Creating a Virtual-entertainment Field in a Real Commercial Shopping Complex: Customer-trajectory Analysis of Experimental Event "HIKARINO Magical Quest"

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Abstract—**The results of a customer-trajectory analysis of an experimental event at a shopping complex are presented, and the manner in which the event participants are engaged with the shopping center is demonstrated. In particular, movements of participants are modeled with a mixed Markov model (MMM), and the position-data collected by PDAs given to the participants is used for estimating the parameters for the model. Since the data reflects participants' reactions to the services offered in the event, the trajectory analysis can be used to evaluate levels of customer satisfaction in regard to the experience of the participants in the shopping-center event.**

Keywords—**Engagement, Town marketing, Trajectory analysis**

I. Introduction

Commercial shopping complexes are usually designed for shoppers to see, feel, choose and purchase goods and services. However, such functional aspects of commercial complexes are not enough to attract people, especially, non-shoppers. HIKARINO Magical Quest, held in February 2010 at *Hankyu-Sanbangai*, a large-scale shopping mall in Osaka, Japan, was a demonstrative event using PDAs with GPS-like positioning devices. Each PDA provides marketing functions such as a recommendation engine. At the same time, it invites the participants in the event to relax at cafés, presents coupons, and so on, which serves to create longer stays at the shopping complex.

In March 2006, the Advertising Research Foundation announced the first definition of a concept referred to as "customer engagement," namely, "Engagement is turning on prospective customers to brand ideas enhanced by the surrounding context". Since then, marketing researchers and practitioners have been actively studying the nature of the concept. Example studies include a theoretical framework [1] and roles of new digital media [2] for creating customer engagement.

Although HIKARINO Magical Quest looked like a treasure-hunting game, it was based on a new concept, called a "field-engagement service" (FES). A FES is not merely a marketing service but engage customers with contexts and experiences in commercial complexes and urban areas. It defines a set of functions of digital media (as explained in the following section).

To understand how customers are engaged in the field (shopping malls, etc.), it is necessary to track data of customers' activities in the field. The PDA device used in the experiment enables indoor GPS positioning and LED visible light communication (VLC) and keeps track of the position of customers. In addition to this tracking data, customer-satisfaction data was collected from the participants by questionnaire.

The tracking data was combined with the questionnaire data and subjected to trajectory analysis. The results of this analysis revealed the relationship between customers' movement and levels of satisfaction. The two key results are the appropriate duration of participation in the event and the statistical correlation between the customer's trajectory pattern and his or her mindset.

II. Field-engagement service

A. Field engagement and related works

Most conventional marketing methods focus on how to attract customers. Customers' activity, however, is not only aimed at buying goods. What motivates customers to come to a certain place is important because people who never go there will never buy anything there. People who have a good time in the field will become loyal customers there. Moreover, they will share their experiences with people who have never been there. Through their experiences, particular brands in the field will be established and attract more customers.

An FES creates one reason to come to a certain field. Presented with what the field has to offer, people will be entertained and share better perceptions of the field. To develop ordinary commercial complexes into be fields of customer engagement, digital technologies are essential and believed to be the most promising enabler. In a similar manner to that in another study [2], in the present study, five functions that must be supported by the IT devices and platforms used by an FES are defined as communities, entertainment, user-friendly operation, recommendation, and sensing/positioning.

B. HIKARINO Magical Quest

At a glance, HIKARINO Magical Quest is like a treasure-hunting game. That is, guided by a map on a PDA, each participant walks around the shopping mall and finds lucky items and coupons. Actually, the map is controlled by a recommendation engine. The locations of the items and coupons are determined according to each participant's store preferences. In other words, the items and coupons are hidden near or on the way to the shops that are recommended by the system.

The PDA used in the quest facilitates indoor GPS positioning and VLC. The VLC device receives (through a camera) only a location ID at each location where items and coupons are hidden, and the items or coupons to be found are assigned by the recommendation engine installed in the PDA. Recommendation of shops and products and customization of the map are provided by this procedure. The indoor GPS positioning, on the other hand, is used to constantly monitor each participant's location in the mall. Customer-position data collected in the quest is stored in the PDA and copied to a server at the end of the quest.

