Museum Content Evaluation based on Visitor Behavior

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***Abstract*— Visitor behavior analysis has always been a topic of interest for museum operators; however, common key issues arising such endeavors are the management and evaluation of collected data. In this paper we propose a models for analysis visitor behavior in terms of appropriate content presentation. This model will be used as a guide for exhibition arrangement and the determination of content provided at each point of interest. The proposed model analyze the audio content duration versus the visitor spending time at each point of interest. We provide the criteria to evaluate the suitable audio content duration for each point of interest. These methods were used to evaluate and generate recommendations for the Chao Sam Praya National Museum, located in the heart of Ayutthaya province. Evaluation results reveal and need for improvement in content length. In terms of audio content duration, only 9 out of 40 points of interest consist of suitable audio content duration, the others are either too short or too long and require adjustment.**

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

I. INTRODUCTION

Visitor behavior analysis has always been a topic of interest for museum operators. However, tracking visitor behavior in museum is not an easy task. [1] used 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. With the advent of smartphones, the tracking of museum visitors through mobile application is possible [2]. Target audience behavior can be tracked by the number of hits at each POI, represented by a QR code, which the applications then use to acquire information from servers.

[3] proposed a model called Path And Residing Time displaY (PARTY) to generate visitor circulation patterns from collected data, 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, [4] proposed three different interactive visualization methods to reveal participant movement patterns, to deduce behavior from participants' movements, and to 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 [5] analyses museum visitor trajectories via ubiquitous sensors in Science Museum 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.

In this paper we analyze audio content length and time spent at each POI. By using box chart, we will be able to determine the appropriate audio content length for each POI. This dimension can be used to determine the optimal audio content length at each display. Evaluation results reveal that Chao Sam Praya National Museum required some improvement on the audio content design.

The rest of this paper is organized as follows. The system architecture of the proposed system are stated in Section 2. The evaluation and discussion of audio content duration are explained in Section 3. The conclusion is stated in Section 4.

II. SYSTEM ARCHITECTURE AND IMPLEMENTATION

While most of museum applications focus primarily on providing mobile interface, our system [2] generates a web-based function which enables museum curators to participate in application development, as well as to manage museum items. When the visitor is located within museum boundaries by their mobile connects to museum Wi-Fi, the mobile application connects to the local database to acquire further details such as floor plans and media items that elaborate on specific displays as shown in Fig. 1. QR codes are used as the primary tool for visitors to access information from local databases and displays. Although this system is based on a BYOD (Bring Your Own Device) concept [6], the participating museums are required to provide basic infrastructural elements such as Wi-Fi.

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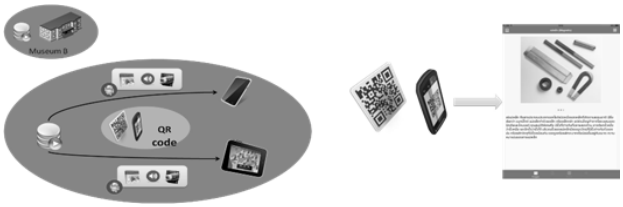
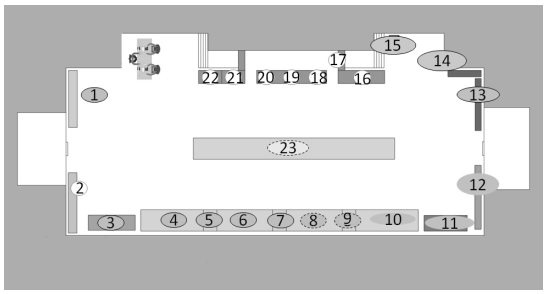


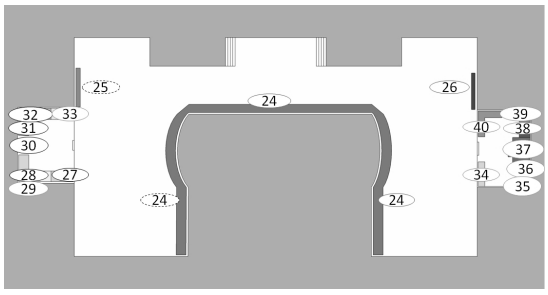
Fig. 1. Diagram of mobile application connection when visitors are located within a participating museum

Currently, there are three museums and two temporary exhibition involved in this project: the Science Museum, Information Technology Museum, Chao Sam Praya National Museum, and exhibition in NECTEC-ACE 2014 and NECTEC-ACE 2015. In this paper, we evaluate the visitor behavior at Chao Sam Praya National Museum, using various statistics related to each display item to analyze the current exhibitions arrangement.

