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A Gamified Participatory Sensing for Tourism: The Effect to a Sightseeing

Shogo KAWANAKA [a,1], Yuki MATSUDA [a,2], Hirohiko SUWA [a], Manato FUJIMOTO [a], Yutaka ARAKAWA [a,3], and Keiichi YASUMOTO [a]
[a] *Nara Institute of Science and Technology, Japan*

Abstract. We have been working on a real-time tourism guidance system to improve the tourist's satisfaction in sightseeing. In this system, participatory sensing is leveraged to collect real-time sightseeing contents or data. The amount and quality of data collected in participatory sensing depend on the user's contribution. Therefore, gamification is generally utilized as an incentive mechanism. Few existing studies addressed the appropriateness of the gamification design or target tourists. In this paper, we design a gamification mechanism consisting of two types of sensing tasks and three types of rewarding methods and implement the mechanism in our participatory sensing platform called ParmoSense. We conducted a sightseeing experiment supposing three different user types. As a result, we confirmed that some type of tourists (participants) can collect sightseeing information while enjoying sightseeing through behavior change.

Keywords. Gamification, Participatory Sensing, Sightseeing, Behavior Change

1. Introduction

In Japan, the number of inbound tourists has increased by three times in the last 5 years. A further increase of inbound tourists is expected in upcoming years, especially around Tokyo Olympics in 2020. To help inbound tourists enjoy sightseeing comfortably, richer tourist information must be provided. Hence, we have been working on a real-time tourism guidance system to improve the tourist's satisfaction in sightseeing by means of participatory tourism information collection and curation of the collected infotmation [1]. This system provides tourism content to tourists taking into consideration not only user preference but also the dynamic information including time-limited events and congestion degree information on sightseeing spots, in addition to the static information which can be obtained from conventional guidebooks and websites. To collect detailed and dynamic information of sightseeing spots, a participatory sensing [2] can be used for generating and updating tourist information, thereby obtaining up-to-date tourist information at low cost. However, the amount and quality of collected information are contributor-dependent in participatory sensing. So, the motivation of users who

[1] Nara Institute of Science and Technology, 8916-5 Takayama-cho, Ikoma, Nara 630-0192, JAPAN; E-mail: kawanaka.shogo.kp1@is.naist.jp.
[2] Research Fellow of Japan Society for the Promotion of Science
[3] JST PRESTO

participate in sensing tasks is important to continuously and stably collect information. As a method for motivating users, *Gamification*, which uses game design techniques and mechanisms is often used. So far, many participatory sensing systems have incorporated gamification, and the usefulness of gamification has been shown through evaluation on the difference of quality and quantity of data depending on the presence or absence of it [3,4,5]. However, there are few concrete studies that address the appropriateness of the gamification design or target tourists. To realize a sustainable participatory sensing system in the tourism domain, a detailed gamification design should be discussed.

In this study, we aim to investigate the difference of contribution in participatory sensing affected by gamification design and attributes of users. We designed several gamification mechanisms which have a different type of sensing tasks and different rewarding methods, and implement them into ParmoSense [6], an integrated participatory sensing platform we developed. The designed gamification mechanisms consist of two types of sensing tasks: a task of walking around a certain area (Area Mission) and a task of taking a picture in a checkpoint (Check-in Mission) and three types of rewarding methods: static, weighted and dynamically weighted reward points for each task. Moreover, we obtain user's attributes through questionnaire and classify the users into three groups based on the motivation of participating in tasks (game, reward and sightseeing oriented). To confirm effects of the designed gamification mechanisms, we conducted a real-world experiment in Kyoto, Japan with 33 participants. Participants used a smartphone application for sensing during sightseeing. After the experiment, we collected questionnaire and analyzed the questionnaire data. As a result, we obtained the following insights on effects of gamification:

- The gamification significantly increases user's fun, even during sightseeing.
- Reward-oriented users tend to be affected by gamification, and easily change behavior during sightseeing.
- Users tend to give priority to Check-in missions compared to Area missions.
- Check-in missions are useful for collecting information of the specific place, but Area missions are better in creating comprehensive tourist information while maintaining sightseeing satisfaction of participants.

