Attempt to mitigate congestion by providing latent information with walk-rally application

Yuya Ieiri
Waseda University
Tokyo, 169-8555 Japan
ieyuharu@ruri.waseda.jp

Yuu Nakajima
Toho University
Chiba, 274-0072 Japan
yuu.nakajima@is.sci.toho-u.ac.jp

Reiko Hishiyama
Waseda University
Tokyo, 169-8555 Japan
reiko@waseda.jp

ABSTRACT

At events and sightseeing spots, congestion can be a factor that lowers customer satisfaction, so there is need for methods that mitigate congestion. Currently, there are methods for mitigating congestion such as changing the layout of an event and restricting customer behavior. However, there are problems in that it is difficult to reduce congestion at events in which the layout cannot be changed, and there is a risk that the satisfaction level will be reduced due to restricting customer behavior. Therefore, in our study, we propose a method aimed at reducing congestion by allowing users to voluntarily select a detour to avoid congestion by providing the users with not only obvious information but also latent information with a walk-rally application. In demonstration experiments at real events and sightseeing spots, we confirmed that the proposed method is effective at reducing congestion and clarified how to use latent information effectively for mitigating congestion.

CCS Concepts

• Human-centered computing→Collaborative and social computing • Human-centered computing→Ubiquitous and mobile computing

Keywords

congestion reduction, detour, non-monetary incentive, walk-rally application.

1. INTRODUCTION

At events and sightseeing spots, improving customer satisfaction is very important for improving their feeling of value. However, congestion problems can often happen because events and tourist spots attract a lot of people. Higgins et al. [1] states that congestion is a waste of time, which is an important asset, and it burdens many people with financial and mental stress. Kim et al. [2] also reveal that, in the service environment, a higher degree of congestion often lowers customer satisfaction. Furthermore, Papaioannonu et al. [3] show that, particularly at sightseeing spots, factors such as congestion that affect the comfort level of services will lead to a decrease in customer satisfaction.

Thus, at events and sightseeing spots, it can be said that mitigating congestion is important for preserving value. There are methods for reducing congestion at events such as by changing the layout of the target environment [4] or forcibly reducing congestion by restricting customer behavior [5]. However, there are problems in that it is difficult to reduce congestion when an event layout cannot be changed, and there is a risk that the level of satisfaction will be reduced due to restricting customer behavior.

Therefore, in our study, we propose a method aimed at reducing congestion by allowing users to voluntarily select a detour to avoid congestion by providing them with not only "obvious information" but also "latent information" with a walk-rally application. Obvious information refers to information on popular places provided to customers such as in pamphlets and guidebooks, and latent information refers to information on places that is not listed in pamphlets and guidebooks although these places are thought to be worth visiting.

Using the proposed method, we conducted two experiments at a university's school festival as an event and in Kyoto as a sightseeing spot and analyzed the usefulness of the method. There are three points to our study:

1. Propose a method to help reduce congestion without restricting customer behavior regardless of the target environment with a walk-rally application,
2. Analyze the impact of the method on congestion mitigation with demonstration experiments at actual events and sightseeing spots,
3. Consider how to effectively use latent information for congestion mitigation by analyzing the experimental results.

In this paper, we describe the usefulness of the proposed method in consideration of these points.

2. Related Work

There are various studies on methods for mitigating congestion.

Asahara et al. [4] conducted experiments aimed at reducing congestion by improving the movement of pedestrians at an event. They measured and analyzed pedestrians' movement with a pedestrian tracking system using LiDAR. Then, by planning measures to change the layout of the event venue, they succeeded in spreading out the congestion at the venue. Their method aimed for use at events is similar to our proposed method. However, our research differs in that our method can reduce congestion without depending on the location, while their method can only reduce congestion in places where the layout can be changed.

Ishikawa et al. [5] showed a method for reducing congestion at sightseeing spots. They noticed that, at national parks, the appropriate management measures must be implemented in order to minimize the impact of congestion on ecosystems because congestion is caused by the park being recognized as a sightseeing attraction, and this congestion affects the ecosystem. Therefore, they tried to mitigate congestion by applying a traffic cellular automaton model (CAM) as a decision support tool for relieving congestion at Shiretoko National Park in Japan. As a result, they clarified that it is possible to reduce congestion by adjusting the traffic inflows of everyday visitors. Their method aimed for use at sightseeing spots is similar to our proposed method. However, our research differs in that our method allows users to select a detour in order to reduce congestion voluntarily without restricting their behavior, while their method attempts to reduce congestion compulsorily by restricting their behavior.

