

Busy versus Empty Museums: Effects of Visitors' Crowd on Users' Behaviors in Smart Museums

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ABSTRACT

There is a growing interest in integration of Internet of Things (IoT) in smart environments, which creates an opportunity to understand users' information needs using onsite physical sensor logs. However, the physical context creates numerous external factors that play a role in users' information interactions, thus creating new external biases in the collected information interaction logs. In order to provide an effective personalized experience for users in a smart environment, we need to take care of these external biases in the behavioral user models. Our general aim is to understand users' onsite physical behaviors for providing online and onsite personalized services like personalized tour guides. We focus on the cultural heritage domain and collect onsite users' physical information interaction logs of visits in a museum. This prompts the question: How to understand users' behavior in the existence of external biases? Our main finding is that users behave differently in their solitude in comparison to a busy museum situation. Specifically, visitors' crowd bias has a considerable effect on users' following position rank bias based check-in behavior. Our study investigates on understanding users' onsite physical behavior accurately, which can improve the state-of-the-art onsite behavioral user models.

KEYWORDS

Human information interaction, Onsite logs, Internet of things

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1 INTRODUCTION

Due to the growing interests in deploying smart devices and integration of Internet of Things (IoT) in smart environments [1-3, 7, 8] (e.g., museums [4-6]), implicitly understanding users' onsite information needs using users' physical information interactions rises lots of interests among researchers interested in personalization in both industry and academia. To this aim, users' onsite physical interactions are logged using integrated sensors in smart museums.

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However, onsite physical information interaction logs are noisy, which makes understanding users' interests and information needs a very challenging task.

Many external factors might contribute in the collected onsite physical information interactions logs, which leads to different biases in the collected logs. Hashemi et al. [4] studied walk-through position bias, which is highly correlated with museums' exhibition design. Walk-through position bias is users' tendency in visiting point of interests one after the other, based on proximity in the real world, from check-in to check-out stations, even though users are free to visit any POI in any order.

The walk-through position bias causes two other biases in collected users' physical information interaction logs, namely, position rank bias and time rank bias [4]. Position rank bias is based on the fact that users spend more time in front of point of interests installed in the beginning of the exhibition, and their dwell-time decreases by reaching step by step to the end of the exhibition. Time rank bias is the bias created based on the observed users' tendency in spending less time at the end of their visits and users' fatigue of using technology in museums as they are reaching to the end of visits.

Moreover, Hashemi and Kamps [5] observed visitors' crowd bias on the collected onsite physical information interaction logs. They observed a considerable effect on users' onsite behavior based on other visitors around them. In [5], they addressed users' skip-or-stay behavior prediction in the existence of visitors' crowd in the museum space. In addition to the studies on the available onsite biases and users' onsite skip-or-stay behavior prediction, users' check-in behavior prediction in a smart museum using behavioral user models based on their onsite physical and online digital information interaction behaviors have been investigated in [6].

Although users' onsite physical behavior prediction in the existence of different biases have been studied in [4-6], a comparison of users' behavior in the existence of visitors' crowd to users' behavior in an empty museum in their solitude have not been addressed previously. In this paper, our main aim is to study the question: *How does visitors' crowd have effect on a user onsite physical behavior?*

The rest of this paper is organized as follows. In Section 2, we give a short summary of the experimental data being used in this research. The comparison of users' behaviors in their solitude to their behaviors in a busy museum is detailed in Section 3. Finally, we present the conclusions and future work in Section 4.

2 EXPERIMENTAL DATA

The dataset of this study is based on onsite information interaction logs collected at an exhibition in Allard Pierson Museum¹, which

¹<http://www.allardpiersonmuseum.nl/en>



Figure 1: An interactive POI in a museum physical space

is an archaeological museum. As it is shown in Figure 1, in the exhibition, RFID tags are provided as a key to access some additional information about objects being shown in the museum.

The museum visitors can enter their preferences at the check-in station of the museum exhibition in order to personalize the content being shown in all of the POIs. These preferences are the perspectives of the narratives, as well as language, gender and the user's age range.

After checking in, users are free to put their keys on RFID readers of POIs to unlock contents being shown about objects available at the POIs. Each POI contains 3 different archaeological objects and corresponding content related to each of the available objects. At each POI, users can watch short movies, interact with 3D photos of the POI's objects, or read contents about objects being shown at the POI.

Users are free to interact with POIs in any order by using the RFID tag to unlock the personalized curated content. At last, users might check out in a summary station, in which they might leave their name, birth date and email address. In this paper, five months onsite logs of the museum with more than 21,000 sessions are used. In our collected onsite information interaction logs, about 16,000 out of 21,000 sessions either did not have any interactions with POIs or they did not check out at the summary station.

We exclude all sessions have not checked in at any POI at the exhibition. We also exclude sessions that did not check out at the summary station as users who did not visit the whole exhibition and for whom we do not have all implicit judgments of their interests in POIs. As a result of this preprocessing step, 5,017 out of 21,000 high-quality onsite information interaction sessions remain for doing experiments.

3 BUSY VERSUS EMPTY MUSEUMS

In this section, we study how visitors' crowd has effect on users' follow position rank bias behavior, in which we answer our research question: *How different are users' behaviors in their solitude in an empty museum in comparison to their behaviors in a busy museum?*

In order to compare users' behavior in empty museum to their behavior in busy museums, we need to define an empty museum as well as a busy museum. We call a museum an empty museum for a given user A at time t_A , if while she has checked in at a POI at time t_A , nobody check-in at any POI from 30 seconds before the t_A to 30 seconds after the t_A (i.e., $t_A + /-30s$). Otherwise, we consider the museum for the given user A at time t_A , a busy museum. In

the setup of this experiment, an empty museum for a user means a museum is empty of other users interacting with POIs. Therefore, in an empty museum, all POIs are free to be used. However, in our definition of an empty museum, there might be some other users visiting the museum who do not use RFID cards and therefore, do not interact with POIs.

In order to study effects of visitor crowds in users' following position rank bias behavior, we have studied the percentage of follow position rank bias behavior over all the cases that users come to a decision to follow or unfollow the position rank bias based check-in behavior. Follow position rank bias behavior means visiting next POI, which is the closest POI in the closest path to the summary station. Otherwise, the user behavior is unfollowing the position rank bias behavior including skip or backward behaviors based on the position rank of POIs. The result of this experiment indicates that users who are in an empty museum generally tends to follow the position rank bias based check-in behavior relatively more than users interacting with a busy museum. Specifically, 15.9 % of users follow the position rank bias based check-in behavior in busy museums while 17.1 % of users follow the position rank bias based check-in behavior in empty museums.

4 CONCLUSIONS

The main focus of this paper is to study effects of visitors' crowd on users' onsite physical interaction behaviors. Specifically, we have observed a higher probability of following position rank bias based check-in behavior in empty museums in users' solitude in comparison to their behavior in busy museums. As a future work, we are going to investigate on capturing more external factors that potentially cause biases in collected onsite users information interaction logs, and use them to improve onsite behavioral user models.

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