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Demonstration experiments of a distributed questionnaire service using multiple robots with the aim of marketing at a tourist site

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Abstract

Recently, the concern with tourism destination marketing, which is conducted marketing research from a tourism destination view point, has been growing. We have proposed a distributed questionnaire service using multiple robots, with the aim of application to marketing at a tourist site and an exhibition. In this paper, we described the problem of conducting a questionnaire service using robots in a crowded space, which was obtained from the demonstration experiment in FY 2015. In order to solve these problems, we proposed (1) a mechanism that enables the respondent to answer the questionnaire displayed on the robot with a smartphone, (2) a mechanism that dynamically generates a questionnaire according to the questionnaire collection process, (3) improvement of robot motion and interaction as a calling function and a nodding function. Moreover, we implemented these as a distributed questionnaire service using multiple robots and conducted demonstration experiments at international conferences EAIS 2016, Japan Robot Week 2016, and Fukagawa museum road shopping street, and verified the effectiveness of our proposals.

Keywords: Robot Services; Web Services; Robot Signage; Tourism destination marketing

1 Introduction

Recently, the concern with tourism destination marketing [1], which is conducted marketing research from a tourism destination view point, has been growing. In tourism destination marketing, it is necessary to find a preferred customer segment for its own region (e.g. tend to increase a level of satisfaction of customers, there are high economic effects). Moreover, it is necessary to clarify an uptake measure of the customer segment and to maintain a visit of tourist (continue to re-visit). Therefore, a tourism destination side is required to collect information of their own tourist and analyze them by oneself. However, the data for a marketing strategy are not accumulated locally, since such information collecting system has not been established.

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As a method of obtaining customer information in the Web field, there is Web marketing to get the user information and the location information based on the ID information. Particularly, there are accumulation of search history in Google, accumulation of purchase history and extraction of similar user's information in Amazon, accumulation of post history to Facebook and LINE, and SNS analysis. On the other hand, in the Robotics field, robot-service researches that utilize robots in places where people gather, such as commercial facilities and public facilities, are being conducted. A study of a promotional service using a remote controlled robot in a commercial facility [2][3], and a study of advertising effectiveness of the robot system that combines a big robot and a small robot [4], are conducted. In addition, a demonstration experiment of guidance, information service and coupon issuance by multiple robots [5] are conducted. These robot services are intended to provide a service of transmitting information to users who gather in front of the robot. So, methods of obtaining information of users who gather in front of the robot are not clear.

From this background, we have proposed a distributed questionnaire service using multiple robots, with the aim of application to marketing at a tourist site and an exhibition [6][7]. An overview of our robot's service is shown in Figure 1. This system comprises multiple robots, servers providing robot services, smartphones installed with the application that can cooperate with the service and a QR code reader application, and web browsers that display the aggregated result of information in real time. The authors defined the Enquete profile for developing this service. The Enquete profile is a service module for implementing questionnaires service on the platform of RSNP (Robot Service Network Protocol) [8], which is a common specification for robots. (A "profile" is a common name of each functional module and each service modules on RSNP.) Using this Enquete profile, we constructed a prototype system of a distributed robot's questionnaire service for marketing at exhibitions and sightseeing spots. In addition, we conducted demonstration experiments at the International Industry Exhibition November 2015 [6] and the International Robot Exhibition December 2015 [7] using multiple robots, and verified the effectiveness of our robot's questionnaire service. However, problems unique to the questionnaires service using robots were found though these demonstration experiments. In this paper, we describe the problems found from the previous demonstration experiments and propose the solutions for these problems. Moreover, we improve our prototype system according to these solutions, conduct demonstration experiments, and verify the effectiveness of the solutions.

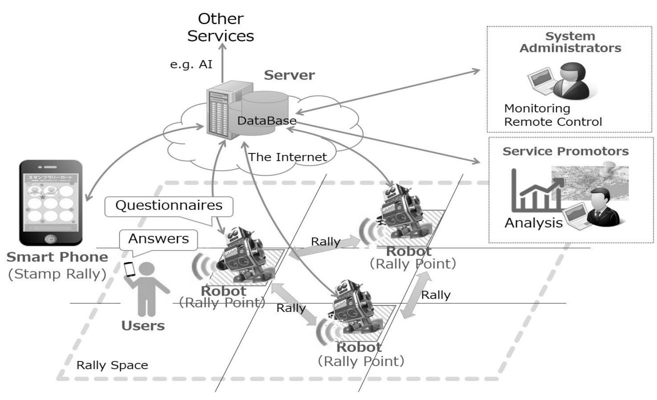

Figure 1: An overview of our robot service

The rest of this paper is organized as follows. We discuss related works in Section 2. And, we find new problems based on the discussion of results obtained by previous demonstration experiments and show solutions to the problems, in Section 3. Moreover, our implementation of the prototype system according to our solutions, and demonstration experiments are described in Section 4, and we evaluate the solutions in Section 5. Finally, we discuss our three solutions and conclude with a remark of our next research direction in Section 6.

2 Related works

We mention related works of “use of robot” and “providing service via the Internet”, which are characteristic of our service, from the viewpoint of tourism destination marketing.

2.1 Use of Robots

Advantages of using a robot to questionnaire survey in a tourist site and an exhibition event are as follows:

(1) It is possible to obtain exactly the time and location.

(2) There is an effect that attracts people.

(3) It is possible to flexibly deploy.

