Institute of Systems Science, National University of Singapore

GRADUATE CERTIFICATE INTELLIGENT REASONING SYSTEMS PRACTICE MODULE REPORT

Itinerary Planning System

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1 EXECUTIVE SUMMARY

With the development of society and improvement of material life, more and more people are accepting and willing to travel regularly. Whether the purpose of traveling is for a short break or to explore the unknown, nobody wants to spend too much energy and time on the preparatory part such as itinerary planning.

In the era of fragmentation and mobile Internet, considering that users will prefer one-stop solutions to shorten the travel decision-making process as much as possible. The itinerary planning system is designed and developed for young users in the free travel market. There is an artistically designed, stylish, and user-friendly UI interface, which intuitively allows users to self-direct the entire travel process while having a deep experience.

Besides, personalized itinerary planning services are provided by the system. The generated itinerary planning proposal is mainly influenced by two factors: one is the shortest distance between the destinations selected by the user, and the other one is the travel time per day preferred by the user, which is indicated from the selected travel way. Just follow the process shown on the interface, choose the scenic spots to visit and the type used to travel, and then the user can easily generate a customized itinerary.

2 BUSINESS PROBLEM DESCRIPTION

Tourism plays an essential role in Singapore's economy. As reported in 2019, Singapore attracted more than 19 million visitors, and tourism revenue reached about 27.7 billion dollars, accounting for 5.4% of nominal GDP, even higher than that of construction and information communications.

Despite the fact that tourism was hit hardly in 2020 due to the coVID-19. According to news, on July 23, the Singapore Tourism Board, Singapore Enterprise Development Board and local tourism development companies jointly announced that they will spend 45 million dollars to launch the "Re-discover Singapore" campaign to boost the local tourism industry and respond to the impact of the new crown epidemic on the tourism industry.

Through this trend, it can be certainly predicted that with the gradual recovery from the epidemic, the foreseeable future year will be the time to revitalize the tourism industry. At the same time, it is undeniable that a number of tourism-related industries, such as technology-based applications of travel assistants, will welcome a huge development space.

2.1 BACKGROUND

With the rise of people's living standards, material and economic conditions are no longer restrict people to go travel. Travel gradually becomes an indispensable part of life for many people. Whether traveling around or traveling abroad, individuals are content to take time off work to explore the world. While Singapore's tourism market is in high demand, not only for its residents but also for many tourists from all over the world.

Itinerary planning is a necessary preparation before starting a trip. Traditionally, the public prefers to choose offline travel agencies and arrange their trips according to the

advice of professional travel planners. But most of these itineraries are patterned, easily transformed into stylized boring trips, like get on to sleep and get off to take pictures, which actually missing the true joy of travel. In addition, it is undeniable that shopping is often an indispensable part of the itinerary for the profit pursuit of travel agencies, whether or not the customers need it.

With the development of technology, more and more online tools have been widely accepted by people. However, in order to make a detailed schedule, the workload is huge and time-consuming. As a result, people are already exhausted before stepping out in great possibility. At present, there are still the following problems in travel itinerary planning:

(i) Travel guides are complex, travel notes of professionals vary, as a result, it is difficult for users to choose the best suitable one;

(ii) The current freewheeling offerings do give users too much freedom that they don't give users depth;

(iii) The price of customized itinerary products to meet the needs of different segments is relatively high, and ordinary people cannot afford them. In other words, personalization is not universal.

2.2 COMPETITIVE PRODUCT

There are a number of applications in the application mall that have the function of itinerary planning. As the Singapore government believes that the rapidly developing Asian economies are an important driving force for Singapore's next round of tourism growth. So we do a research about popular travel applications in China, which is Singapore’s second largest source of tourists, has great market potential. After experienced the top three among them, we list the following comparison results:

App Name	Advantages	Disadvantages

Mafengwo	It provides detailed guides, topic recommendations, and travel notes. Especially, it has hotel reservations service and ticket purchase channels.	It only enables users to collect and rank attractions, but not supports the itinerary planning and route.
Qyer	It develops a chat room function during the journey, which can provide a platform for real-time communication between travelers.	In the destination page, there are mainly tourism products, destination-related itinerary planning accounts for a too small proportion.
Bread Travel	It offers customized services of travel products, record in the form of travel notes, and a footprint tracking function, that can automatically form short videos for sharing after the trip.	Redundant functions and unclear positioning.

In conclusion, by comparing the relatively popular travel planning products on the market, it is found that they have different limitations. Some applications only provide scenic spots collection functions and neglect to provide itinerary planning services; some applications place too much emphasis on profitability, and the itinerary planning provided is too commercial and lacks depth.

2.3 PROJECT OBJECTIVE

Our itinerary planning system is designed and developed to help customize the itinerary according to individual needs. In particular, it focuses on two factors that mainly influence the itinerary planning: the distance between user-specified destinations and the travel time users plan to spend.

