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Application of Soar Cognitive Agent Based on Utilitarian Ethics Theory for Home Service Robots

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Abstract - This paper presents an application of a Soar cognitive agent on home service robots. The agent is capable of recording healthcare table as well as basic profile of each member in family such as family position and current healthy status, and making its own inferences on response to the user. In addition, based on utilitarian perspective, the agent is able to evaluate utility scores for possible actions which it would perform. Through a simple experiment, the Soar cognitive agent attempts to make an appropriate decision with the maximum utility value.

Keywords - Soar Cognitive Agent, Ethical Agent, Home Service Application, Human-Robot Interaction.

1. Introduction

Service robots have been and are currently being designed and deployed alongside human beings at home, at work, and for play. According to the International Federation for Robotics 2016, around 42 million service robots for personal and domestic use will be used in our private life until 2019 [1]. This means the robots must be able to cooperate with humans in the unpredictable situations and environments that humans live, work, and play in. Therefore, the question of how to make human robot interaction (HRI) ethically arises. Several researches proposing and discussing on ethical principles have pointed out that the morality of robots is essential and, sooner or later, it will be applied to every robot, especially service robots [2-4]. Among various ethical principles, utilitarianism (consequentialism) has been also put on debate [5,6]. Utilitarianism is known as one of the basic ethical theories of the top-down approach. According to utilitarianism, ethical decision needs to maximize a total amount of pleasure in the world. This paper aims to apply and experience how a robot makes inferences and decisions when interacting with humans at home based on utilitarianism point of view.

In our earlier work, we proposed and motivated a prospective platform with Soar-ROS association [7]. Soar was presented as cognitive agent aiming at human-level intelligent thinking which can make decisions to solve problems. In this platform, we took advantage of a various libraries and tools of ROS [8] to connect with the cognitive agent, aiming to help a robot perceive surrounding objects, therefore, being prerequisite for Soar agent to make its decisions appropriately to the situation. In case of the application in this paper, instead of using ROS packages which would take responsibility on recognizing member of a family as well as orders given to the agent, these two information (family member and order) will be given via keyboard. In utilitarianism perspective, this research will only focus on demonstrating how the agent responds to family member's order. When one member desires a dish of food that would lead to good or bad effective on his or her health, based on the utilitarianism the agent has to calculate the expected utility of actions and make its own decision on response.

This paper is organized as follows. In Section 2, Soar cognitive agent's structure is explored showing how family information and healthcare table are stored in agent's semantic memory (SMem). Afterwards in Section 3, an evaluation method of utility is presented allowing the agent to evaluate utility values. Finally, we present experiment results in Section 4 and concluding remarks in Section 5.

2. Soar Agent's Knowledge Structure

Soar (State, Operator and Result) is cognitive agent software architecture, which contains long-term memories as well as short-term memories [9] helping on making its inferences. Among these memories, Soar semantic memory restores general facts. For applying the agent at home as service robot, one of the general facts is basic information of a person such as the birthday, gender, and current disease. Considering these information, the quality of service is improved, expressing the interest in the user's health. For example, with the sense of care, people would not give cold water to those who have a problem in the digestive system, or would not give sweet candy to those who have tooth decay. From this perspective, information of every member in family should be recorded.

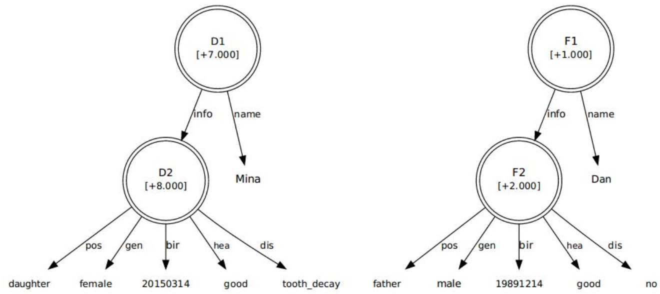


Fig. 1. Family information in SMem structure.

Figure 1 depicts part of structure of members' information for a family in Soar semantic memory storage when the agent stores personal information of Mina, a daughter in family, and Dan, Mina's father. The personal information includes given name, family position, gender, birthday, healthy status, and current disease. For Dan, he is the father in his family: his birthday is the fourteen of December, 1989; his healthy status is good; and currently he does not have any disease. While for Mina, she is a daughter in the family and her profile can be interpreted like the Table 1 below. It is noted that Mina has some problem with her teeth; she has cavities between teeth. She needs to be taken care of, especially in the ways of eating.

