A Map Guidance System by Multiple Dialog Robots Cooperation

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Abstract. The purpose of this study is to release user's feeling of unease and loneliness, which occur in people's mind while heading for the destination, by appropriate encouragement by multiple robots. In our development, we combined the robot technology with "good old-fashioned guidance know-how" and employed five concepts: Manual less, Operation free, Device free, corporeality of robot and Advantage of network robot. A comparative experiment was conducted. It proved the effectiveness of robot giving ease and joy to user. At the same time, we have found that the user come to feel uneasy with increasing distance from the robot. Therefore, measures for improving this problem have been studied. Those are the quantification of psychic distance concerning unease and the introduction of mobile robot.

Keywords: multiple dialog robots, guidance, networks, cooperation, encouragement.

1 Introduction

Nowadays, the navigation system of smart-phone has been getting popular. However, we have found that it causes some new problems especially with people who are not good at using smart-phone. It is a little dangerous while walking on the street because users are forced to look at the map in it again and again until they arrive at the destination. It causes the distraction around a user such as the obstacle near feet, passerby and so on, and it makes users feel at "unease" and "burdened" to head for the destination. Moreover, users are compelled to become accustomed to use smart-phones, taking much time. Naturally, it also inspires the feeling of "burden" to users. Furthermore, users feel lonely because of such a cool device which is totally different from general companion who can talk together freely. As a result, we focus on how to solve such problems of the guidance system.

It was proposed that by using the RFID tags and ubiquitous sensors, information of visitor's experiences at the science museum is obtained and the robot autonomously interacts with visitors based on such information [1]. It revealed that the combination of free-play interaction and exhibit-guiding contributed to promote visitor's interests at the museum. Also, there is a study that the guidance robot in shopping mall makes

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a conversation with sophisticated dialogue strategy in order to try to be familiar with customers more in the long term [2]. It showed that it can be intimate customers by remembering them one by one and talk to customer about the individual topic. Also, under the background it's difficult to guide a lot of audiences at once in the museum, the method of how to decide an appropriate person to ask the question about exhibit to guide was proposed [3]. It is based on user's nod and direction of eyes and it revealed that to choose a person having prior knowledge about the question can attract interest of audience and facilitate talk.

In these prior studies, although the guidances in indoor environment such as in museum and in shopping mall were studied, the questions of guidance in outdoor environment are still open. To develop such a guidance system, we had to face the unsolved problems. There is the typical problem for heading for the destination through the unfamiliar streets. It is to occur the feeling of "unease" and "loneliness" in people's mind. Therefore, we considered releasing such negative feelings by the robot dialogue. Moreover, there are obviously the users who have long distance to the destination in outdoor environment. However, the systems in previous studies didn't mention such a condition. It's almost impossible for an only robot to lead such a user to the destination. Therefore, we considered multiple robots cooperation to lead user to the destination. In order to do those, we developed the guidance system which multiple robots appropriately encourage the user again and again, sharing user's information via networks: face, destination and route, so that user can easily get to the destination even if the distance from the user to the destination is too far.

We have been proceeding the research about the behavior of robot in the era there are a lot of robots in daily life to help people. We adapt the robot technology to guidance system to achieve following purposes.

(a) So that the user can enjoy heading for the destination, multiple robots along the way encourage the user to reduce the "burden" and "unease".
(b) So that the user can easily head for the destination, the system reduce the "burden" by forcing neither the memorization nor the manipulation to use the system.
(c) So that the user can feel like being with companion, multiple robots make a conversation and encourage the user to reduce the "loneliness".

2 The Map Guidance System Which Multiple Robots Cooperate

2.1 Concept of the System

There was "good old-fashioned guidance know-how" that people simply catch a person who is walking by and ask how to get to the destination repeatedly until getting there. The era there are a lot of robots deployed in almost all street corners (like Japanese police box) is being expected. Therefore, we reached a notion combining the robot technology with such "good old-fashioned guidance know-how", shown in Fig.1. Moreover, such guidance know-how was improved more by the robot technology. We have found out five concepts in our system ("Manual less", "Operation free", "Device free", "Corporeality of robot" and "Advantage of network robot").