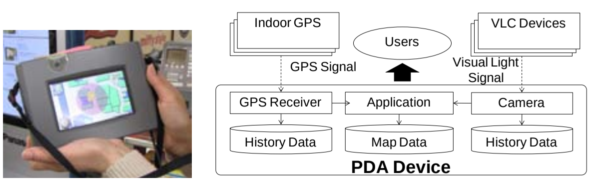


Fig. 1: Experimental system

III. TRAJECTORY ANALYSIS

A. Methods of trajectory analysis

Trajectory analysis [3] is a technique for extracting abstract information from stored trajectory data. The trajectory data in this experimental event is a time series of position data, generated by the indoor GPS and VLC devices. Participants in the quest act differently according to their motives, especially their attitudes towards services offered through PDAs. Even so, the trajectory data reflect how much the participants are satisfied with the services.

The trajectory analysis has three steps (Fig. 2). First, the trajectory of each customer is divided into several segments. If some segmented trajectories of different users are close, these trajectories are recognized as similar and grouped into one cluster. In other words, the cluster represents these trajectories. By repeating this process, each trajectory is represented by a series of clusters [4]. Second, the status of each user in a cluster is estimated. The status usually corresponds to actions taken by users, such as walking and running. Third, status transition is modeled as a probabilistic model, which makes it possible to extract useful information. A small likelihood of a particular trajectory, for example, indicates that the trajectory was obtained in an exceptive case.

The first and second steps for the experiment are relatively simple because the data structure, namely, position with time stamp, is very simple. It was assumed that people who stayed in the area for a short time were just walking through it and that people who stayed for longer (a few hours or so) were engaged in some kind of activity there. The third step, however, is not so simple because customers' interests and behavioral patterns vary widely and one single model cannot capture customers' statuses very well.

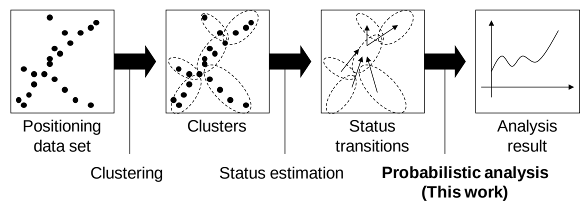


Fig. 2: Steps of trajectory analysis

B. Mixed Markov model for participants

In the third analysis-step described above, a mixed Markov model (MMM) [5] was applied to the trajectory data. An MMM is a mixture of Markov chains, and each chain represents a group of customers with common characteristics. Each trajectory is generated by one of the chains, but it is impossible to determine which chain generates which trajectory. A latent vector, z (where $z_k = 1$ when the kth model generated the trajectory, and $z_k = 0$ otherwise) was thus employed.

The probability-distribution formula used in the MMM is given as

$$P(\vec{d}) = \sum_k \pi_k P_k(\vec{d}) = \sum_k \pi_k \prod_n P_{k,\mu\to\nu}^{d_{n\mu\nu}},$$

where π_k is a mixing coefficient, which is a probability of z_k ; $P_{k,\mu\to\nu}$ is the probability of movement from point μ to point ν under the kth model; and $d_{n\mu\nu}$is the number of transitions from state μ to state ν in the nth trajectory.

MMM parameters π_k and $P_{k,\mu\to\nu}$ and latent variables z_n of all trajectories must be determined simultaneously; accordingly, the Expectation-Maximization (EM) method [6] is used to estimate them through the following four steps.

Step 1
Initialize $P_{k,\mu\to\nu}$ by random values.

Step 2
Calculate responsibilities γ_{nk} for each trajectory, where $\gamma_{nk} = \pi_k P_k(d_n) / \sum_{k'} \pi_{k'} P_{k'}(d_n)$.

