A Method of Expressing Intention of Contribution for Suppressing Careless Responses in Participatory Sensing*

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Abstract. In recent years, with the spread of smartphones, "participatory sensing," in which users are asked to contribute information such as their surrounding environment via their smartphones, has attracted attention. However, in active participatory sensing, which asks users to upload photos or input text, there is a problem that respondents try to complete the request quickly and effortlessly, thus not always responding accurately. In this study, we propose a method to expressing one's intention to contribute to participatory sensing tasks for suppressing careless responses. In order to confirm the effects of the proposed method, we conducted an evaluation experiment using our system. As a result, we confirmed that the number of careless responses was significantly reduced when expressing intention was requested.

Keywords: participatory sensing · mobile sensing · response reliability · satisficing · answering behavior

1 Introduction

In recent years, with the widespread use of smartphones, participatory sensing [3] has been attracting attention as a means of collecting the data of surrounding environments by requesting people to contribute using their devices. Participatory sensing has advantages such as not requiring the installation of sensors and enabling the acquisition of data from a wide area. In particular, active participatory sensing, in which the user of a mobile device consciously provides information,

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it is possible to acquire data based on human perception, such as the degree of congestion, noise, and scenery, which cannot be acquired by physical sensor sensing [9].

As a known issue of participatory sensing, there is a problem that respondents try to complete the request quickly and easily and do not always respond accurately, when users are asked to contribute to sensing tasks (e.g., upload photos, input subjective feedback). An approach that detects and excludes careless responses from the collected response data is effective when there is a large amount of data such as in a crowdsourcing-type survey. However, this approach might cause a lack of data in participatory sensing. In the field of paper-based questionnaires and few online questionnaires, some research has been conducted to suppress careless responses by asking users to express their intention to give careful answers. These studies are based on the human psychology that once we make a decision or take a certain position, we are minded to stick to that decision or position [11]. To the best of our knowledge, the effectiveness of methods for suppressing careless responses by expressing intentions has not yet been tested in the field of participatory sensing.

In this paper, we newly employ the *expressing intention of contribution* (*EIC*) method to participatory sensing for improving its reliability. As a prototype system, we implemented two types of EIC methods: a tap screen and a gesture action. A tap screen is a simply motion of pressing a button on a dialog with a finger. A gesture action is a motion of holding the smartphone and shaking it up and down. Through the lab-condition experiment with 20 participants over 2 weeks, we confirmed statistical significance that our EIC method suppresses the careless response. In addition, we provide a discussion of the effects and challenges of the EIC method by analyzing the number of responses and response time, and also results of the post-survey.

The structure of this paper is as follows. First, in Section 2, we describe related research and show the position of this research. In Section 3, we describe the proposed method and the participatory sensing system that we constructed. In Section 4, we describe the setup of an evaluation experiment using the system, and in Section 5, we present the experimental results and discussion. Finally, in Section 6, we summarize this paper and discuss future prospects.

2 Related Work

In the field of questionnaire-survey, it is pointed out that the attitude of respondents who try to complete a task effortlessly and quickly, called *satisficing*, leads to a decrease in the reliability of the results. In a study by Miura *et al.* [10], an online questionnaire survey of 1,800 people was conducted by two research companies, and the result has shown 51.2% and 83.8% of the responses were inappropriate, respectively. Careless responses caused by satisficing are undesirable in that they make the interpretation of the survey results difficult.

2.1 Careless Response Detection

To address this problem, Maniaci *et al.* [6] devised the ARS (Attentive RespondingScale) and DQS (Directed Question Scale) methods for detecting Satisficing. ARS can be divided into two types: Inconsistency and Infrequency. Inconsistency focuses on the difference between the answers to questions with the same content but slightly different wording. Infrequency focuses on the difference between the expected choice and the actual choice, given a question with a choice that everyone is expected to choose. In both scales, the higher the total difference score, the more likely it is to be Satisficing. In DQS, participants are instructed to choose a specific answer in a sentence, and if they do not follow the instruction, they are judged to be satisficing.

Gogami *et al.* [5] have developed a system for detecting Satisficing by recording time-series data such as the amount of screen scrolling, response time per question, and changes in options when answering web surveys using smartphones.

However, it is difficult to use these methods in participatory sensing where a small number of questions is generally given and a short response time can be assumed. Even if the discrimination of good and careless responses could be done, the lack of data will be a problem when excluding careless responses.