3 KNOWLEDGE BASE

3.1 TRADITIONAL PATH ALGORITHM AND HEURISTIC ALGORITHM

The traditional path planning algorithm (e.g., Greedy, Dijkstra) selects the nearest distance each step, which often gets caught up with the local optimal solution and fails to fetch the global optimal solution. Therefore, the best route cannot be obtained in the actual route planning. Another disadvantage is the high time complexity. The more complex the calculation, the longer it takes.

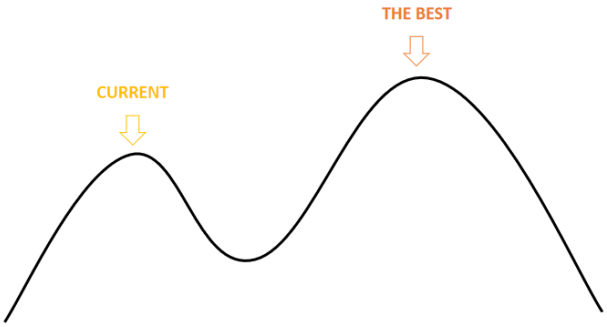

Figure 1

If you resolutely refuse to accept a worse solution, you will get stuck in the 'current position' in figure 1. If you accept a few worse solutions and move them to the valley, you can break through the local optimal solution and get the global optimal solution.

Heuristic Algorithm (Genetic Algorithm, Simulated Annealing) is to be able to find the optimal solution. And the more complex the situation, the better the time complexity. The disadvantage is that the optimal solution is not the best solution. According to the complexity of the path planning of our data, the best solution can be obtained in a short time.

3.2 BASIC IDEA OF SIMULATED ANNEALING ALORITHM

Simulated annealing is a kind of heuristic algorithm, which specifically studies the

process of metal heating and cooling in metallurgy. It was invented by S.Krkpatrick, C.D.Gelatt and M.P.Vecchi in 1983. V. Č ern also invented this algorithm independent in 1985.

How does the simulated annealing algorithm simulate the principle of metal annealing? The main idea is to apply the theory of thermodynamics to statistics, to think of searching for every point in space as molecules in the air; The energy of the molecule is its own kinetic energy; And searching for every point in space, like air molecules, carries "energy" to indicate how appropriate that point is to the proposition. The algorithm starts by searching for an arbitrary point in space: at each step, a neighbor is selected, and then the probability of reaching the neighbor is calculated from the existing location. If the probability is greater than the given threshold, it jumps to the "neighbor"; If the probability is small, then stay in the original position.

Simulated annealing is not only a heuristic algorithm, but also a greedy algorithm, but its search process introduces random factors. When iteratively updating the feasible solution, a solution worse than the current solution is accepted with a certain probability, so it is possible to jump out of the local optimal solution and reach the global optimal solution. As shown in the figure 2, assuming that the initial solution is the blue point A on the left, the simulated annealing algorithm will quickly search for the local optimal solution B. However, after searching for the local optimal solution, instead of ending at this point, the simulated annealing algorithm will accept the left move with A certain probability. Maybe after a few of these moves that are not locally optimal you get to the global optimum D, and then you jump out of the local minimum.

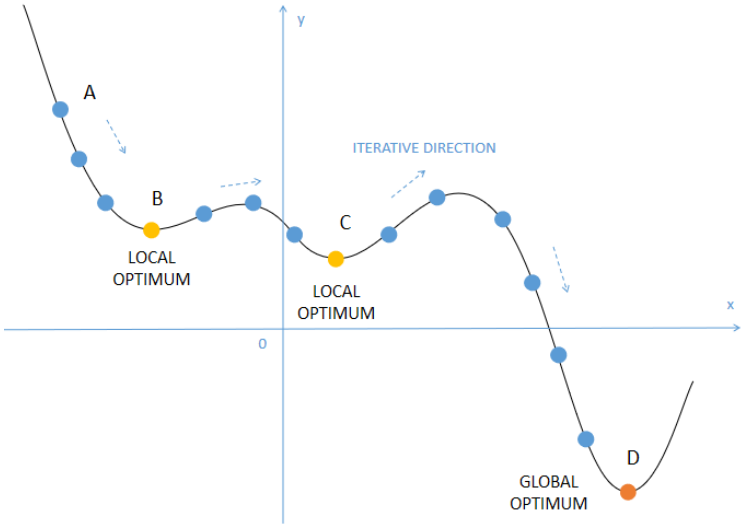

Figure 2

3.3 STEPS TO GENERATE AND ACCEPT NEW SOLUTIONS OF SIMULATED ANNEALING ALORITHM

The generation and acceptance of new solutions of simulated annealing algorithm can be divided into the following four steps:

(i) The first step is to generate a new solution in the solution space from the current solution by a generation function; In order to facilitate the subsequent calculation and acceptance, the time of algorithm is reduced. It is usually selected that the new solution can be generated by simple transformation of the current new solution, such as replacement and exchange of all or part of the elements that constitute the new solution, etc. It is noted that the transformation method of generating new solutions determines the neighborhood structure of the current new solutions, which has certain influence on the selection of the cooling schedule.

