Arnav Limaye
15 June 2022
Dr. Kobayashi

Iidabashi Station Simulation Report

Introduction

Located near the heart of Tokyo, Iidabashi is a district known for its bridge crossing the Kanda river. The most populated part of the district, however, is its famous station first constructed in 1928. Iidabashi station services many parts of the Tokyo area through different means primarily through both the JR trains and the Tokyo metro. For my simulation in FSE394, I chose to do the Chūō-Sōbu Line tracks which is the only JR operated line in Iidabashi station. The rest of the station is served by the Tokyo Metro, primarily the Tozei Line and the Yūrakuchō Line. The different parts of the station are accessed by gates operated by the Suica IC card that passengers use to access and transfer lines. The JR track is located above the station while the Tokyo Metro is underground, as a result passengers traveling between the lines would increase or decrease their elevation accordingly. Additionally, there is also the possibility that a passenger chooses to leave the station entirely and enter Iidabashi itself. To do that, they would simply follow the exit signs to get out of the station area.

Fig 1. The E231-500 series EMU train that is typically used to service the Chūō-Sōbu Line. The yellow color matches the line's symbol.

Fig 2. Satellite view of Iidabashi station and its surroundings. The main track going through the station is the Chūō-Sōbu Line.

Fig 3. IC card reader in Tokyo stations. Note that they come in a variety of colors including pink and purple.

Investigation

Tokyo's stations are infamously crowded. During peak hours it can often be difficult to relax between train rides due to the rush caused by commuters. This extends to the trains - many of which are standing room only in the evenings and become difficult to embark and disembark due to the large number of people already inside. As a result, the central question is more obvious than ever. How can train lines reduce the number of people in the stations? To answer this, there are two central theories that arise. The first is that the companies should simply run their trains in more frequent intervals to "flush" the crowds out of the station and lower foot traffic. The other scenario is the current situation, where the frequency of the trains remains on a slower scale and the trains are packed to capacity. Many passengers wonder why they have to continue to travel in congested carts when there is a potential solution that simply needs to be activated and relieve station crowds. That's why I created my simulation to investigate which solution is better for reducing crowds forming inside the station.

Simulation

The 3D simulation would be built within the 2021 version of the Unity game engine. Unity is a platform that allows users to build 3D game situations that can be expanded to make simulations. Since this was an abstract simulation basic shapes would be used to represent the people and objects rather than detailed avatars. Passengers would be represented as small cylinders. Arriving passengers from the trains would be shown in purple, while departing passengers seeking to board the train are blue. The trains are shown as rectangular prisms on each side of the track, and when they turn yellow it means that within the simulation the train has arrived. Each train has 5 compartments and each has passengers board and exit them. On each slope of the track are purple gates which represent IC card readers. Passengers who cross each gate are considered to have scanned their card and are now entering or exiting the station depending on their color. Upon crossing the gate there are several options a passenger may choose to take. On both sides of the station is a green area which indicates an exit to the streets of Iidabashi. On one side, there are two transfer connection options to the Tokyo Metro. The Tozei Line in light blue and the Yūrakuchō Line in brown. The passengers are randomly given a destination upon creation. Within the simulation, users will have the ability to adjust the spawn speed of the passengers departing Iidabashi station, passengers arriving off each train, and the interval of the trains. Additionally, it is worth noting that within the simulation 1 second represents 10 seconds of actual time in Iidabashi station. After running the simulation, a results page will show the amount of people entering and leaving Iidabashi station's JR terminal, along with how many arrivals made a transfer, and how many exited the station entirely.

