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CISC7010 DISCRETE SYSTEM SIMULATION

Year: 2022/2023

Final Project

Theme Park Simulation Based on ARENA: A Case
Study of Universal Studios Japan (USJ)

5th May 2023

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1 Introduction

As COVID-19 control measures are lifted, the tourism industry is gradually returning to pre-pandemic levels, with more and more people eager to travel and visit theme parks such as Disney and Universal Studios. However, with increasing crowds, long waiting times have become an inevitable issue. In order to maintain competitiveness and ensure better customer satisfaction, the management of these amusement parks needs to make every effort to reduce wait times. This project takes Universal Studios Japan (USJ) as an example, simulating the operational situation of April 30th, 2023, and attempting to reduce visitor waiting times within a reasonable range while providing recommendations.

The remainder of this paper is organized as follows. Section 2 introduces the data sources and processing results of our project. Section 3 presents our modeling approach and the final model implemented in ARENA. Section 4 showcases our simulation results and provides improvement suggestions. Section 5 concludes our project.

2 Data Resources

In this project, we need to take into account several factors related to USJ, including its operating hours, the visitor flow on April 30th, 2023, the ride duration and the maximum number of people allowed per ride for each attraction, as well as the waiting time required for each ride. Most of these data can be obtained from the USJ official website [2], third-party data websites [1], and applications.

According to the information we have gathered, USJ is open from 8 a.m. to 10 p.m. JST, and visitors staying at Official Hotels can enter 15 minutes in advance. USJ has 10 parks, and events are held for a limited time, the Top 10 rides on April 30, 2023 is shown in Figure 1. Since the distribution of the Top 10 rides is relatively even, according to experience, other rides will be played in the process of playing the Top 10 rides. The visitor flow on that day is about 37,000, the details and queues wait times of the TOP10 ride attractions on April 30, 2023 are shown in Table 1.

Ride Attraction	Capacity	Time Requirement (min)	Wait Times (min)
Demon Slayer Kimetsu no Yaiba XR Ride	26	10	83
Mario Kart: Koopa's Challenge	32	5	71
Yoshi's Adventure	20	5	54
Hollywood Dream The Ride	36	3	46
Flight of the Hippogriff	16	2	41
Elmo's Go-Go Skateboard	32	2	33
The Flying Dinosaur	32	3	33
The Flying Snoopy	24	2	31
Harry Potter and The Forbidden Journey	188	5	26
Moppy Balloon Trip	32	2	25

Table 1: Top 10 ride attraction details and wait times.



Figure 1: Distribution of Top 10 rides in the USJ.

2.1 Data Fitting to Distributions

The ARENA model requires the data as an input to run and analyze the situation. For convenience, ARENA needs the data in the form of a distribution which best fits the raw

data. But we are looking system efficiency and utility for this project so, the only matters for us is wait times.

However, we still need to take into account the hourly park capacity. Since the official data is not available, we made assumptions based on experience, and the results are shown in Table 2. Additionally, we cannot determine how many visitors are staying in the Official Hotels and entering the park early, so we calculated based on a 60% occupancy rate, estimating 3,500 visitors staying overnight with the first three hours seeing 2,000, 1,000, and 500 visitors entering, respectively.

Timeslot	Visitors Arrival (per hour)	Timeslot	Visitors Arrival (per hour)
8:00-9:00	10730	15:00-16:00	925
9:00-10:00	8140	16:00-17:00	1110
10:00-11:00	4400	17:00-18:00	1850
11:00-12:00	3885	18:00-19:00	740
12:00-13:00	1850	19:00-20:00	550
13:00-14:00	1480	20:00-21:00	111
14:00-15:00	1110	21:00-22:00	74

Table 2: Assume visitors enter per hour.

3 Simulation and Modeling

Our project mainly simulates the operation of USJ for a single day. After arriving at the entrance, visitors go through security checks and ticket inspections. Visitors staying in Official Hotels can enter the park early. Those who have not made reservations through the APP must go through manual ticketing channels. Rides are arranged on a first-come, first-served basis, and we assume that each visitor can only ride up to four TOP10 attractions. After riding four TOP10 attractions, visitors can choose to ride other attractions or leave. We also assume that after 21:30, no new visitors are allowed to queue up for any ride, and visitors gradually leave the park. The overall process is shown in Figure 2.