(ii) The second step is to calculate the difference of the objective function corresponding to the new solution. Since the objective function difference is generated only by the transformation part, it is better to calculate the objective function difference incrementally. It turns out that for most applications, this is the

fastest way to calculate the difference in the target function.

(iii) The third step is to determine whether the new is accepted, the basis of judgment is an accepted principle, the most commonly used accept rule is rule of Metropolis: if Δ T < 0 received S', as a new current solution S or otherwise probability exp (- Δ T/T) accept S' as a new current solution S.

(iv) The fourth step is to replace the current solution with the new solution when the new solution is confirmed to be accepted, which only needs to realize the transformation part corresponding to the new solution in the current solution and modify the objective function value at the same time. At this point, the current solution implements an iteration. The next round of tests can be started on this basis. When the new solution is judged to be discarded, the next round of test is carried on the basis of the original current solution.

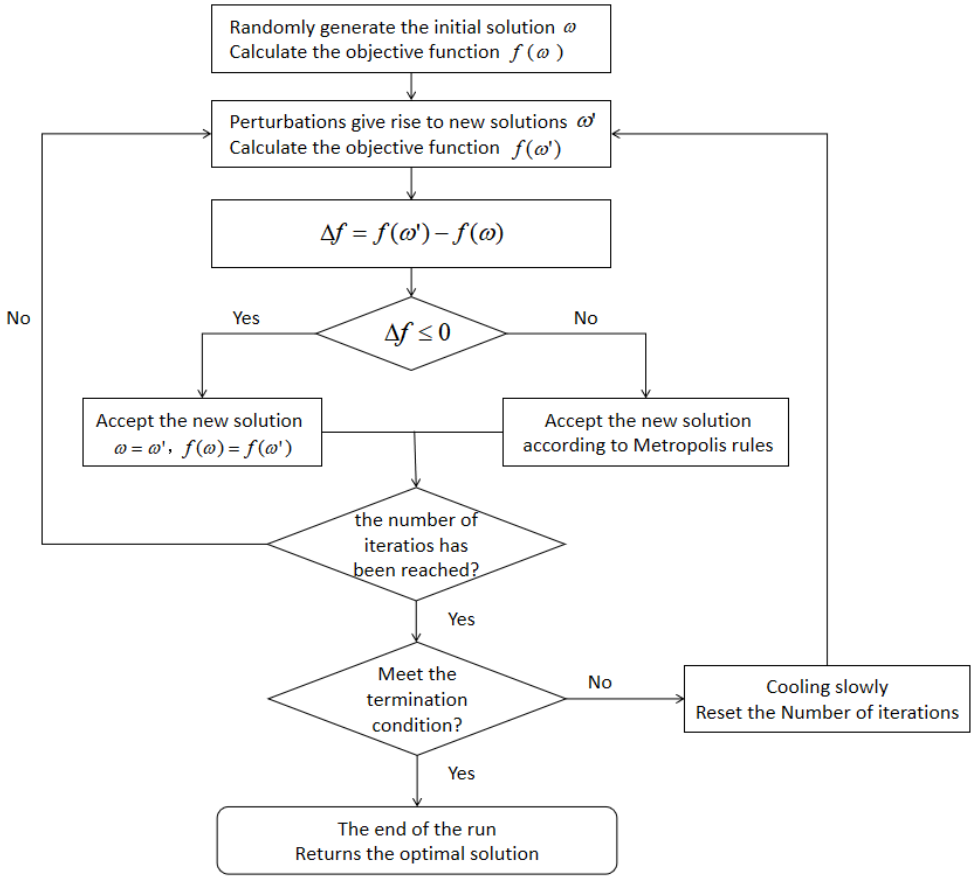

Figure 3: Flow chart of simulated annealing algorithm

4 SOLUTION OUTLINE

4.1 SYSTEM ARCHITECTURE (domain modelling & system design)

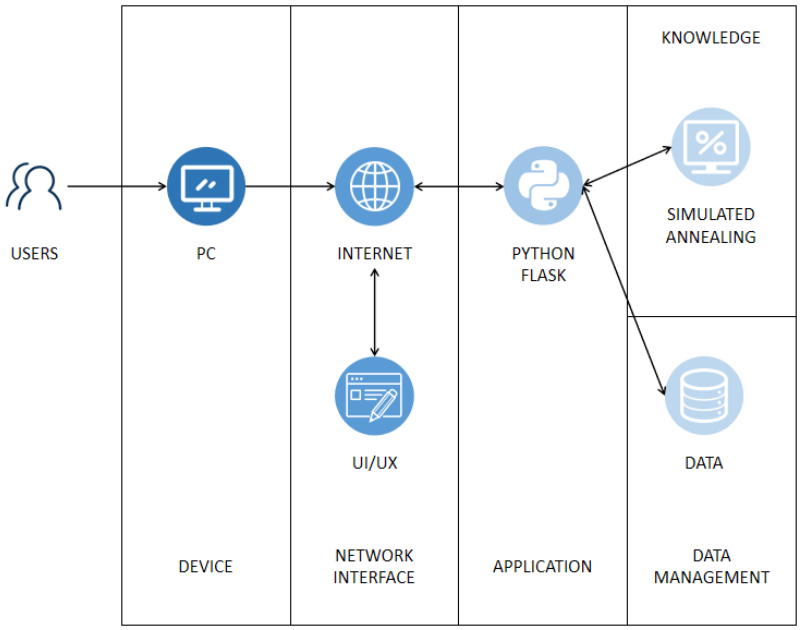

Figure 4: System Architecture

Our system is implemented using the Python programming language in the form of a Web-based graphical user interface that users can easily interact with. The system architecture diagram in the diagram illustrates how front-end applications relate to back-end rules-based systems and databases. The latter is to store location information mined digitally from the Internet