2. Related work

Since a participatory sensing approach relies on voluntary participation of public people, motivating users is essential to get continuous contributions. There are two types of methods to motivate users: 1) monetary incentive and 2) non-monetary incentive. The monetary incentive is effective for attracting users, but there is a limit of the total budget for rewards. The non-monetary incentive gives *experience*, e.g., fun, usefulness, as compensation for participant's contribution [7,8,9]. For example, *gamification* is one of the non-monetary incentive methods. This method incorporates game element into existing systems and enhances user's behavior [3]. Niels et al. [5] proposed the crowdsourcing application, called GeoOulu, with the gamification mechanism. They confirmed that participants of the application are encouraged significantly by using gamification methods such as animation of UI and leaderboard. Also, gamification contributes to the improvement of data quality as well. Ueyama et al. [4] proposed the participatory sensing system adopting both monetary incentive and gamification mechanism. They showed

that the gamification contributes to not only motivating participants but also suppression of monetary reward raises. Medusa [10] incorporates a different type of experience using gamification effectively. Medusa adopts the concept of reverse incentive (obligation/responsibility of executing tasks) as compensatory privilege of performing the task in order to retain participants. This method prevents participants from quitting the system in the middle of sensing tasks.

However, existing studies have not concretely discussed how gamification mechanism can motivate users and suppress monetary rewards. In this paper, we elucidate the extent of effectiveness in each gamification mechanism of the participatory sensing system through a case study.

3. Gamification Design

We investigate whether there are differences in contribution depending on the gamification type and the user's oriented type in information collection by participatory sensing for tourism. We designed the gamification with different tasks and different point acquisition conditions, and implemented them on our user-participatory sensing platform (ParmoSense). Our designed gamification has the following six types: two tasks, "Area Mission" that requests walking around a specific area and "Check-in Mission" that requests taking a photo at a specific place; three point acquisition conditions, Constant rewarding, Weighted rewarding, and Dynamic-weighted rewarding. We also set three types of motivations for participation as user's oriented type, Game oriented type, Reward oriented type, and Sightseeing oriented type. In the following sub-sections, the details of *ParmoSense*, mission design, rewarding method and user types are described.

3.1. ParmoSense

Our smartphone application for participatory sensing is called *ParmoSense* and it consists of six screens shown in Fig. 1 (1)–(6). The details of the screens are described below.

(1) This is the main screen of the application that indicates sensing tasks with pins or polygons as missions. User's ranking and points are displayed on the upper right corner of the screen.
(2) This screen is displayed when the user taps a mission pin in the map. It shows a detail of the check-in mission. Check-in is allowed only when the user is within a certain distance from the pinned place.
(3) This screen is displayed when the user taps the mission button in the bottom of the screen. In this screen, the details of missions in the map are shown in a list form.
(4) This screen is displayed when the user taps the check-in button in (2) to take and upload a photo or taps the camera button in the bottom of the screen for free posting.
(5) This screen is displayed after taking a photo in (4). The user can input texts on information or impressions of the photo (spot).
(6) This screen is displayed when the user taps the timeline button on the bottom left corner of the screen. It shows the photos and comments posted by other users.

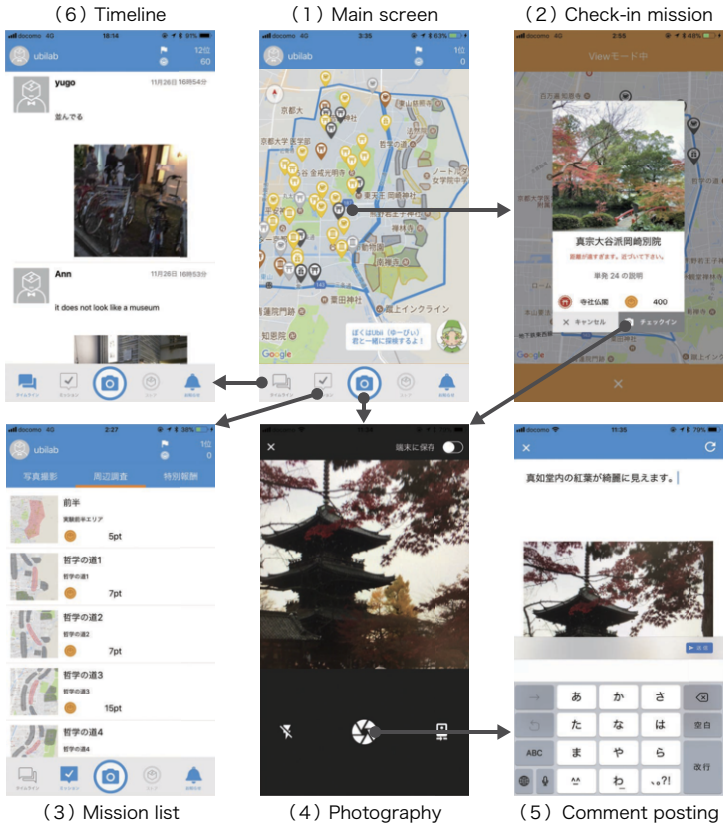


Figure 1. (1) Map-based main screen. (2) Check-in mission screen. (3) Mission list screen. (4) Photography screen. (5) Comment posting screen (6) Timeline screen

The timestamp, GPS information, acceleration, gyroscope, geomagnetism and illuminance values of the smartphone are collected at the sampling rate of 10 Hz while this application is running (even in background). These data are transmitted to the server every 5 seconds. These sensor data are collected at the moment when the user takes a photo and is sent to the server with the taken photo independently of the periodic sensor data.