As for “Manual less”, there’s no necessity for memorization on how to use the system since it’s only necessary to make a conversation with robot to take directions so users can easily and immediately use the system.

As for “Operation free”, actually, there are the users, especially elderly people who complain about navigation system because they can’t easily manipulate the device such as smart-phone because of size of it although they sufficiently understand how to use the system. However, by virtue of dialogue robot, users aren’t compelled to manipulate complicated operation since having a dialogue is the most natural and the easiest behavior of human-beings.

As for “Device free”, the situation that a user has the device to get directions causes unpredictable dangerous situation for him/her. That’s why, not making users use a device while heading for the destination was needed. However, because of proposed system, since asking robot is only needed, users don’t need to have a device so it can allow users to pay attention to their surroundings while heading for the destination in order not to face such situations.

As for “Corporeality of robot”, In comparison with CG and the other devices which don’t have appearance of creature, people can naturally talk to a robot and feel like that I’m actually talking to it. Furthermore, even if a user gets lost on the way, another robot can be easily found. Therefore, users never feel lonely.

As for “Advantage of network robot”, by sharing information of user with the other robots via networks, they can cooperate with each other. As a result, it can realize that talking and encouragement based on user’s progress and smoothly lead the user to the destination.

Fig. 1. Appearance of guidance by robot

2.2 Outline of the System

The dialog robot which is used for our study is “Phyno” made in Yuvizoukei. This robot has 34 cm in height, 21 cm in length, and 26cm in width, and can move 3 degrees of freedom (DOF) in head, 1 DOF in arms, and 1 DOF in body. This robot can speak words by a voice of a mature woman with gestures. It works with camera, speaker, and microphone. In order to detect and distinguish the person, it’s programmed by being used OpenCV, and in order to recognize the voice the user speaks, we used Julius. Then, we used Dijkstra’s Algorithm as the short path problem to extract the best route to the destination. Finally, this system can share information of the users via networks with multiple robots by using Winsock. A picture illustrating the multiple robots cooperation, which includes a range of robots considered for future works in the 6 Paragraphs, is shown in Fig.2. By sharing user's information (face, destination and route which the user passed) with the other robots, it can distinguish users and smoothly tell directions without asking his/her destination again. In addition, the robot can talk to a user depending on the user's progress circumstance and choose a suitable dialogue (e.g., "Welcome, I was looking forward to your visit. You are in the right place") and encouragement (e.g., "You can do it. You are almost there") in order to evoke a feeling of joy. The procedure of proposed system is listed below.

When a user approaches the robot, the user's face is detected by camera and sent to the server. And then, it's distinguished whether it's the first time for him/her to call on the robot or not. As a result of that, if this is the first time, the user will be asked the destination by the robot and take not only directions but also the nearest location of the robot from the user in order to reduce the burden to remember the route. After that, information of the user will be sent to the server to stockpile. On the other hand, if not the first time, the user will get directions without asking the destination again by reason of information in the server. Furthermore, appropriate conversation according to user's progress will be conducted by referring to stockpiled information in the server. And then, also revised information will be stockpiled everytime a user meets robot. A picture illustrating above procedure is shown in Fig.3.

As a result, proposed system can provide the following effects.

- Users can easily use the system because of using only dialog
- Users can enjoy heading for the destination and reduce the feeling of loneliness by being encouraged appropriately by multiple robots
- The burden of memorization of the route can be reduced by reason of no necessity to memorize all routes to the destination
- Users can feel at ease and reduce the feeling of loneliness by being remembered by the robot and talking to them as many as a user meets them

