Analytics in Action: Optimizing Visitor Flow through Simulation Modelling

Using Visitor Data and Analytics to Optimize the Design and Operations of Large and Complex Venues

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Introduction

This paper discusses the use of predictive analytics to model visitor flow in large and complex venues, such as UNESCO World Heritage Sites (WHS) and museums, where visitors may use different routes to explore different exhibits and objects based on their preferences.

At times, the high number of visitors raises concern from the authorities responsible for these sites' up-keeping about the condition of the displayed art and the spaces themselves. This apprehension is well-founded. Tourists increase the amount of humidity, carbon dioxide, dust and lint at these cultural sites, which in turn effects the conservation of these spaces. Perhaps even more harmful is physical damage inflicted, usually in and around visitor entrance/exit points of the sites. WHS are great examples of the necessity of implementing visitor flow optimization at cultural sites, because they often attempt to fit millions of visitors into small, "must-see" venues. To complicate matters, governments and travel industries often wish to increase visitor numbers at these sites in order to facilitate economic growth in the tourism industry, while local communities may have different ideas about the "desirable" amount of tourists. So, while the success of these sites depends on perfect execution of conservation projects and collaborations between conservation groups and government institutions, predicting visitor flow and its optimization are key factors in these processes as well.

But visitor flow optimization is more than simply organizing lines in and out of sites. It is developing and testing multiple visitor flow optimization strategies that take into account visitor arrival volume forecasting, determining sites' "carrying plan", and peak demand management, among other factors.

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In the rest of this paper, the use of analytics in the form of statistical and simulation models for the development and testing of these strategies will be explored.

A simulation model is a digital representation of a venue with all its elements: The salient characteristics of the venue, its architecture, visitors, and services offered to the visitors. A properly developed simulation model mimics the real site in compressed time and can accurately predict the operational characteristics pertinent to visitors' experience. It also allows to test various scenarios and what might happen in years to come. Since it takes only a few minutes to simulate each scenario, valuable insights can be gained by experimenting with multiple "what…if" assumptions.

Using the following case study, the use of analytics and simulation modelling to optimize visitor flow will be explained.

MOGAO GROTTOES – DUNHUANG, CHINA CASE STUDY: Simulation Modelling in Action

The Mogao Grottoes, located near the city of Dunhuang in the Gansu province of China, consist of almost 500 "cave temples" (grottoes) that contain the largest repository of ancient Buddhist wall paintings and sculpture in China, created between the 4th and the 14th centuries. In 1987, the site, which was managed by the Dunhuang Research Academy, became one of the first cultural-historical attractions in China to be listed by UNESCO as a World Heritage Site.

Managing the visitor experience at many Cultural and Natural Heritage sites is complicated by the dynamic environmental conditions within which they operate. At the Mogao Grottoes, decades of conservation research have been utilized to determine what combination of environmental factors (e.g. carbon dioxide levels, air exchange rates, air temperature, relative humidity, cave wall salt content, etc.) and visitor factors (e.g. tour group size, cave visit time, number of tours per day, etc.) are acceptable in providing a high-quality visitor experience, while ensuring that the cave artwork is protected from further damage. As the relationships between these factors are not obvious, a tool was needed to account for them in order to derive a daily visitor carrying capacity of the Grotto Zone that would ensure that the cave walls were protected.

At the time, the Dunhuang Academy was planning to construct a new Visitor Center off-site that would serve as an introductory experience prior to visiting the caves, provide for a buffer to be able to turn away visitors on days when demand exceeded capacity and enable the site to support higher visitor volumes. A separate challenge was to help the Academy correctly determine the ideal size of the Center to ensure sufficient capacity in key facility areas (parking, ticket windows, theatres, lobby space, etc.) and critical service operations (shuttles, restaurants, retail shops, etc.) to provide a good overall visitor experience.

In collaboration with the Dunhuang Academy and the Getty Conservation Institute, Kiran Consulting Group developed a capacity management planning tool to assist managers in managing the scheduling of the cave tours. This maximized the daily visitor volume while ensuring that the cave walls were not impacted by adverse environmental conditions.

Various statistical analysis tools and data analytics were used in developing the capacity management planning tool. In addition, a visitor flow simulation model that optimized the sizing of key program elements of the planned Visitor Center was developed. These two efforts were combined to comprise the first phase of the project.

The second phase involved developing a separate and detailed visitor flow simulation model of the Grotto Zone, enhancing the capacity management planning tool and integrating all of the models and tools into one system, called the Dunhuang Academy Visitor Management System (DAVMS).