3. Proposal

As mentioned, we propose a method aimed at reducing congestion by allowing users to voluntarily select a detour in order to avoid congestion by providing them with not only obvious information but also latent information with a walk-rally application. We developed the application to provide obvious information, that is, information on popular places known to many people, and latent information, that is, information on places that are not known by many people although they are thought to be worth visiting at the same time. In this chapter, we describe the walk-rally application, the devices we used, and our hypothesis for congestion mitigation.

3.1 Flow of Application

In the application, the following four steps are repeated.

1) Select a destination,

2) Move to the destination using a navigation screen,

3) Check in (enter keywords, take a photo),

4) Try a quiz.

Example screens of the application are shown in Fig. 1. A list screen and check-in screen are shown. In the list screen, all content (the obvious and latent information) that can be navigated to in the application are displayed, and users select their next destination from among them. After that, the navigation screen is displayed, and users move to the destination on the basis of the navigation. After arriving at the destination, users check in and can earn points if the check-in is completed correctly. In our study, check-in is completed if users can enter a 4-digit keyword correctly in the event experiment and if users can take as photo that is the same as a designated photo in the sight-seeing experiment. After users check in correctly, a quiz on the destination is given, and users try to answer questions. If they answer correctly, they can earn points.

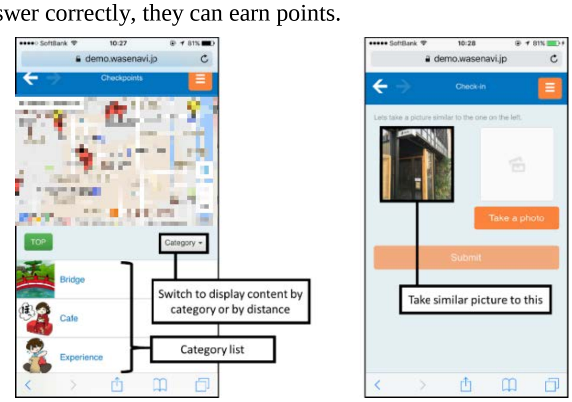

Figure 1. Example screens

(left: list screen, right: check-in screen).

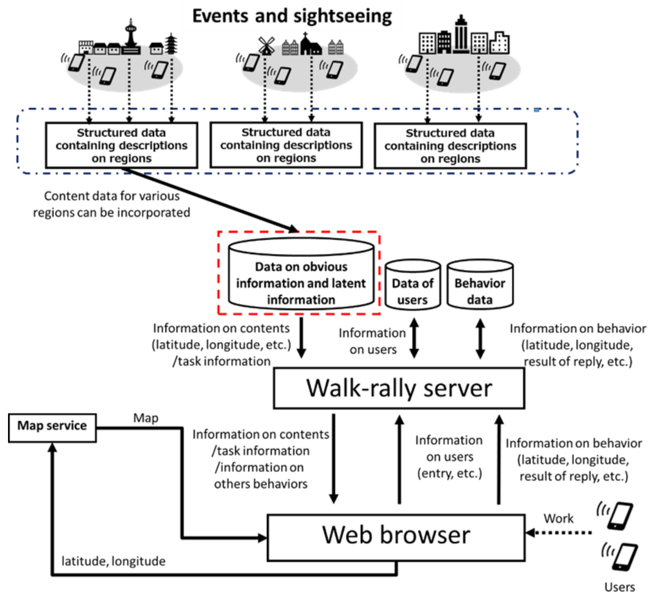

Figure 2. System architecture.

3.2 System Outline

In our study, we adopt a building block method in order to enable the application to be used at various events and sightseeing spots. The building block method is a method that develops a system by dividing it into detailed elements and enables it to be reconstructed by combining them [6]. This method makes it possible to give the application high versatility. The system architecture is shown in Fig. 2. Information on events and sightseeing spots is sent from "Data of obvious and latent information" to the walk-rally server. Information on users is sent from "Data of users" to the server, and information on behavior is sent from "Behavior data" to the server. Then, information on content is sent from the server to a web browser, and users use the application by activating the browser on a smartphone.

3.3 Devices and Hypothesis for Congestion Mitigation

Ueyama et al. [7] show that the incentives provided by gamification, such as with ranking systems and quiz systems, motivate users. Therefore, in our study, we introduced a point system, a ranking system, a quiz system, and so on in order to give our application non-monetary incentives to let users spontaneously move to non-congested areas.