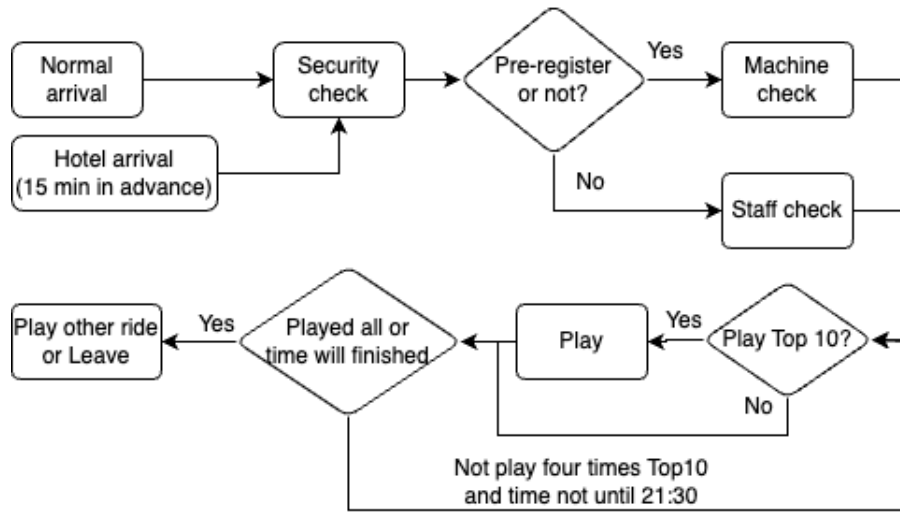


Figure 2: The process of usj simulation.

3.1 ARENA Model

Before starting this section, we'll explain that because the ARENA Student Version has a limit of 150 entities, it must be simulated using the version without model restrictions. We are using the ARENA 15 Professional Edition.

We set up USJ with 18 gates, 18 X machines, 10 ticket machines, and 5 staff to check ticket, and visitors will pass with $EXPO(1/9)$, $EXPO(1/8)$, $EXPO(1/10)$ and $EXPO(1/4)$ respectively. Assume that 80% of visitors are pre-registered to check in at the machine. The process in ARENA is shown in Figure 3.

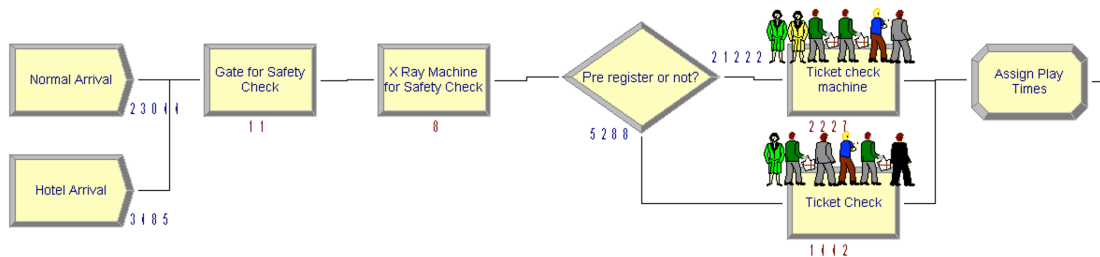


Figure 3: The process of Enter the USJ.

Subsequently, we assumed that 95% of visitors would like to experience the Top 10 rides, while the remaining 5% would try other rides first. Since the Top 10 rides were determined based on their wait times, we also calculated the probability of choosing a

certain ride based on its wait time, as shown in Table 3. In addition, it is unrealistic to assume that all visitors would only queue for a few rides. Therefore, we set the queueing conditions (shown in Figure 4) based on the average wait times on April 30, 2023, and if the number of visitors queueing for a particular ride exceeds the limit, they would choose other rides instead. This process in ARENA is shown in Figure 5

Ride Attraction	Probability (%)	Ride Attraction	Probability (%)
Demon Slayer Kimetsu no Yaiba XR Ride	20	Elmo's Go-Go Skateboard	7
Mario Kart: Koopa's Challenge	18	The Flying Dinosaur	7
Yoshi's Adventure	15	The Flying Snoopy	5
Hollywood Dream The Ride	10	Harry Potter and The Forbidden Journey	4
Flight of the Hippogriff	10	Moppy Balloon Trip	4

Table 3: Probability of choosing which Top 10.