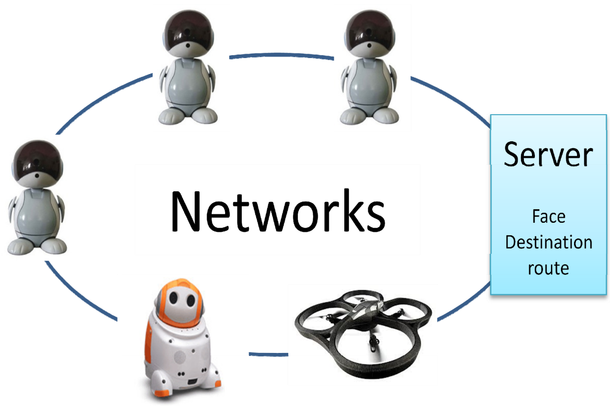

Fig. 2. Multiple robots cooperation via networks

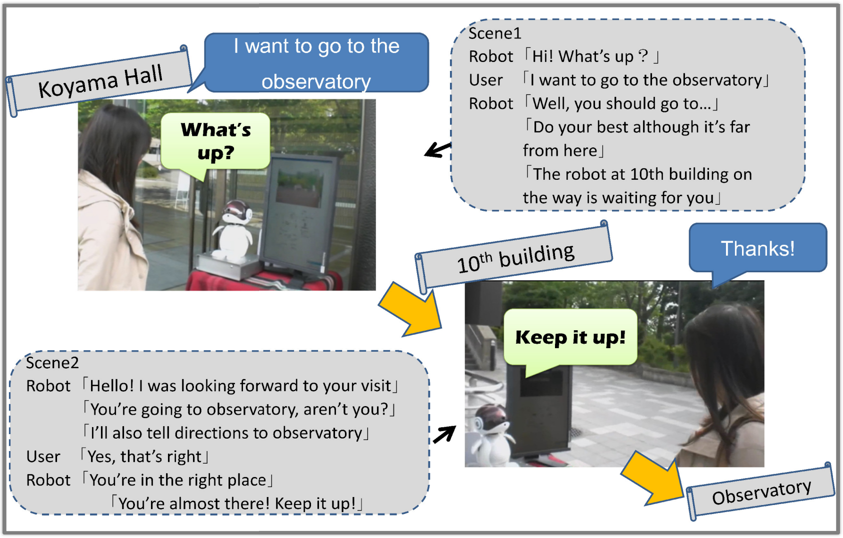

Fig. 3. Procedure of the proposed system

3 Experiment

We conducted an experiment under the following purpose.

"The route which easily enhances the feeling of unease about whether to be able to get to the destination because there are dimness, many corners and stairs is prepared. Even if users walk such a route, users don't feel uneasy because of talking to robot, and feel joy and easy."

Twenty undergraduate students at Kyoto Sangyo University who had never visited at the building conducted our experiment, participated in experiment as subject. The reason why we chose such people is to eliminate people who can get to the destination without guidance. The subjects were required to get to the destination given by experimenter through the complicated route, shown in Fig.4 and 5, taught by the guidance system. In Fig.4, the left figure is the 3rd Floor (3F) map, and the star represents the departure point, and the (X) represents the robot (display). Subjects walk along the arrow. The right figure is the 1st Floor (1F) map. The triangle represents the arrival point and the (Y) represents the robot (display). We conducted a comparative experiment, and used a between-subjects design, and prepared two conditions for experiment, shown in Fig.6.

Outline of both conditions are listed below.

(a)Proposed guidance system

The robots were deployed at the departure point and at the stopover point. The subject tells the destination, which was given by experimenter, to the robot at the departure point and takes directions. And then, s/he smoothly gets the guidance again from the robot at the stopover point without telling the destination.

(b)Conventional guidance system
The displays were deployed at the same points as proposed system. The subject manipulates it with mouse to choose the destination among 6 places to get the guidance at the departure point. And then, s/he manipulates it again at the stopover point.

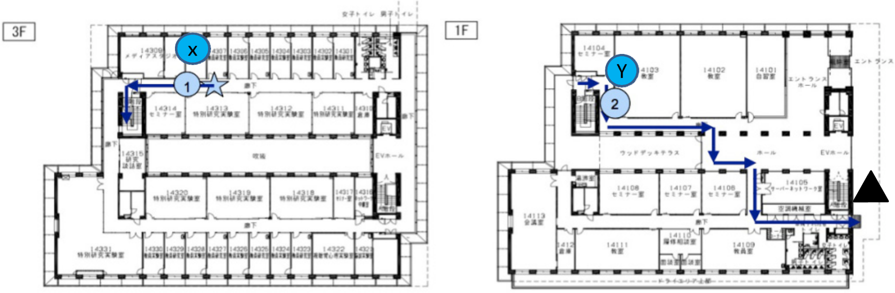

Fig. 4. Floor plan of the experiment

Fig. 5. Complexity of the route; stairs (left) and corridor (right)

Fig. 6. Snapshots of experiments; robot (left) and display (right)

In the questionnaire for the subjects, three bipolar words ("Ease", "Isolation" and "Joy" and the scale of 1 to 7) were used in order to evaluate the individual impressions in both conditions. In addition, four bipolar words ("Natural", "Persuadable", "Humanly" and "Joy") were also used in order to evaluate the individual impression for robot in only condition of the proposed system.

