Museum Layout Evaluation based on Visitor Statistical history

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ABSTRACT— ***Museum layouts form a crucial component of the museum experience. However, it is not an easy task to evaluate and validate the performance of particular layouts. Currently, methods are used to track organic visitor paths in relation to layout design. With new technology, visitor tracking data can be collected through mobile applications or various sensors. While most researchers are interested in the density of visitor traffic gathered at each point of interest, our proposed methods focus on identifying the most visited path in the museum. Through the analysis of data collected from visitors, we can recreate the most visited path from probability calculations of any given visitor traveling from one point of interest to another. This method has been applied at the Chao Sam Praya National Museum and our results reveal 4 broken paths in the path of heaviest traffic. In addition, we found that not all points of interest included on this path. These findings indicate that the museum curator may need to further investigate or redesign the display layouts to highlight any overlooked points of interest. One limitation of the proposed method is its reliance on statistical data collected from visitors. This means that viable results are predicated on large and clean datasets for processing.***

Keywords— visitor behavior analysis, museum layout evaluation, museum mobile application

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1. INTRODUCTION

Museum layouts form the heart of the museum experience according to [1]. However, depending on whether the institution's purpose is related to art, history, or science, each museum has its own unique characteristic needs, which are reflected in the arrangement of displays and the museum's interaction with visitors. The field of museology has developed various theories related to museum layout design [2]. However, it can be very subjective to evaluate one layout as better than the other due to the difference in nature and intentions of each museum. As such, our project applies information technology to create a statistical model that is capable of representing the relevant qualitative information as qualitative information. For example, if we can track the path of travel for each visitor and aggregate the collected data, we can then interpret whether museum goers are viewing and experiencing the museum according to original designs.

One way to analyze visitor behavior is to track their route while they are exploring the museum space. Although tracking museum goers is not an easy task, there are many researchers working within this topic. [3] utilized Radio Frequency Identification (RFID) wristbands in an attempt to track visitor movement, but due to the simplicity of the pilot project setup, which utilized 5 points of interest (POI), the study yielded insufficient data for effective behavioral analyses. [4] proposed a model called Path And Residing Time displaY (PARTY) to generate visitor circulation patterns from a dataset of 36 synthesized visitors, represented as 2-Dimensional layout independency visualizations. Although this model presents the density of the visitors at each POI, the sequential relationships between 2 points were left out from the analysis. Additionally, [5] proposed three different interactive visualization methods to reveal participant movement patterns, allowing analysis to deduce behavior from participants' movements, and show transitions between sessions and topics. These diagrams present the movement of each individual participant and the total movements between points were left out. Meanwhile, [6] studies visitor trajectories via ubiquitous sensors in science museums in terms of space, visitor patterns and relationships between patterns. Their analysis identifies crowded and uncrowded areas, with typical visitor patterns showing particular focus on highlighted displays such as robots.

While most researchers focus on the density of visitor traffic around around each POI, our method maps the transition of visitors between any two POIs to generate a visitor route. Our model predicts the most traveled path by calculating the probability of a visitor moving from one POI to another from the collected data in [7]. The curator at Chao Sam Praya National Museum tasked our team with evaluating the impact of an exhibition rearrangement against current visitors' navigation patterns. Our model generates the most popular visitor path as it is calculated from the highest probability of a visitor transitioning between two POI's. Evaluation results reveal that the route in Chao Sam Praya National Museum is fragmented into many disparate routes. This indicates that there may be a lack of clear direction in the exhibition hall which requires curator attention for further action.

The rest of this paper is organized as follows: the system architecture of the proposed method is described in Section 2, the result and discussion of the museum path is located in Section 3, and the conclusion is stated in Section 4.

2. METHODOLOGY

[3] proposed the idea of developing a mobile application that would serve as a retrieval mechanism for all museum guides. When the visitor enters a participating museum, his/her mobile connects to the museum Wi-Fi network, which allows the designated mobile application to access a local database to acquire and display relevant information such as floor plans and media items. Fig. 1 illustrates the process. QR codes are used as the primary vehicle for information access. As the visitors navigate the museum space, the server records user IDs (from the mobile application) and logs the requests for information associated with each display items for further analyses. Although this method is based on a BYOD (Bring Your Own Device) concept [7], the participating museums are required to provide basic infrastructural elements such as a viable Wi-Fi network.