Also, congested routes are generally predicted to be boulevards, so users avoiding congested routes means that they are away from big streets. Therefore, it is desirable to have devices that make walking enjoyable such as by providing a way to actively pass through detours. Kinoshita et al. [8] developed a city-walking system that uses a compass to make the atmosphere along the road easier to feel and to be more enjoyable walking on. Therefore, for our application, we adopt a navigation system that displays a compass (the direction to the destination) and the distance to the destination as shown in Fig. 3 to encourage users to voluntarily take a non-congested route. This navigation system is the same as that used in the study by Ieiri et al. [9].

Furthermore, in our study, we predict that the behavior of users will affect congestion mitigation, so we hypothesized that in order

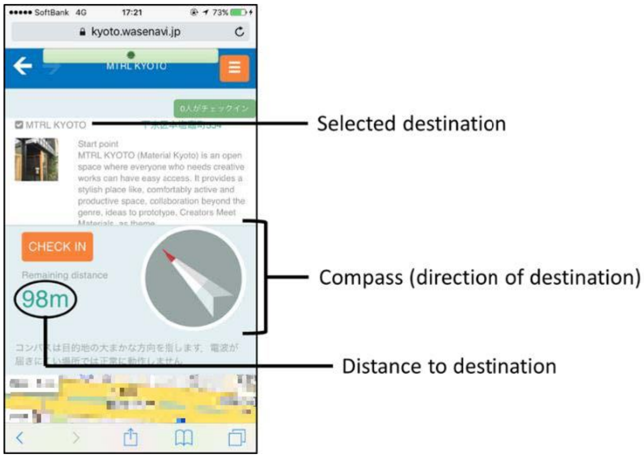

Figure 3. Navigation screen [9].

to acquire more points, users will more likely go to a destination that is closer to their current location, and, as a result, it is possible to lead them to take a detour. Through experiments, we examine whether the hypothesis is correct or not and whether such detours led to congestion mitigation.

4. Mitigating Congestion at Event

4.1 Outline of Experiment

In our study, as a demonstration experiment aimed at mitigating congestion at an event, we conducted an experiment at Waseda Festival 2016 (5th and 6th of November 2016), which is a festival held at Waseda University (Shinjuku-ku, Tokyo). As of 2015, the Waseda Festival is considered to be the largest school festival in Japan, and in 2015, the festival welcomed over 160,000 visitors with approximately 450 events at Waseda and Toyama Campuses [10]. Thus, congestion mitigation has become very important at the festival. Figure 4 shows the layout of the university. The festival faces two major problems regarding congestion. The first is that area “A” in Fig. 4, which is the center of the festival, is very crowded, while area “B” is far from the center, and there are not many visitors. The second is that, especially in area “A,” the green road in Fig. 4 is very crowded because the streets are narrow and there are customers queuing for food stands.

Therefore, we developed the walk-rally application based on the proposed method in order to solve the congestion problem. A total of 68 locations were programmed in the application, and 58 of them were related to entertainment, that is, obvious information, and 10 of them were related to latent information. The positional relationship between them was as shown in Fig. 4. Ten checkpoints, for which numbers are written, indicate the latent information, and the dots indicate the locations of obvious information. Regarding the latent information, on the basis of the hypothesis given in Section 3.3, we selected the locations so that a flow line to a non-congested area could be formed. Then, we tried to solve the congestion problem as explained above by using the application.

4.2 Results and Discussion

In the experiment, 291 people registered for the application. Among them, 48 users walked around Waseda University and checked in at various checkpoints to gain points. We analyzed the behavior logs obtained from these users.

As shown in Fig. 5, it was confirmed that there was a detour. The detour was a route that connected the following three buildings.

Figure 4. Congestion at event and locations of content.

Building No. 5

A building housing the “Theater Museum” and “Statue of Syoyo Tubouchi”

Building No. 6

A building housing the “Petroleum Gas Well Drilling Bit”

Building No. 14

A building housing “Mr. Yabuno’s Painting in Building No. 14”

The four spots included in these three buildings were latent information intentionally programmed in this study. A total of 11 users out of the 48 who obtained points used the detour. Originally, the detour was a street that the visitors usually avoid during the Waseda Festival because there is no entertainment and food stands along the detour. Nevertheless, it became possible for users to walk along the detour by providing latent information to them through this application, and it mitigated congestion. As a result, the detour was formed by providing latent information. It can be assumed that the detour was made because these four spots were located close to each other. Therefore, our assumption was correct that, to acquire more points, users are more likely to go a destination that is closer to their current location, and as a result, it is possible to lead them to take a detour.