	Name	Type	Percent True	If	Value
3	Decide Doraemon	2-way by Condition	50	Expression	Count Play 1 == 0 && NQ(Demon Slayer Kimetsu no Yaiba XR Ride.Queue) * 10 <= 120
4	Decide Mario	2-way by Condition	50	Expression	Count Play 2 == 0 && NQ(Mario Kart Koopa Challenge.Queue) * 5 <= 70
5	Decide Yoshi	2-way by Condition	50	Expression	Count Play 3 == 0 && NQ(Yoshi Adventure.Queue) * 5 <= 55
6	Decide HDR	2-way by Condition	50	Expression	Count Play 4 == 0 && NQ(Hollywood Dream The Ride.Queue) * 3 <= 45
7	Decide FH	2-way by Condition	50	Expression	Count Play 5 == 0 && NQ(Flight of the Hippogriff.Queue) * 2 <= 40
8	Decide EGGS	2-way by Condition	50	Expression	Count Play 6 == 0 && NQ(Elmo Go GO Skateboard.Queue) * 2 <= 30
9	Decide FD	2-way by Condition	50	Expression	Count Play 7 == 0 && NQ(The Flying Dinosaur.Queue) * 3 <= 30
10	Decide FS	2-way by Condition	50	Expression	Count Play 8 == 0 && NQ(The Flying Snoopy.Queue) * 2 <= 30
11	Decide HP	2-way by Condition	50	Expression	Count Play 9 == 0 && NQ(Harry Potter and The Forbidden Journey.Queue) * 5 <= 25
12	Decide MBT	2-way by Condition	50	Expression	Count Play 10 == 0 && NQ(Moppy Balloon Trip.Queue) * 2 <= 20

Figure 4: Each ride queueing conditions.

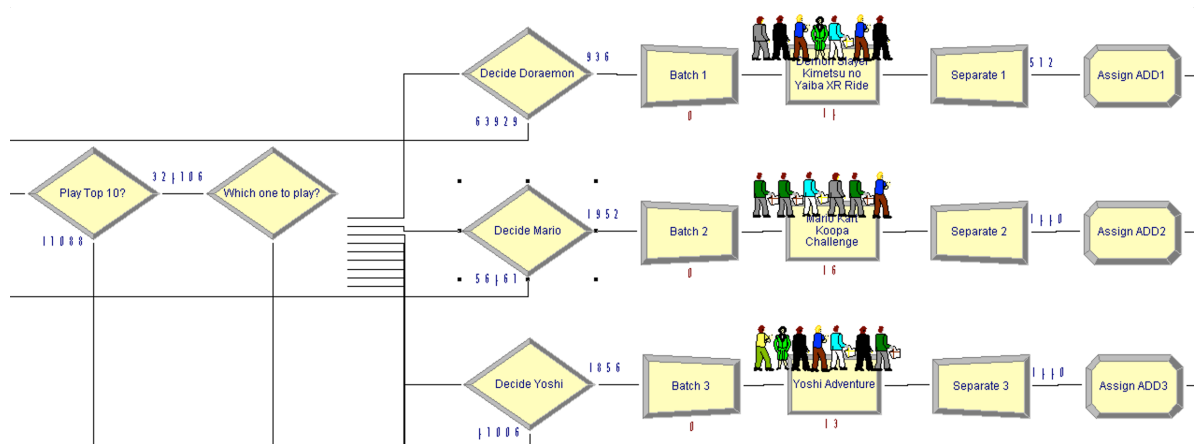


Figure 5: The process of play rides.

As we mentioned earlier, after playing the four Top 10 rides, visitors choose to play other rides or leave, or until 21:30 visitors begin to leave. This process in ARENA shown

in Figure 6. For easy display, we dragged the Decide module named “Play Top 10?” in Figure 5 here.

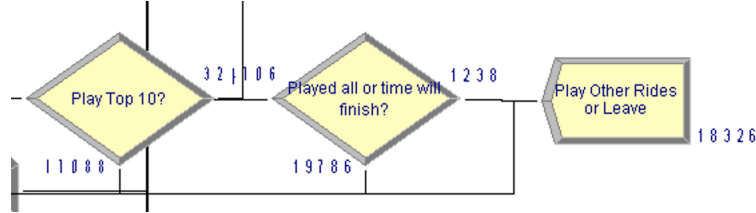


Figure 6: The process of end simulation.