4 Results

As shown in Fig.7, the evaluated value in the proposed system (with robots) is on the whole greater than the conventional system as we expected. We could find that the difference of "Ease" and "Joy" between both conditions is statistically significant although the words used in experiment in both conditions were same. The reason is that there were existence and encouragements of robots, according to free description in questionnaires. That is to say, the robot can have an appreciable effect on enhancement of those feeling. On the other hand, as for "Isolation", it could not be found although it seems that the value in the proposed condition is greater. The reason why the evaluated value of "Isolation" could not show a significant difference is that although talking to robot, the users felt happy and didn't feel lonely, after departing from the robot, they started feeling lonely and at unease. As shown in Fig.8, the evaluated value of "Persuadable" and "Joy" are relatively higher. In addition, we found the significantly different rate between both conditions that the subjects could get to the destination without getting lost during experiment from the observation. In the proposed system, the number of such subjects was 8 out of 10, whereas as for the conventional system, it was 2 out of 10. It shows that the robot's intimate behaviors that gaze at user and encourage user could evoke the motivation to try to remember the route more than one-sided navigation in the conventional system.

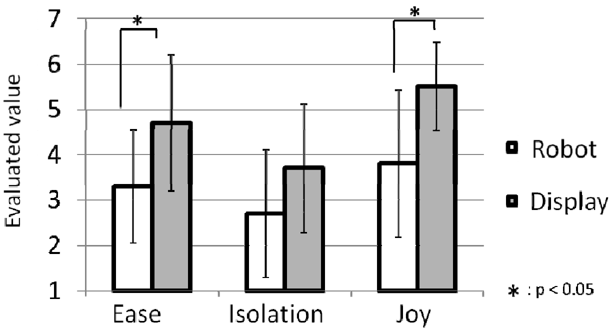

Fig. 7. Comparison of the robot and terminal

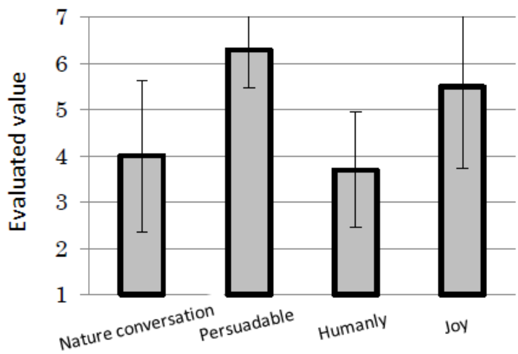

Fig. 8. Impressions of the robot

5 Discussion

We confirmed that users can easily use our system without learning how to use it. We also noticed the question seen in human conversation between the subject and the robot in order to take directions again. It shows that the subjects used the proposed system as if they talk to someone, which is to say it can decrease the burden of users as effect of “Manual less” and “Operation free”. Moreover, the users using the proposed system got to the destination without facing dangerous situation, paying attention to their surroundings during experiment. It shows that the proposed system can allow users to afford to pay attention for security as effect of “Device free”. Also the opinions that the subjects delighted to see the robot on the way were seen so it shows that the appearance like creature enhances the feeling of delight on meeting as effect of “Corporeality of robot”. Also obviously the conversation and the encouragement based on user’s progress could contribute to enhance the feeling of joy as effect of “Network robot”.

We found that the synthetic voice was stereotyped and monotone so it gave weird feeling to subjects. However, we found also the remarks that “because the robot was beside me, I surely had consciousness to talk to the robot”, which is to say the robot was regarded as conversational partner. That’s why, we are convinced that the evaluated value of “Humanly” didn’t plummet and kept intermediate value. It shows that the synthetic voice has to be improved by putting intonation and cadence. By doing this the feeling like being with robot will be given to users potently.