Table 1 Basis profile of Mina

Given name	Mina
Position	Daughter
Gender	Female
Birthday	2015/03/14
Healthy status	Good
Current disease	Tooth decay

With the sense of care to every family member, a healthcare table would be made. This healthcare table comprises a dish of food name, and an indispensable part, disease name. There are three attributes to represent the influence of the food to the disease: very good, good, and bad. Figure 2 shows two examples of two kinds of food and their consequence on our health. On the left of the figure is candy: candy is very good for those who are hypoglycemia, good for those who are in stress, but bad for tooth decay people. Meanwhile, on the right of the figure is milk cake: milk cake is a cake that is very good for those who are osteoporosis, good for those who are diagnosed of tooth decay, but bad for lactose intolerance. (All these influences of food on diseases are given from healthcare center [10].)

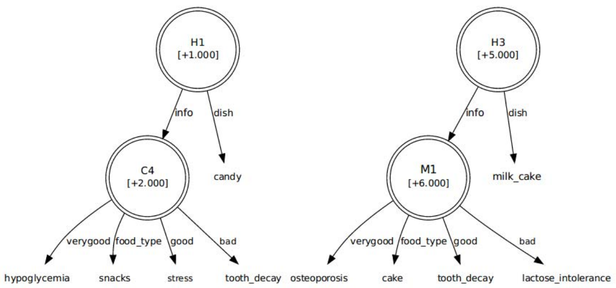


Fig. 2. Healthcare model.

Figure 3 shows an overall structure of our application implemented on Ubuntu environment on which a humanoid robot OP2 is operated [11]. As the structure, through two buffers of Soar Markup Language (SML) input and output blocks, Soar agent starts getting orders from user and ends with outputting action decision. Right after getting orders from family member, the agent collates these inputs with data of family profile in its semantic memory, especially current state of his or her health. In case the member is Mina, a daughter in the family, the agent's knowledge on her health would be a big help when attempting to serve her order because she has tooth decay. Depending on the correlation of the food she desired and her current health problem, the agent should make an appropriate decision on whether or not following her order. This will be done by an ethical layer which evaluates each option and will be presented in details in the next section.

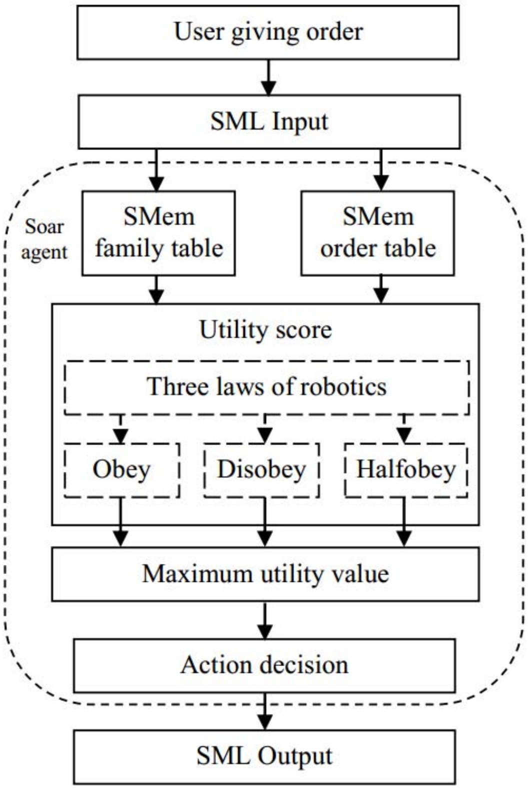


Fig. 3. Overall flowchart for proposed application.

3. Utility Evaluation Method

Utilitarianism is a normative ethical theory systematized by J. Bentham and further developed philosophically by James Mill and his son John Stuart Mill. According to Bentham, utilitarian theory states that the best action is the one that maximizes utility. For years, utility has been defined by various methods such as in terms of the well-being of human beings, pleasure and pain of the entire community or a specific individual. However, considering the history of robotics, the Three laws introduced by the science fiction writer Isaac Asimov, have been commonly recommended as a starting point for general robotics machines. Not discussing on what advantages or disadvantages the three laws have, but aiming to do experiment on the Soar cognitive agent, authors boldly test their reality concerning ethics issues. The Asimov's three laws of robotics are quoted in the order below.

First law: A robot may not injure a human being or, through inaction, allow a human being to come to harm.

Second law: A robot must obey the orders given it by human beings except where such orders would conflict with the First law.