We mainly divided the system into three parts.

(i) We provide a number of scenic spots for users to choose the places they want to visit.

(ii) According to the scenic spots selected by users, simulated annealing method introduced in Part 3 is used to generate the shortest path through each scenic spot.

(iii) Display the image of the shortest path to the user. And according to the average visiting hours of the tourists every day, the recommended visiting plan is

also given.

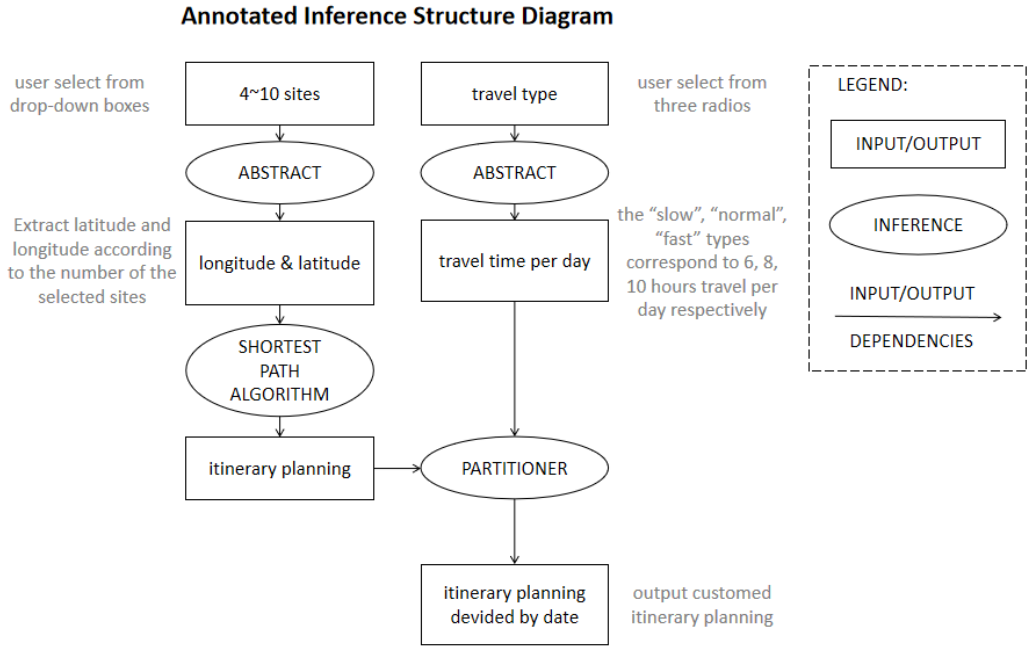

Figure 5: Annotated Interence Structure Diagram

4.2 SYSTEM IMPLEMENTATION (development & testing approach)

4.2.1 Users choose scenic spots to visit

We use the flask framework to build our Web system framework. In the front end, we use HTML to display the page. After logging in, users can select the scenic spots they want to visit in the selection box. Click the 'add Site' button to add a new selected city. Click the 'calculate' button to calculate the data to the back end after selecting it.

4.2.2 Calculate shortest paths in the background

The longitude and latitude information of corresponding cities can be obtained through n cities selected by the user. We store longitude and latitude information

in a dict. We will create an n * n distance matrix. Calculate the distance between two cities by their latitude and longitude. Stored in the corresponding position of the distance matrix.

Mark n cities from 0 to n-1. Randomly generate a sequence as the initial path sequence `route`. Calculate the total length of `total_dis` appearing in the path sequence by the distance matrix. Define a best path variable and assign `route` to `Best`. Define a shortest path total distance variable `best_total_dis` and assign `total_dis` to `best_total_dis`.

Enter the simulated annealing algorithm.

