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Tourism Route Optimization for Portland, Oregon

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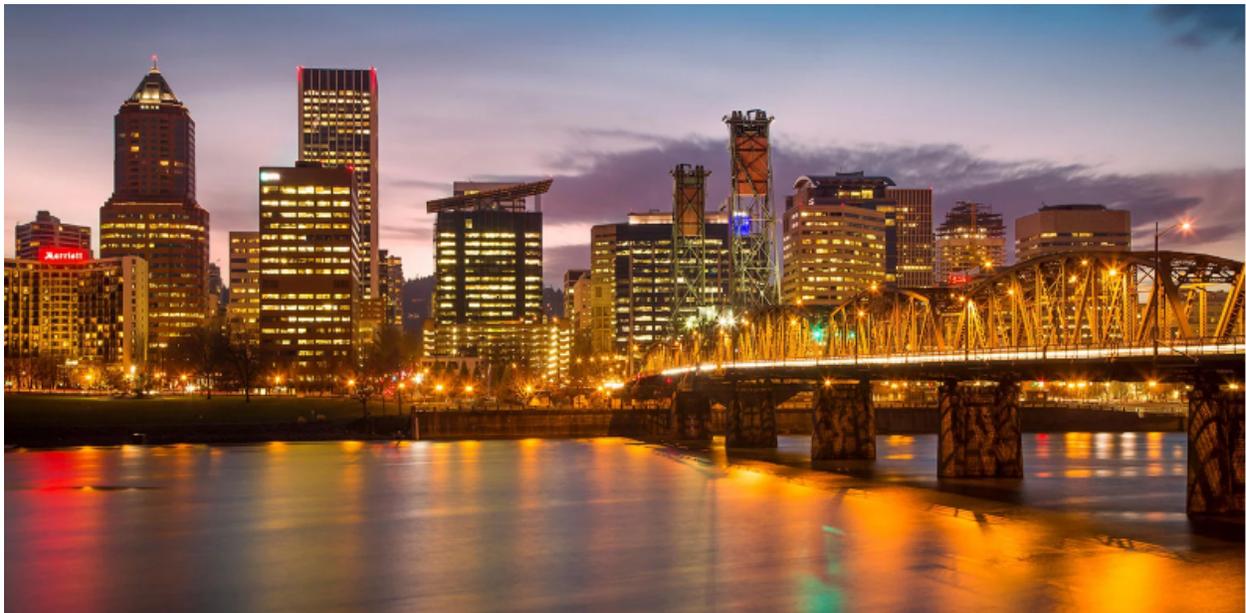
Murray, Duane; Thawab, Mohammed; Binmahfood, Adnan; Zaid, Mohammed; and Owens, Colin, "Tourism Route Optimization for Portland, Oregon" (2021). *Engineering and Technology Management Student Projects*. 2315.

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Tourism Route Optimization for Portland, Oregon



Course Title:	Operations Research
Course Number:	ETM 540/640
Instructor:	Dr. Timothy Anderson
Term:	Fall 2021

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Abstract

The city of Portland, Oregon has experienced an unprecedented reduction in tourism due to the COVID-19 pandemic. This reduction in tourism has had a negative impact on all businesses in the area. This paper provides a methodology and tool that can be used to help local businesses potentially gain patrons, and at the same time help visitors in maximizing their time while minimizing costs. when visiting the city after the pandemic abates. To accomplish this, first, an itinerary of selected attractions are filtered by the visitor. Next, a linear programming method using a travelling salesman problem (TSP) algorithm is implemented to minimize travel costs for tourists. The user interface (UI) for this tool uses the programming language “R” and the “shiny” library to graphically display a list of selected attractions in a web browser, including input filter sliders, a map showing the location of each attraction, and generates a plot showing the optimal path that a tourist should take to visit each attraction.

Executive Summary

In the 21st century’s world of technology, finding unique places to travel should be easy. However, it is often a hassle to find enough clear information to make a simple itinerary in these desirable destinations. In addition to this, the pandemic has diminished traveling/tourism tremendously, along with numerous other reasons throughout the world. However, that is all about to change in Portland, Oregon, United States. Tourbella Travel Company, located in Portland, Oregon, has initiated a collaboration with our consulting firm to design an optimal method for traveling and touring itineraries in Portland. There will be over 51 locations available for the traveler or tourist to evaluate the best experience. Tourism Route Optimization for a Portland, Oregon Itinerary will consist of the traveler or tourist’s specific requests and information such as the financial requirements, activities, timeframe, distance, and more to model and formulate an ideal itinerary fit for any type of group, with any type of budget. The itinerary uses features from RStudio and Shiny to evaluate specific variables, constraints, and objectives to define the ideal outcome and represent those outcomes simply and effectively to the traveler or tourist. Determining the optimal itinerary uses linear (continuous) and nonlinear (non-continuous) functions, summations between upper and lower bounds with certain variables to find the minimum and maximum information, all being subject to certain constraints. The traveler or tourist will be able to evaluate how to best spend their time, money, and experiences all in a safe, efficient, and straightforward manner, saving them time to have fun on their trip instead. Furthermore, by integrating research, applications such as RStudio & Shiny, planning, mapping and scheduling into one single platform, this allows our collaborative company to create revenue and opportunity by increasing demand for local businesses, thereby improving tourist satisfaction by providing a link to Portland’s historical destinations, activities within, and attractions sure to capture anyone’s interests.

