Topic Selection for Interactive Robot Based on Knowledge Estimation by Bayesian Network

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***Abstract*- We propose a dynamic topic selection for human-robot interaction, which mediates information among multiple persons. By using Baysian network, the robot calculates topic values with considering contexts and users' knowledge models. Then, the topic with the highest value is chosen. When the robot finds that the knowledge models have inconsistent information, it calculates likelihoods for each information of the model. Then, the robot tells the information with the largest likelihood to the person who has that with the least likelihood.**

I. Introduction

In recent years, research on the human-robot interaction is done actively. Although it is difficult for us to master the information technology which developed highly, all people can use them easily when their interface is natural language. We are studying about the way a human-robot and a user communicate smoothly. Previous work in human-robot interaction has studied the interactive information guidance system[1] and tour guide robot[2]. Although the robot can provide a user with information by these researches, they had some problems as follows: i) When a user converts topic suddenly, it is difficult for a robot to follow the topic which was converted. ii) A robot tells that the user well-known information. iii) These methods which proposed in previous work are static dialogue control based on an if-then type of action rule. iv) The robot cannot respond, when there is a disagreement of knowledge between a user and the robot. So, this paper aims at realization of the robot which chooses suitable topic flexibly.

II. Knowledge State Presumption by Baysian Network

A. Definition of knowledge state

We expressed the knowledge state by "the kinds and those elements of information" and "reliability of elements" (fig.1). The reliability is denoted by probability that the element may happen. Our method guesses this probability about both user and robot. Then we guess changes of reliability when robot can provide this probability to user. In addition, the method makes it possible to express the ambiguity of the knowledge that the correctness of information decreases as time passes. By using this method, since reliability was presumed when a disagreement occurred to the information between a user and a robot, a robot could be judged whether user's information is correct or not. Therefore, the robot can take the action for canceling a disagreement now. Therefore, the robot can take the action that fixes a disagreement.

B. Probability estimation by Baysian network

In order that a robot estimates reliability, we prepared Baysian network for each type of information (fig.2). Fig. 2 shows the relationship of Baysian network when user A said to the robot his recognition to X. In this Baysian network, the node X expresses the robot's recognition to X. It is equivalent to information to clarify. The prior probability of X is probability distributions of information to clarify and, we set the probability distributions as heuristics. Moreover, node X_A, X_B, and X_C correspond to the user A, B, and C recognition. If the robot differs between the X_Z and X's event of the highest probability, he will make it a disagreement. A robot gives a user the information for making the X_Z's event of the highest probability brought close to the X's event of the highest probability, and tries dissolution of a disagreement.

III. Topic Selection Based on Knowledge State Estimation

A. The dialogue control algorithm

By always calculating worth of each topic, we chose the worthiest topic. A robot always calculates worth of each topic in conversation with a user, and talks the worthiest topic. Fig. 3 shows the situation. The selection makes a robot enable flexible correspondence to topic. The calculation method of worth of the subject is stated to the next paragraph.

B. The calculation method of worth of topic

We defined all the users' set as $\boldsymbol{U}$, arbitrary-user as u_k, all the robots set as $\boldsymbol{R}$, arbitrary-robot as r, robot talking about the topic i to the user u as A_i^u, the worth of topic as $U(A_i^u)$, the time required to talk about the topic as $T(A_i^u)$, and the related degree of the last topic k and the topic i as $R(A_i^u|A_k^u)$. In addition, $H_i(T)$ denotes the variation of the entropy which computed from the kind i of each information between the time T and the time T-1. The worth of talking is let by Equation 1.

$$V(A_i^u) = \frac{U(A_i^u)}{T(A_i^u)} \cdot R(A_i^u|A_k^u) \cdot defH_i \quad (1)$$

$$defH_i = \frac{(H_i(t) - H_i(t+1))}{maxH_i} \quad (2)$$

$$H_i(T) = -\sum_j^{N_i} P_T(K_{i,j}^u) \cdot \log_2 P_T(K_{i,j}^u) - \sum_j^{N_i} P_T(K_{i,j}^r) \cdot \log_2 P_T(K_{i,j}^r) \quad (3)$$

$$maxH_i = \log_2 N_i \quad (4)$$

We set $U(A_i^u)$, $T(A_i^u)$ and $R(A_i^u|A_k^u)$ as heuristics this time. Therefore, we can calculate worth of topics. The robot speaks about the topic of the maximum worth.