2.2 Motivation Improvement with Monetary/non-monetary Incentives

To improve the quality of responses, the methods for improving user's motivation using monetary or non-monetary incentives are proposed in the domain of crowdsourcing and participatory sensing.

The monetary incentive directly provides rewards (e.g., points, which can be cashed) to responders. General crowdsourcing services such as Amazon Mechanical Turk[5] employ this scheme for arousing people to contribute microtasks. However, several studies on crowdsourcing [12, 7, 2] have reported that monetary incentives do not improve the quality of responses.

The non-monetary incentive provides a kind of experience as a reward such as giving fun, filling approval desire. In conventional participatory sensing, Arakawa *et al.* [1] have attempted to increase users' motivation to contribute by using gamification mechanisms. Gamification motivates users by adding game elements into sensing systems and tasks. However, many studies using gamification have shown that it can increase the amount of data, but the cases where it can even improve the quality of data are only in limited situations.

2.3 Careless Response Suppression

Ward *et al.* [14] warns when the quality of responses is low. The results showed a significant interaction between the virtual presence and the instruction, although the virtual presence alone had no effect. However, it has been pointed out that this display is not suitable for small screens such as smartphones.

[5] `https://www.mturk.com/`

Masuda *et al.* [8] introduced an opening pledge (a question that asks whether the respondent pledges to answer seriously before answering) to prevent Satisficing in PC-based web surveys. The idea is to take advantage of the fact that once a person declares a certain position, there is a natural psychological pressure to behave consistently with that commitment [13]. The group that answered "I will answer seriously" to this question showed better values than the control group in several indices of the quality of their answers. We got insights that these approaches can be useful for improving response behavior to questions in participatory sensing. Here in after, we define these approaches as the *EIC* (*expressing intention of contribution*) mechanism.

2.4 Position of This Study

Approaches for detecting careless responses are not suitable for participatory sensing, and also motivating methods by monetary and non-monetary incentives have not been able to improve the quality. In our study, we aim to establish the method for suppressing careless responses in participatory sensing by employing the EIC mechanism. In the following sections, we propose a new participatory sensing system with the EIC mechanism and verify its effectiveness.

3 Proposed Method

3.1 Expressing Intention of Contribution (EIC) Method

In this section, we propose a new participatory sensing system with a mechanism of *expressing intention of contribution* (*EIC*) for suppressing careless responses.

As mentioned above, Masuda *et al.* [8] succeeded in creating psychological pressure on respondents to "answer seriously" by asking them to click a checkbox next to the sentence "I will answer seriously" before answering a web questionnaire. In order to generate this psychological pressure, the following two conditions must be satisfied:

1. The respondent reads a statement saying, "I will respond seriously."
2. The respondent expresses their agreement with the statement.

To satisfy the above conditions in the participatory sensing system, the EIC method has two steps: Step (1) making the user read the sentence of agreement, and Step (2) eliciting the user to express their intention of contribution.

Step (1) making the user read the sentence of agreement: In the previous research [8], agreement sentence and checkboxes were placed at the end of instructions about the questionnaire. However, unlike web-based questionnaires, the tasks assumed in participatory sensing require only a short amount of time to answer each question (i.e., a question-and-answer format), so displaying a large amount of information on a single screen is considered a cause of skipping. In addition, since expressing consent generates psychological pressure, it is thought

that whether or not to read the consent statement is also affected by the action taken immediately before. Therefore, we propose a mechanism that makes it easier for the user to read the consent statement by changing the timing of the statement from "before reading the question" to "the moment the user taps the response field to respond to the question."

Step (2) eliciting the user to express their intention of contribution: Previous studies have adopted the method of having the user click a checkbox next to the agreement sentence. In this study, we adopt the button tapping method similar to the conventional method. We also propose a new method of expressing consent using gesture recognition based on the accelerometer in the smartphone. This study adopts the gesture of "shaking smartphone," which requires enough large movement and is easy to imagine since many standard smartphone applications adopt it.

The following section describes how to apply the express intension function in a participatory sensing application.

3.2 Implementation

In order to collect response data with the proposed method applied, we designed and implemented a smartphone application for participatory sensing, named *OathSurvey*. The system flow is shown in Fig. 1.