We found also the incidents that all subjects didn’t keep an eye on the robot while taking directions. After experiment, we asked them the reason and figured it out. It was that they concentrated on not the behavior of robot but listening to the guidance. Therefore, we figured out that our dialogue design was not sufficient so the dialogue design of study in Saitama University that make a decision about person whom the robot talk to based on person’s nod and direction of eyes will provide a clue to solve our problem. At least the behavior while giving directions and the behavior while greeting user should be made into different one.

6 Future Works

6.1 Quantifying of Psychic Distance Concerning Unease

According to some remarks from the free descriptions, we realized that the necessity for deploying the robot in appropriate place where users don’t feel at unease while heading for the destination. In order to do that, we have to figure out how long the distance between robots is suitable not to make users feel at unease. In addition, it’s involved in not only physical distance but also the number of corners, stairs and so on. Moreover, since the degree of feeling of unease caused by the distance depends on a person, if that psychic distance becomes obvious basically, the guidance and the notice depending on each people will be able to be given to them.

6.2 Introduction of Mobile Robot in the Proposed System

Even if we figure out the psychic distance, whether the robot can be deployed in appropriate place or not is not reliable and so we have an additional idea to diminish the feeling of unease. By introducing mobile robot in our system, all the user who is about to depart to the destination through the route which has a possibility to evoke a feeling of unease have to do is just to follow mobile robot. Two styles of robot (fixed, mobile) have each role. Giving directions compactly, the fixed robot can equally guide to every user, and engaging in a user, taking time, the mobile robot can dependently guide to specific users.

We found that there is the compatibility between these styles. Since the fixed robots are deployed in given place, the user just calls on the robot, which gave directions before, again whenever the user feels like visiting another place. It can give the feeling of ease that "going to a place where I took directions, I can meet the robot again" to user. It's difficult to imagine that all users prefer following the robot all the way even if the robot has great performance of ambulation. Most people must prefer heading for the destination at their own pace. Therefore, typically, fixed robot is used as a kind of landmark and asked directions again and again, and mobile robot is used when needed. We think it is the most suitable role. Moreover, we have come up with flying robot as one kind of mobile robot. As the advantage of flying robot, it can easily lead users to the destination even if the surface of streets is not flat such as unpaved road, stairs and so on. Therefore, in the indoor environment, it is appropriate that mobile robot using wheel is used, while in the outdoor environment, it is appropriate that flying robot is used. The point is that various robots are cooperated to appropriately lead users to the destination, depending on each condition.

7 Conclusion

We proposed the guidance system combining robot technology with good old-fashioned guidance know-how. In our system multiple robots are deployed in almost all streets. This system solves the problems of the common navigation system which make users feel uneasy and lonely.

The proposed system is based on five concepts: Manual less, Operation free, Device free, Corporeality of robot, and Advantage of network robot. Thus, the burden to become familiar is removed. Danger caused by walking while watching the mobile phone is reduced. Feeling of loneliness is also reduced. Robots can encourage and entertain the user. We proposed a new approach that multiple robots cooperate mutually via networks to tell directions with appropriate dialogue and encouragement based on user's progress circumstance. An experiment for comparing with proposed and conventional guidance system was conducted to prove the effectiveness of robot. As a result, it revealed that the difference of the evaluated values of "Ease" and "Joy" between both conditions is statistically significant. The result also shows that user can enjoy heading for the destination, and feel easy. The evaluated value of "Persuadable" and "Joy" as impression against the robot got much higher. It shows that the guidance by the robot can inspire the consciousness to listen to directions more than the guidance by the display and is more enjoyable. Moreover, we have found the problems to be solved. Those are the inappropriate part of the dialogue strategy of robot guidance, artificiality of synthetic voice, and the fact that user get to feel uneasy and lonely after departing from robot. We also proposed the methods of solution. Those are quantifying of psychic distance concerning unease and introduction of mobile robot. We are expecting that the knowledge obtained by this study will adapt to the various systems employing robot, and contribute to the development on symbiotic society of human beings and robots.

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