(1) As studies of the information acquisition method of visitors of a tourism destination, there are statistics, questionnaire surveys, GPS logger, IC ticket and a behavioral survey using picture projection [9]. According to [9], the use of the diary survey by questionnaire format is one of the valid research methods to obtain specific actions of the individual tourists and to analyze them. However, the diary survey is a big burden on the tourist. Moreover, it is a big burden also on the investigators to enter and analyze the data of both elements of time and space. Additionally, even if they are described by spending a lot of effort, it has been pointed out to remain on qualitative interpretation. The questionnaire survey using a robot makes it possible to formalize the input, to enable easy handling of both time and space. Thus, it is possible to interpret them quantitatively.

(2) Concerning the formalization of input and the handling of both time and space as mentioned at (1), they may be realized by a computer simply deployed to the survey site. However, it hardly attracts tourists. Therefore, we focused on the attraction effect of a service robot. It is pointed out that the existence of a robot attracts people [2][3]. Using this robot’s feature, the service operation experiments had been performed during more than 4 years. Moreover, it has been pointed out that a person has more attachment to a robot than a personal-computer, when dealing with the same information in the electronic device [10][11]. In addition, the effects of physical embodiment and physical presence are explored [12]. The result has shown that the physical robots were more persuasive and perceived more positively than virtual agents. Therefore, by adding operation of gestures and movement, facial expressions, and character that symbolizes the tourist spots to a robot, we believe that this robot’s feature will be utilized more effectively in tourist destination marketing.

(3) If we simply focus on the effect to attract the people, there is also a method to achieve it by the image effect of a large panel, such as a digital signage. In fact, as services for visitors in the digital-signage field, there are Mei-chan [13], which is the voice guidance services of the Nagoya

Institute of Technology, a digital signage system using a virtual human for getting attention of passersby [14], and a large information board, which provides the photography- service for tourists of the street of Las Vegas. However, in these system, the service terminals are fixed to the points. On the other hand, by using the robots and the signage-robots shown in this paper, the organizers of a regional event and an exhibition booth even for a limited time are able to deploy them flexibly.

2.2 Providing Robot Services via the Internet

In section 2.1, we mentioned the advantages of use of robots. However, a questionnaire survey using robots alone is not enough to reduce the labor cost. It is needed to have a mechanism that aggregates the data collected by robots and accumulates and analyzes the data, since the robot service more reduces labor cost and is utilized effectively in marketing. In this paper, we assume a model that each robot is deployed to multiple tourist points, information is gathered from these robots, the information is analyzed and provided to a third party, and feedback it to the service providing process[15]. When we consider a robot as an input device, this model is similar to the model of the IoT platform which was studied in the ubiquitous field.

Recently, business applications of IoT platform combined with artificial intelligence technology is realized on a large scale by IT companies. Watson IoT Platform of IBM [16], Azure IoT Suite of Microsoft [17], AWS IoT Platform of Amazon [18], and others have been released one after another. In Europe, there are FIWARE [19] and Node-RED [20] for IoT application development. On the other hand, as research of a common platform of service robots in the robot field, there are RTM projects [21], the Next generation robot Intelligence technology development project, and Robot Operating System [22] by Open Source Robotics Foundation. Additionally, as research of a robot service platform using the network, there are the results of the Ubiquitous Network Robot Platform [23] and the Robot Services initiative that the authors worked on [24] [25].

3 Proposal of System

3.1 System requirements

As mentioned before, we conducted demonstration experiments at the International Industry Exhibition November 2015 [6] and the International Robot Exhibition December 2015 [7] using multiple robots, and verified the effectiveness of our robot’s questionnaire service. The results of the experiments suggested that the system works effectively. However, in order to effectively utilize the robot’s questionnaire service at exhibition events and sightseeing spots, it is necessary to consider that it is a crowded space where many people come and go. In addition, the visitors do not visit this place for answering the questionnaire. They are busy visiting the exhibition events or enjoying the sightseeing spots. Therefore, we set the following issues and propose these solutions.

1) Some people care what other people think, when operating the robot's display and answering questionnaires in a public place: In the demonstration experiments in [6][7], the questionnaire service was conducted with robots equipped with a display, which were called signage robot and concierge robot. In this case, the visitors answer the questionnaires by pushing the buttons on the display of the robots. Their operations on the robot display are seen by other peoples. Therefore, it turned out that some respondents were a little hesitant to answer the questionnaires.

2) Multiple visitors are not able to answer the questionnaires at the same time: In the previous system of demonstration experiments, when multiple visitors have gathered in front of one robot, the visitors are not able to answer the questionnaires at the same time. If the number of visitors increases, a long wait will occur. This also relates to the next issue of the stay time. It is necessary to be able to answer the questionnaires without waiting for a long time.

3) It is difficult to make visitors stay on the spot for a long time: In this paper, the robots or/and staff speak to visitors at exhibitions and sightseeing spots and ask them to answer the questionnaires on the spot. Because the service is provided under such context, it is difficult to make visitors stay in front of the robot for a long time. Even if the visitors willingly answer the questionnaires, they would like to finish it as quickly as possible. The more the number of questions decreases, the more the response time decreases, and the respondents are able to finish it rapidly. On the other hand, the event organizers and the sightseeing spot marketers want to ask various kinds of questions and want to get a lot of answers. Therefore, it is necessary to have a mechanism to collect many responses to various kinds of questions in a short time.

4) The interest in answering to the questionnaire is low. In addition, there is a case that even if the visitors start answering, they may withdraw before completion: This is a disadvantage that occurs when conducting questionnaires on a machine, and the same occurs for a web questionnaires conducted on a personal computer. It is necessary to make the visitors to have interest in answering the questionnaires, and to prevent their withdrawal.

