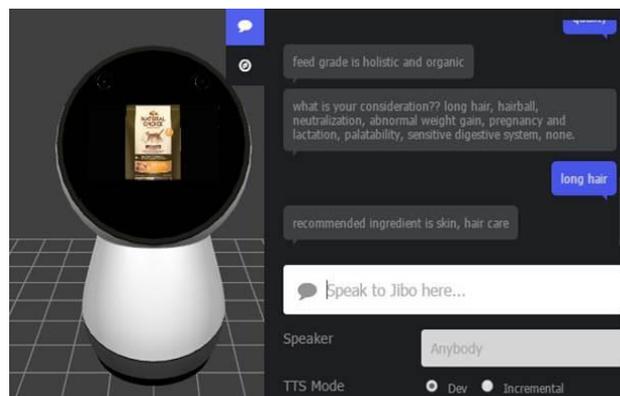
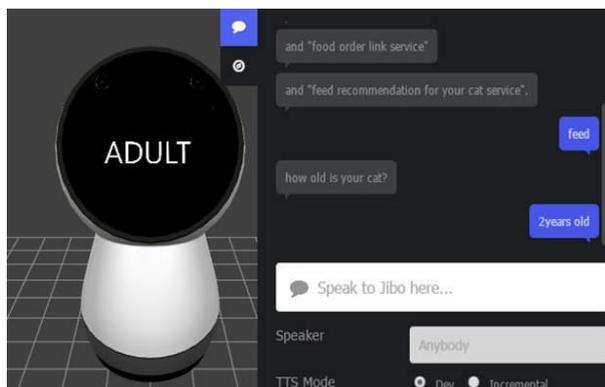


Fig. 8. Operation of feed recommendation social robot service.

V. CONCLUSIONS

In this paper, we designed and implemented feed recommendation service provided by social robots for users who are raising pet animals. This is an attempt to combine social robots among emerging technologies in accordance with the increasing demand for companion animal services and the expansion of market and the arrival of the fourth industrial revolution based on the changing times.

In order to design and implement the service, we conducted a preliminary survey on trends and current status of the pet animal related market. Based on this, we set up the service objects and characteristics and designed the rules of the service through the rule based expert system. The designed rules were created as inference module through the process of mounting in the robot. Then, we developed a behavior module for communication with users. And they worked together to build one service. The service can act as a prototype of the new service model required in the changing current flow. For that reason, we expect to construct a broader category of services through the creation of services in other fields of the service implemented in this paper.

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