Introduction

The Portland Ideal/Optimal Travel Itinerary wants to bring travel back to Portland in a safe, efficient, friendly, and interesting way. The itinerary will be using a model to evaluate and identify from the traveler/tourists input such as activities, attractions, and approximate locations. The client will provide an estimated budget, their time/availability, areas of interest, and then the model will be generated for specified time in Portland with the ideal routing. The itinerary will provide the activity, the associated fees, the distance between attractions/events, and potentially optional transportation methods. The entire itinerary is designed to meet the needs of any tourist or client by including as many entertainment venues, sight-seeing, and events within Portland's boundaries as possible with respect primarily to time management.

Traveling can be stressful and time consuming, both of which take away the fun of being in a new city. Moreover, being in a new city can require a lot of research to organize entertainment, transportation, and time for events for each day. Tourbella Travel Company has set up a dedicated service to meet the needs of tourists in Portland, Portland to reduce the stress of traveling. The service connects all the processes, requirements, needs, and resources for clients, optimizing travel for convenience.

Tourbella Travel's service utilizes a "Shiny Application" to build itineraries for clients/tourists. Once the client provides an estimated budget, time frame, and attraction selections, the model will generate an itinerary for each day they will be in town. The itinerary will provide the activity, the associated fees, the distance between attractions/events, and potentially optional transportation methods. The entire itinerary is designed to meet the needs of clients by including as many entertainment venues, sight-seeing, and events within the Portland metro-area as possible with respect primarily to time management.

Prioritizing the time and budget optimizes the travel routes and destinations accordingly. Through this model the client will maximize their trip and have higher satisfaction that their needs were met without comprising time and energy on their behalf. The entire purpose of cooperating with Tourbella Travel is to have an enhanced experience. When considering travel, people do not often return to a destination; therefore, doing the most throughout the trip for sightseeing and immersing into the culture is the key to leaving without feeling disappointed.

Milestones

Throughout the collaboration process with Tourbella and our consulting firm, we aligned on multiple milestones to successfully identify a process where we can measure the status of the project. By identifying the appropriate milestones for each section of the project represented a well-defined plan to achieve quality excellence. Our firm consulted internally to determine these milestones so we would like a focused plan and goals throughout the project. Once finalized our firm engaged with Tourbella to receive feedback and modify the milestones so both

parties had complete alignment. Through that extensive discussion, both parties resulted in the following Milestones.

In the first stage, the scope for our travel region was assigned and bound to the specific region of the United States being Portland Oregon. The success criteria needed to be identified such as the budget, timeframe, attractions, distance, transportation, and a selectable itinerary. With these different factors the risks associated needed to be identified which are what is the access due to COVID-19 and the traveler/tourists' willingness to travel. The second stage is built off the first stage, decisions where research and data collection will be conducted in Portland to understand different criteria for all travel/tourist locations. The region of Portland is vast where we need to identify the ideal locations and then reduce the data set to the desired location of our customer. Through the specific data collected the success criteria can be associated with each attraction. In the third stage, the early model starts to form through the variables and constraints by developing a decision-making process with the identified boundary and criteria. The fourth stage continues the development of the early model with the implementation of RStudio to integrate our data, constraints, variables, and objectives with RMD (R Markdown). The fifth stage starts the preliminary development of the Shiny interface and the RStudio model. In this stage, the user interface needs to be recognized and simplistic with the itinerary model to the Shiny interface. The sixth stage finalizing the entire model and integrating it into the Shiny interface. All data will be reviewed with Tourbella to finalize the data set which will then be integrated into RStudio. Then the connection between the RStudio model will have the conclusion incorporated into the Shiny interface for user usage. The final Seventh stage will compile a complete guide for the Tourbella travel company and the future travelers/tourists.