(i) Initialization temperature `T0` and end temperature `Tend`, the number of iterations `L`, temperature attenuation coefficient `a`, initialize a path `route`, and calculate the initial distance `total_dis` (We define T0= 30, Tend=1e-8, L=50, a =0.98)

(ii) while t > Tend

(iii) for rt2 in range(L)

(iv) Generate the new path solution, calculate the new path total distance `new_total_dis`, compare `new_total_dis` with the previous total distance `total_dis`

(v) if delt = `new_total_dis` - `total_dis` <= 0, accept `new_total_dis` as the new current solution; otherwise accept `new_total_dis` as the new current solution with probability exp(-delt/T)

(vi) t times the temperature decay coefficient gradually decreases, t = t*a until the termination condition t<Tend, output the current solution as the optimal solution, end the program

4.2.3 Calculate and get a recommended tour plan

We checked the recommended visit time of each scenic spot from the Internet and stored it in a dict. In the previous step we obtained the sequence information of shortest paths. Traverse the shortest path city and calculate the recommended travel information of each day according to the daily visit time entered by the user and the recommended visit time of each scenic spot.

4.2.4 Return the shortest path information and recommended tour plans

Draw a path diagram according to the shortest path information, normalize the recommended travel information obtained in the third step, and return them to the front-end interface for display to the user.

4.3 SYSTEM'S PERFORMANCE & VALIDATION

The application scenario is shown in the figure.

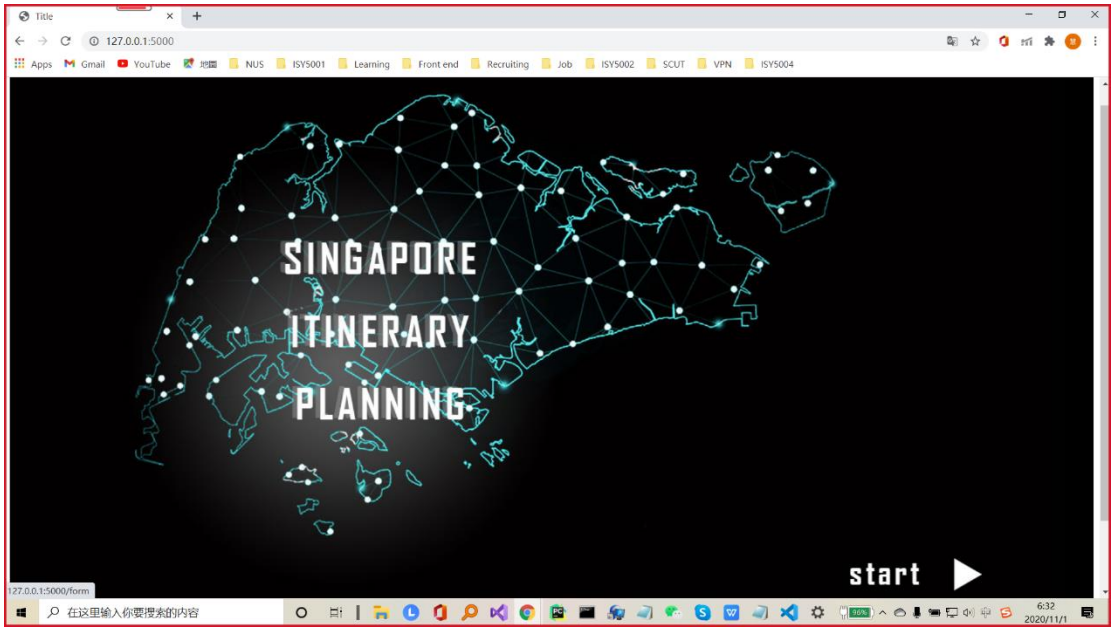

Figure 6: Welcome page

Firstly, the user selects five places to visit. Then he clicks “next” button to the next page and chooses the “normal” type to travel, which indicated that the user would like to travel 6-8 hours every day.