For solving issues 1 and 2, this paper makes it possible to not only answer the questionnaires on the robot directly, but also answer them using a smartphone. This service is designed to be able to construct the services in cooperation with smartphone applications [26]. Therefore, by applying this mechanism, we make it possible to switch the input devices for answering questionnaires. For solving issue 3, we design a mechanism to dynamically generate a questionnaire according to the situation of questionnaire accumulation and/or the place of implementation. For solving issue 4, as mentioned in Section 2.1, the robot's features of gestures and movement, facial expressions, and character may attract the visitors, may contribute to improvement of response rate. So, in this paper, we implement a calling function and a nodding function. Next, we describe each solution method in detail.

3.2 System Design

3.2.1 Switch to questionnaire-answer on smartphone

For solving issue 1 and 2, we enable the respondent to answer the questionnaire displayed on the robot with a smartphone. To accomplish that purpose, it is necessary that visitors to the robot must be reliably guided to questionnaires on the smartphone. However, in many case, it takes time and effort to get an application installed on the smartphone. Furthermore, there is high psychological resistance to install an application that is not famous for visitors, or an application with only temporary use. For these reasons, it is not practical to have visitors install an application for the smartphone. Therefore, without installing an application of questionnaire service, a questionnaire should be conducted on the smartphone. Furthermore, it is necessary to have a triggering method to launch a questionnaire commonly on different smartphone OS such as iPhone and Android.

To solve these problems, we adopt a method of reading the QR code by an existing application and starting up the browser on a smartphone. Figure 2 shows the image. Actual steps are (1) Display the QR code on the digital photo frame and place it near the robot, (2) The respondent reads QR code by QR code reader application of his/her smartphone, (3) When the reading has been completed, the browser on the smartphone is activated and the questionnaire service from the server is called up. This solution is feasible because the QR code reader application on the smartphone is widely used in general. If a questionnaire robot (called “Smartphone Robo”) is developed with JavaScript to run on the browser, it is independent of the smartphone model or OS. In NFC tags, it takes for visitor’s time and effort to set up depending on the smartphone model. In BLE beacons, it is found that there is some difficulty in reliability of reaction [6]. On the other hand, it has been found that when reading QR code printed on paper, the accuracy depends on the illumination environment. Thus, by stabilizing the lighting environment by displaying the QR code on the display of the low price digital photo frame, we adopt the QR code as the start trigger for the service in this paper.

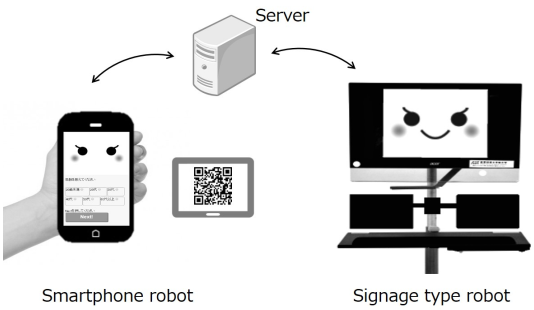

Figure 2: Switch to answer a questionnaire

3.2.2 Design on a Dynamic Questionnaire Generation

For solving issue 3, we design a mechanism to generate a flexible questionnaire dynamically to get answers for variety questions with fewer questionnaires. Figure 3 shows the position of the dynamic questionnaire mechanism in the whole system. It is necessary to refer the accumulated questionnaire results on the server that depend on types of events to conduct questionnaires. To implement this mechanism and communication between the robot and the server, we used the getEnquete method of the Enquete profile as mentioned in Section 1. This getEnquete method calls the server with the respondent information, robot information and the kind of the questionnaire to require, and get a questionnaire for the robot to ask respondent. Receiving this request, the server selects an appropriate questionnaire among a questionnaire template defined on the server beforehand. Thus, the server generates the questionnaire dynamically and deliver it to a robot. When a respondent answers a questionnaire, it is transmitted to a server as answer data.

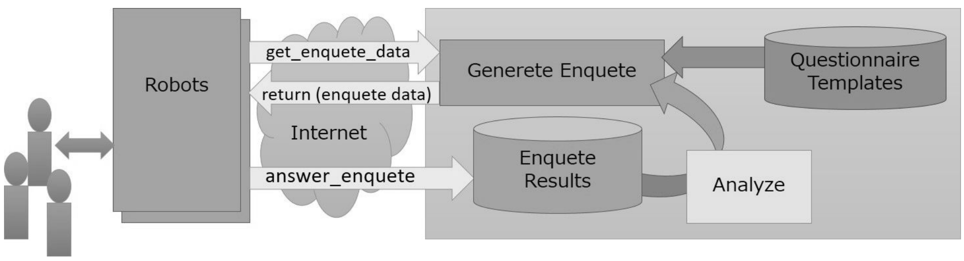

Figure 3: Dynamic Questionnaire Generation

3.2.2.1 ID and Data Management for Dynamic Questionnaire Generation

In order to generate the questionnaires, robot information, respondent information and accumulated questionnaire results are required. The robot information includes robot ID (*robot_id*) and other information such as the location information. As for the respondent information, when a respondent answers a questionnaire on a robot, the respondent is required to input his/her ID (*visitor_id*), which is given previously. When a respondent answers a questionnaire on a smartphone, he is not required to input *visitor_id*, but *visitor_id* is generated and distinguished automatically using a cookie of the browser. Neither uses the personal information of the respondent directly, and the anonymity of the questionnaire is retained. The respondent's location information at this time is identified by robot information or QR code. Accumulated questionnaire results include a certain respondent's answer history and the number of collected answers for a particular question.