In addition, the number of users who moved from area “A” in Fig. 4, which is the center of the festival, to area “B,” which is far from the center, was 2 out of the 48 who obtained points. It can hardly be said that the congestion in area “A” was reduced, so the attempt to reduce congestion failed. In the experiment, on the basis of our hypothesis, we included the 8th piece of latent information, “Statue of Azusa Ono,” as a location in addition to the obvious information between these two areas in order to lead users from area “A” to “B.” Therefore, it is considered that the reason this attempt failed is because area “B” was not a destination close to the current location because the distance

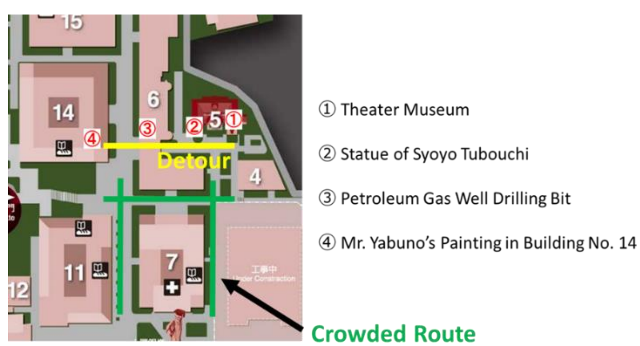

Figure 5. Detour route at event.

between "Statue of Azusa Ono," used to guide users from area "A," and area "B" was very far. Therefore, it is clear that, when we form a detour by using latent information, we need to pay attention to the positional relationship of each location; otherwise, there will be no effect on congestion when the distance between locations is too far away.

5. Mitigating Congestion at Sightseeing Spot

5.1 Outline of Experiment

We conducted a city-walking experiment in Kyoto City on Thursday, March 2, 2017 as an experiment aimed at reducing congestion at a sightseeing spot. We conducted simulated sightseeing for about 4 hours with 18 test subjects in their twenties. The start point, goal point, and location of each piece of content are shown in Fig. 6. The shortest route was about 3 km from the start point to the goal point, and this distance was sufficient enough to walk within the specified time. Regarding the locations, we selected and programmed 44 spots regarding obvious information from several travel guidebooks in Japan for Kyoto published during the last 10 years. Furthermore, we extracted 36 spots that were not listed in travel guidebooks but are considered to be worth visiting regarding latent information on the basis of a multiple field survey done by the authors while getting support from long-term (over 15 years) residents in the city.

Also, to identify which routes are crowded in the targeted areas, we conducted a preliminary experiment to clarify what kind of route tourists will choose from the start point to the goal point when giving them only the 44 pieces of obvious information included in application. In this experiment, we gathered 19 test subjects in their twenties, and we investigated what kind of route they would like to take for sightseeing by using the map, which included the locations and information on the 44 spots. We then analyzed the effect on congestion mitigation with our proposed method by deciding which routes in Kyoto are crowded and comparing them with the behavior log obtained in the city-walking experiment.

5.2 Results and Discussion

First, we describe the results and discussion on the preliminary experiment conducted to identify crowded routes. The results are summarized in Fig. 7. The figure shows 44 spots regarding obvious information provided to the test subjects and the confirmed crowded routes indicated by blue lines. A route chosen by more than one-third of the total number of test subjects was defined as a crowded route. As can be seen, crowded routes formed on the way from the start point to the goal point. In particular, there were many test subjects who selected routes that had many popular spots on the left and right, and 18 of the 19 test subjects responded that they would use one of the two routes of "A."

Figure 6. Locations (left: only obvious information, right: obvious and potential information).

In addition, the conditions of the crowded routes were confirmed from the results of the preliminary experiment. For example, the routes were confirmed to not be in area "B" in Fig. 7. The cause is considered to be that the test subjects did not concentrate on one route because the number of locations provided in area "B" was large, resulting in an increase in choices that the subjects had to make. Also, in area "C" in Fig. 7, there was almost no content to be provided, but congested routes formed. The cause is considered to be that the subjects selected the avenue that seemed to be the easiest to walk as the target direction was determined to be the goal direction. From the above two cases, it was revealed that the number of attractions presented affected how crowded routes formed. When the number was large, the number of choices of routes increased, making it difficult for crowded routes to form. When the number was small, crowded routes formed due to the physical aspects of the route (the width of the road, the number of people walking on the road, etc.).

Next, we describe the results and discussion of the city-walking experiment. With the proposed method, it was predicted that congestion would be reduced by the formation of detour routes in the three areas in Fig. 7. The reason the routes of these three areas were expected to form is based on the hypothesis that to acquire more points, users will more likely go to a destination that is closer to their current location, and, as a result, it is possible to lead them to take a detour . Analyzing the behavior logs, it was found that 2 of the 18 test subjects used the route of area "D" in the Fig. 7, that 7 of 18 test subjects used the route of area "E," and that 15 of 18 test subjects used the route of area "F."