The respondent installs OathSurvey (hereafter "app") on their smartphone in advance. When the respondent receives a response request notification from the app and opens the app, a question and a text form for response input are displayed. Then, the respondent taps on the text form, a dialog box asking the respondent to express their intention appears on the app's screen. This dialog shows the agreement statement and the action to take in expressing one' s intentions when agreeing. By performing this action, the user is able to enter the answer input form.In this application, the user is presented with either "tap the button," which is the same as the conventional method, or "shake the smartphone," which is a newly proposed method in this paper. The screens displayed in each method are shown in Fig. 2 (a) and (b), respectively.

Moreover, in order to analyze the response behavior in this experiment, we implemented a function to record the timing of the following screen operation events: "notification published," "notification tapped," "text form tapped," "express intension dialog displayed," "express intension completed," "response data sent," "application goes to foreground," and "application goes to background." The response data is also stored in the database.

4 Evaluation Experiment

In this chapter, we describe an evaluation experiment to verify the effectiveness of the proposed method. This study was approved by the Ethical Review Committee for Research Involving Human Subjects of Nara Institute of Science and Technology (Approval No.: 2020-I-16).

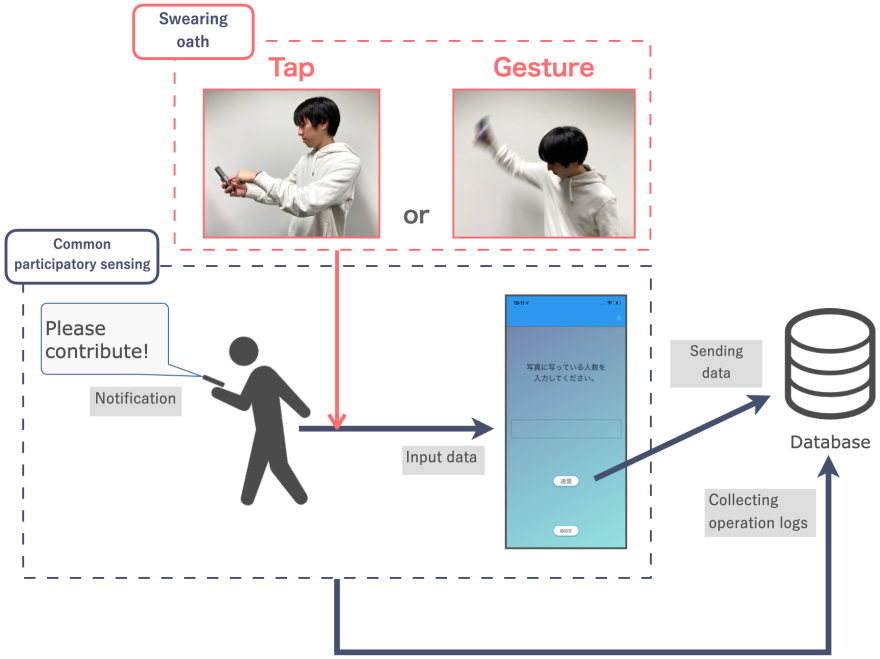


Fig. 1: System overview of "OathSurvey"

4.1 Experimental Settings

The purpose of the evaluation experiment was to clarify the effect of EIC in participatory sensing on suppressing careless responses. For this purpose, we asked the participants in the experiment to use the application implemented in Section 3.2 to check whether the presence or absence of a EIC and the difference in the EIC method affected the quality of responses (correct response rate) and response behavior (response time).

The participants of the experiment are 20 graduate students in their 20s who belong to our laboratory. The experimental period is two weeks, from April 13 to 27, 2021. The participants were briefed in advance and submitted a consent form before participating in the experiment. In the preliminary explanation, we explained only that this was a survey on participatory sensing and did not explain about careless response behavior because explaining it as a survey on careless response behavior would affect the responses. After the experiment was completed, we explained that the experiment was about careless response behavior and confirmed the participants' consent to participate in the experiment.

Before participating in the experiment, the participants installed the app on their Android or iOS devices. The app requests the sensing tasks described in the next section. For each request, one of the following methods is selected and

(a) Tap (b) Gesture

Fig. 2: Screen examples requesting "EIC"

presented to the experiment participants: "nothing any EIC (nothing)," "tapping a button (tap)," and "shaking a smartphone (gesture)." The participants follow the instructions of the presented EIC method and input their responses. The participants can also ignore the request.