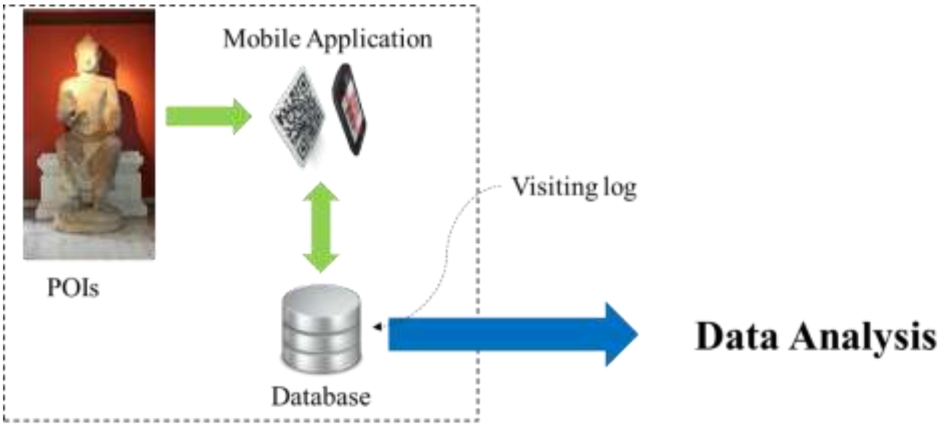
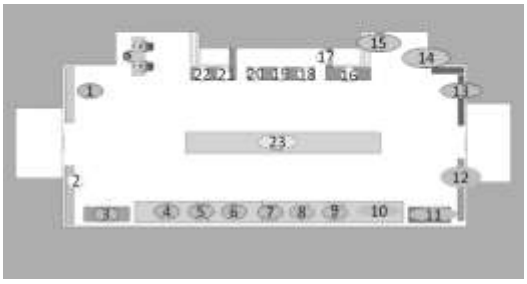
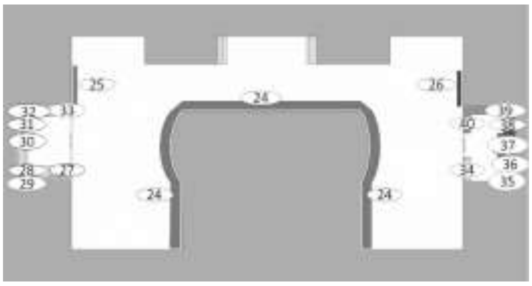


Figure. 1. Diagram of mobile application connection when visitors are located within a participating museum

Currently there are 3 museums involved in this application, namely Chao Sam Praya National Museum, the National Science Museum, and the Information Technology Museum. Chao Sam Praya National Museum is a two-story building located in Ayutthaya Province, and was founded 50 years ago. It is the first museum in Thailand that provides an open space experience whereby there is no specific direction guidance for the visitors as to which direction they should be walking. The floor plan is shown in Fig. 2. Museum administrators selected 40 objects or POIs to include in the mobile application; the contents of these POIs include photos, diagrams, descriptions, audio files and video. We collected data generated by the application users from January 4, 2015 to Dec 30, 2015, to reach a total of 2,000 persons. With this mobile application, we were able to track the number of visits per POI as well as the order in which each POI was visited.



(a) First Floor



(b) Second Floor

(C) First Floor

(d) Second Floor

Figure 2. floor plans and inside Chao Sam Praya National Museum

As the Chao Sam Praya National Museum presents an open space format, visitors may choose to move between any two POIs within the hall. Let X be the first POI, therefore there are n POI's [Y_1, Y_2, ..., Y_n] around X as shown in Fig. 3. $P_X \rightarrow Y_i$ is the probability of traveling from X to Y_i, calculated from the number of visitors who traveled from X to Y_i divided by the total number of visitors who stopped at X and traveled to all POI's as shown in Equ. 1.

$$P_{X\rightarrow Y_i} = \frac{M_i}{\sum_{j=1}^{n} M_j} \qquad (1)$$

Where $P_{X\rightarrow Y_i}$ is the probability of traveling from X to Y_i and M_i is the number of visitor who traveled from X to Y_i.