3.2.2.2 Methods of Dynamic Questionnaire Generation Mechanism

We define a questionnaire template for generating dynamic questionnaires. A questionnaire template holds several question groups or several questions, and a priority is assigned to each question group or question. A questionnaire template holds several question groups. A question group is a collection of a questions. Examples of question groups are as follows: a question group on respondent's attributes such as the age, the gender, the occupation and the address, a question group for comments on events which the event stakeholders are interested in, a question group for specific research purpose such as opinions on robots, and a question group depending on places such as comments on the exhibits at the venue. There are two methods of dynamic questionnaire generation mechanism:

a) Several related questions are managed as one question group and prepared multiple question groups in the template. Each question group is able to be switched with priority level. In this method, questions with high dependency can be easily expressed as one question group. So, respondents can easily answer the questions. The priority level is expressed by arranging the question groups in the order of that they want to investigate.

b) Multiple questions are prepared in the template. Each question is able to be selected with priority level. Using this method, it is possible to finely control which questions on a template are presented. On the other hand, if there is a dependency between questions, another mechanism to express each priority level of the questions is required. So, the control becomes complicated.

3.2.2.3 Algorithm of Dynamic Questionnaire Generation Mechanism adopted

In this paper, we adopt the method a) as described above, which is that of switching for each question group, because we ask relatively simple questions in the demonstration experiments of next Section 4. When the robot requests a questionnaire by the getEnquete method, the questionnaire is generated by the following procedure:

a. If the respondent has not answered a question group of his/her attributes, the service selects the questionnaire about respondent's attributes. The priority of the question group of respondent's attributes is the first.

b. If there is a questionnaire about a specific place (impression about the exhibit on the spot, start point and goal point of the rally game, etc.), the service selects the questionnaire about a specific place. The priority of the question group of depending on places is the second.

c. If the number of answers of the highest priority question group in the template has not reached the reference value (as follows) and the respondent has not answer to it, the service selects this question groups.

d. If it's the number of answers of the question group with the highest priority has reached the reference value, the service searches the question group with the next highest priority.

e. When the number of answers of all the question groups reaches the reference value, the service raises the value and repeat the above procedure.

f. The service composes a return value of the getEnquete method based on the selected question group and returns this value to the robot.

The reference value, which is represented "level" in procedure (c), means an item for presetting the number of questionnaire answers (i.e., number of samples) to be collected. The number of samples required for statistical processing is determined by the number of people in the population and the error range. On the other hand, the actual number of collected questionnaires can vary depending on the event environment and situation. Furthermore, when we consider the other statistical information based on a subset such as "men aged 30s and those who are interested in robot" etc., it is necessary to acquire more samples in advance. That is, when generating a dynamic questionnaire, there is a choice to generate the same question until a sufficient number of samples for a specific statistical processing can be achieved. In addition, there is also a choice evenly various questions which stakeholders are interested in. Therefore, by "level" of the number of samples, we can handle these choices in our implementation.

3.2.3 Robot's Actions

For solving issue 4, we implement the function to attract visitors and to call them to come in front of the robot. This is done while the robot does not conduct the questionnaire process, which is a series of conversation actions that show questions to a respondent and obtain answers. Furthermore, while in the questionnaire service, as the interaction between the robot and the respondent, we implement the nodding function based on the voice of the robot and facial expressions.

This calling service and questionnaire service are described in XML definition, which is called Enquete Service XML. That is, not only a questionnaire but also a calling message to be uttered by the robot, a phonetic for each answer, and so on can be defined. For the call-in function, we implement moving facial expressions and reading aloud messages by voice. In the nodding function, while providing the questionnaire service, we implement interaction with the user based on robot's voice and facial expressions. Enquete Service XML consists of the questionnaire data （EnqueteData） which is sent to the robot from the server, and the answer data （AnswerData） which is sent from the robot to the server.

EnqueteData is a list that consists of multiple questions and corresponding answer choices (answers). Each question in EnqueteData is identified by a question ID (question_id). EnqueteData is identified by an enquete ID (*enquete_id*). In the questionnaire data, it is possible to define information such as an explanation before questionnaire and each question, a talk just after each question is completed, a talk between questions, a number of question left to answer, and a thanks message at the end of the questionnaire. This way, the robot interprets this XML and realize the interactive questionnaire. Figure 4 shows EnqueteData structure. AnswerData is a list of answers which a respondent chose from each question of questionnaire identified by *enquete_id*. Moreover, since AnswerData holds a time stamp of the answer starting/ended time for the whole questionnaire and each question. By using these information, it is possible to observe a respondent's behavior. As our implementation is in Java, we handle XML data structure with JAXB（Java Architecture for XML Binding） classes.

```
enquete_data
  enquete_id                      # enquete identifer
  ietf_language_tag               # language information
  enqueteList class="java.util.ArrayList"        # a list of enquetes (questionnarie)
    enquete     # each enquete
      question_id  # question identifier
      before_question_annotation  # a string which Robot shows before the question starts
      before_question_annotation_voice # a string which Robot speaks before the question starts
      after_question_annotation   # a string which Robot shows after the question ends
      after_question_annotation_voice          # a string which Robot speaks after the question ends
      question                    # a string which Robot shows as the question
      question_voice              # a string which Robot speaks as the question
      answers class="java.util.ArrayList"      # list of choices as the answer to the question
        answer_block
          answer_string         # the first choice string
          next_enquete_id       # move to the specified enquete
                                # answers are sent to the service on the serer
          next_question_id      # move to the specified question in this enquete
        answer_block
          answer_string  # the second choice string
before_enquete_annotation       # a string which Robot shows before the enquete starts
before_enquete_annotation_voice                # a string which Robot speaks before the enquete starts
after_enquete_annotation        # a string which Robot shows after the enquete ends
after_enquete_annotation_voice # a string which Robot speaks after the enquete ends
```

Figure 4: XML structure of the EnqueteData

4 Demonstration experiment

4.1 Purpose of the experiment

We implemented each mechanism designed in Section 3 on the distributed questionnaire service and verified the effectiveness of the solutions. In order to assume marketing service at a tourist site and/or an exhibition, the experiment demonstrations were selected technical exhibitions and shopping streets that can be opened to the public in general. In the experiment, the following three items are set as verification items.