3.2. Mission design

We designed two kinds of mission: “Area Mission” and “Check-in Mission” as sensing tasks. Additionally, “Free posting” was also designed so that the users can freely post photos on places they find interesting and share them with other tourists.

Area Mission

Area mission is displayed as polygons in a specific sightseeing area on the map, as shown in Fig. 2. By walking around this area and collecting sensor values, points are given to the user at fixed time intervals. A gold area, a silver area, and a bronze area are set according to the points to be given.

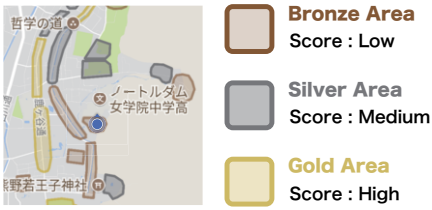


Figure 2. Area Mission

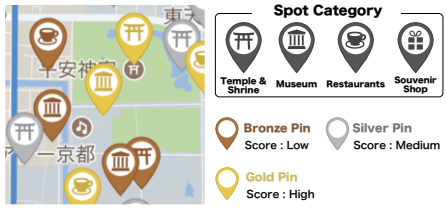


Figure 3. Check-in Mission

Check-in Mission
Check-in mission is displayed with a pin in a specific sightseeing spot on the map, as shown in Fig. 3. It is possible to check in when the user is within a certain distance from the pinned place. By posting photos and comment on the spot, check-in is completed and points are given. Temples/shrines, museums, restaurants, and souvenir shops which are commonly mentioned as category of sightseeing spots are set as types of pins. The colors of the pins are set according to the points, similar to the area mission.

In addition to the above missions, "Free posting" is also introduced. In this mission, users can take photos freely at places where they are interested and post the photos with comments. Posted contents are shared by all users on the timeline.

3.3. Rewarding method

Three kinds of rewarding method are designed as shown below.

Constant rewarding
Constant points are obtained depending on the type of mission (Area Mission, Check-in Mission).

Weighted rewarding
Points are changed according to spots. The points are determined by the demand level of information about the spot. In the experiments described in section 4, the number of hits that were hit when searching the web for each sightseeing spot name are assumed as the demand level of information, and the points were determined accordingly.

Dynamic-weighted rewarding
In addition to the weighted points, the amount of information collected by participatory sensing is reflected as weights at fixed time intervals. For the sake of simplicity, we set the weight in advance and change it every 30 minutes accordingly in the experiment.

3.4. User's oriented type

We determined the user type of each participant based on the response to the following question while participating in a stamp-rally that gives point-based reward, what do you think the most important in the following? – Enjoy stamp-rally (Game oriented), Aim to get more reward (Reward oriented), Enjoy sightseeing (Sightseeing oriented).

4. Sightseeing Experiment

We conducted experimental sightseeing using the developed application to investigate the effect of our designed gamification and difference of user's oriented types. In the following sub-sections, we explain the detail of recruiting, grouping and procedure in our experiment.

4.1. Recruitment and Grouping

We recruited 33 participants (21 lab members and 12 others) in total. There were 25 male and 8 female participates. Most of the participants were in their 20s (one 30s and one 40s). The number of Japanese and non-Japanese are 29 and 4 respectively. Among them, 17 participants are classified to Sightseeing type, 7 participants to Game type, and remaining 9 participants to Reward type.

The participants are assigned to the three groups taking into account the age, sex, nationality, and the oriented type. The size of each group is 11. Different reward methods are applied to the groups: constant rewarding for Group A, weighted rewarding for Group B, and dynamic-weighted rewarding for Group C.

4.2. Experimental Procedure

The experiment was conducted in Kyoto in November 2017. In this experiment, we asked the participants to do sightseeing in an area of Kyoto city while earning points by clearing the mission. After the experiment, we collected questionnaire from the participants. To clarify the effect due to the difference in mission type, we requested participants to engage in area mission and check-in mission separately in the first and second half of the experiment respectively. The experiment time was set to 4.5 hours in total which consists of 2.5 hours course and 2 hours course planned with reference to the sightseeing model course. Ahead of the experiment, we asked participants to install our developed application on their smartphone. After that, we fully explained the usage of the application and the contents of each mission for each group.