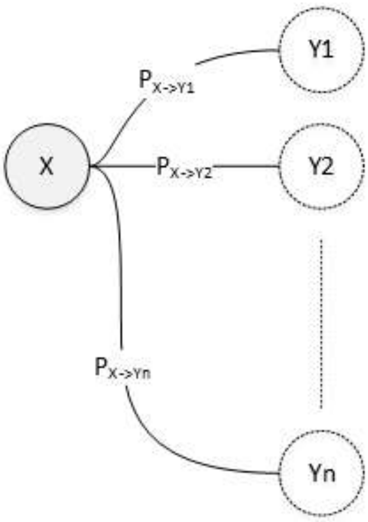


Figure 2. The probability of traveling from X to all possible Y's

From the diagram created by Equ. 1, we can create an approximation of the most popular museum path taken by visitors by choosing the progression of POIs with the most visits or highest probability of travel. Let $X_i \mid i \in N_0$ where X

is the POI and i is the position number as shown in the diagram (for example X_3 represents POI 3 and X_5 represents POI 5). Let $P_{X_a \to X_b} \mid a, b \in i$ be the probability that a given visitor travels from X_a to X_b. Let $R = \{r(m,n) | m, n \in N_0\}$ be the visiting route, which consist of a set of reference POI, $r(m,n)$, where m is number of sub-paths and n is order of visiting POI's. In other words, $R = \{r(0,0), r(0,1), r(0,2), r(1,3), r(1,4), r(2,5)\}$ represents the visiting route consisting of three sub-paths ($m_{max} + 1 = 3$) and consist of 6 POI's ($n_{max} + 1 = 6$) where sub-path 0 is $r(0,0) \to r(0,1) \to r(0,2)$, sub-path 1 is $r(1,3) \to r(1,4)$ and sub-path 3 is $r(2,5)$, as shown in Fig. 4.

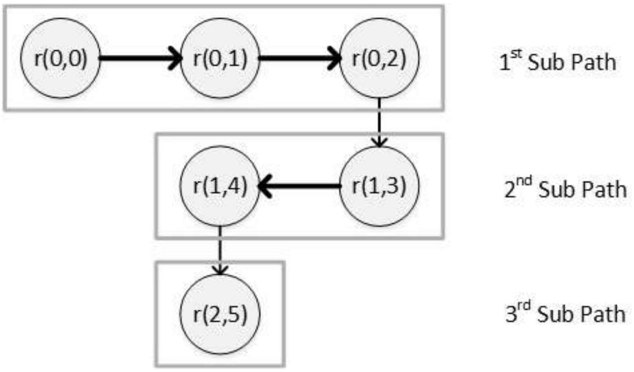


Figure 4. Generating the museum path

The visitor path is then developed based on the process illustrated in the following flow chart. The proposed model creates generates the most popular traffic route and represents it in terms of X and R. Let $k, m, n \in N_0$ be 0 for the initial state.

In order to create any path R, we proposed a method that maps between a POI X_i and a reference point $r(m,n)$ is needed where m in each X_i case is chosen by the following rule:

- Let R_{mode} be the most popular path calculated from the highest probability.
- The current reference visitor position is $r(m,n)$ at POI X_a .
- The next reference visitor position is $r(m, n+1)$ mapped to POI X_k which is $MAX(P_{X_a \to X_k})$ including X_k that was not passed in the path R_{mode} taken thus far.
- In case of no available X_k the next reference visitor position $r(m+1, n+1)$ is considered.
- The next reference visitor position $r(m+1, n+1)$ maps to X_{l1} where $l1 \notin \{k\}$ and $MAX(P_{X_a \to X_{l1}})$ including X_{l1} that was not passed in the path R_{mode} taken thus far.