Successful planning achieves quality excellence. Identifying the appropriate milestones would compliment the success of this project. Extensive discussions among the team members had resulted in the following milestones:

- 1) Identify travel by focusing on the following domains:
 - a) Scope: City of Portland is the boundary.
 - b) Success Criteria: Identify budget, timeframe, attractions, distance, transportation and selectable itinerary.
 - c) Risks: Access due to COVID-19 and traveler/tourists willingness to travel.
- 2) Research & Collect data of locations.
 - a) Base understanding and initial data set.
- 3) Develop Variables & Constraints.
 - a) Travelers/Tourists
 - i) Budget, time/availability, interests, and selections.
 - b) Locations/Attractions

- i) 51 locations were included.
 - ii) Type/classification.
 - iii) Operating hours.
 - c) Costs
 - i) Admission, & Travel (distance).
- 4) Develop initial Model with RStudio.
 - a) Integrate data: Produce an executable RMD and produce PDF files.
- 5) Develop Shiny Interface with RStudio Model.
 - a) Integrate Itinerary model with a “Shiny” interface.
- 6) Final integration of Model then integration with Shiny interface.
 - a) Finalize all data for model in RStudio.
 - b) Connect Itinerary Model with Shiny interface.
- 7) Compile a complete guide for Tourbella Travel Company and the future Travelers/Tourists.
- 8) Produce a complete interactive solution.

Data Collection

Database

In the data collection process, research and data is defined in order to correlate with the scope and criteria for all travels/tourists' locations in Portland, Oregon. The area of Portland is tremendous where we really want to recognize the best areas, and afterwards, diminish the informational index to the ideal area of our client. Through the data collection process, all sources were identified with Google Maps [5], Travel & Leisure [1], Travel Portland [7], Travel Alerts [6], and Tourbella database. These diverse sources helped derive the utmost ideal and optimal locations for all travelers/tourists, with the criteria implemented to determine budget, timeframe, attractions, and distance. The locations were sourced through these data sites by determining the travel restrictions, widely known and concealed locations, hours of operation, addresses (latitude and longitude), and the cost. Each variable provided would be applied into the model to help identify the ideal travel itinerary for the user. The latitude and longitude will help determine the local positioning throughout the Portland area and obtain the optimal route of destinations. These different locations will also be identified by the operation hours in military time to understand the possibility and sequence these attractions can be visited. The attractions cost will be the final characterization identified from these sources to quantify the user's budget. The data set can be identified in Figure 1 and in Appendix A.

Attraction	Cost	Attraction Address	Open Time	Close Time	Latitude	Longitude	Classification
International Rose Garden	2.00	400 SW Kingston Ave, Portland, OR 97205	1000	1530	45.520432	-122.706772	eco, scenic, adventure
Japanese Garden	16.95	611 SW Kingston Ave, Portland, OR 97205	500	2200	45.518139	-122.708771	eco, scenic, adventure
Oregon Zoo	24.00	4001 SW Canyon Rd, Portland, OR 97221	900	1730	45.50928256	-122.7159482	eco, scenic, adventure
Pittock Mansion	12.00	3229 NW Pittock Drive, Portland, Oregon	1000	1600	45.52540223	-122.7163622	architecture, history
Powell's City of Books	5.00	1005 W Burnside St, Portland, OR 97209	1000	2100	45.52320581	-122.6813512	shopping

Figure 1: Sample Data Set

RStudio Function

Data Filters

To provide the best possible visitor experience, the tourist/traveller has the ability to filter the attractions they are interested in before generating their itinerary. Several selection areas are given (Figure 1) to the visitor that include the budget for each attraction, the areas of interest (Figure 2), specific tourist attractions they would like to see (Figure 3), and the start & end times of day they are available for touring.

What is your budget per location?:
 0 50

Choose the areas that you are interested in:
 History Scenic Landmark

Choose Specific Locations:
 International Rose Garden

Start Time (24 Hr)?
 0 900 2,400

End Time (24 Hr)?
 0 1,800 2,400

Reset RUN MODEL

Figure 1: Main data filter panel

Choose the areas that you are interested in:

- Art
- History
- Adventure
- Scenic
- Sports
- Foodie
- Music
- Shopping

Figure 2: Areas of interest

Choose Specific Locations:

- International Rose Garden
- Japanese Garden
- Oregon Zoo
- Pittock Mansion
- Powell's City of Books
- Oregon Musume of Science and Industry
- Lan Su Chinese Garden
- Forest Park

Figure 3: Specific locations to visit

These filters are used to limit the list of possible locations included in the dataset (Appendix A) to only those that the visitor is interested in. Additionally, by reducing the dataset through this filtering, the system will only need to process locations that are specific to the traveler. This is important, as the solver runtime will also be reduced with a smaller refined dataset rather than processing the full list of visitor attractions available in the area.