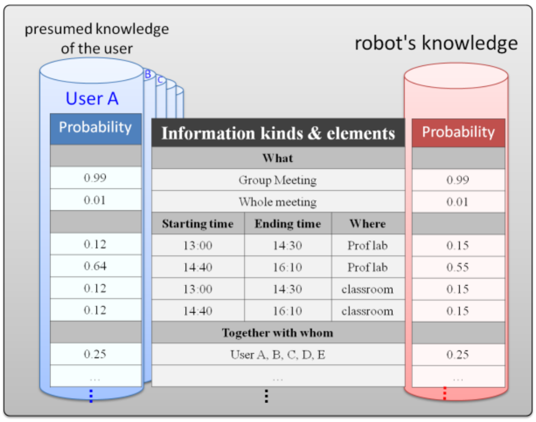

Figure 1: The knowledge state presumed for every user

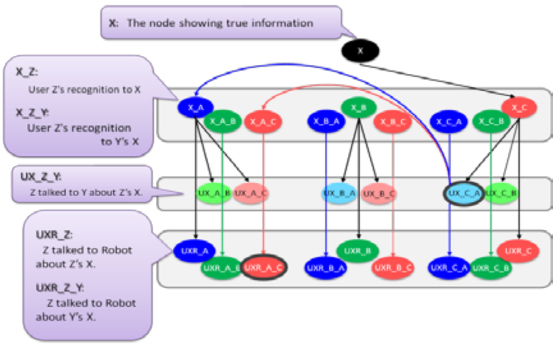

Figure 2: Baysian network when A talks to Robot

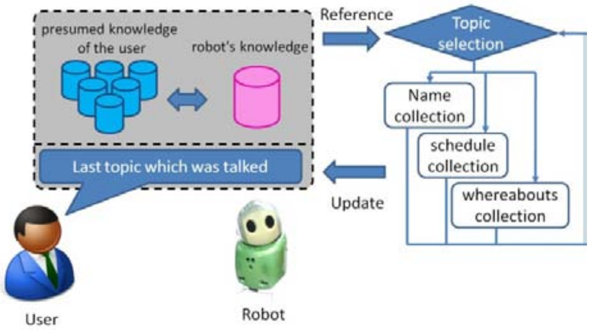

Figure 3: Overview of dialogue control

C. The topic selection method in case a disagreement is between a user and a robot

When a disagreement occurs to the information between user robots while going ahead with the dialog, a robot judges what is right using Baysian network. When user is believing wrong-information, a robot shows a user right information and reason.

D. Evaluation

The robot acts for the purpose of managing and adjusting the schedule and whereabouts of our laboratory member. The robot collects that information by talking with our laboratory member. If the robot finds a disagreement in talking, the robot talks to user for solving the problem.

	Robot's remark		User A's remark
1	Who are you?	→	I'm A.
2	Hello Mr.A. Have you any plans?	→	I have group meeting.
3	Would you teach the time and the place of the plan?	→	The plan will be held by 14:40 to 16:10 in prof lab.
4	How did you get the information?	→	From C.
5	Is there any other participant?	→	C says he, B, and D and E participate.
6	Have you other plan?	→	Noting.
7	Do you go to somewhere after this?	→	I go to eat something.
8	When do you go back?	→	I'll be back at 14:00.
9	Who are you looking for?	→	Mr E.
10	Sorry, I don't know too.		
11	Can I tell E that you are looking for E?	→	Yes, please.
12	OK. Have a good day!		
	Robot's remark		**User E's remark**
13	Who are you?	→	I'm A.
14	Hello, Mr. A was looking for you.		
15	Have you any plans?	→	Where is Mr. A rather than that?
16	Mr. A has gone to the dining-room now.		
17	He had said that he'll be back at the 14:00 times.		
18	Have you any plans?	→	I have group meeting.
19	Would you teach the time and the place of the plan?	→	The plan will be held by 14:40 to 16:10 in prof lab.
20	How did you get the information?	→	I checked by e-mail.
21	Is there any other participant?	→	They are A, B, and C and D.
22	Have you other plan?	→	Noting.
23	Do you go to somewhere after this?	→	I go to a dining-room to look for A.
24	When do you go back?	→	I'll be back at 14:00.
25	Who are you looking for?	→	No.
26	OK. Have a good day!		
	Robot's remark		**User B's remark**
27	Who are you?	→	I'm B.
28	Hello Mr.B. Have you any plans?	→	I have group meeting.
29	Would you teach the time and the place of the plan?	→	The plan will be held by 14:40 to 16:10 in classroom.
30	How did you get the information?	→	From D.
31	However, Mr. E had said that the meeting is held		
	in prof lab.	→	Is that so?! I'll tell Mr. D.
32	Is there any other participant?	→	D says he, A, and D and E participate.
33	Have you other plan?	→	Noting.
34	Do you go to somewhere after this?	→	No, I stay here.
35	Who are you looking for?	→	No.
36	OK. Have a good day!		

Figure 4: The result of the conversation

The conditions which we set up in the experiment are as follows: i) The user A, C, and E has the same information about the meeting. ii) The users B and D have a disagreement only about the place of a meeting. iii) The robot talked in order of the user A, E, and B.

E. Result

Fig.4 shows that the robot can deal with it, even if a user changes topic suddenly like No.15 remark. Furthermore, in the conversation of No.29-31 remarks, even if the disagreement arose in conversation with the user B, the robot was able to show the user B the robot's information, and take action of resolution.

IV. Conclusion

Because we made a robot calculate worth of topic, the robot enabled it to choose the optimal topic from some topics dynamically. Moreover, we proposed the method of computing reliability for a user's information using Baysian network, and a robot can solve the disagreement with user. In future work, we will improve about the heuristics element in value calculation of subject.

References

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