Chao Sam Praya National Museum is a two-storey Building located in Ayutthaya Province. The floor plan is shown in Fig. 2. Museum administrators selected 40 POI's to incorporate in the mobile application; the contents of these POI's include photos, diagram, descriptions, audio files and video. We asked participants to install mobile application in question during their visit. We then collected information generated by the application users from January 4, 2015 to June 30, 2015, to reach a total of 162 persons created more than 1500 records. With the "museums pool" mobile application [2] we were able to track number of visits per POI as well as the order in which each POI was visited.



(a) First Floor



(b) Second Floor

Fig. 2. Floor plan of Chao Sam Praya National Museum

III. EVALUATION

A. Visiting Duration Analysis

With the Museum Pool mobile application, the system is capable of estimating the time spent by each visitor at each POI. This information is very useful in terms of analyzing the appropriate audio content length for each display, based on assumption that every visitor listens to the audio content while spending time at POI. The estimated time spent at each POI is calculated from the time stamp difference between one POI and the next POI in the path. [7] have studied the age-related changes in speed of walking. The results shows that there was a 1 to 2% per decade decline in normal walking speed. From the database, the tested museum has visitor's age range from 10 to 60 years old. It can be say that the difference pace between children and elder about 10%. With the limited space in this museum, we assume that there is no significant different of visitor pace from different age.

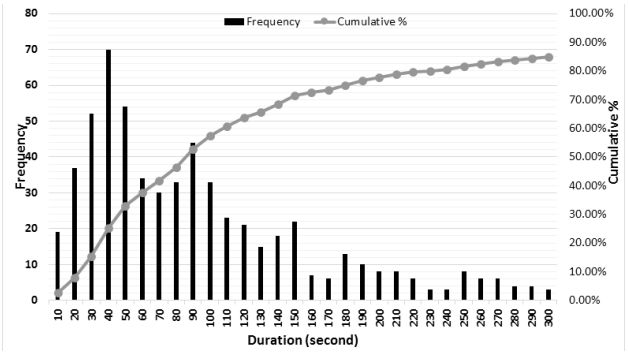


Fig. 3. The average time spent at each POI

Fig. 3 illustrates the average time spend at each POI, the x-axis represents time in second and y-axis represents the frequency of visit. From the graph, it can be seen that window of time spent at each POI of most visitors is around 40 to 100 seconds. However, this estimation did not take some events into account, such as the possibility that a visitor left the museum while the application still running, causing the time estimation exceed 600 seconds, which is not possible. Therefore, a threshold is used to cut out some outlier data.

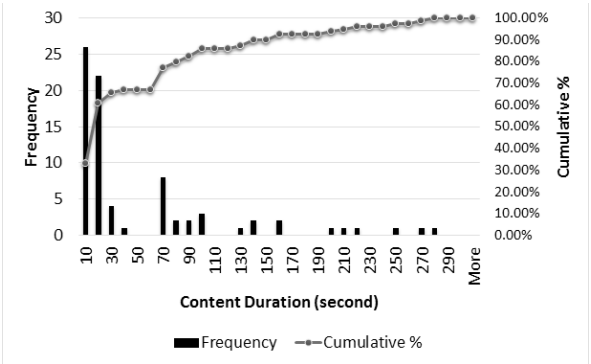


Fig. 4. The distribution of content perusal in the Chao Sam Praya National Museum

Our study shows that for the 40 POI's in this museum, the percentage of audio content lasting in 15 seconds is 31.25%, the percentage of audio content lasting in 16-25 seconds is 26.25%, and the remaining percentage (exceeding 26 seconds) is 42.5%, as shown in Fig. 4.

Visitor's time allocation at each POI can be interpreted from Box chart, where x-axis represents the POI and y-axis represent duration time in seconds. The median visiting time is represented with a circular dot and the duration of the audio content represented with a diamond dot. Interquartile Range is set at 25th percentile (lower quartile) and 75th percentile (upper quartile).