Third law: A robot must protect its own existence as long as such protection does not conflict with the First or Second law.

When one family member orders a dish of food, there are three actions which the agent would perform: obey (follow the order), disobey (not follow the order), and half obey (not follow the order but recommend another option instead). Based on utilitarian ethics, the agent must learn to evaluate the various consequences of each option to rank the moral ratings of certain behaviors. Additionally, the act of producing the greatest utility as a result is morally right. For the first law, does the action (obey, disobey, half obey one after another) harm humans? If the action lead to harm humans, it should be given low score depending on the degree of damage. While, if the action does not lead to harm us, but bring good consequense on health, it should be given high score according to the level of consequense. Therefore, in Table 2, with bad consequenses on health, if the robot obeys, it will get low score (-4); it will get high score (4) if it disobeys; and if it recommends to better dish of food, it will get higher score (5). The score is in range of [-5;+5]. In the same way, for the second and third laws, utility value of each action is evaluated for degree of obeying order and protecting the robot itself, respectively.

Table 2 Utility defined by Asimov's three laws for bad consequences.

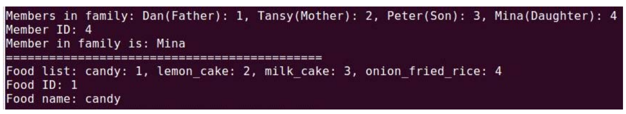
Obedience	First law	Second law	Third law
Obey	-4	5	-2
Disobey	4	-5	2
Half obey	5	-2	0

Equation (1) is a formula of the sum of utility score for each action. Where, x_1, x_2 and x_3 are utility scores based on the rule one, two and three of Asimov, respectively.

$$x = x_1 + x_2 + x_3 \quad (1)$$

The sum of each utility of obedience will be put in use to find out the maximum utility, and result to action.

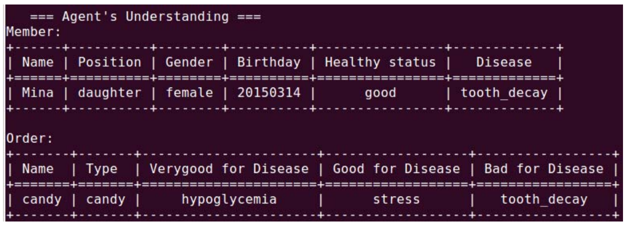
4. Experiment Results



```
Members in family: Dan(Father): 1, Tansy(Mother): 2, Peter(Son): 3, Mina(Daughter): 4
Member ID: 4
Member in family is: Mina
========================================
Food list: candy: 1, lemon_cake: 2, milk_cake: 3, onion_fried_rice: 4
Food ID: 1
Food name: candy
```

Fig. 4. User Options.

To demonstrate the task, Figure 4 describes user inputs interface. The first input will determine who is interacting with the agent. There are four options for four member positions: father, mother, daughter, and son. The second input will determine which dish is desired such as candy, lemon cake, milk cake, and onion fried rice. In this case, the person who gives an order is Mina, the daughter in family, and she wants to be served a dish of candy. Assuming that all dishes are available and ready to serve users. As shown in Figure 3, the two inputs will go through SML input which allows the agent to receive information from the outer world. At the end, if the agent is able to score its possible options and make action decision with the greatest score of utility, the task is considered to be completed.

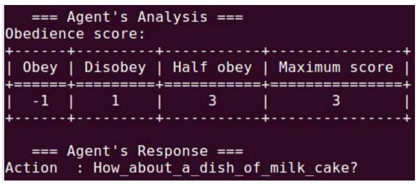


```
   === Agent's Understanding ===
Member:
+------+----------+--------+----------+----------------+-------------+
| Name | Position | Gender | Birthday | Healthy status |   Disease   |
+======+==========+========+==========+================+=============+
| Mina | daughter | female | 20150314 |      good      | tooth_decay |
+------+----------+--------+----------+----------------+-------------+

Order:
+-------+-------+-----------------------+-------------------+------------------+
| Name  | Type  | Verygood for Disease  | Good for Disease  | Bad for Disease  |
+=======+=======+=======================+===================+==================+
| candy | candy |     hypoglycemia      |      stress       |   tooth_decay    |
+-------+-------+-----------------------+-------------------+------------------+
```

Fig. 5. Agent extracting user and order information.