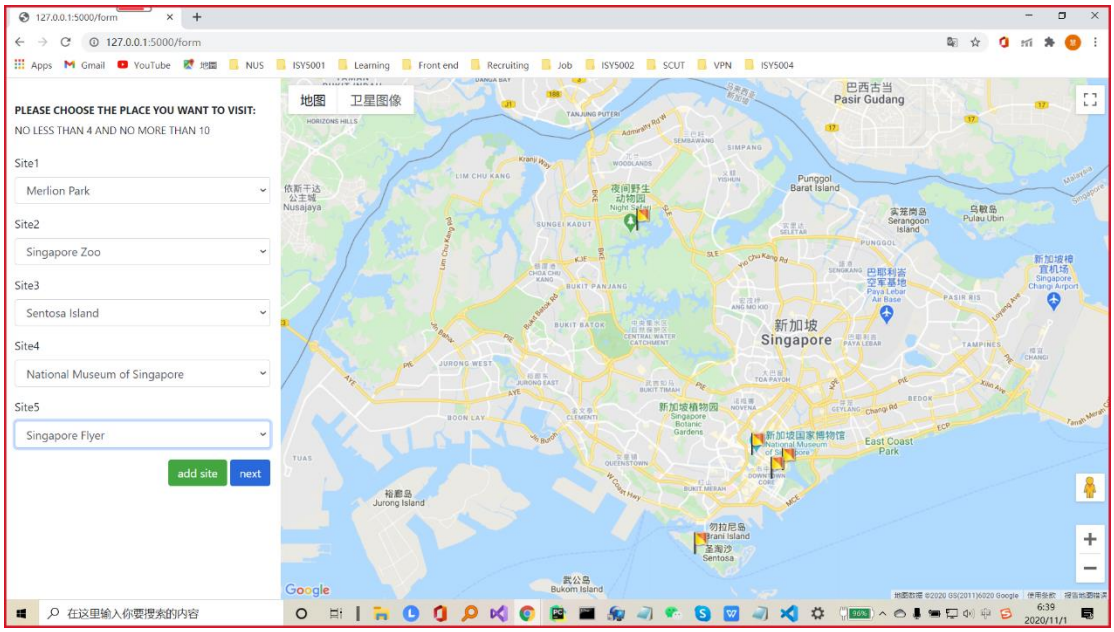

Figure 7: User Selection Page 1

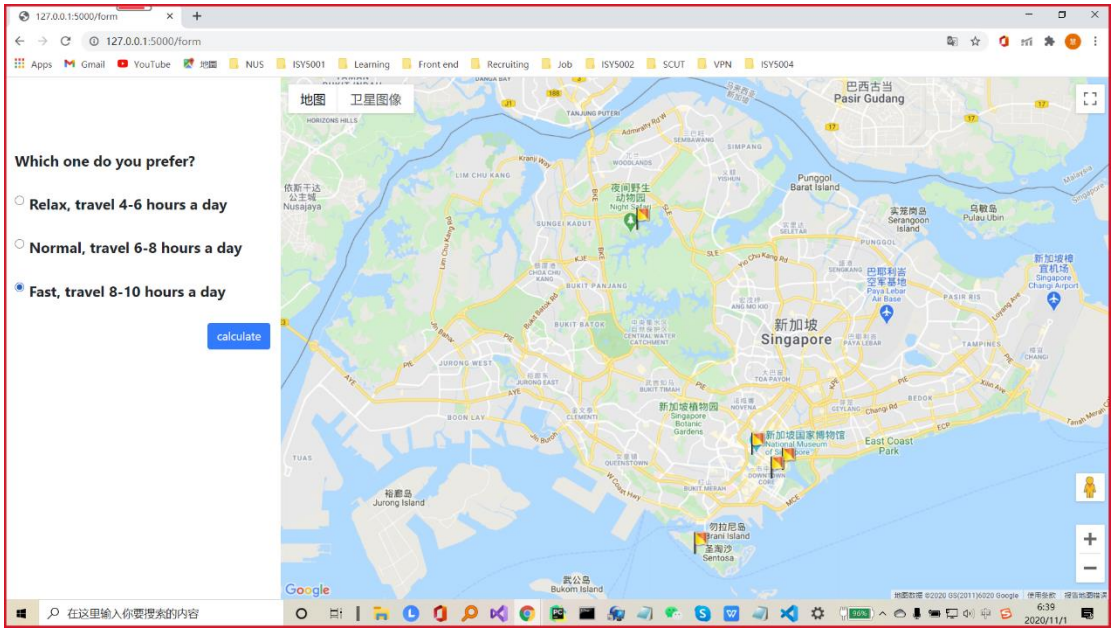

Figure 8: User Selection Page 2

Finally, the user successfully receives a copy of customed itinerary planning.