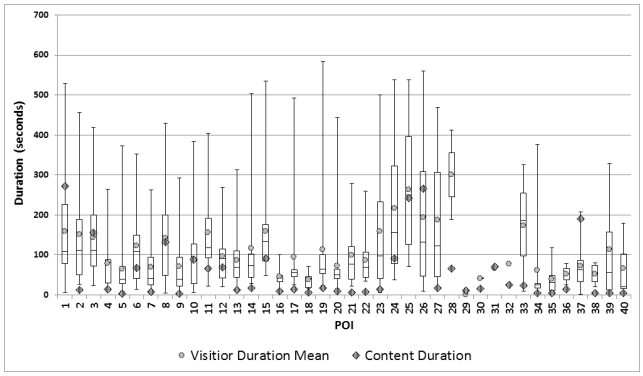


Fig. 5. Box chart of visitor spending time at each POI in comparison to content perusal duration at each POI

To evaluate appropriate content at each POI, we look at the relationship between the visitors' time spent and the content duration. By comparing the content duration (diamond dot) with the distribution of time, we determined the following criteria:

- When the content duration falls within the interquartile range, it is considered appropriate.
- When the content duration falls outside of the upper quartile range, the POI is considered to have an overly lengthy audio content duration.
- When the content duration falls outside of the lower quartile range, the POI is considered to have overly brief audio content duration.

From the above criteria, out of the 40 POI's observed, 25 POI's had overly brief content duration, 9 POI's had an appropriate content duration and 2 POI's had overly long content duration. The other 4 POI's lacked information to make any conclusions.

Two of the observed points with long content durations are POI 1 and 23. Content duration at POI 1 is 271.8 seconds (98th percentile) while the median is at 108 seconds. Therefore, this POI is required to reduce the content duration to at least 227 seconds, which lies within the interquartile range. The content duration at POI 23 is 190 seconds (92nd percentile) while the median is at 64 seconds. Therefore this POI is also required to reduce the duration into interquartile range, which is 86 seconds.

Meanwhile, content duration at POI 10 is 66.6 seconds while the median is at 118 seconds. This might reflect that visitors' interest in this POI is disproportionate to the amount of information offered, resulting in more time spent beyond the content duration.

The content duration of the remaining 9 POI's is considered to be appropriate since the content duration lies comfortably in the interquartile. The other 4 POI's lacked information to make any conclusions.

B. Characteristic of Point of Interest

We apply skewness testing to evaluate the distribution of the visiting time. There are 3 types of skewness as shown in Fig. 12.

a) Negatively-skewed or Left-skewed Distribution is the distribution that indicates the mean value is less than median and mode, and the skewness value is negative.

b) Symmetrical or Non-skewed Distribution is the distribution that indicates the mean value is equal to median and mode, and the skewness value is 0.

c) Positively-skewed or Right-skewed Distribution is the distribution that indicates the mean value is greater than median and mode, and the skewness value is positive.

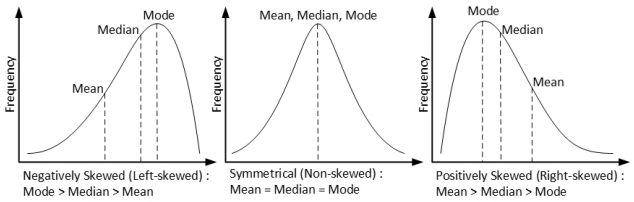


Fig. 6. Types of skewness

According to [8] The Skewness can be calculated form

$$Skewness = \frac{3(mean - median)}{\sigma} \quad (1)$$

A skewness value between [-1, 1] is considered to be Symmetrical or Non-skewed Distribution. We evaluate the visiting time with skewness test and the results shown in Fig. 7.