Step 3
Update parameters π_k and $P_{k,\mu\to\nu}$, where $\pi_k = N^{-1} \sum_n \gamma_{nk}$, and $P_{k,\mu\to\nu} = \frac{\sum_n d_{n,\mu\to\nu} \gamma_{nk}}{\sum_{n,\nu} d_{n,\mu\to\nu} \gamma_{nk}}$.

Step 4
Reiterate steps 2 and 3 until convergence.

Trajectories are classified into sets containing trajectories with common latent variables, because the latent variables indicate the trajectory-data patterns.

The aim of this study was to determine the causes of the trajectory-data patterns. Attributes, namely, information about each participant, give many hints to discover the causes of trajectory patterns. If many trajectories in one pattern have a common attribute value, the value is presumed to determine the pattern. Hence, χ^2 tests on the attributes in the patterns were applied. An attribute value showing a statistical significance in a pattern represents a feature of that pattern. The attributes were obtained by giving questionnaires to the participants after the experiment.

C. Results of experiment

Table 1 lists the basic attributes of the participants. 691 trajectories taken in HIKARINO Magical Quest were analyzed. The target of this experiment was sets of parents and children (see Fig. 4). (The average age in this experiment is not significant.) Children younger than 10 years old made up 38.6% of participants, and people in their 30s with children less than one-year old made up 19.3% of participants. This distribution shows that the targeting was successful.

Figure 4 plots the distribution of duration of participation during this event (i.e., quest). Two peaks appear in this distribution. The first peak appears around 30 minutes. These people seem not interested in the quest. The second peak appears around 100 minutes and indicates duration of participation of the interested people. The second peak is much larger than the first, meaning most participants seemed to have enjoyed the event.

Figure 5 plots of duration of participation in terms of time spent in passageways to event spots and time spent at event spots. It is clear that the participants were in passageways for a shorter time, and they stayed for longer (300 seconds) at an event spots. The appropriate length of content to be presented at each event spot, such as digital signage, is therefore about five minutes.

Table 1: Participants' attributes

Attributes	Values
Data set	691 participants' trajectories
Average age	28.0 years old
Gender	Male: 62.8%; Female:37.2%
Duration of event participation	1 hour 31 minutes

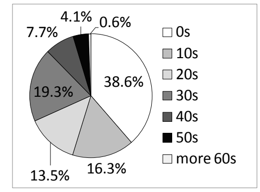


Fig. 3: Age distribution of participants

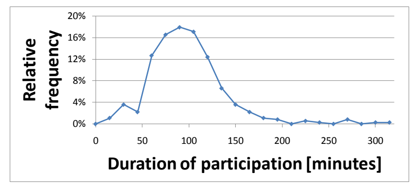
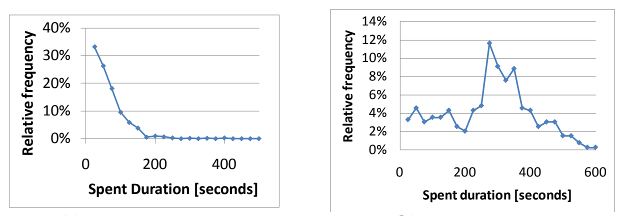


Fig. 4: Distribution of duration of event participation



(a) In passageways (b) At event spots

Fig. 5: Durations spent in passageways and at event spots

Trajectory analysis was applied to trajectory data collected in this experiment. To discover tendencies regarding parents and children, 210 trajectories of participants with family members were analyzed. Two patterns in this data (A and B in Fig. 6) were obtained. The color intensity of the arrows between event spots represents participants' transition probabilities. The differences between patterns A and B are circled in the figure. It is clear that most participants went around the outer passageway as shown by pattern A because the aquarium attracted them. On the other hand, pattern B shows different movements; they visited less event spots.

