

# Visualizing Museum Visitors' Behavior

Joel Lanir, Tsvi Kuflik, Nisan Yavin, Kate Leiderman, Michael Segal  
University of Haifa, Mt. Carmel, Haifa, 31905, Israel

ylanir@haifa.ac.il, tsvikak@haifa.ac.il, nisan.yavin@gmail.com, kateleiderman@gmail.com,  
msegal14@campus.haifa.ac.il

## ABSTRACT

Museum curators are interested in understanding what is happening in their museum: what exhibitions and exhibits do visitors attend to, what exhibits visitors spend most time at, what hours of the day are most busy at certain areas in the museum and more. We use automatic tracking of visitors' position and movements at the museum to log visitor information. Using this information, we provide an interface that visualizes both individual and small group movement patterns, as well as aggregated information of overall visitor engagement.

## CCS Concepts

• **Human Centered Computing** □ **Visualization** □  
**Visualization application domain** □ **Information Visualization**  
• **Human Centered Computing** □ **Ubiquitous and mobile computing systems and tools**

## Keywords

Museum behavior; Museum mobile guide; Visualization;

## 1. INTRODUCTION

It is very important for museum curators and museum personnel to understand and be able to analyze the activity and behavior of visitors in their museum. The behavior of visitors can provide curators with feedback on what is happening at the museum – which exhibits are successful, where do people go, and in general, how people interact with the content and exhibits that they have designed.

In order to understand visitors' behavior, museum researchers rely today either on self-reported questionnaires or on manual tracking of individual visitors using unobtrusive observation, measuring variables such as total time in an exhibit, number of stops, proportion of visitors who stop at a specific exhibit and more [5, 13]. However, with the advent of technology, systems exist that track and record visitors' movements and paths during their visit at the museum. This creates the opportunity to provide much more detailed and accurate information to the museum curators that relies on data of hundreds and thousands of visitors.

In this work, we present a prototype system that visualizes visitors' behavior at the museum. We use information of visitors' movements gained from an indoor positioning system situated in the museum. We first conducted several interviews with museum curators and personnel in order to understand the requirements of

such a system. Based on these interviews, we designed a system that visualizes museum visitors' behavior patterns. Initial feedback suggests that this can be a valuable tool that can provide much insight and understanding for museum personnel.

## 2. RELATED WORK

Many museum researchers analyse museum visitors' behaviour to help museum practitioners to improve their exhibits, provide better interpretations, and better understand the way the audience is experiencing the exhibits and content provided to them [2]. These works often use ethnographic observations to examine issues such as visitors' circulation [1], use of signage and labels [McManus], interaction with exhibits [13] and social interaction [10]. Using manual tracking and timing of visitors' behavior using unobtrusive observations, museum researchers have measured variables such as: the total time in an area, total number of stops, proportion of visitors who stop at a specific exhibit, visitors' path, time of non-exhibit-related behavior and level of engagement with the exhibit [5, 13]. Summarizing these variables while focusing on visitors' interaction with exhibits, two measures are often used in museum studies [2, 12]. Together these variables effectively capture how thoroughly visitors were engaged with an exhibit:

- **Attraction power** indicates the relative amount of people who have stopped in front of an exhibit during their visit. It is calculated by dividing the number of people who stop, by the total number of people who have visited the museum. This measure provides us with an initial idea of the power of attraction of the exhibit.
- **Holding power** measures the average time spent in front of an exhibit. It is calculated by summing up the time a visitor spent in front of a specific exhibit. This measure provides us with an initial idea of the power of an exhibit to hold the interest of a visitor.

Lately, automatic tracking and positioning technologies make it easier to gather large quantities of data on the way visitors behave and interact. Zancanaro et al. [14] used automatically generated logs of visitor positioning to categorize visitors' behavior. Lanir et al. [8] found differences between the behavior of visitors who

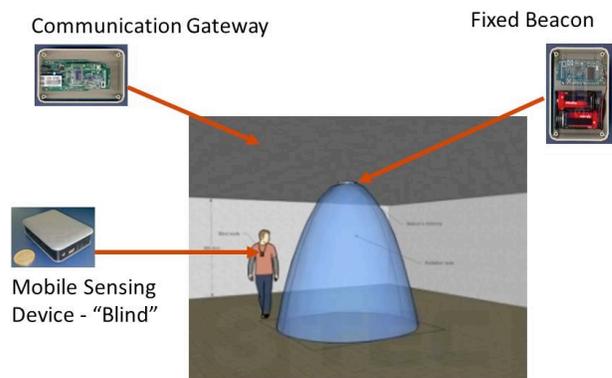


Figure 1. Positioning system equipment and usage scenario

used a mobile guide in their visit with those who did not. Kanda et al., [14] used spatial clustering to show visiting patterns and estimate visitor trajectories. While these studies examined specific aspects of the visit behavior, there is no research that we are aware of that used automatic tracking for an open-ended **visual** analysis of museum visitor behaviour. In our previous work, we designed static visualizations to enable analysis of visitor behaviour based on a novel glyph design [9]. However, feedback from curators revealed that they require a simpler, more interactive system. In this work, we take a different approach, designing a full interactive system built on top of a visitor database to enable a more generalizable system with easy access and understanding of visitor behaviour.