In case of no available X_{l1} the next reference visitor position $r(m+2, n+1)$ is considered and mapping with X_{l2} where $l2 \notin \{k, l1\}$ and $MAX(P_{X_a \to X_{l2}})$ including X_{l2} that was not in previous R_{mode}.

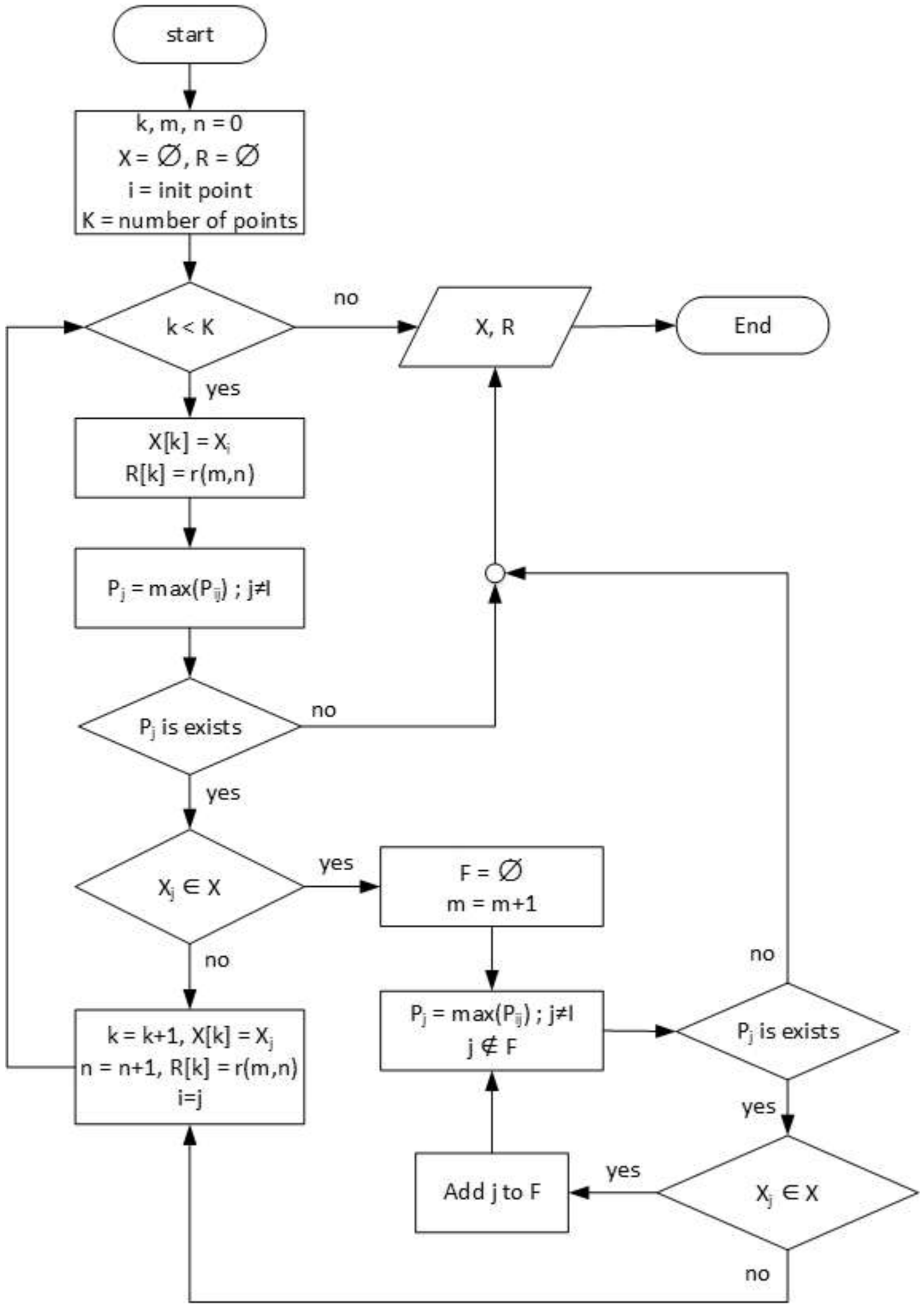


Figure 5. Flow chart of creating visitor path

3. RESULTS AND DISCUSSION

From Eq. 1, we can create a diagram connecting each POI with the the probability of moving to other POIs as shown in Fig. 6. Each POI is represented by a number; the connected line represents