The filtering process uses the input provided by the visitor first through reducing the list of locations as follows:

1. Budget: only include locations that cost less than or equal to the dollar value selected for entry to the venue.
2. Interest Areas: only include locations that match the visitors interests, such as art, history, scenic areas, sports, or music.
3. Specific Locations: be sure to include these attractions in the itinerary.
4. Start Time: the time of day (24 hour clock) to begin the tour. This is matched to the opening time of the venue.
5. End Time: the time of day (24 hour clock) to end the tour. This is matched to the closing time of the venue.

Once the visitor has set up the criteria of the attractions they would like to visit in the main data filter panel (Figure 1) there are two options they can take. First, the data filtering and dataset can be reset to default by clicking on the “Reset” button. This will clear all of the filter settings they have entered and allow the visitor to effectively start over. The second option is the click on the “Run Model” button, which will then pass the filtered dataset to the optimization model for processing and output.

Model

The model consist of three parts: objective, variables and constraints:

- 1) Objective: The main goal is to look for the shortest & cheapest distance tour where a tourist/user can take (within his/her budget limit). Therefore, mathematically, the objective is to “Minimize” the cost of visiting all of the user selected attractions, by computing and displaying a map showing the route that the user will need to take to hit all of the attractions within the same day.
- 2) Variables: There are two major variables used in the model, the decision variables and the auxiliary variables. First, the decision variables used are binary, either 0 or 1 is assigned for every movement between attractions. Second, auxiliary variables, the use of auxiliary variables, is to eliminate the formation of sub-tours or sub-branches. The auxiliary variables idea has been taken from the Miller-Tucker-Zemlin (MTZ) formulation for Traveling Salesperson Problem (TSP) [8], this approach will be explained more in Constraints section.

3) Constraints: Given the goal is to minimize the cost of visiting all of the user selected attractions...eq (1), this is subjected to the following constraints:

1. Decision variable to avoid going to the same attraction more than once... eq (3)
2. Decision variable to avoid leaving from each attraction more than once... eq (4)
3. Inequality to eliminate the formation of subtourseq (5-6)

$$\min \sum_{i=1}^n \sum_{j=1, j \neq i}^n c_{ij} x_{ij}, \quad (1)$$

subject to (2)

$$\sum_{i=1, i \neq j}^n x_{ij} = 1, \quad j = 1, 2, \dots, n, \quad (3)$$

$$\sum_{j=1, j \neq i}^n x_{ij} = 1, \quad i = 1, 2, \dots, n, \quad (4)$$

$$u_i - u_j + n x_{ij} \leq n - 1, \quad 2 \leq i \neq j \leq n, \quad (5)$$

$$x_{ij} \in \{0, 1\} \quad i, j = 1, 2, \dots, n, \quad i \neq j, \quad (6)$$

$$u_i \in \mathbb{R}^+ \quad i = 1, 2, \dots, n. \quad (7)$$

The constraints goal is to avoid going into the same attraction twice, eq (3) , value of 1 will be assigned for the decision variable only once for going from attraction i to j , and also avoid leaving from each given attraction twice, eq (4), value of 1 will be assigned for the decision variable only once for leaving from attraction j to i. Both assure that the user visits the attraction only once. Moreover, eq (5) is used from MTZ mathematical modeling to introduce auxiliary variables u_i & u_j , and an inequality to avoid the scenario of spinning in a sub-tour, since the model can falsely consider that meeting the objective of minimizing distance. So this inequality basically restricts the formation of subtours by simply (a) forcing the connecting lines between attractions to be less than the number of attractions (b) Added to the constraints above, the formation of one tour -covering all possible attractions only once- will be achieved where the starting point ($n = 1$) is also the end/returning point after going thru all the attractions in the tour.

Moreover, the below snapshot depicts the implementation of the model using the pipeline modeling approach. The variables are defined per section described above, objective function is stated, upper boundaries and constraints are listed. Finally, the auxiliary variables are defined in terms of constraints to restrict the formation of sub-tours. Following that is a solver output example running in the back-end after inputting data in the shiny web interface. The solver output shows multiple iterations before the model finds an optimal solution, that is, showing the minimum cost route computed from the user's input. It's important to note that with more attractions, the computing time increases and solver takes longer to output the optimal solution.