4.2 Sensing Task Setting

The flow of sensing task is shown in Fig. 3. The app scans the iBeacon signal which is placed in the elevator hall, then sends a notification requesting the participants to perform the sensing task when the participant enters there. After receiving the notification, the participant moves to the digital signage near the entrance of the laboratory which is displaying the sensing target, and does the requested task.

The sensing task is "counting the number of people in the crowd image" and the answer can be sent through the app. This task imitates a participatory sensing task that collects the level of congestion in the city, e.g., touristic sights, bus stops, and restaurants. This task is suitable for analyzing the quality of the

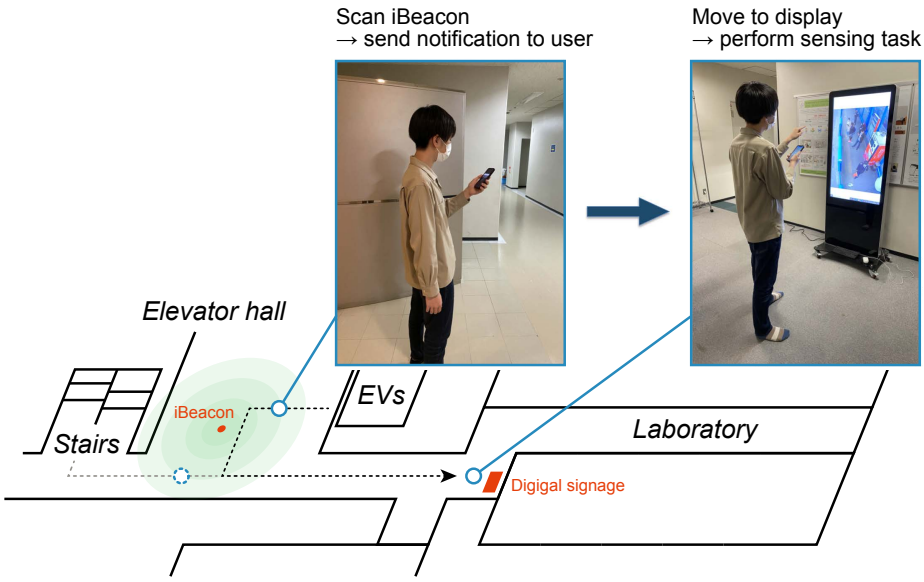


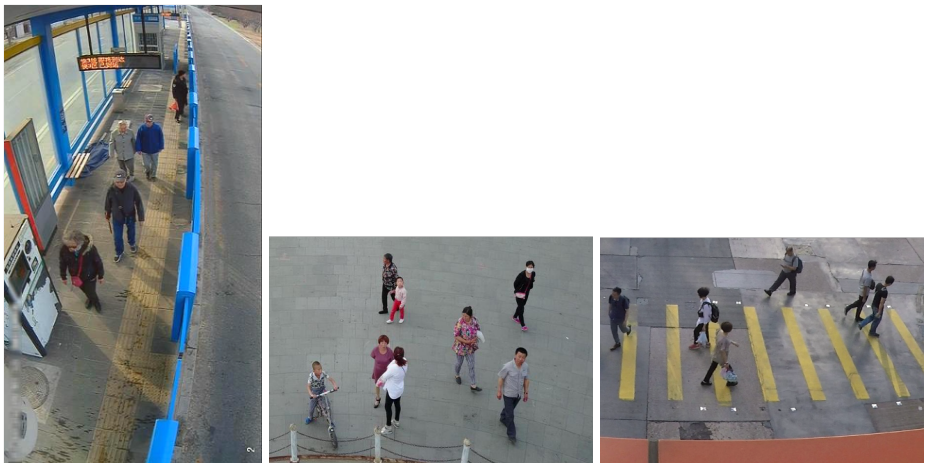
Fig. 3: Answer flow

response data because the correct answer value is uniquely determined. For the crowd images, we used Beijing-BRT-dataset [4], VisDrone2019-SOT dataset [16], and CityStreet dataset [15]. The example images are shown below. An example of an image is shown in Fig. 4. The crowd image is updated at 0:00 (midnight) and 12:00 (noon) every day, and participants can answer up to two times a day.

4.3 Evaluation Method

In order to quantitatively clarify the effects of EIC on the quality of responses and response behavior in participatory sensing, we compared the correct response rate and response time for each EIC method. The correct response rate is calculated from the total number of responses and the number of careless responses for each EIC method. The response time will be collected separately for the EIC time and the response input time, and the sum of these will be used as the response time. The total response time is defined as the total response time.