To interpret these differences between patterns A and B, attribute distributions are shown in Fig. 7. Figure 7(a) shows the answers to the question, "You like to walk in a town to find something new." in the questionnaire, showing a statistical significance. People following pattern B seem not to prefer walking in a town. Figure 7(b) shows the answers to the question "You want to come to Hankyu-Sanbangai again". The results for pattern B are more positive, though a statistical significance between patterns A and B was not obtained. Because the shopping mall has many repeaters, B seems to be a repeater pattern. Customers who follow pattern A should be targeted more than those who follow pattern B. This finding means that events suitable for pattern A, such as aquarium events, are effective for customer engagement. These analyses demonstrate that target attributes can be grouped according to trajectory patterns.

It is concluded that the entertainment aspect of a FES, such as augmented reality at the aquarium, was enjoyed by people who like to walk around in a town to find something new, and this experience leads them to want to visit again.

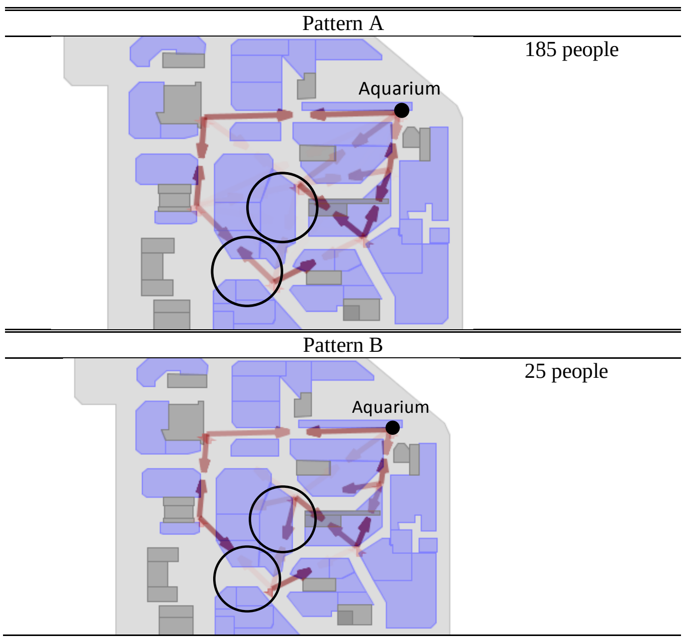
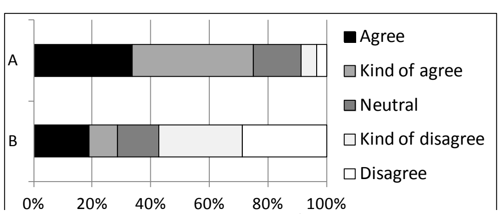
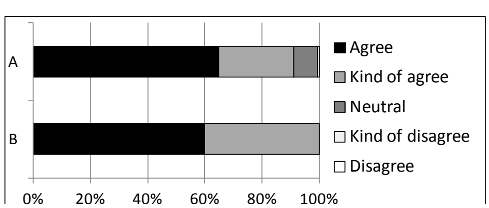


Fig. 6: Contrast between patterns A and B



(a) “You like to walk in a town to find something new.”



(b) “You want to come to Hankyu-Sanbangai again.”

Fig. 7: Attribute for patterns A and B

D. Proposal for FES

The results described above indicate that an FES should meet the following requirements.

1. Time spent on a FES should be around 100 minutes. An FES must be programmed so that participants stay for around 100 minutes, the duration when customer loyalty increases. Hence, mobile terminals for a FES should carry enough battery power to work for over two hours.

2. Target-matched applications should be developed. Patterns A and B demonstrated different tendencies according to participants’ statuses. Applications delivered to participants on PDAs must vary according to participants’ statuses for better customer engagement.

IV. Concluding Remarks

HIKARINO Magical quest was a virtual entertainment program performed in a real commercial field. It was designed to improve an FES by means of trajectory analysis. The analysis shows that a difference in customer-trajectory patterns represents different mindsets towards visiting a shopping complex. Activities observed in this experiment are noncommercial activities because the entertainment aspect of this event was emphasized. The observations of commercial activities by an additional experiment are for future works.

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