Solver Output

```
<SOLVER MSG> ----
GLPK Simplex Optimizer, v4.47
110 rows, 110 columns, 434 non-zeros
  0: obj = 0.000000000e+000 infeas = 2.900e+001 (20)
* 33: obj = 6.330454497e-001 infeas = 0.000e+000 (1)
* 69: obj = 3.167798650e-001 infeas = 0.000e+000 (1)
OPTIMAL SOLUTION FOUND
GLPK Integer Optimizer, v4.47
110 rows, 110 columns, 434 non-zeros
100 integer variables, 90 of which are binary
Integer optimization begins...
+ 69: mip = not found yet >= -inf (1; 0)
+ 148: >>>> 4.996273681e-001 >= 3.167798650e-001 36.6% (14; 0)
+ 397: >>>> 4.526822905e-001 >= 3.220483160e-001 28.9% (45; 3)
+ 622: >>>> 4.455384654e-001 >= 3.319341214e-001 25.5% (56; 24)
+ 741: >>>> 4.384969367e-001 >= 3.363095062e-001 23.3% (76; 26)
+ 808: >>>> 4.361455110e-001 >= 3.377665005e-001 22.6% (75; 41)
+ 926: >>>> 4.333828851e-001 >= 3.407352244e-001 21.4% (79; 43)
+ 1076: >>>> 4.290673584e-001 >= 3.457748678e-001 19.4% (83; 51)
+ 1109: >>>> 4.276667211e-001 >= 3.480159754e-001 18.6% (81; 56)
+ 1389: >>>> 4.226668704e-001 >= 3.605866704e-001 14.7% (96; 64)
+ 3121: >>>> 4.218521083e-001 >= 4.115670579e-001 2.4% (42; 286)
+ 3304: mip = 4.218521083e-001 >= tree is empty 0.0% (0; 485)
INTEGER OPTIMAL SOLUTION FOUND
<!SOLVER MSG> ----
```

Shiny Interface

The visitor is provided with a user-friendly web enabled “shiny” interface to select the tourist attractions they are interested in seeing, and to obtain the optimized itinerary route to follow (Appendix B). Shiny is a library that was chosen to be used within RStudio to build the user interface elements for this optimization application. This includes the filtering elements, such as slider and pull-downs. The interface accommodates the data filtering area, a map display showing all selected locations, a list of these locations, and the final optimized travel path output map on one screen (Figure 4).

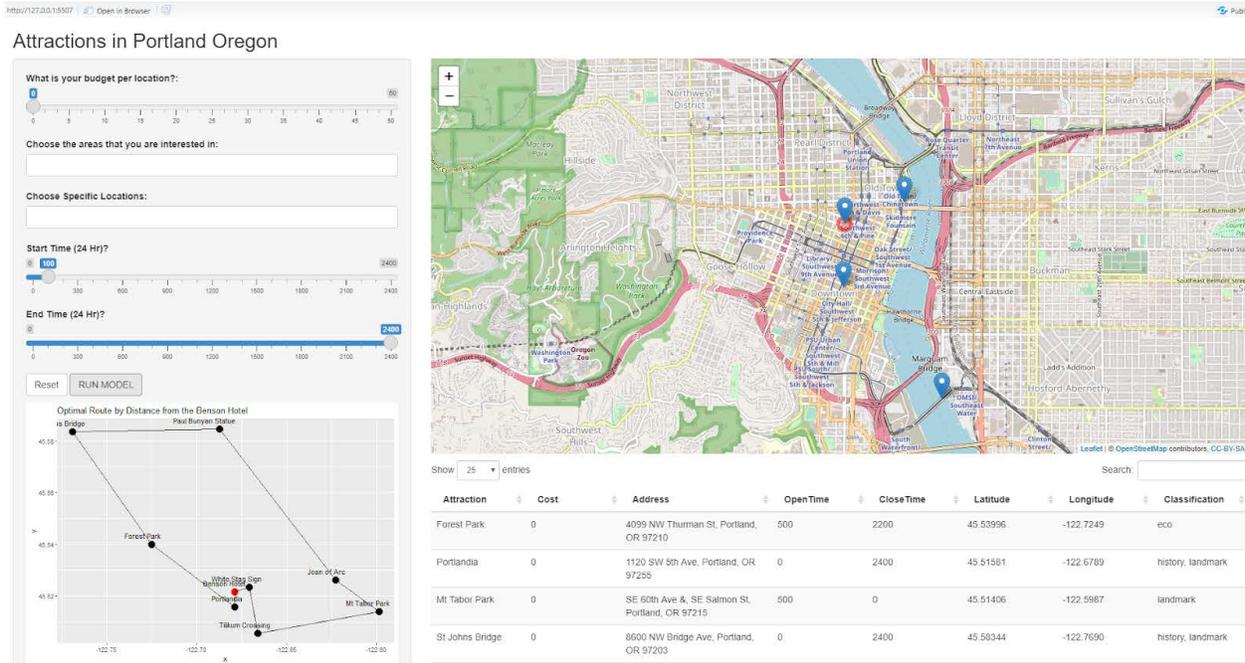


Figure 4: Shiny user interface (filter & optimized route on the left, map & location list on the right)

The map and table listing of locations are interactive. Hovering over a map location will provide a pop-up showing the name of the attraction, and clicking on the map location will provide the physical address. Further, the map can be zoomed in or out, and adjusted for centering. The table list of locations contains the name of the attraction, the cost for entry, the physical address, open time, close time, longitude, latitude, and classifications to identify visitor interest categories. This table can be sorted by the visitor by clicking on any of the column titles.

