Appendix 1

Directory

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1. Literature References

[1] Zhiqiang Zhai Chanjuan-Sun. The efficacy of social distance and ventilation effectiveness in preventing covid-19 transmission. Elsevier.

[2] Louise Viljoen Chris Rohwer, Andreas Hafver. Boarding—step by step: A cellular automaton approach to optimising aircraft boarding time. The UMAP Journal, 2007.

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[4] Rick Durrett. Probability: theory and examples, volume 49. Cambridge university press, 2019.

[5] Megan Farquhar. Boarding processes of passenger aircraft. National Collaboration in the Mathematical Sciences.

[6] Enters for Disease Control and Prevention. Disability impacts all of us infographic. 2020.

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[8] T Islam, M Sadeghi Lahijani, A Srinivasan, S Namilae, Anuj Mubayi, and M Scotch. From bad to worse: airline boarding changes in response to covid-19. Royal Society Open Science, 8(4):201019, 2021.

[9] Serter Iyigunlu, Clinton Fookes, and Prasad Yarlagadda. Agent-based modelling of aircraft boarding methods. pages 148–154, 2014.

[10] Matthew Edwards Michael Bauer, Kshipra Bhawalkar. Boarding at the speed of flight. The UMAP Journal, 2007.

[11] Aaron Wise Qianwei Li, Arnav Mehta. Novel approaches to airplane boarding. The UMAP Journal, 2007.

[12] Horst Rinne. The Weibull distribution: a handbook. Chapman and Hall/CRC, 2008.

[13] Thomas L Saaty. Decision making with the analytic hierarchy process. International journal of services sciences, 1(1):83–98, 2008.

[14] Jason H. Steffen. Optimal boarding method for airline passengers. Journal of Air Transport Management, 14(3):146–150, 2008.

[15] Dimitris Drikakisb Talib Dbouka. On respiratory droplets and face masks. NCBI.

[16] Xu Xiao-Bin. The research of airplane boarding strategy based on experimental method. 2019.

2. Library Usage

Name:	Official site/ Documentations
MatPlotLib	Matplotlib — Visualization with Python
Numpy	NumPy
MoviePy	moviepy-cn 文档

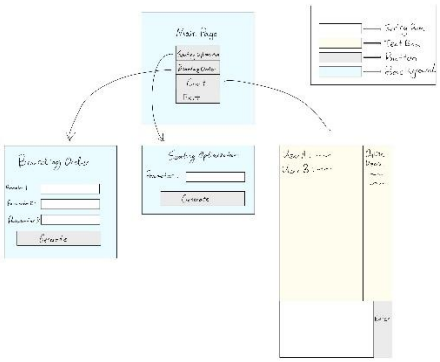
PyProb	pyprob · GitHub
Jpype	JPype documentation — JPype 1.4.2_dev0 documentation

3. First Direct Interactions:

From: <2581468396@qq.com>
To: <ericchanghaipeng@hotmail.com>
Title: Information on Product
Date: 2022/04/16
Hi Eric,
It is good to see you interested in this topic. Your concerns are indeed right, the pandemic hit the industry very hard. Many airline companies are experiencing losses in profit. I really liked the ideas your presented in your statement: I've haven't seen any close to that being actually landed as a product. To answer your question, as a passenger it definitely feels unsafe in the flight. From an engineer's perspective, the concern resides mainly on two issues: boarding and seating. During the boarding process, us passengers are in close contact with each other. During that period, covid transmission is very likely. The other thing is that the seatings on the planes are never optimized. You see clusters of empty and filled seats, which obviously endangers the persons in the clusters. If your program manages to solve those issues, I, as a passengers will feel much more comfortable on flight. Look forward to seeing it. If you want to consult with me more, please add me on WeChat: XXXXX.
From,
Wei Chang

4. Excerpts from WeChat Discussion

[1]
Wei: How have product development been going so far?
Me: I actually have a rough design for the application, do you want to see it?
Me:



Wei: Looks fine to me
Wei: What will the parameters be?

Me: I will update you on that later.
Wei: So, your application is going to be split into three functions? I don’t recall talking about the chatting function.
Me: Yes, I actually made a success criterion for it as well
Me:

Criterias for success

Criteria	Description
A: Interface	The solution must provide a informative and simple interface, along with simple action to interact with it for users to use. There should be a panel where you can switch between pager.
B: Authorization	The solution must provide two different interfaces for airline companies and passengers to use. It should be done though a login scheme where the user can register for an account, and along with username and password comes a option to select the user as Company or Consumer.
C. Communications Page	The communications page should function as a chatting application where messages between individuals are entered through a text box and can be sent at click. There should be a panel to selecting the target of the messages, and a button to refresh the page for new messages.