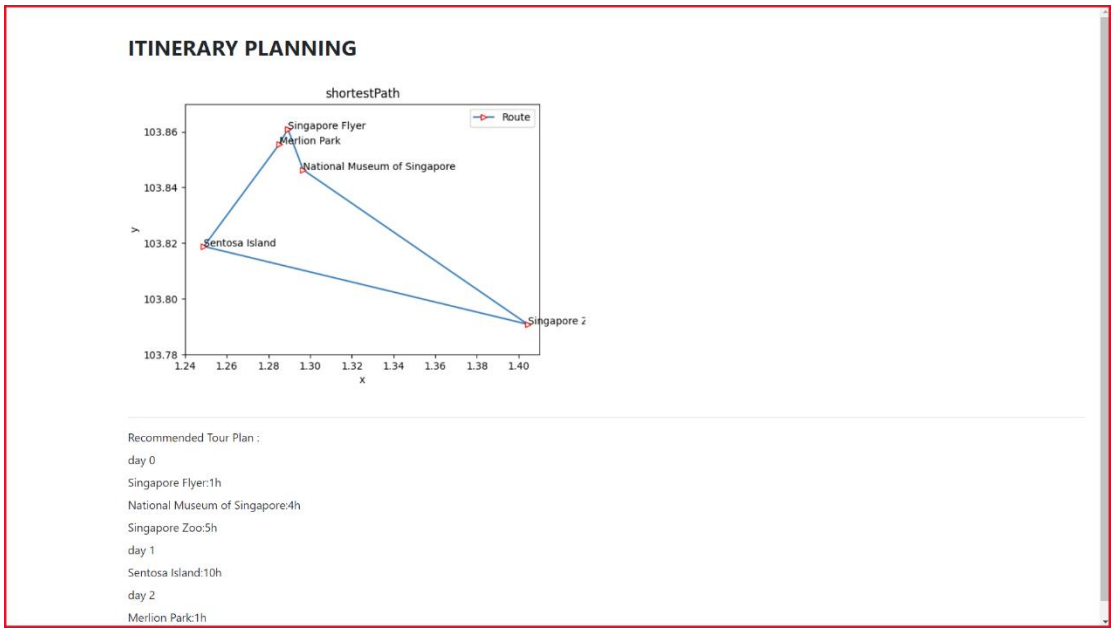

Figure 9: Result Page

4.4 LIMITATIONS

Compared with other travel apps on the market, the shortcoming of our system is the lack of social functions. For young users, it is very natural to share on varies social applications after receiving a customized itinerary. The addition of social functions will undoubtedly greatly increase user stickiness. Additionally, the system's introduction to the scenic spots as well as the food and hotels nearby are not detailed enough. The data collected by our database is not complete due to the time.

5 CONCLUSION & FINDINGS

Our team had a great time on the project and really gained useful skills along the way. The most important thing in our system is the shortest path search algorithm. We have tried traditional algorithms (dijkstra, greedy algorithm, etc.). Heuristic algorithms (such as genetic algorithm, simulated annealing, etc.) have also been tried. The traditional algorithm is not used because the traditional greedy algorithm will lead to the local optimal solution problem.And the reason I didn't use the other heuristic, the genetic algorithm, is that it takes more time to get good results with the genetic algorithm than with the simulated annealing. This made our project much less useful and easier for users to use.

Knowledge gathering is a important part of the process. Without a reliable knowledge base, it is impossible to build a system based on all the rules. Our team now has a better understanding of the common ways to build the knowledge base, and we mainly use the survey method in our project. Investigations allow us to see the problem more fully and more quickly.

5.1 IMPROVEMENTS

If we had a longer time to work on this project, we would make improvements in the following aspects:

1) We will compare distances based on actual distances rather than just longitude and latitude. The actual distance between two attractions will be affected by road conditions, emergencies and many other factors. By collecting more road information, we can better calculate the actual distance between two scenic spots

2) According to the generated shortest path, we will recommend to users

some hotel or other places on the way that users may need. If the user wants to visit for several days, we can provide the user with some hotel information between the two scenic spots, so that the user can complete his journey more conveniently. Of course, this also requires us to collect more knowledge and information.

6 Appendix: Project Proposal

Date of proposal: 1 November 2020
Project title: Itinerary Planning System
Sponsor/Client: Self-sponsored project
Background/Aims/Objectives: With the gradual recovery from the epidemic, the foreseeable future year will be the time to revitalize the tourism industry. At the same time, it is undeniable that a number of tourism-related industries, such as technology-based applications of travel assistants, will welcome a huge development space. By comparing the relatively popular travel planning products on the market, it is found that they have different limitations. Some applications only provide scenic spots collection functions and neglect to provide itinerary planning services; some applications place too much emphasis on profitability, and the itinerary planning provided is too commercial and lacks depth. Our itinerary planning system is designed and developed to help customize the itinerary according to individual needs. In particular, it focuses on two factors that mainly influence the itinerary planning: the distance between user-specified destinations and the travel time users plan to spend. Just follow the process shown on the interface, choose the scenic spots to visit and the type used to travel, and then the user can easily generate a customized itinerary.
Requirements Overview:

- Knowledge of database
- Hands-on programming skills in JavaScript, HTML, CSS and Python
- Knowledge of Web API services
- Knowledge of web application framework like flask
- Knowledge of varies shortest path algorithm, such as simulated annealing

Tasks and Methods:

- Collect the required data and build a database
- Construct the system framework
- Back-end knowledge base and algorithm
- Front-end graphical user interface design

7 Appendix: Mapped System Functionalities against knowledge, techniques and skills of modular courses: MR, RS, CGS

Function	Introduction	Usage
Informed Search Techniques (simulated annealing algorithm**)**	Simulate Anneal Arithmetic (SAA) is a general probability algorithm used to Simulate the optimal solution of a proposition in a large search space. Simulated annealing was invented by S.Krkpatrick, C.D.Gelatt and M.p.Vecchi in 1983. And v. Č erný It was also independently invented in 1985. Simulated annealing algorithm is one of the effective methods to solve TSP problem.	Simulated annealing algorithm is widely used to solve Max Cut Problem, Zero One Knapsack Problem, Graph Colouring Problem, Scheduling Problem, and so on with high efficiency. In our system, simulated annealing algorithm is used to find the shortest total path length of multiple target locations
Knowledge Acquisition and Representation	Knowledge Acquisition is the transfer and transformation of problem solving knowledge into a form that can be used to build intelligent systems. Knowledge representation in machine (white box): A scheme/method that allows the computer system to use or manipulate it to reason and solve problems	We form our knowledge base through knowledge acquisition. We use the method of investigation to acquire knowledge and build a relatively complete knowledge base belonging to our system. The knowledge base is used to deal with the needs of different users. To provide more convenient services for users' life and travel