The bottom left of the interface contains the output of the model. This output graph provides the optimal path for a visitor to follow in order to visit each location selected at the lowest cost. Cost in this model is considered as distance -- which is equivalent to travel expenses -- and the travel time spent by the visitor.

Several R libraries were used to build the user interface. These include:

1. shiny: the web-enabled and interactive components for filter inputs and UI/Server layout including the maps and datatable.
2. leaflet: the mapping library to display locations on a graphical map.
3. ggplot2: the optimal travel path output map/graph component.

Output

The example output below shows the optimal path for a visitor to follow to see each of the attractions they have selected. This example shows a visitor that is staying at the Benson Hotel in downtown Portland, the red dot in the figure (Figure 5). Essentially, the visitor can

choose two options when starting their tour. They can select to first go to Portlandia, or to the White Stag Sign. This selection will determine the order of the attractions to visit, as to remain optimal, they will need to continue in the same direction on the path to the next connected location on the generated route map. The visitor will then continue to each location and finalize their round-trip tour by returning to the Benson Hotel.

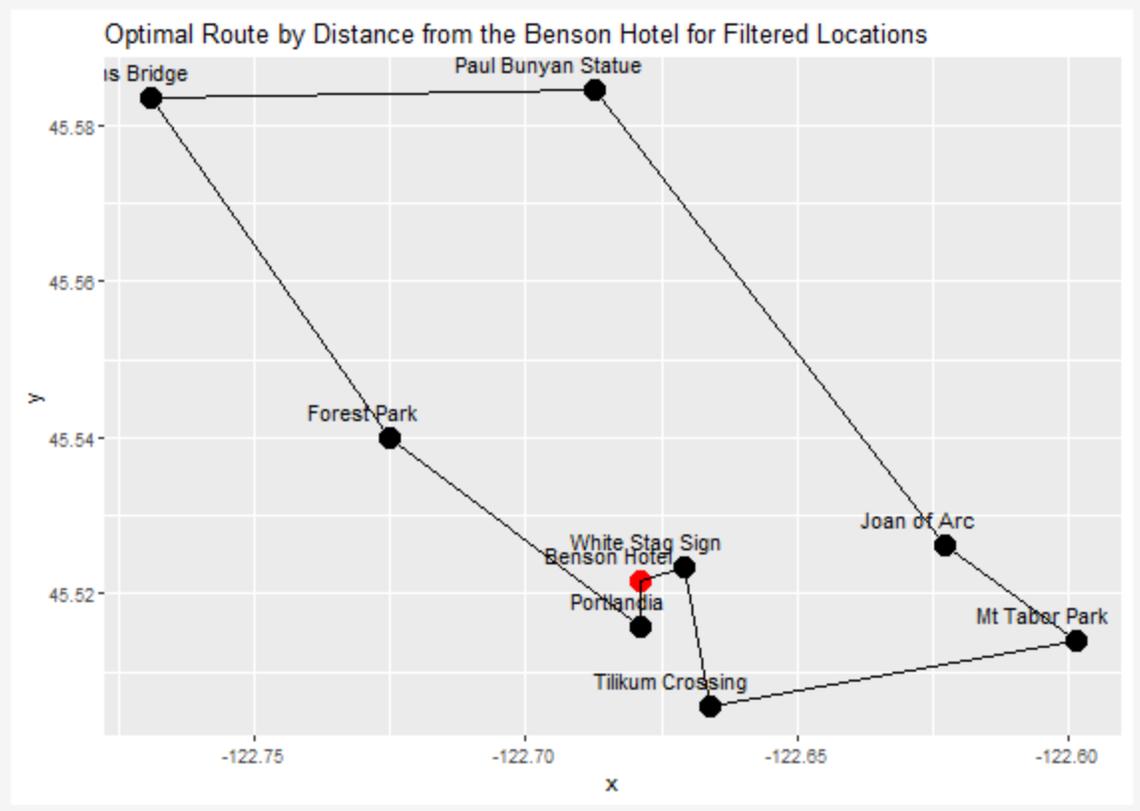


Figure 5: Optimal route map model output

Conclusion & Reflection

Promoting travel to Portland, Oregon with ease by using an attractive, friendly user interface and a plethora of interesting locations were considered. This seems to be an opportunity as Portland, Oregon is approaching near normalcy caused by COVID-19 pandemic. As part of the experience excellence, the solution also tailors to the users' budget, time availability and areas of interests.