A) To verify the acceptability of the general users of the system to answer the questionnaire, which is provided by the robot equipped with a display, by switching to the smart phone.

B) To conduct various kinds of questionnaires with only few questions, and get useful answers from the general users, using the robots implemented the dynamic questionnaire creation procedure.

C) To verify the effect of the improvement of the robot operation and interaction. Furthermore, we connect the multiple people counting system described later to the questionnaire system proposed in this paper and verify that this sensor system can be utilized.

A) and B) are items for evaluating the effectiveness of this proposal. In addition, we verify whether improvement of robot movement and interaction made by this proposal are useful for attracting customers. However, in order to evaluate this at tourist sites and large-scale venues, it is also necessary to quantify the effect by measuring the congestion and flow of people. C) is seeking cooperation with the sensor system in order to quantitatively acquire the data necessary for the evaluation. In addition, both the calling function and the nodding function designed in Section 3 are implemented. However, we focused to evaluate only the calling function in this paper. Section 4.2 shows the outline of the demonstration experiment conducted in FY 2016, and the evaluation is reported in Section 5.

4.2 Outline of demonstration experiment

4.2.1 EAIS2016

We conducted experiments to verify the effectiveness of the improvement of the robot movement and interaction to increase the number of responses and improve the response rate at EAIS 2016 (International Conference on Enterprise Architecture and Information Systems, 2016) held in Kumamoto City in June 2016. Two robots were set up in a corner of a coffee break venue, and it was set as an exhibition booth. In this system, speech synthesis and character display are performed using OS functions. This system is a multilingual questionnaire service which supports Japanese, English, Chinese and Korean. In the XML for the questionnaire service, we prepared two kinds of character strings such as a character string to be displayed by the robot (UTF-8) and

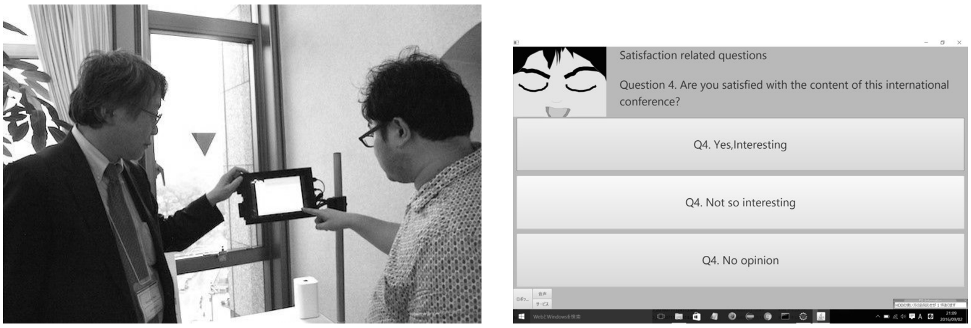

Figure 5: The demonstration experiment at EAIS 2016 (left side) and questionnaires and answer choices are displayed on the robot (right side)

a character string to be uttered (alphabet and Shift-JIS). And we also coped with misreading dependent on speech synthesis engines and limitations on handling character codes. Participants in this international conference were generally Japanese, Asian, Westerners, so during the coffee break, the robot continuously called out in English. The state of the demonstration experiment and the questionnaire display screen are shown in Figure 5.

The robot implemented by the EAIS 2016 is a signage type robot (Figure 6) [27]. A signage type robot is a digital signage-oriented robot which has been developed and enhanced in 2015 with the eye-catching, robot-like interaction being realizable, low cost being required as a requirement. It has a 23-inch touch-screen display and a tablet PC on a life-size stand, so it can attract people's attention. Furthermore, it is featured that it can be built at a low cost while being life-sized. This signage type robot is the implementation of [28]. In this system, a robot application for questionnaire processing was installed in a Windows PC, and questions were presented and replies were acquired on the touch panel type 23-inch display. And we also implemented face expression control application on Android OS set as virtual environment on Windows PC.

4.2.2 Japan Robot Week 2016

For demonstration experiments conducted at Japan Robot Week 2016 held at Tokyo Big Sight in October 2016, Shibaura Institute of Technology, Robot Service initiative, Bay Area OMOTENASHI Robot Society, Tokyo Metropolitan University, Tokyo Metropolitan Industrial Technology Research Institute and Kanagawa robot innovation participated. Six Robocot (a small robot by Takerobo) with a questionnaire profile were installed in each booth, and one signage type robot was installed in the RSi booth. Questionnaire is carried out by these robots, and the answer results are accumulated on the cloud. The system outline of the demonstration experiment is shown in Figure 7.