the probability of moving to the next POI. Only the 3 highest probabilities are included in this diagram. The solid line represents the highest probability path, the dashed line represents the second highest probability path, and the dotted line represents the third highest probability path.

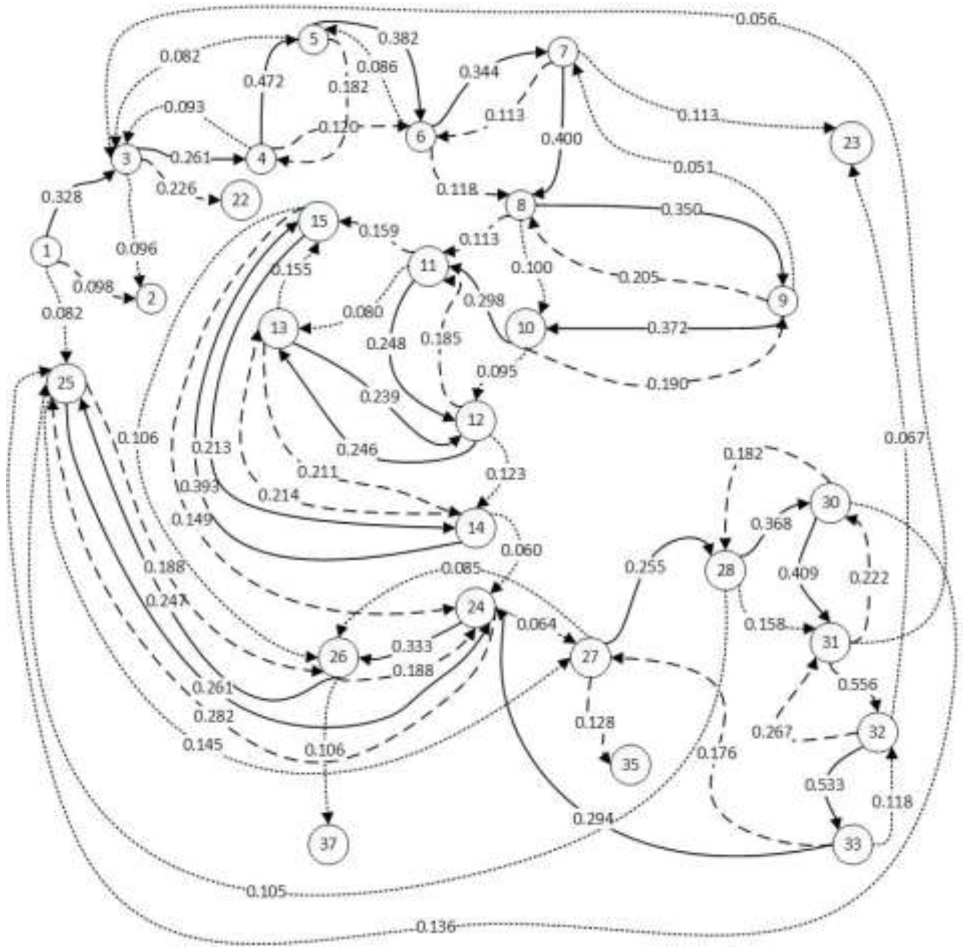


Figure 6. Diagram of probability representing the likelihood of each path from a given POI, showing the 3 highest probability paths

With the proposed rule we generate a visitor path as shown in Fig. 7.