Future Project Opportunities

While the model's focus is on the client's satisfaction and Tourbella Travel generating revenue to sustain their business, this optimization model can also affect outside sources. Further research can identify inputs for the model for commercialization and advertising from

outside businesses that would alter the output events for the itinerary. The itinerary can also be influenced by small businesses. The symbiotic relationship between Tourbella Travel and local attractions to "scratch each other's back" while still providing a unique and positive experience for the client can be pursued. Furthermore, these itineraries are adjusted for individual client's needs, but the possibility of including groups or a tour guide could reduce budgets and time. Future work excellence can be highlighted. With that information, it is recommended to consider some of the focus points to name a few. For instance, completing the implementation of data filtering components such as start/end times, specific locations and interests should be part of the future scope. Also, allowing a selection of different starting/ending locations and various hotels located in Portland would add to the attractiveness of this solution. To enhance user experience, sorting a datatable list to match model output map for locations will compliment positively. As part of experience excellence, enforcing a max limit on the number of locations to manage algorithm runtimes is essential due to the fact that runtimes may take hours in relation to the high number of locations. Hence, identifying the felicitous number of locations is highly recommended while attempting to expand the list of tourist attractions for the user to select from along with attempting to optimize the selection process of categories connecting to all of the focus points mentioned above. It is believed that additional focus points will be unearthed in the future complementing this ideal solution's excellence.

Appendices

Appendix A - Database

Attraction	Cost	Attraction Address	Open Time	Close Time	Latitude	Longitude	Classification
International Rose Garden	2.00	400 SW Kingston Ave, Portland, OR 97205	1000	1530	45.520432	-122.706772	eco, scenic, adventure
Japanese Garden	16.95	611 SW Kingston Ave, Portland, OR 97205	500	2200	45.518139	-122.708771	eco, scenic, adventure
Oregon Zoo	24.00	4001 SW Canyon Rd, Portland, OR 97221	900	1730	45.50928256	-122.7159482	eco, scenic, adventure
Pittock Mansion	12.00	3229 NW Pittock Drive, Portland, Oregon	1000	1600	45.52540223	-122.7163622	architecture, history
Powell's City of Books	5.00	1005 W Burnside St, Portland, OR 97209	1000	2100	45.52320581	-122.6813512	shopping
Oregon Museum of Science and Industry	12.00	1945 SE Water Ave, Portland, OR 97214	930	1730	45.5084765	-122.6660565	science, adventure
Lan Su Chinese Garden	12.95	239 NW Everett St, Portland, OR 97209	1000	1600	45.52564403	-122.6730167	landmark, eco
Forest Park	0.00	4099 NW Thurman St, Portland, OR 97210	500	2200	45.53995879	-122.7248706	eco
Portlandia	0.00	1120 SW 5th Ave, Portland, OR 97255	0	2400	45.51580896	-122.6788705	history, landmark
Mt. Tabor Stairs	0.00	6738 Mt Tabor, Portland, OR 97215	500	1	45.51571016	-122.5922171	history, landmark
Mt. Tabor Park	0.00	SE 60th Ave &, SE Salmon St, Portland, OR 97215	500	0	45.51405604	-122.5987276	landmark
St. Johns Bridge	0.00	8600 NW Bridge Ave, Portland, OR 97203	0	2400	45.58343974	-122.7690292	history, landmark
Joan of Arc	0.00	418-426 NE Cesar E Chavez Blvd, Portland, OR 97232	0	2400	45.52612701	-122.6227313	history, landmark
Tilikum Crossing: Bridge of the People	0.00	Tilikum Crossing, Portland, OR 97214	0	2400	45.50565294	-122.6660294	history, landmark
Paul Bunyan Statue	0.00	8433 N Interstate Ave, Portland, OR 97217	0	2400	45.58448608	-122.6871262	history, landmark
Portland Oregon White Stag Sign	0.00	70 NW Couch St, Portland, OR 97209	0	2400	45.52354016	-122.6709619	history, landmark
The Lorax Houses	0.00	N Albina Ave & Beech St, Portland, OR 97227	0	2400	45.54974349	-122.6743995	history, landmark
Japanese American Historical Plaza	0.00	2 NW Naito Parkway, Portland, OR 97209	0	2400	45.52318533	-122.6702347	history, landmark
Lovejoy Columns	0.00	316 NW 10th Ave, Portland, OR 97209	0	2400	45.52561799	-122.68095	history, landmark
Centennial Mills	0.00	1362 NW Naito Pkwy, Portland, OR 97209	0	2400	45.53401403	-122.6807801	history, landmark
Animals In Pools	0.00	SW Yamhill St & SW 5th Ave, Portland, OR 97204	0	2400	45.51825113	-122.6779626	history, landmark
The Quest	0.00	900 SW 5th Ave, Portland, OR 97204	0	2400	45.51731891	-122.6781128	history, landmark
The Buddha Building	0.00	312 NW 10th Ave, Portland, OR 97209	0	2400	45.52556573	-122.6810646	history, landmark
Old Town Chinatown	0.00	13 NW 4th Ave, Portland, OR 97209	0	2400	45.52332542	-122.6743102	history, landmark
Oregon Holocaust Memorial	0.00	95205 SW Washington Way, Portland, OR 97205	500	2200	45.52295863	-122.7033398	history, landmark
Teachers Fountain	0.00	815 SW Park Ave, Portland, OR 97205	0	2400	45.51892373	-122.681266	history, landmark
Beverly Cleary Sculpture Garden at Grant Park	0.00	Grant Park Path, Portland, OR 97212	500	0	45.54026386	-122.6301575	history, landmark
Share-It Square	0.00	9th Ave And SE Sherrett St, Portland, OR 97202	0	2400	45.46149353	-122.6569777	history, landmark
Portland Spirit Cruises & Events	50.00	110 SE Caruthers St, Portland, OR 97214	900	1900	45.50592059	-122.6645405	eco
World Forestry Center Discovery Museum	5.00	4033 SW Canyon Rd, Portland, OR 97221	900	1700	45.5107982	-122.7179503	eco
The Grotto	0.00	8840 NE Skidmore St, Portland, OR 97220	900	1730	45.55324101	-122.5735328	history, landmark