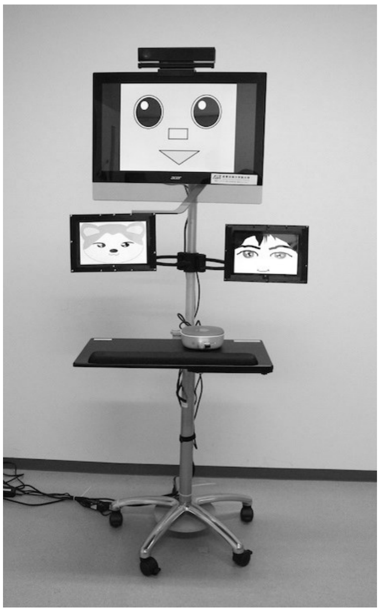

Figure 6: A signage type robot

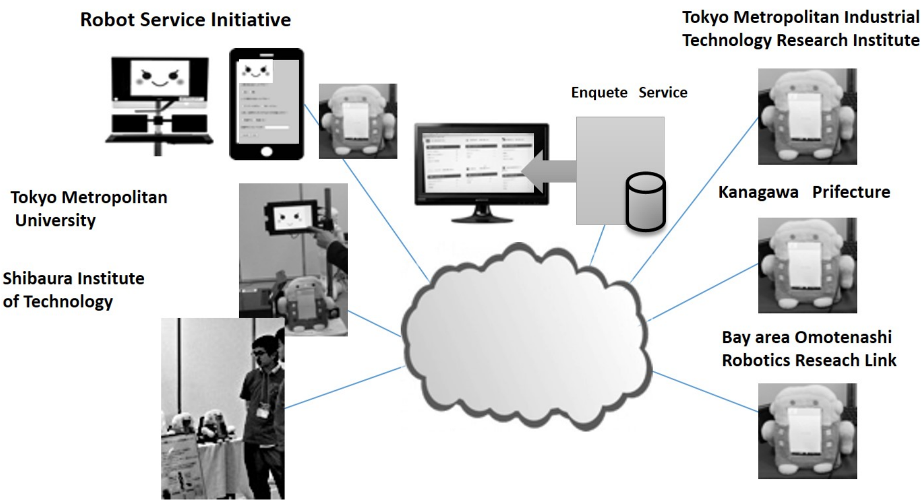

Figure 7: The system outline of the demonstration experiment at Japan Robot Week 2016

Takerobo's Robocot (Figure. 8) [29] is a low-cost robot that consists of a Windows tablet and an Arduino board that controls the servo that moves the hand. The robot application for the same questionnaire processing as the signage type robot was implemented on this robot. Robocot original "face" was displayed on the face of the robot. This Robocot's Windows tablet is the implementation of [28], so it can connect to the server and use the same service as the signage type robot.

In this demonstration experiment, we collaborated with a questionnaire service with the multiple people counting system developed by Shibaura Institute of Technology [30]. In the multiple people counting system, measuring sensors were set up at each booth and the number of people traffic before the booth was measured. Furthermore, we implemented an interaction that the questionnaire service acquired information published to the web server by the multiple people counting system using HTTP, and the recommendation message according to the questionnaire result is sent to the visitor.

4.2.3 Fukagawa museum road shopping street

On December 23rd to 24th 2016, we conducted demonstration experiments at the Fukagawa museum road shopping Street in Tokyo with Shibaura Institute of Technology and Advanced Institute of Industrial Technology. Fukagawa is located in the vicinity of Asakusa and is a sightseeing spot with Edo remains and a shopping street. In this experiment, we placed 6 Robocots with a questionnaire profile, 1 signage robot and 1 robot for commemorative photo at six locations at shops, museums, etc., and a robotic questionnaire rally carried out. The arrangement map of the robot and the state of being placed in the museum are shown in Figure 9. In this demonstration experiment, the function to switch to a questionnaire answer on the smartphone described in Section 3.2.1 was

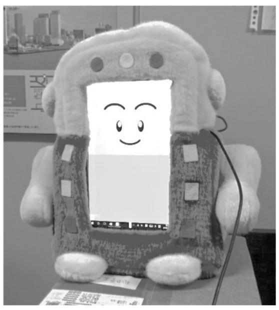

Figure 8: Takerobo's Robocot

Figure 9: The arrangement map of the robot and the state of being placed in the museum

concretely implemented, and five smartphone stations (QR code for activating smartphone robot) were placed at the rally point. Service for answering the questionnaire on a smartphone was developed with HTML and JavaScript and deployed on a server. The smartphone communicates with the Gateway on the server with WebSocket, and this Gateway communicates with the questionnaire service built on the server via RSNP. The interface on the smartphone is the same as that of the robot.

In addition, the dynamic questionnaire-generating mechanism described in 3.2.2 was implemented. In this demonstration experiment, we prepare seven question groups (first_enquete, second_enquete,..., last_enquete), hold them as a template, and give priority to the questions. Three questionnaire questions were assigned to one question group. Specifically, the first is the question group on the attribute of the respondent, the second group is a group of questions to inquire the opportunity of visit and visit history, the third group is a question group that asks questions of the familiarity with the questionnaire robot, the fourth group is a group of questions asking the easiness of answering to the questionnaire, the fifth is a question group on the function of the questionnaire robot, the sixth is a question group using the questionnaire robot as an inquiry group, the last seventh is to ask about this event and impression to the shopping district. Figure 10 shows an implementation in which the second priority question group (second_enquete) is generated by the request of the getEnquete method. Implementation of these question groups is described in the questionnaire service XML and programmed in java. Moreover, in this demonstration experiment, the target value (level) was set to 30 so that questions will appear evenly in order to verify the operation of the dynamic questionnaire generation function. If there is a possibility that the questionnaire response number does not reach the target value at a certain event, it is necessary to lower the target value.

```
level=30;
if ((answerDataService.countEnquete1("second_enquete") < level) && (an-
swerDataService.countAnswer1("second_enquete",responder_id)) < 1){
enqueteData.getEnqueteList().set(0,enqueteData2.getEnqueteList().get(4));
enqueteData.getEnqueteList().set(1,enqueteData2.getEnqueteList().get(5));
enqueteData.getEnqueteList().set(2,enqueteData2.getEnqueteList().get(6));
enqueteData.setEnquete_id("first_enquete");
```

Figure 10: An implementation in which the second priority question group

5 Experiment evaluation

In this Section, we evaluate each item (A), (B) and (C) of Section 4.1 based on the results of each demonstration experiment of Section 4.2.