Criteria	Description
D. Calculations page.	The calculations page should be available to the consumers in a way that the consumers are allows to enter their statistics. The statistics should be recorded in a database and utilized in running the genetic algorithms and cellular automata. After the programs are ran, the page should show the results of the calculations
E. Visualization page	The process of the genetic algorithm and cellular automate are expected to be visualized on this page in the form of videos. It should be able to switch between videos when swiped and play the video on click.

Wei: Seems like you know what you're doing, we'll see how it goes.

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[2]

Me: Hey, are you interested in seeing my current progress.

Wei: Sure.

Me: [Genetic.py]

Me: [Chat.py]

Me: [Cell.py]

Wei: These are your three algorithms?

Me: Yes, you can try running them.

…

Wei: The first one doesn't seem to work

Wei: When I tried to run it, it just crashes

Me: Oh you might not have JVM installed, try getting one, the other ones should work fine though

…

Wei: Being honest, I don't see the point in making the chatting function. There are many replacement to, like how we are using WeChat right now. Having to enter IP addresses to chat just seems to primitive for me.

Me: Ok ill consider that.

Wei: Also, I can't see the visualization for your algorithm, was there a bug.

Me: try downloading PyCharm

Wei: You can't me asking me to install everything… the real client you want to address in the world won't have access to you like I do. Besides, it is quite ridiculous to have the function of the app to be only available in an ide.

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[3]

Me: I have finalized my product, can you please take a look

Me: app.zip

Me: Try running the main file

… (Me guiding Wei through the program)

Wei: I am impressed. This is so much more completed in functions than the one before. The user experience feels a lot better. Seems like you accepted a lot of my advice.

Me: Thanks!

Wei: In terms of your test criterions, I believe your product satisfies it pretty well. You have a main menu page that is leads to all other pages and has an exit button. The algorithms all seem realistic, and the outputs looks indeed like it was optimized: even though some runs produced different optimized results, I believe that it was from your intentional incorporation of random chance. I thought the video visualization method was really creative. There wasn't any difficulties interpreting the results of your algorithms: the visualizations were simple enough. I also saw that you took my suggestions and added error handling methods. When I "accidentally" added weird values for your programs, it didn't accept it.

Wei: I see a lot of potential in this product. Have you considered expanding the function of it to other platforms other than window? The app will be a lot more convenient on mobile devices. The GUI could still be improving: that part of it is far from being commercial.

5. Rules for Cellular Automata

$M_{i,j}$ begins at the start of the simulation empty. At each time interval, we update the matrix through the following steps.

- First we check whether $M_{0,3}$, representing the entrance, is empty. If the entrance is empty, we remove the next passenger from the pre-generated passenger queue and input this passenger into this position $M_{0,3}$. This process is expressed in Equation (1).

$$\textbf{if} \quad M_{0,3} = 0, \quad \textbf{then} \quad M_{0,3} = P_k,\ k = k + 1 \tag{1}$$

Where $M_{0,3}$ is the value at position $(0, 3)$ in matrix of the simulation, P_k is the k-th passenger of the passenger list, and k is the index of the next passenger not yet input into the matrix.

- Then, we propagate through each term on the third column, i.e. $M_{i,3}$ and update each passenger found on this column. For each passenger who is not yet at the correct aisle yet, determine whether the position immediately in front of them is empty. If empty, this passenger can advance forward one step.

$$\textbf{if} \quad (M_{l+1,3} = 0 \quad \textbf{and} \quad l \neq a_k), \quad \textbf{then} \quad M_{l+1,3} = M_{i,3},\ M_{l,3} = 0 \tag{2}$$

Where $M_{i,3}$ is the value at $(i, 3)$ in matrix of the simulation, i is the current aisle position of the passenger in question, a_k is the aisle number of the k-th passenger, and k is the index of the passenger currently in question.

- Upon finding a passenger who has is at the correct aisle, we either seat this passenger if their time to seat is 0, or subtract one from their time to seat.

$$\textbf{if} \quad t_k = 0, \quad \textbf{then} \quad M_{a_k,s_k} = 1,\ M_{i,3} = 0 \quad \textbf{else} \quad t_k = t_k - 1 \tag{3}$$

Where t_k is the remaining time to seat for the k-th passenger, k is the index of the current passenger in question, M_{a_k,s_k} is occupation state of the seat at index (a_k, s_k), a_k is the aisle number of the k-th passenger, s_k is the seat letter of the k-th passenger, $M_{i,3}$ is the value at position $(i, 3)$ of the simulation matrix, and i is the aisle position of the passenger currently in question.