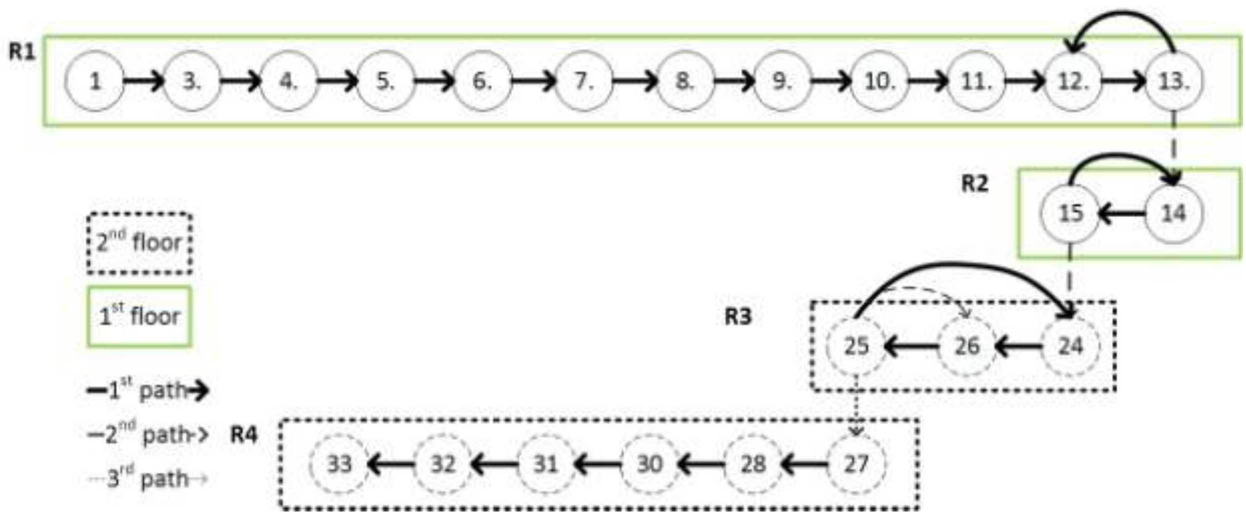


Figure 3. Most popular visitor paths from the proposed method

Fig. 7 illustrates a visitor path consisting of 4 sub-paths, R_1- R_4. There are 3 types of connecting lines between each POI according to their probability. Thicker lines represent a higher probability of travel. The displayed visitor path was created from the route of highest probability. Whenever the highest probability is not possible, the second highest probability is chosen to create a second sub path. As seen in Fig. 7, the most popular destination from POI 13 is POI 12, which is already incorporated in the sequence thus far; therefore, the second highest probability is chosen which is POI 14. It can be seen that the first sub-path ends at POI 13 and the second sub-path starts at POI 14.