§ *Evaluation (A)*

We describe the acceptability for the general users of our proposal system, which enable the respondents to answer the questionnaire on the screen of their own smart phone by access with QR code to the robot equipped with a display. In the demonstration experiment at the Fukagawa museum road shopping street described in Section 4.2.3, we implemented a switching function to smartphones and were able to obtain a questionnaire answer from the smartphone. In this demonstration experiment, 55 participants were gathered on the occasion of the local event on the day, and 120 responses were obtained for the cumulative total of each rally point. Among the 55 respondents, 24 respondents from smartphones accounted for 43% of all respondents. Figure 11 shows the breakdown of the devices used and the total number of responses at each rally point. In order to answer the questionnaire from the smartphone, it is necessary to install the QR code reader in advance. However, at each rally point, the response rates of the robot and the smartphone were almost the same. This indicates that this proposed method was accepted by general users. It is effective to use both smartphone and robot questionnaire responses as a way to protect the respondents' privacy and to respond efficiently in crowded places.

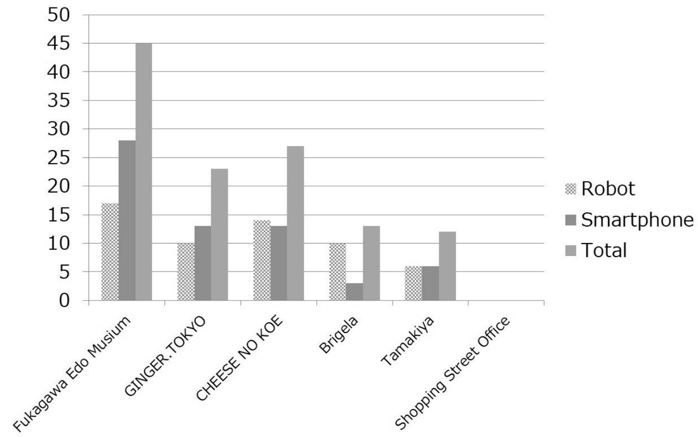

Figure 11: Breakdown of the devices used and the total number of responses at each rally point

§ *Evaluation (B)*

Using the robots implementing the dynamic questionnaire creation procedure, we conducted various kinds of questionnaires with only few questions, and verified to get useful answers from the general users. This demonstration experiment was conducted simultaneously with the one above (A). Regarding the dynamic questionnaire switching function, we controlled to switch to

Table 1: Number of responses to each question group

Name of question group	Number of responses
first_enquete	55
second_enquete	19
third_enquete	16
forth_enquete	11
fifth_enquete	10
sixth_enquete	9
last_enquete	4

Table 2: Number of responses to each question group

Number of repeat	Number of people
1 time	55
2 time	24
3 time	18
4 time	11
5 time	8
6 time	8
7 time	1
Total	125

another questionnaire every time ten questionnaire responses with a specific priority were accumulated. From the number of responses to each question group shown in Table 1, it is understood that the questionnaire was carried out according to the priority and many kinds of questionnaires were done evenly with few questions. Furthermore, from the results in Table 2, it can be seen that the visitor's linked by respondent ID or cookie. When the same respondents respond to questionnaires at different rally points, we realized a mechanism to recognize that they are the same person who has the answer history. As a result, since question groups on attributes of respondents assigned to first_enquete can be omitted, the number of questionnaires can be reduced.

Analysis of the questionnaire response result is not subject to consideration in this paper, but in order to show that useful survey results were obtained in the implementation of the questionnaire rally by robot, a questionnaire question and a part of the number of its responses are shown in Table 3. From the result of Q 9 in this table, it is understood that there are many respondents who feel that a reduced question number is preferable.

§ *Evaluation (C)*

About the connection of the multiple people counting system to the questionnaire system proposed in this paper and verification that this sensor system can be utilized, we report together with results of EAIS 2016 in Section 4.2.1 and Japan Robot Week 2016 in Section 4.2.2.

As a demonstration of coffee break time at EAIS 2016 shown in Section 4.2.1, a questionnaire by robot was carried out. The contents of the questionnaire are attributes of respondents, satisfaction level of meeting and venue, impression about questionnaire service and questionnaire robot, and the like. The number of respondents to the questionnaire obtained was 24 and the average age of respondents was 30s. The service provided time totaled 7 hours, and we were able to obtain responses from about 8% of participants on the day. This response rate is higher than the previous demonstration experiment. Therefore, the calling function by the robot during the demonstration experiment is useful for attracting customers, and it can be said that there was the effect of improving robot operation and interaction.