First half experiment (Area Mission)

In the first half of the experiment, area missions were assigned to the participants. The course started from the Keage station to Ginkakuji temple. The participants were asked to do sightseeing freely using our application. The points are given to each participant based on the following rules:

(A) Get 10 points every 10 seconds within the experiment area of the first half of the experiment.
(B) Get 15, 10, 7 points every 10 seconds in case of the special areas such as gold area, silver area, and bronze area, respectively.
(C) The special areas are updated every 30 minutes.

The number of special areas set in this experiment is 33 (11 areas for gold, silver, and bronze, respectively) in total. Also, 30 points are given for free posting.

Table 1. Questionnaire items after experiment

Item No.	Questionnaire Detail
Q1	Did you enjoy sightseeing by using our application?
Q2	How many times did the mission change your destination or the route of travel?
Q3	Which did you prioritize, sightseeing or mission in first half of the experiment?
Q4	Which did you prioritize, sightseeing or mission in second half of the experiment?

Second half experiment (Check-in mission)

In the latter half of the experiment, check-in missions were assigned to the participants. The course started from Ginkakuji temple to Higashiyama station. The participants were asked to do sightseeing freely using our application. The points are given to each participant based on the following rules.

(A) Get 400 points at any check-in spots
(B) Get 730 $\sim$ 620 points, 370 $\sim$ 310 points or 180 $\sim$ 150 points in case of checking in at the gold pin, silver pin and bronze pin, respectively.
(C) The special check-in spots with colored pins are updated every 30 minutes.

In this experiment, we set 45 special spots; 23 spots for temples and shrines, 7 spots for museums, 4 spots for souvenir shops, and 11 spots for cafes. Also, the highest point of all the group is set to be constant. Similarly to the first half, we decided to give 30 points for one text posting.

Questionnaire

We asked five questions after the experiment for clarifying the influence of gamification and user's oriented type. Table 1 shows the questions which ask:

- Fun of sightseeing. (Q1)
- Influence of missions to a sightseeing. (Q2)
- The difference of priority against a sightseeing and missions. (Q3, Q4)

All of these questions were asked to answer by 5 grades evaluation.
In Q1, 1 means "not pleasant at all" and 5 means "a lot of fun." In addition, we asked the participants to describe the reason why they felt so. In Q2, 1 means "0 times," 2 means "1 $\sim$ 3 times," 3 means "4 $\sim$ 6 times," 4 means "7 $\sim$ 10 times," 5 means "more than 10 times." In Q3, Q4, 1 means that a participant strongly gave a priority to a sightseeing rather than missions. 5 means the opposite.
Finally, impression and feedback against the experiment were collected by free description.

5. Results & Discussion

In order to clarify the fun level of sightseeing based on gamification and user's oriented type and the influence of gamification on sightseeing, the results of each questionnaire item are analyzed by a group and by user's oriented type.

5.1. Result

5.1.1. fun

Regarding the fun of sightseeing in Q1, the total average score was 4 or more. In addition, as a result of one-way analysis of variance (one-way ANOVA) for each group and each user's oriented type, there was no significant difference ($p > 0.05$). That is, the participants enjoyed sightseeing, and it was confirmed that there are no difference depending on the type of gamification and user's oriented type. In the free description for Q1, the following opinion was obtained as a positive opinion: "Because in order to complete the mission, I could go to places where I could not normally go." or "There was a game element that enabled competition with other users."

5.1.2. behavior change

For the number of behavior changes by gamification in Q2, the mode was 2 (1 to 3 times) and the average was 2.88. As a result of one-way ANOVA by a group, there was no significant difference ($p > 0.05$). Meanwhile, as a result of one-way ANOVA by user's oriented type, a significant difference was confirmed ($p < 0.001$). The average scores of the game oriented type, the reward oriented type, and the sightseeing oriented type were 2.57, 4.11, and 2.35, respectively, and it was confirmed that the reward oriented type users changed their behavior in comparison to others. In other words, it was found that the reward oriented type users change the destination and the movement route according to the mission.