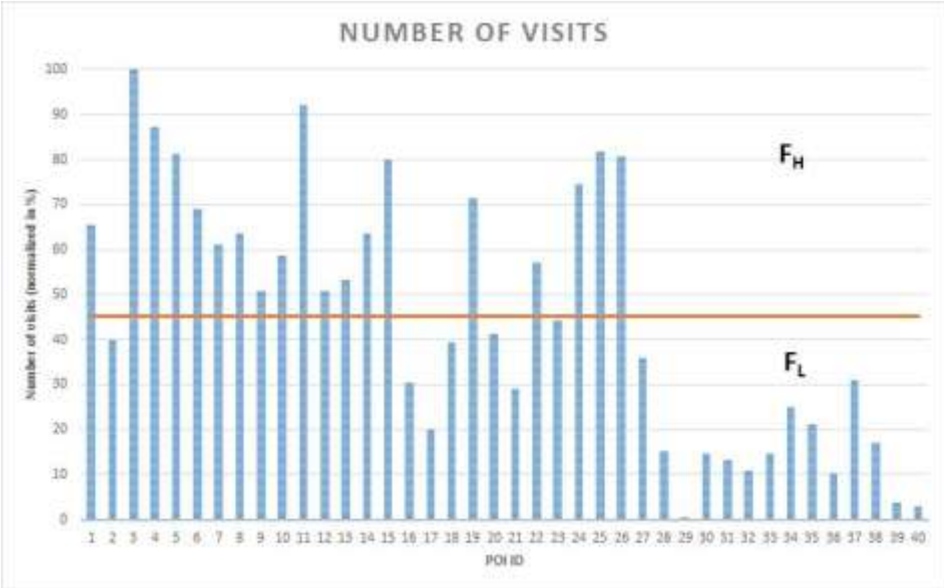
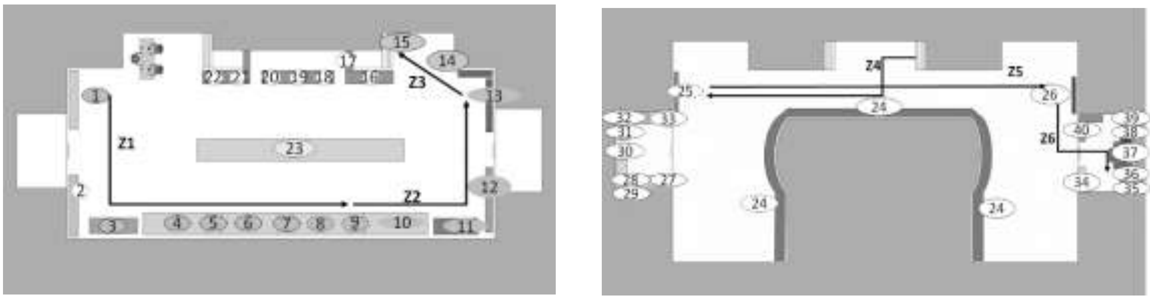


Figure 8 number of visitors at each POI



(a) First Floor

(b) Second Floor

Figure 9. The most visited path on the museum floor plan

Although every POI has received visitors as shown in Fig. 8, not every POI appears in our model of the most popular path taken to navigate the museum space. This is mainly due to the fact that the number of visits accrued by those POI do not generate enough impact to appear on the most visited path. Fig. 8 illustrates our model of the visitor path in the context of the museum layout. In Fig 8.a, it can be seen that the main path ends at POI 13 and continues on 14 and 15 before leading to the second floor. POIs 16-23 gained relatively fewer visits than the other displays, and are therefore not present in our model path. From Fig 6 b, we observed that visitors rarely take interest in the POI's located in the annexes located on the both ends of the second floor. We believe this may be due to the museum policy prohibiting photos in these areas. The result of our evaluation shows a broken path, which indicates that there may be room for improvement in the exhibition design. As such, our recommendation to the museum curator involves further investigation.

The results of proposed method are consistent with the museum original design which is open space. However, the current curator' would to create a more confined path. Therefore, the Chao Sam Praya National Museum should focus efforts on the first floor, with regards to the placement and presentation of POIs 16-23, perhaps generating a more confined path that helps guide visitors through the designated flow. Based on our consultation with the curator, we suggest larger signage be installed on the second floor in order to increase traffic into the annex displays.

We note here that one limitation of the proposed method is its reliance on statistical data collected from visitors. Therefore, we require large and clean datasets for processing.

4. CONCLUSION

The layout of a museum often forms the heart of the museum experience; however, each museum has its own unique characteristic flow and purpose. However, it can be very subjective matter to determine one layout as better than the other. To mitigate the subjectivity, we apply statistical concepts to collect data from visitors and generate a model that is capable of validating the layout design by determining the most visited museum paths within the current format. Our proposed model generates a museum path from the highest probability of movement, and thus determines the most popular route of navigation within the museum space. When this generated path is broken, it reflects a lack of flow or clarity in the exhibition layout design. In these cases, the museum operator is recommended to conduct further analyses for improvement. This method was applied to evaluate, and provide recommendations, for Chao Sam Praya National Museum. Our results show that there are 4 broken paths within the model. In addition, a portion of POIs are omitted from the most visited path. This may also indicate that further communication is needed to encourage visitors to include less popular displays in their experience.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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