In Japan Robot Week 2016 shown in Section 4.2.2, robots were installed in six booths from October 20th and 21st, and a questionnaire service was carried out. The contents of the questionnaire ask about the attributes of the respondents, the reason for stopping by the booth, opinions on the effectiveness of the questionnaire by the robot, and the like. In this experiment, a total of

131 responses were obtained. The number of responses at each booth is shown in Table 4. As the number of responses from International Robot Exhibition 2015 last year was 81, it shows that more responses were obtained than last time. This is mainly due to the large number of robots. In addition, it can be seen that RSi booth where signage type robot with calling function is arranged

Table 3: A questionnaire question and a part of the number of responses results

Question group	Questions	Answers	Numbers responded	Total
1	Q1. How old are you?	Under 20	3	
		20's	18	
		30's	14	
		40's	11	
		50's	4	
		Over 60	5	55
	Q2. What your occupation?	Student	10	
		Company (Sales)	14	
		Company (Technical)	14	
		Research institution	8	
		Other	6	
		Undefined	3	55
	Q3. What is your gender?	Male	34	
		Female	19	
		Undefined	2	55
2	Q4. How many times did you come to this shopping street?	First time	6	
		Every day	2	
		Once a week	7	
		Once a month	2	
		Once a year	2	19
	Q5. How did you find out about this event	Web site	3	
		Flyer	3	
		Word of mouth	3	
		Other	8	
		It happened to pass	1	
		Undefined	1	19
	Q6. Do you know that questionnaire robots are being used at regional events?	Yes, I know	7	
		No, did not know	5	
		I have actually used it	6	
		Undefined	1	19
3	Q7. When conducting a questionnaire, which medium do you think is good?	Robot	8	
		Smartphone	5	
		Paper	5	
		People	0	
		Other	0	18
	Q8. When answering the questionnaire, what would you like to answer if there are any of the following?	It is not necessary	1	
		Gifts	5	
		Game	4	
		Granting points (discount coupon)	6	
		Other	0	16
	Q9. Is it easy to answer how many questions at a time?	1 - 3 questions	10	
		4 - 6 questions	2	
		7 - 9 questions	1	
		More than 10	3	16

Table 4: Number of responses at each booth at Japan Robot Week2016

Booth name	Oct. 20th	Oct. 21st	Total
RSi (Questionnaire robot)	27	40	67
Bay Area OMOTENASHI Robot Society	18	10	28
Kanagawa Robot innovation	10	10	20
Tokyo Metropolitan University	4	4	8
Shibaura Institute of Technology	2	2	4
Tokyo Metropolitan Industrial Technology Research Institute	4	0	4
Total	**65**	**66**	**131**

Table 5: Questionnaire: Opportunity to stop by this booth

What is the opportunity to stopped by this booth	Number of re-sponses
Calling from robot	16
Originally interested in questionnaires by robots	16
Weather control robot (Exhibit)	15
Somehow	11
Interested in RSi	5
Interested in the design of the questionnaire robot	4

has more responses than other booths. Table 5 shows the result of conducting a questionnaire about "What is the opportunity to stopped by this booth" at this RSi booth. There are 16 answers "Calling from robot". From these, it can be said that calling with a robot was useful for attracting customers.

In order to quantitatively acquire the data necessary for the evaluation, the number of people before each booth was measured by the multiple people counting system as a trial of cooperation with the sensor system. By using the number of respondents of the questionnaire at each booth, the number of passage people before each booth by the multiple people counting system (Table 6), and the total number of visitors by Japan Robot Week 2016 (Table 7) [31], we can know the response rate of the questionnaire of a specific booth. For example, at the RSi booth on October 21st, 1,909 visitors were measured. As the total number of visitors on October 21st is 12,887 people, it is shows that about 13% of all visitors passed in front of the RSi booth. Furthermore, since there are 40 respondents in the RSi booth, it can be said that about 2% of the visitors before the RSi booth answered the questionnaire. In this way, it is meaningful to be able to grasp the response rate of the questionnaire quantitatively, and the effectiveness of cooperation with the sensor is understood.

6 Conclusion

In this paper, we described the problems of conducting a questionnaire using robots in a public crowded space where people are continuously coming and going. For solving these problems, we proposed the following solutions:(1) the mechanism that enables the respondents to answer the questionnaire not only on the robot directly, but also with a smartphone, (2) the methods of dynamic questionnaire generation according to the situation of questionnaire accumulation and/or the place of implementation, (3) the improvement of robot operation and interaction such as a calling function and a nodding function. In addition, we implemented these as a distributed questionnaire service with multiple robots, and conducted the demonstration experiments at the international conference EAIS 2016, Japan Robot Week 2016, and Fukagawa museum road shopping street, and verified the effectiveness of the proposal.

As for (1), we conducted the experiments in public spaces included a technical meeting, an industrial exhibition, and a tourist spot and reported them. As for the generation mechanism of dynamic questionnaire of (2), the application of machine learning and artificial intelligence are sometimes expected in the design. In this paper, because the questionnaire questions are the questions themselves that the event organizers and marketers of sightseeing spots want to ask the visitors, we do not use machine learning or artificial intelligence technology to generate the questions. However, with regard to the algorithm for question selection, when a lot of data is accumulated, we expect that current machine learning and artificial intelligence, as described in 2.2, enables effective questionnaire analysis from few samples. As for (3) of the improvement of robot's operation, in this paper, we focused on only evaluation of the calling function. With regard to the nodding function to prevent the withdrawal in the middle of answering the questionnaires, as the future work, we plan to additional trial and evaluation, such as controlling short conversations and timing of nodding with artificial intelligence technology.

Further studies are needed in order to clarify the method of efficiently collecting and accumulating human data with the robot. We will accumulate the correlation between robot service and human behavior and the data for system analysis conforming to service. In Addition, we plan to develop distributed cooperative services that provide services by sharing the roles in the system according to robot type.

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