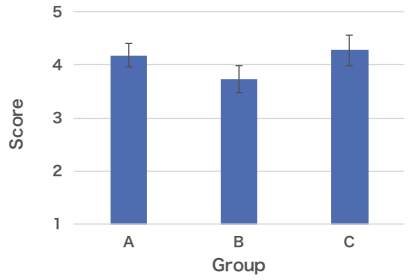
5.1.3. mission VS sightseeing

The average scores of answers on priorities of sightseeing and mission, in the first half experiment (Area Mission) and the second half experiment (Checkin Mission) of Q3 and Q4 were 2.39 in the first half and 3.82 in the second half. The main effects were confirmed only in the first half and the second half ($p < 0.001$), as a result of the two-way ANOVA in the first half and the second half of the experiment and gamification type or user's oriented type. Neither interaction was confirmed ($p > 0.05$). From these results, it was found that regardless of group and user type,the participants prioritize missions more than sightseeing in check-in missions than area missions. In addition, the following opinions were obtained in the free description for the experiment: "I was able to enjoy sightseeing in the first half, but I could not enjoy sightseeing in the second half," "I could not afford to do sightseeing because I was desperate for collecting points," "I was distracted by the app."

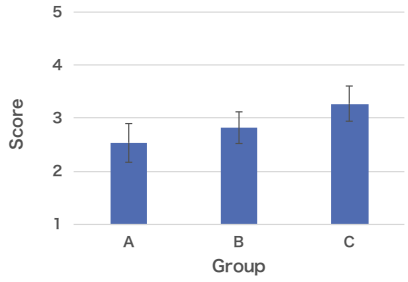
5.2. Gamification suitable for sightseeing

It was confirmed that sightseeing can be enjoyed even if gamification was introduced during sightseeing from the result of Q1. Additionally, we found that introducing gamification during sightseeing can lead to behavior change from Q2. As a result, we confirmed that it is possible for tourists to enjoy sightseeing and, experience behavior change while participating in collection of sightseeing information.

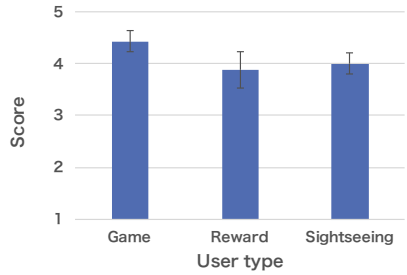
Here, an important point is the mission adopted as gamification. From the results of Q3 and Q4, it was found that the check-in mission has priority over the area mission. In



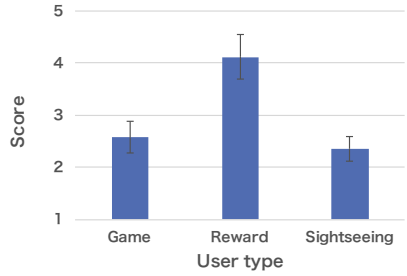
(a) Group - Q1



(b) Group - Q2

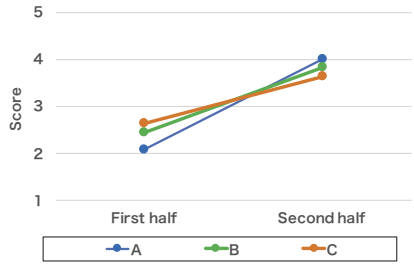


(e) User type - Q1

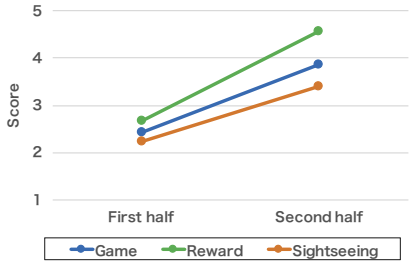


(f) User type - Q2

Figure 4. Results of one-way ANOVA



(a) Group - Q3,Q4



(b) User type - Q3,Q4

Figure 5. Results of two-way ANOVA

addition, with a free description, multiple opinions were obtained that, during check-in mission, users could not concentrate on sightseeing. The check-in mission is an effective way to collect specific information, but focuses on clearing the mission beyond enjoying sightseeing. Therefore, considering a sightseeing satisfaction of the user, the check-in mission is considered to be unsuitable. For these reasons, we consider that the area mission should be adopted as gamification in sightseeing situation. In order to encourage a behavior change, we think that more effective gamification is necessary for reward oriented type users.

6. Conclusion

In this paper, targeting participatory sightseeing information collection, we proposed several gamification types with different types of sensing tasks and different rewarding methods. We also implemented the types in a smartphone application. We conducted a real-world experiment in Kyoto, Japan with 33 participants. Participants used the smartphone application for sensing during sightseeing. Through analysis of the questionnaire data, it was confirmed that sensing tasks can be requested to some type of tourists who can collect sightseeing information while enjoying sightseeing through behavior change. We also confirmed that the check-in mission is an effective way to collect specific information, but it may urge tourists to clear the mission rather than enjoy sightseeing.

Acknowledgment

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