Because visitors staying at Official Hotels can enter early, for the sake of simulation we assume that they can enter one hour early, that is, USJ starts at 7:00 and therefore closes at 22:00, 15 hours later. Our Set up setting is shown in Figure 7. We used the Windows virtual machine with M1 Max, allocated 4 CPU and 16GB of memory, and it took 3 minutes to complete the simulation.

Start Date and Time:
☒ 2023年 4月30日 7:00:00

Warm-up Period:
 0.0

Time Units:
 Hours

Replication Length:
 15

Time Units:
 Hours

Hours Per Day:
 24

Base Time Units:
 Minutes

Terminating Condition:
 TNOW >= 900

Figure 7: Simulation Set up setting.

4 Result and Improvement

Our goal is to improve the visitor experience by reducing waiting times, so we mainly analyze the Queue Time in the simulated results (shown in Table 4, Origin Model).

Looking back at our simulation model from a practical perspective, we cannot change the waiting times for Top 10 rides. The operational strategy of the theme park also precludes the removal of other rides to expand popular ones, as this may impact the visitor experience and normal operations. Moreover, expanding popular rides cannot guarantee a reduction in visitor waiting times, as the popularity of rides is determined by visitors. Therefore, we consider reducing the waiting times for entry and ticket checks.

Our simulation model has two types of ticket checks: machine check and staff check. We found that staff ticket checks take a long time, while machine checks are quick. By encouraging more visitors to use the machines, we can reduce waiting times. We increased the number of ticket machines from 10 to 20 and increased the pre-registration probability to 90%. The results of running the model are shown in Table 4, Improved Model.

Waiting Time	Origin Model		Improved Model	
	Average	Maximum	Average	Maximum
Demon Slayer Kimetsu no Yaiba XR Ride	116.77	129.87	115.67	129.78
Elmo Go GO Skateboard	20.6259	32	17.2625	31.6084
Flight of the Hippogriff	35.3957	41.8674	26.5138	41.8706
Gate for Safety Check	3.8374	12.4140	3.8302	12.2106
Harry Potter and The Forbidden Journey	17.5364	29.2339	12.6495	27.7685
Hollywood Dream The Ride	33.8650	48	28.2151	47.7378
Mario Kart Koopa Challenge	66.2210	75	63.3392	74.8542
Moppy Balloon Trip	13.4486	21.6536	9.7024	21.2493
The Flying Dinosaur	21.4710	32.9449	18.6425	32.5743
The Flying Snoopy	19.9843	31.7661	17.5413	31.7343
Ticket check machine	8.6050	25.0879	0.0005	0.086
Ticket Check	30.9275	75.9231	0.0491	0.9969
X Ray Machine for Safety Check	5.0953	16.8276	4.3705	15.5457
Yoshi Adventure	52.8331	60	49.5545	59.7610

Table 4: Waiting time (min) comparison of the original model and the improved model.

We found that the Waiting Time for Ticket Check decreased from 30.9257 to 0.0491, which although exaggerated and unlikely to happen in reality, demonstrates the feasibility of the improvement.

5 Conclusion

In this project, we simulated the queue waiting time of rides in USJ for a day and proposed an improvement plan to reduce user Waiting Time in order to enhance user experience. However, there are some discrepancies between the simulated model in this project and the real world:

- ◇ We only used the average value of one day's data, and if we use the average value of a year or a more appropriate time period as the data, the simulation results may be more fitting.item
- ◇ The express pass can improve the Waiting Time for some visitors, but it does not affect the overall queue time, so we did not consider it in this project.
- ◇ Visitors' behavior and preferences are not purely probabilistic. We only speculated visitors' behavior based on our own plan.

References

- [1] T. Data. Wait times at universal studios japan. [https://www.thrill-data.com/](https://www.thrill-data.com/waits/park/unit/usj/)
[waits/park/unit/usj/](https://www.thrill-data.com/waits/park/unit/usj/).
- [2] U. S. Japan. Universal studios japan website. <https://www.usj.co.jp/web/>.