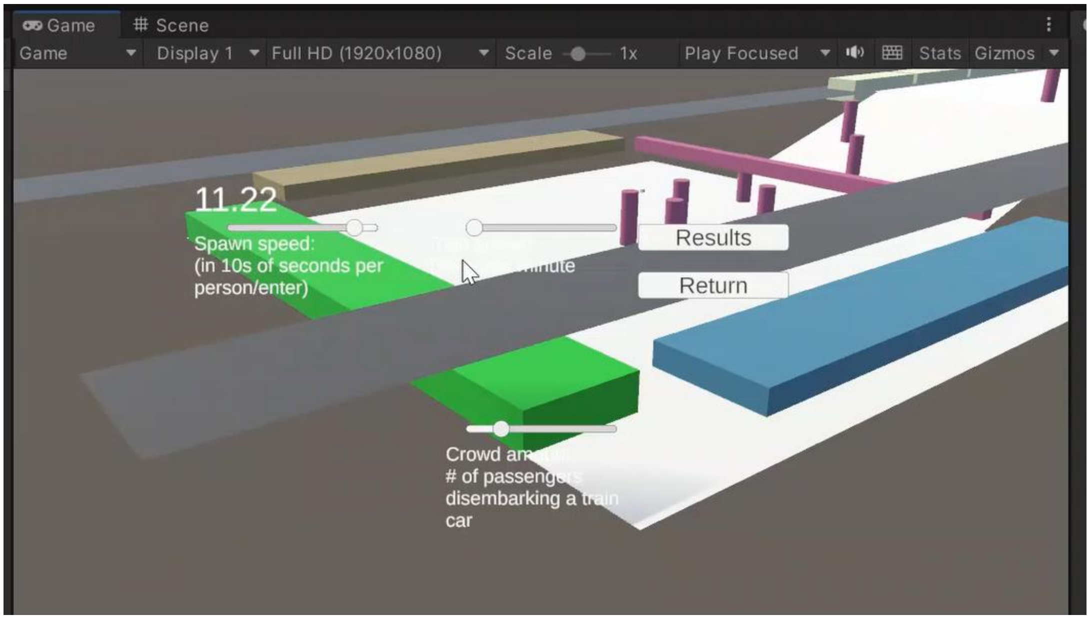

Fig 4. The side of the station that contains the exit and transfer. The exit to Iidabashi is green, while the Tozei line transfer is blue, and the Yūrakuchō line is the tan/brownish area. Note the cylinders crossing the purple gate before going up the platform to the trains. They swipe the Suica machine as they exit to the platform which registers the movement. The “floating” gray bars on top are simply the rail lines and provide no value to the simulation as they are just for stylistic effect. The original plan was to have the trains move on them but that was cut due to time issues. As seen on the screen there is a timer that shows the amount of time that has lapsed since the simulation has started. The top left slider controls the spawn speed, which is the number of seconds (scale of 10) it takes for a person to spawn. The top right slide is hard to see but it is the train speed which is the number of trains a minute (remember the scale of 1:10). Finally, the bottom scale represents the amount of people disembarking each train cart with 1 at the lowest amount. The results button at the end will return the number of departing and arriving passengers, along with transfer amounts. Additionally, it will yield the amount of people entering and exiting the Suica gates ever ten seconds. The simulation is being ran inside the Unity software as an external .exe file would not allow the user to adjust the camera angle to see better while the software would.

Experiment

For this experiment I ran the simulation two times for sixty seconds each. Due to the time scale this would be representing around 600 seconds in Iidabshi station or around ten minutes of time passing. Since the experiment needs a constant variable, for both experiments the amount of people spawning for the departures will be kept the same in both simulations to medium settings. This simulation is finding the best option for managing the trains and how crowded they are, so there is no reason to change the amount of people spawned to leave the station. For the first experiment it will simulate JR running the current situation which is around 3 people leaving each train car with the trains arriving at a standard rate. The second experiment will aim to simulate the alternative version which will see trains arrive at the station very quickly while only 1 passenger leaves each train cart. After sixty seconds both simulations will be stopped, and the calculated results will be compared to see which has the most amount of people passing through the Suica gates in the JR terminal of Iidabashi station every ten seconds. The trial will be repeated for each scenario twice.

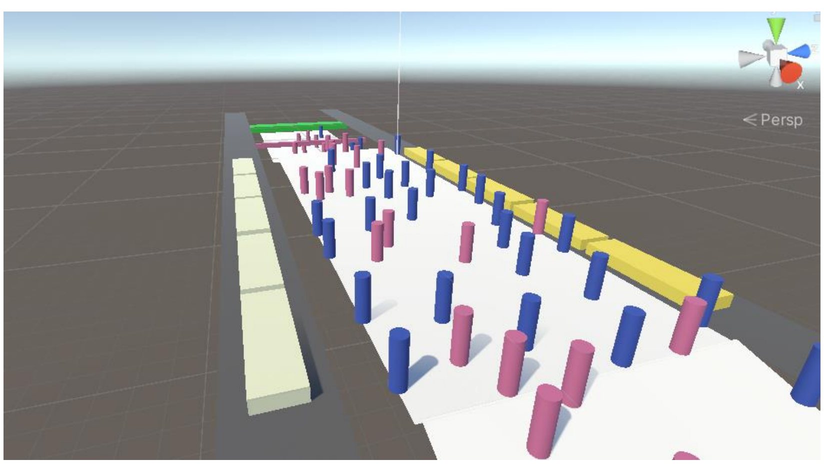

Fig 5. The simulation for the first case being run, note the passengers boarding and departing the active train on the left.