The results of the experiment are summarized in Fig. 8. The crowded routes before presenting the latent information are the blue routes in the figure. The detours formed by presenting the latent information are the orange routes. From this, it becomes clear that our proposed method was effective at mitigating congestion because we were able to make the users of the application use the orange routes more than the blue ones thought to be mainly used by non-users of the walk-rally application.

It is also considered that the reason the route of area of "D" in Fig. 7 could not be a detour is that it went in the opposite direction from the goal point to the start point. Therefore, it was difficult to guide users to places away from the final destination, although the proposed method was certainly effective at reducing congestion on the way to the final destination. Furthermore, we conducted a

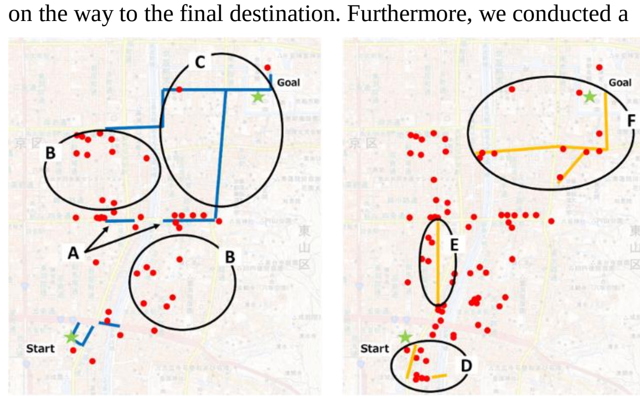

Figure 7. Crowded routes (left: in preliminary experiment, right: in city-walking experiment).

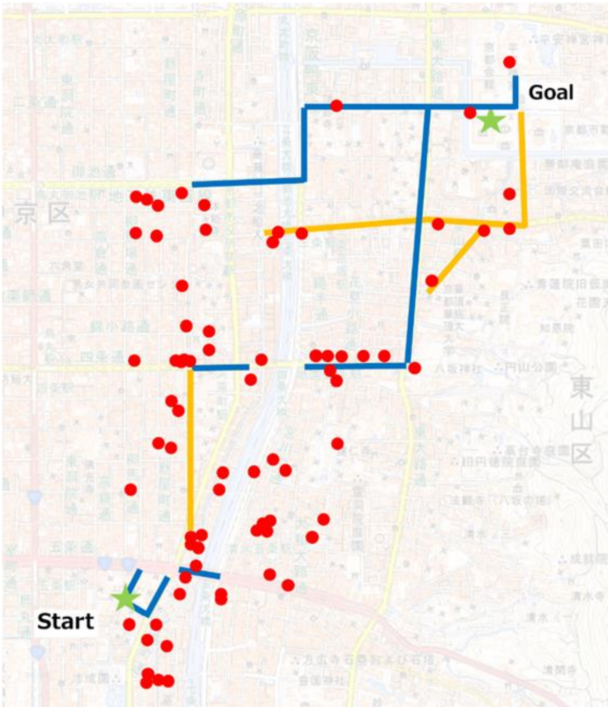

Figure 8. Detour routes during sightseeing.

questionnaire survey after the city-walking experiment. When we asked "What did you emphasize when choosing your destination?", 15 of the 18 test subjects answered "how short the distance was." Thus, it can be said that the part of the hypothesis stating that users will likely go to a destination that is closer to their current location is correct. We also asked "Could you find a point of interest by using the walk-rally application?" with 6 as the highest value, and the average value of the answers of the 18 test subjects was 5.28. Thus, it can be seen that one of the purposes of the proposed method, to allow users to voluntarily select a detour to avoid congestion, was achieved.

6. Conclusion

We proposed a method aimed at reducing congestion by allowing users to voluntarily select a detour to avoid congestion by providing them with not only obvious information but also latent information with a walk-rally application. We conducted two experiments at a university's school festival as an event and in Kyoto as a sightseeing spot and analyzed the effects of the proposed method. The contributions of our research are shown below.

1. We developed the walk-rally application, which provides both obvious and latent information and can be used in any environment. A questionnaire after the experiment confirmed that it was possible to let users voluntarily select a detour to avoid congestion by using the application.
2. We conducted demonstration experiments at an actual event and sightseeing spot and analyzed action logs. We showed that the proposed method can guide users to take a detour, reducing congestion.
3. When we aimed to guide users to a detour to reduce congestion by using latent information with the proposed method, it became clear that we need to pay attention to the positional relationship between the locations of the walk-rally application and the positional relationship to the final destination when selecting latent information to provide.

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