In order to confirm the impact of the EIC on the psychology of the respondents, a subjective evaluation was conducted through the post-survey. The following questions using the Four-Point Likert scale were asked: Q1: Did you find it troublesome to declare your position by tapping, Q2: Did you find it troublesome to declare your position by gestures, Q3: Did you think that the number of responses decreased because you were asked to declare your position, and Q4: Did the declaration of position make you feel that you should answer seriously?



Beijing-BRT-dataset[4] VisDrone2019-SOT[16] CityStreet[15]

Fig. 4: Examples of crowd images we used

Table 1: Experimental results (summary of response data)

EIC method	All responses	Careless responses	Correct response rate[%]	EIC time[s]	Response time[s]	Total response time[s]	Dropout rate[%]
Nothing	99	7	92.9	-	8.6	8.1	7.5
Tap	113	3	97.3	1.2	9.1	10.3	14.4
Gesture	90	3	96.7	2.2	9.3	11.5	17.3

Additionally, we asked participants to give free-text comments for getting feedback on the EIC method (Q5: What did you think about being asked to state your position when answering?), and OathSurvey application (Q6: Do you have any suggestions for improving the OathSurvey application?).

5 Experimental Results

5.1 Quantitative Results

The results of the quantitative evaluation experiment are shown in Table 1. The quality of the responses and the differences in response behavior are described respectively.

Analysis of Response Quality: From Table 1, there was no significant difference in the total number of responses for each EIC: 99, 113, and 90. The total number of responses for each EIC was 99, 113, and 90, with only 7, 3, and 3 responses being incorrect. We believe that this is due to the fact that the participants in the experiment were students who belonged to the same laboratory as the sensing client.

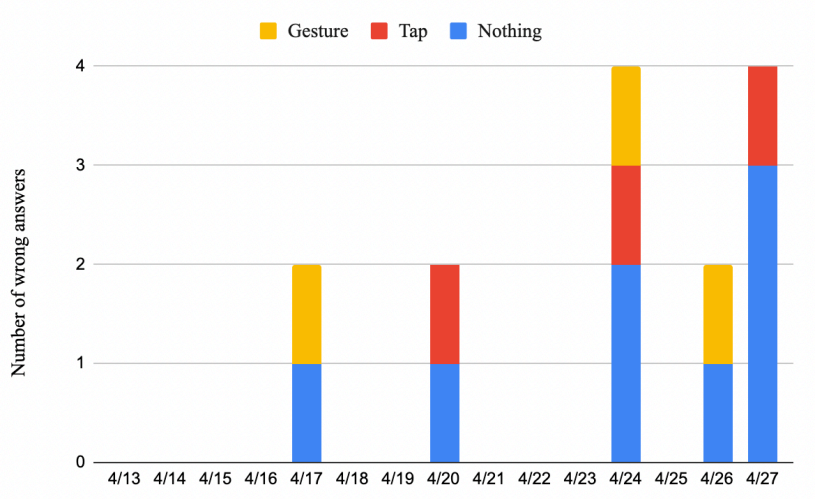


Fig. 5: Number of careless responses by day

The correct response rate when the EIC was not requested was lower than that when the EIC was requested. The results of the residual analysis of the cross-tabulation table showed that the adjusted standardized residual (one-sided P-value) for no EIC was 5% significant, confirming that the actual frequency of careless responses was significantly larger than the expected frequency. This result indicates that the EIC had a positive impact on the respondents' awareness.

In this experiment, we did not find any difference between the two types of EIC (button tap and gesture). This point needs to be clarified through future experiments with more subjects to see if there are differences.

Analysis of Response Behavior: From Table 1, it can be confirmed that the total response time from the EIC to the completion of answer input increased by 1.2 seconds and 2.2 seconds, respectively, with the addition of button tapping and smartphone shaking. However, even when only the response input actions were compared, the total response time increased by 0.5 to 0.7 seconds in the case of the EIC. We believe that this is due to the fact that the respondent's awareness was affected by the EIC, and that they tackled the task more carefully than usual.

Analysis on Dropout Rate: From the response data, we calculated the attrition rate (the percentage of respondents who stopped answering in the middle of the survey). Table 1 shows the average withdrawal rate for each statement method during the entire experiment. From the results, we can confirm that the withdrawal rate increases when EIC is required. This may be due to the fact that requiring respondents to express their intention is stressful for them.