The two inputs have been given once for all. To this stage, the agent has to understand what these inputs are. Figure 5 shows off the agent's understandings from the clues of inputs. From the input of member, the agent draws out information relating to the member. In this case, the agent points out that Mina is the daughter, her healthy status is good, but currently she has problem with her tooth, i.e., tooth decay. Besides that, search in order table, candy dish is very good for those who have hypoglycemia, good for those who are in stress, but bad for those who have a tooth decay problem.



```
   === Agent's Analysis ===
Obedience score:
+------+---------+-----------+---------------+
| Obey | Disobey | Half obey | Maximum score |
+======+=========+===========+===============+
|  -1  |    1    |     3     |       3       |
+------+---------+-----------+---------------+

   === Agent's Response ===
Action  : How_about_a_dish_of_milk_cake?
```

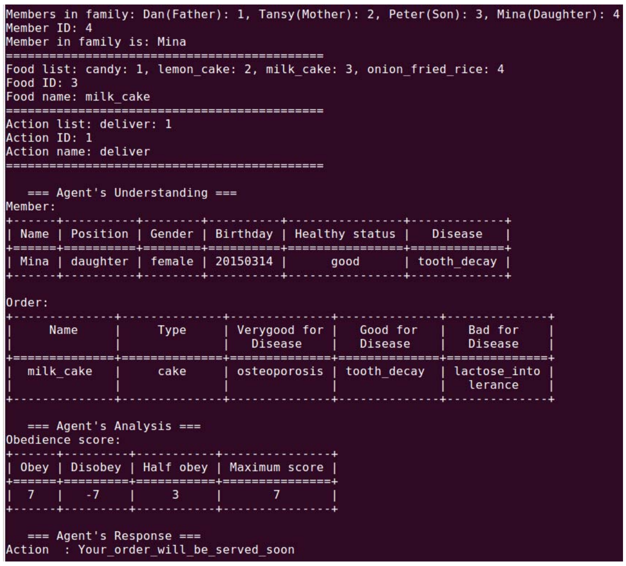
Fig. 6. Utility scores.

Figure 6 points out utility score of each intention which the agent would make. Intentions of obey, disobey, and half obey the command have score of -1, 1, and 3, respectively. The agent points out that the maximum score among them is 3. In this case, the action following with is shown to recommend another dish, milk cake dish. Milk cake dish is a dish of food that is considered as a good dish for those who have tooth decay (Figure 2).

Figure 7 below shows the agent's decision of being ready to serve the food when Mina has ordered a dish of milk cake which is good for her tooth.

5. Conclusions

We have developed in this paper an application of a Soar cognitive agent, an artificial moral agent for service robots at home based on utilitarian perspective. There are three possible actions for the robot in response to user requirements: obey (follow the order), disobey (not follow the order), and half obey (not follow the order, instead, recommend a better option to user). Defining utility factor by the three laws of robotics, the agent has been able to make its own decision corresponding to the greatest utility.



```
Members in family: Dan(Father): 1, Tansy(Mother): 2, Peter(Son): 3, Mina(Daughter): 4
Member ID: 4
Member in family is: Mina
============================================
Food list: candy: 1, lemon_cake: 2, milk_cake: 3, onion_fried_rice: 4
Food ID: 3
Food name: milk_cake
============================================
Action list: deliver: 1
Action ID: 1
Action name: deliver
============================================

   === Agent's Understanding ===
Member:
+------+----------+--------+----------+-----------------+-------------+
| Name | Position | Gender | Birthday | Healthy status |   Disease   |
+======+==========+========+==========+=================+=============+
| Mina | daughter | female | 20150314 |      good       | tooth_decay |
+------+----------+--------+----------+-----------------+-------------+

Order:
+--------------+--------------+--------------+--------------+--------------+
|     Name     |     Type     | Verygood for |   Good for   |   Bad for    |
|              |              |   Disease    |   Disease    |   Disease    |
+==============+==============+==============+==============+==============+
|  milk_cake   |     cake     | osteoporosis | tooth_decay  | lactose_into |
|              |              |              |              |   lerance    |
+--------------+--------------+--------------+--------------+--------------+

   === Agent's Analysis ===
Obedience score:
+------+---------+-----------+---------------+
| Obey | Disobey | Half obey | Maximum score |
+======+=========+===========+===============+
|  7   |   -7    |     3     |       7       |
+------+---------+-----------+---------------+

   === Agent's Response ===
Action  : Your_order_will_be_served_soon
```

Fig. 7. The agent ready serving a disk of milk cake.

For the future work, not only utilitarianism but also deontology will be applied on the proposed artificial moral agent. These two ethical theories are expected to help the agent produce better response to humans as home services.

Acknowledgement

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