Results

The results have been calculated and are shown in the tables below. Average values except for the rate are calculated to the nearest whole numbers.

Scenario 1: Standard train frequency, high number of passengers per compartment

	Arrived	Tozei Transfer	Yūrakuchō Transfer	Iidabashi as Final Destination	Departing Iidabashi station	# Passing Through Suica Gates Every 10 sec
Trial 1	93	14	21	49	120	3.511
Trial 2	91	19	15	42	120	3.494
Average	92	17	18	46	120	3.502

Scenario 2: High train frequency, only 1 passenger arriving per compartment

	Arrived	Tozei Transfer	Yūrakuchō Transfer	Iidabashi as Final Destination	Departing Iidabashi station	# Passing Through Suica Gates Every 10 sec
Trial 1	91	25	23	24	120	3.491
Trial 2	80	19	15	41	122	3.301
Average	86	22	19	33	121	3.396

Analysis

Contrary to the beliefs of many passengers, the results do not show much of a difference between the scenarios. The number of passengers departing Iidabashi station is nearly identical in both scenarios. Arriving passengers also have similar numbers in the trials although it slightly decreases with the faster train frequency. The biggest noticeable difference that is observed is the amount of people passing through the Suica gates every 10 seconds. There is about a 0.1-person difference which means overall around 1 person less goes through the gates every minute and forty seconds. Overall, however, it is a very miniscule difference, and these results lead to the conclusion that there is no decrease in station traffic regardless of the train speed and how occupied the trains are on arrival.

Since this is an abstracted simulation, there is potential of error for multiple factors. Firstly, while the cylinders utilized the Unity game engine's Navigation AI it is important to realize that their main goal is to simulate moving objects and not people. True human behavior is much more varied and real movement would be much more complex than what is shown in this simulation. Additionally, the number of people disembarking from each train car would never be constant. While the numbers would be similar, there would still be variation between each individual train car, and they wouldn't be the same per train. Furthermore, while the destinations of the passengers were randomly designated, it wouldn't be truly random. There would be much more of a bias on where people choose to end up going based off popular commute locations and it would vary during business hours. In summary, while the simulation model provides a good grasp of Iidabashi Station, it is not perfect in its ability to accurately simulate the actions of real humans in the real-world environment. As for the aesthetic or visual portions of this simulation, the purpose of this was to calculate numerical values rather than provide realistic imagery of the station. Ideally, the trains would move from the platform station periodically, but that feature was cut due to time constraints. However, it does not affect the actual simulation at all besides providing some stylistic motion. An astute observer may notice that the number of passengers leaving Iidabashi station, or transferring to the subway lines does not equal the number of arriving passengers. This is because at the point the simulation is completed, not every passenger has moved between the Suica gates and the exit or subway lines. As a result, those who are currently walking between the areas are considered arriving passengers in Iidabashi station but have not completed their connection or exit. Finally, the map in this simulation provides only two exits. The design of Iidabashi station has complex tunnels and over ten exits. However, due to the simplicity of this simulation, that has been reduced to focus on the abstracted view of data.

Discussion

As the results of the simulation showed, there is almost no difference between the current system of running the JR trains or having a faster interval of trains with less speed. As a result, it provides JR more of an incentive to maintain the status quo than to answer to the discomfort of the customer. Although the trains are currently crowded, it is much cheaper for JR to operate and save costs. After all, while efficient public transport is their goal, they are still a business and profit are their priority. Running less trains allows them to maintain a solid profit margin while limiting expenses. As for the customers who are passengers, the railway line should find other ways to ease their dissatisfaction by providing more space within the station itself. One possibility is rate limiting the amount of people allowed to pass through the Suica gates every few minutes. There are a few issues with this approach, as it can cause anger amongst travelers who are late for their commute. As a result, the tardiness could damage productivity and hurt the Japanese economy. Another possibility is transferring passengers to get a faster exit option from the JR terminal since they need to catch another train to continue the rest of their commute. Whereas, passengers whose final destination is Iidabashi may have to wait longer but since they are already at their destination leaving quickly isn't as much of a priority. In conclusion, this simulation demonstrates that changing the train frequency compared to the current situation does not affect things much and that there are better ways worth exploring to find a stronger connection between the two situations.

Works Cited

“お世話になります～Kato「E231系500番台 中央・総武線」のお話.” *Goo Blog*, blog.goo.ne.jp/k-boy20141/e/acc85607487487aee8b5da11526fd16a. Accessed 20 June 2023.

Google Maps, maps.google.com/. Accessed 23 June 2023.