Table 2: Post-survey questions and result of subjective evaluation

Question No.	Sentence
Q1	Did you feel it is troublesome? (Tap)
Q2	Did you feel it is troublesome? (Gesture)
Q3	Do you feel your answering frequency has decreased?
Q4	Did you feel the need to answer seriously?
Q5	What did you think about being asked to state your position when answering? (Free-text comments)
Q6	Do you have any suggestions for improving the OathSurvey application? (Free-text comments)

Question No.	Number of answers				Average Score
	Very much	A little	Not much	Not at all	
Q1	1 (5.0%)	2 (10.0%)	6 (30.0%)	11 (55.0%)	0.65
Q2	5 (25.0%)	9 (45.0%)	3 (15.0%)	3 (15.0%)	1.80
Q3	0 (0.0%)	0 (0.0%)	12 (60.0%)	8 (40.0%)	0.60
Q4	7 (35.0%)	11 (55.0%)	2 (10.0%)	0 (0.0%)	2.25

Analysis on Time-series Changes: The daily trend of the number of careless responses during the experiment is shown in Fig. 5. From this graph, it can be confirmed that the defective responses are biased toward the latter half of the experiment. The reason for this reduction in the effect of suppressing careless responses may be that the respondents became bored or stressed by the frequent requests for EIC, or that they became accustomed to the behavior of responding.

5.2 Subjective Evaluation

The results of the subjective evaluation through the post-survey are shown in Table 2.

The result shows that the majority of the participants answered that they did not find tapping the button troublesome at all, while the majority of the participants found shaking the phone troublesome to some extent. We believe that this is partly due to the fact that the intensity required for shaking the phone was too high, as mentioned in the comments from the respondents below.

Through the free-text comments to the EIC method (Q5), we found several valuable insights. The summary of comments is following.

- Positive comments
  - I am no longer inclined to respond in a random manner.

  - I think it was good to have the expressing intension because it made us aware that we should not answer carelessly.
- Negative comments
  - I thought it would be quite stressful to have to state a position several times before answering.
  - Uncomfortable feeling of not being trusted .
- Other comments
  - I didn't think much of it (I was trying to answer seriously from the beginning).
  - I didn't think anything of it.

The positive comments suggest that EIC have a certain effect in participatory sensing. The negative comments refer to the stress of repeatedly stating one's position. This point may be due to the negative effects of the characteristic of participatory sensing, in which a large task is divided into smaller tasks and solved by many people, and the psychological pressure exerted by stance statements. In order to solve this problem, it is necessary to investigate how long the effect lasts after the declaration of position, and to introduce a mechanism that does not require the declaration of position every time.

Another possible solution is to estimate the number of people who need to express their intention (e.g., those who have answered inappropriately in the past) and to encourage them to express their intention at an appropriate time.

We also asked for suggestions for improving the OathSurvey application (Q6). The summary of comments is following.

- I had to shake it very hard to get it to work.
- I felt that if I waved my phone in the street, I might be worried what people around me think.
- The text asking for a expressing intension should be in red to give a sense of urgency.
- I felt more variety of expressing intension are needed.

5.3 Limitation

Several limitations are present in this study. As mentioned in Section 5.1, the overall quality of the data collected in this experiment was high. In this experiment, the respondents were students in the same laboratory as the client, so it is possible that they originally took the task more seriously than usual. In the future, it will be necessary to conduct experiments with people with various attributes, as in ordinary participatory sensing.

In addition, the effect of suppressing careless responses decreased as the latter half of the experiment progressed. This may be due to the fact that the respondents became bored, stressed, or accustomed to the high frequency of EIC every time they tried to answer. In the future, it will be necessary to find a new way for requesting EIC that does not make the respondents feel bored or stressed, and that does not cause them to become accustomed to it.

6 Conclusion and Future Prospects

In this paper, we propose a new participatory sensing system with a mechanism of expressing intention of contribution for suppressing careless responses. Currently, two types of expressing methods, button tap and gestures, have been inplemented, and can be applied regardless of the task content of participatory sensing. In the evaluation experiment, we investigated the effect of the EIC on the quality of the response data and the response behavior. In the evaluation experiment, we investigated the effects of EIC on the quality of response data and response behavior. In the future, we plan to conduct a survey under conditions similar to those of actual participatory sensing, and to explore more effective methods of stating a position.

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