8 Appendix: Installation and User Guide

Code: https://github.com/nus-iss-pm-group-6/ShortestPath.git

1. Find the file sia.py, line 28, save_path variable under the folder shortestWay/SA/, and change it to the address of the user's server
2. Run the *app.py* file in your project, and the flask project will start.
3. Open a browser and input url : *localhost:5000* in the address bar to jump to the main page

9 Appendix: Individual Project Report

Your name	**LIN Yinglin**
Your personal contribution to the project	a) Project design and market research b) Report and video presentation c) Web front-end development
What you have learnt from the project	What is most significant for me is how to evaluate the business value and define user portrait when we determine the scope of the project. Besides, the practice of building the knowledge base to solve the problem brings me a new way to thinking and analyze logically and systematically. Last but not least, I learn a lot from my teammates. From the perspective of technology, they show me various ways to connect the front-end and the back-end in a project. Moreover, their good communication skills and time management skills are what I lack currently, which are very important for online team works.
How you can apply this in future work-related projects	In this project, it is a valuable experience to do research and think about tourism products. This kind of product has certain commercial value and development prospect, which can be considered in the product design works. In addition, knowledge base could be used to solve logic problems in future work-related projects.

Your name	**Song Bingheng**
Your personal contribution to the project	a) Data collection (Latitude and longitude information and tour time information) b) Back-end development (Algorithm, generate result image and recommended tour plan) c) Front-end development
What you have learnt from the project	Our project is mainly about path search algorithms. In this practice, we experiment with traditional algorithms (such as Dijkstra algorithm). Genetic algorithm and simulated annealing are also tested. Through the practice and comparison of different search path methods, I have a more profound understanding of the algorithm principle and use of genetic algorithm and simulated annealing method. It helped me consolidate the relevant knowledge in class, and also provided help for my future study and work development. Knowledge gathering is also an important part of this process. Without a reliable knowledge base, it is impossible to build a system based on all rules. I have a better understanding of the common methods of building a knowledge base, and I mainly use the survey method in our projects. Investigations allow us to find problems more fully and more quickly.
How you can apply this in future work-	Simulated annealing algorithm is widely used to solve the maximum cut problem, zero one knapsack problem, graph coloring problem, scheduling problem and so on. In my future work and life, the path search algorithm is a very common algorithm, often using relevant

related projects	knowledge. The knowledge base resume is also a very important part in the future study and work. Without sufficient knowledge base, users' needs cannot be more accurately understood in the development process of the system. In the process, I learned a lot of ways to set up a database, which made me complete the project better in the future.

Your name	**Xiong Hui**
Your personal contribution to the project	a. Project idea proposer and System design b. Web front-end development c. Project manager d. Report and Video manufacture
What you have learnt from the project	What learnt is most useful include two points: a. Because I am a person who likes to travel around at my spare time, It's very tiring for me to make travelling plan every time I go for a trip. However I couldn't find a simple application can meet my need. So I come out an idea about developing an itinerary plan system to help those who are stuck into making travelling plan and decision. Thanks for the learning journey of intelligent reasoning system, it helps me to know how to construct an intelligent system and bring my idea to reality. And let me know business problems most come from practice and daily-life, we need to keep sharp-eyed about daily life even a small need, which may bring large profits someday. b. Due to the covid-19, our team members are at different place, it's hard sometimes to work together sometimes, but we overcame it and cooperated with each other. I found everyone has their characteristics, someone may talk less, but they may do more. We can arrange tasks according to different characters. Active people can do well in design and idea while talk-less people can help project land. It's important to help everyone to play their role in the project, which can make project more perfect.
How you can apply	First of all, with the knowledge of intelligent reasoning system, I know how to design, develop and deploy an intelligent system in real life

this in future work-related projects	which can help me offer more values in work. Second, with the experience of manage a project, I know how to organize people effectively to reach our goals and perfect project.

Your name	**Zuo Zongyuan**
Your personal contribution to the project	• Collect and build the Knowledge Base • System architecture design • Project report
What you have learnt from the project	I've learnt how to apply the previous learnt knowledge to practical projects in order to solve real-world problems. Besides, I also gained the experience of collecting and building the knowledge base, and combine with Genetic Algorithm to get the optimum solution. What's more, I get to know the basic methods to design a complete system. I think the most important thing is to co-work with my teammates, and I've learnt a lot from them.
How you can apply this in future work-related projects	I will apply my experience in this project to build a better knowledge base in further projects. I'm already aware of a well-structured and clear designed knowledge base can help in machine learning. Besides, I can new better break down the problem to genomes and use Genetic Algorithm to solve it.

10 Appendix: References

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heuristic-algorithm

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