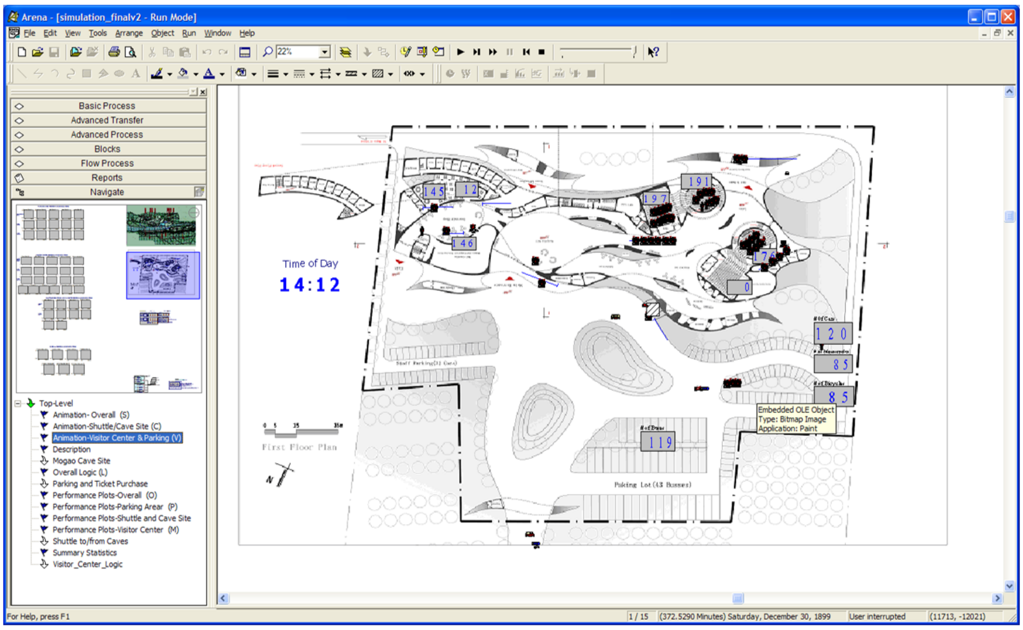

Fig. 1. A Simulation Model of Mogao Caves Visitor Center (© authors)

The simulation models enabled various scenarios to be run by allowing changes to be made to variable input parameters (e.g. acceptable wait time, attendance, staffing, transaction times, etc.) and also displayed visual animation of the visitor flows. A dashboard was created in the model that gave management an overall snapshot of the operating efficiency and performance of the Visitor Center and Grotto Zone. After the models were built, “what-if” scenarios were reviewed to determine the most feasible course to optimize the facility operations and resource requirements. The model also provided the functionality to vary the visitor arrival pattern, arrival modes, capacity constraints, and resource allocations.

The DAVMS system has enabled the Dunhuang Academy to proactively plan for a variety of visitor volume and environmental conditions, and determine the maximum daily visitor carrying capacity that will not cause further damage to the cave walls. In addition, the system provides managers with an operational tool to modify existing cave tours or develop new tours should environment conditions dictate that certain caves need to be “rested” in order to prevent potential damage. Finally, the system was designed to be flexible, so that as additional data and research results became available, the system could be easily updated with the latest available data.

The simulation model also used an optimized “Carrying Plan”, an answer to a frequently asked question by the authorities: The maximum number of satisfied visitors that the site can accommodate without further damaging the site.

Using the developed simulation models it is found out that the Mogao Grottoes can carry up to 3,000 visitors per day when all the “must-see” caves are included in the tours. However, it’s carrying capacity can increase to 6,000 visitors per day by limiting visitors to 4 minutes in some of the “must-see” caves. This capacity can even go above 6,000 if some of the “must-see” caves become “optional”.

In the example above, it can be seen that the site’s carrying capacity increases and decreases according to the number of visitors who visit the “must-see” caves. Management can control carrying capacity for the whole site by simply controlling the number of visitors who see the more famous caves.

As in the case of Mogao Grottoes, instead of planning for the site’s carrying capacity, organizers should develop a “carrying plan.” This plan should specify what actions might be needed to achieve different visitation volume goals. In the case of the grottoes, limiting the visitation times for the “must-see” caves could be one strategy for a carrying plan that serves to control the high peak visitor days. This carrying plan should also include carrying capacity targets with time dependencies. For example, let’s say a carrying plan allows visitors to see all the caves when the daily visitor volume is forecasted to be less than 3,000 per day. But when the visitation volume exceeds 3,000 the plan calls for limiting access for the must-see cave access to certain ticket holders or, alternatively, letting “regular” visitors see only a subset of must-see caves, while alternating the caves for different groups. This type of strategy is essential to a carrying plan, because unless one controls the entrance into every part of a site, it is inevitable that there will be more visitors in certain areas at different times. Thus, a carrying plan must take into account the probability of having a variable number of visitors over time in a particular area.

Conclusions

Digital simulation models can help create and implement optimal visitor flow strategies. The input data used for the simulation models is a key component of a successful model. Use of the statistical analysis and data analytics are the cornerstones of the development of these models. As heard in the case study presented, digital tools, such as digital simulation models, are the keys to protecting historical sites while maximizing the visitor experience and volumes. Furthermore, predictive analytics and modelling can keep historical sites safe for future generations, while helping with every-day operations at the site.

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