### 3. INFRASTRUCTURE

The PIL research project focuses on exploring the possibility to use novel technologies to enhance the museum visit experience [7]. In the framework of the project, the Hecht<sup>1</sup> museum, a small to medium sized museum containing both archeological and art exhibits located on the campus of the University of Haifa, was equipped with a radio frequency (RF)-based positioning system based on a wireless sensor network (WSN) (see [6] for details). Figure 1 shows the details of the positioning system. Beacons were statically located at entrances and exits, as well as near



Figure 2. Individual visitor's path through the museum

relevant locations of interest in the museum, while visitors carry small matchbox-size sensors called Blinds. When a Blind is in proximity of a Beacon (determining location) that Blind reports this information to the server, determining that the visitor was in proximity to that known location. While providing a reasonable indoor positioning solution, the system's major weakness is that it only knows when a person is in proximity to a Beacon, not being able to detect positioning in transition from one Beacon to another. Thus, the system provides sporadic rather than continuous movement data. A research prototype of a location-aware mobile museum guide was developed and then converted into a working museum visitors' guide. The guide was handed off to regular museum visitors visiting the museum over a period of 10 months. Log data was gathered for analysis. A total of 423



Figure 3. Temporal view of small group visiting times in each exhibition.

visitors (194 females) using the mobile guide during their visit. Average age of visitors was 43.2 years (SD = 18.4). We cleaned and imported these logs into a database, for the use of the system. The system was built as a web client able to access the database from anywhere. D3 was used to produce the visualizations.

### 4. SYSTEM DESCRIPTION

The system is divided into three main modules. Individual visitor analysis, group analysis and general information.

The individual visitor view allows seeing an individual user's path during his or her visit at the museum. The path is shown on top of the museum map. The view enables "playing" the path of the visitor, which uses a footstep icon that moves on the map and emulates the visitor's path. The user can fast forward the view to the end where the entire path is seen (Figure 2). In addition, a list of exhibits, times spent at each exhibit, time between exhibits, and a list of presentations seen by that visitor on the mobile museum guide is available.

The group analysis view enables seeing the behaviour of a small group of visitors arriving together. Many visitors arrive in small groups of family and friends, and it is important for curators to be able to also understand group behaviour. The first view plots the path of each member of the group on the map, similar to Figure 2, with each member of the group having a different color. However, this does not show the temporal aspect of the visit and even though two lines are overlapping, this does not mean that visitors were at the same exhibit at the same time. To understand the temporal aspect of the group visit, we provide a timeline view of a small group visit (Figure 3). This view is also available for a single visitor's visit. The view charts the time (starting from the start time of the visit) on the x-axis, and each exhibition room on the y-axis. Each visitor is depicted by a color, and time spent at each exhibit within each exhibition room is shown. For example, it is easy to see that visitors started visiting the museum together and spent time at the same exhibition. At about minute 12:52, they parted with the "red" visitor following the "blue" visitor. At the end of the visit, the visitors joined back in the first exhibition room.

The aggregated view shows overall visitor information per exhibit (Figure 4). It shows the information in a spatial view on top of the



Figure 5. Aggregate view showing heatmap of attraction power at the museum.

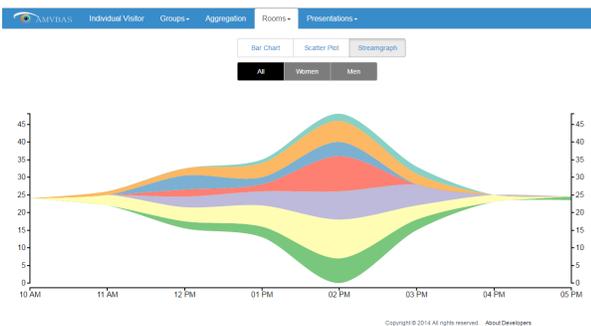


**Figure 4. Aggregated view. Blue circles show number of visits at a location (attraction power), gray opaque circles show amount of time in each location (holding power). In addition, several filters are available.**

museum map. The blue circles show the percentage of visitors visiting that location from all visitors at the museum (attracting power). The grey opaque circle, shows the average time spent at that location (holding power). In addition, it is possible to filter the data according to age range, sex or language used in the mobile guide (the mobile guide supports 3 different languages – Hebrew, Arabic and English). The image can show various patterns of different behaviors at different exhibits. For example, the location annotated with “1” is the entrance to the museum. Because explanations and initial use of the mobile guide was performed there, the both attraction power (every visitor starts there) and holding power there are high. Locations 2 and 3 are at the corridor in which visitors go through to enter the museum. This explains both the high attraction and holding power. Location 4 is the main decision point of the museum where visitors decide whether to go to the left exhibit, straight ahead, or up the stairs (to the right). That explains the high attraction power and relative

moderate holding power. Exhibits 5 and 6, show two points in the main attraction of the museum – a 2400-year old ship extracted from the sea. Thus the high holding power of point 6, is not surprising. Finally, location 7 shows the second floor. It can be seen that very few visitors visit the second floor – a point for concern for the museum staff. Figure 5 shows the same view, using a heatmap on the attraction power. In addition to the map view, the system shows the exact numbers for the average time spent and the percentage of visitors attending (holding and attracting power) of each exhibit using a simple bar chart (graph not shown here).