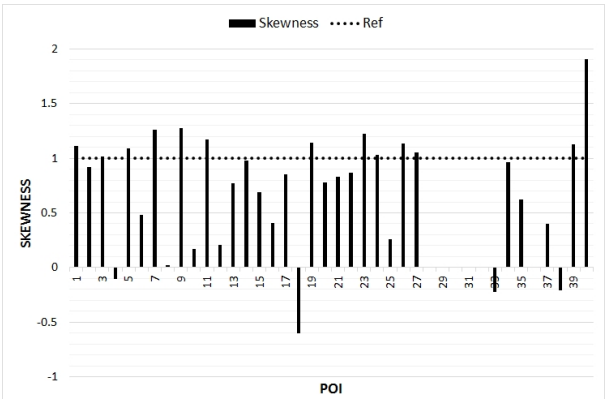


Fig. 7. The skewness of visiting time at each POI

From Fig. 7, it can be seen that, out of the 40 POI's, only 12 POI's consider to have a positive skewness. This can be explained by the possibility that although most visitors stop at these points very briefly, a few visitors spend a significant amount of time at these POI's. We can only postulate that these visitors are very interested in particular display. It can be said that with some adaptation on content, these points may attract a longer perusal duration, or the display themselves can be modified to become more highlight points.

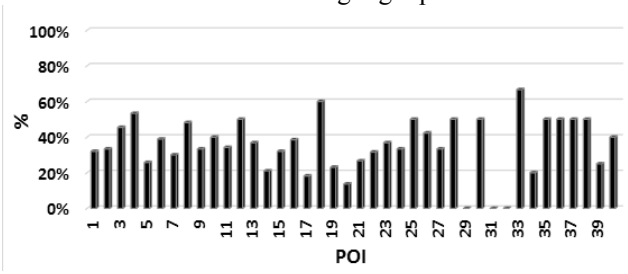
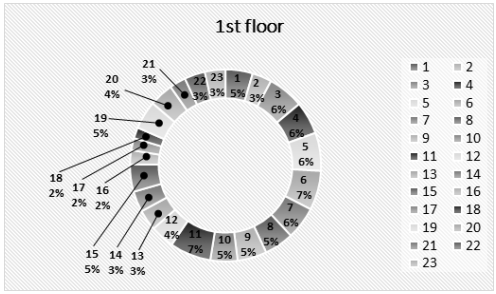
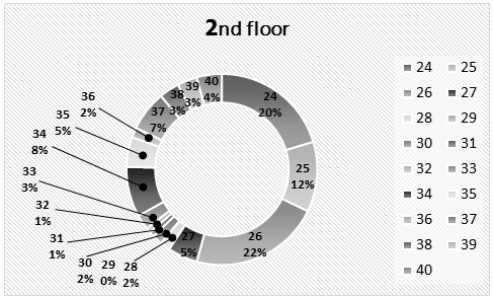


Fig. 8. The percentage of visitor that the time spent more than the average time spent at each POI

On the skewness test, we investigate further into the time spent at each POI. Fig. 8 shows the percentage of visitors spending an above average period of time at each POI. Only a few POI's are above the 50% of the average line, confirming our suspicions that most visitors do not stop for the extended period, with a few exceptions. This infers that the display qualities are weak, and it is the area that museum curators may need to improve.



(a) First Floor



(b) Second Floor

Fig. 9. The density stopped visitor at each POI

The density of visitors stopping at each POI can be seen in Fig. 9. It can be seen that visitors stopped at most POI's and total time spent on the first floor is evenly distributed, with some POI's demonstrating a stronger attraction value. Museum operators may need to investigate further to boost density on weaker displays.

IV. CONCLUSION

We proposed a model to analyze the collected data to be used to determine the proper museum paths and to adjust for the appropriate content duration. The proposed model evaluates the audio content length by comparing to the visitors' time spent at each POI. Our results reveal that, only 9 out of 40 points of interest consist of suitable audio content duration, the others are either too short or too long and require adjustment. We also use skewness test to evaluate behavior of visitor at each POI. 28 POI's out of 40 POI's consider to have a normal skewness, only 12 POI's have a positive skewness. This can be explained by the possibility that although most visitors stop at these points very briefly, a few visitors spend a significant amount of time at these POI's. In term of density of time that visitor spent in each POI, we found that the total time spent on the first floor is evenly distributed, while visitor spent more time on some POI on the second floor. These POIs can be promote to be a highlight POI. The proposed models may be used as a guide for museum operators in arranging exhibitions and providing content at each POI for Chao Sam Praya National Museum. From the results above, the necessity of improvement in content duration at the tested location.

ACKNOWLEDGMENT

I would like to express our gratitude to Chao Sam Praya National Museum for providing the testing location.

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