Finally, for providing overall information, the system shows the distribution of visitors at the museum according to visitor hours using a stream graph [3]. Figure 6 shows for the distribution of visitors per hour of day at the museum. Each line color shows the average number of visitors at a different exhibition room. Hovering over the line provides the name of the room and the number of visitors at that hour. The overall width of the graph shows the overall number of visitors at that time at the museum. At the Hecht museum, opening hours are 10:00 to 16:00 (with Tuesdays open till 18:00). Looking at the graph, we can see that by far, 14:00 is the busiest time at the museum, with most visitors visiting between 13:00 and 15:00.



**Figure 6. Distribution of visitors per hour at the different exhibition rooms**

## 5. CONCLUSIONS

We presented a system that visualizes various visitors’ behaviors at the museum. A curator can use the system to investigate what happens at the museum by looking at the paths of individual visitors, small groups of visitors, or general aggregated information. We intend to evaluate the system by presenting it to museum curators and museum personnel and conducting semi-structured interviews. By receiving qualitative feedback, we hope to gain insight regarding the useful features and the general

usability and usefulness of the system. After receiving feedback, we plan to deploy the system at the Hecht museum for the actual use of the staff.

## 6. REFERENCES

- [1] Bitgood, S., 2006. An analysis of visitor circulation: Movement patterns and the general value principle. *Curator: The Museum Journal*, 49(4), pp.463-475.
- [2] Bollo, A. and Dal Pozzolo, L., 2005, July. Analysis of visitor behaviour inside the museum: An empirical study. *In Proceedings of the 8th International Conference on Arts and Cultural Management*, Montreal (Vol. 2).
- [3] Havre, S., Hetzler, E., Whitney, P. and Nowell, L., 2002. Themeriver: Visualizing thematic changes in large document collections. *Visualization and Computer Graphics, IEEE Transactions on*, 8(1), pp.9-20.
- [4] Kanda, T., Shiomi, M., Perrin, L., Nomura, T., Ishiguro, H. and Hagita, N., 2007, April. Analysis of people trajectories with ubiquitous sensors in a science museum. *In Robotics and Automation, 2007 IEEE International Conference on* (pp. 4846-4853). IEEE.
- [5] Klein, H.J., 1993. Tracking visitor circulation in museum settings. *Environment and Behavior*, 25(6), pp.782-800.
- [6] Kuflik, T., Lanir, J., Dim, E., Wecker, A., Corra, M., Zancanaro, M. and Stock, O., 2011. Indoor positioning: challenges and solutions for indoor cultural heritage sites. *In Proceedings of the 16th international conference on Intelligent user interfaces* (pp. 375-378). ACM.
- [7] Kuflik, T., Wecker, A.J., Lanir, J. and Stock, O., 2015. An integrative framework for extending the boundaries of the museum visit experience: linking the pre, during and post visit phases. *Information Technology & Tourism*, 15(1), pp.17-47.
- [8] Lanir, J., Kuflik, T., Dim, E., Wecker, A.J. and Stock, O., 2013. The influence of a location-aware mobile guide on museum visitors' behavior. *Interacting with Computers*, p.iwt002.
- [9] Lanir, J., Bak, P. and Kuflik, T., 2014. Visualizing Proximity-Based Spatiotemporal Behavior of Museum Visitors using Tangram Diagrams. *Computer Graphics Forum*. 33(3), pp. 261-270.
- [10] Leinhardt, G. and Knutson, K., 2004. *Listening in on museum conversations*. Rowman Altamira.
- [11] McManus, P.M., 1989. Oh, yes, they do: How museum visitors read labels and interact with exhibit texts. *Curator: The Museum Journal*, 32(3), pp.174-189.
- [12] Serrell, B., 1997. Paying attention: The duration and allocation of visitors' time in museum exhibitions. *Curator: The museum journal*, 40(2), pp.108-125.
- [13] Yalowitz, S.S. and Bronnenkant, K., 2009. Timing and tracking: Unlocking visitor behavior. *Visitor Studies*, 12(1), pp.47-64.
- [14] Zancanaro, M., Kuflik, T., Boger, Z., Goren-Bar, D. and Goldwasser, D., 2007. Analyzing museum visitors' behavior patterns. *In User Modeling 2007* (pp. 238-246). Springer Berlin Heidelberg.