Shanghai Tunnels	0.00	120 NW 3rd Ave, Portland, OR 97209	1100	2200	45.52451779	-122.6726939	history, landmark
Hoyt Arboretum	0.00	4000 SW Fairview Blvd, Portland, OR 97221	500	2200	45.51583415	-122.7152427	eco
Tom McCall Waterfront Park	0.00	98 SW Naito Pkwy, Portland, OR 97204	0	2400	45.52149064	-122.6699479	eco, landmark
Portland Art Museum	25.00	1219 SW Park Ave, Portland, OR 97205	1000	1700	45.51630688	-122.6833193	art, history
Pioneer Courthouse Square	0.00	701 SW 6th Ave, Portland, OR 97205	0	2400	45.51867737	-122.6792634	landmark
Oregon Historical Society Museum	10.00	1200 SW Park Ave, Portland, OR 97205	1200	1700	45.5158065	-122.682324	history
Mill Ends Park	0.00	56 SW Taylor St, Portland, OR 97204	0	2400	45.51634843	-122.6728993	landmark
Portland Saturday Market	0.00	2 SW Naito Pkwy, Portland, OR 97204	1000	1700	45.52276662	-122.6697254	shopping, festival, foodie
Downtown Park Blocks	0.00	1436 SW Park Ave, Portland, OR 97201	0	2400	45.51451006	-122.6829461	landmark
National Hat Museum	5.00	1928 SE Ladd Ave, Portland, OR 97214	1000	1700	45.50947496	-122.6498082	history
Providence Park	0.00	1844 SW Morrison St, Portland, OR 97205	0	2400	45.5218655	-122.6908498	sports
Portland Aerial Tram	10.00	3303 S Bond Ave, Portland, OR 97239	530	2130	45.49941144	-122.6708667	adventure, scenic
Wishing Tree	0.00	2954 NE 7th Ave, Portland, OR 97212	0	2400	45.54467021	-122.6582317	landmark
Stark's Vacuum Museum	0.00	107 NE Grand Ave, Portland, OR 97232	900	1700	45.52399706	-122.6609825	history
Lincoln Street Kayak & Canoe Museum	0.00	5340 SE Lincoln St, Portland, OR 97215	900	1900	45.50792669	-122.6072095	history, eco
Laurelhurst Park	0.00	SE Cesar E Chavez Blvd & Stark St, Portland, OR 97214	500	2230	45.51944584	-122.6230634	history, eco, scenic
Kelley Point Park	0.00	N Kelly Point Park Rd, Portland, OR 97203	600	2200	45.63757481	-122.7538917	eco, scenic
Collin's Beach (Clothing Optional)	0.00	NW Reeder Rd, Portland, OR 97231	400	2200	45.65321377	-122.831583	history, eco, scenic, portlandia
Powell Butte Nature Park	0.00	16160 SE Powell Blvd, Portland, OR 97236	700	2000	45.4907	-122.497	eco, scenic
Sellwood Riverfront Park	0.00	1221 SE Oaks Park Way, Portland, OR 97202	500	1200	45.4668	-122.6634	eco, scenic, landmark

Appendix B - Github Repository

<https://github.com/DuaneMurray/ETM540>

References

1. Sarah Z. Wexler August 18, 2015. (n.d.). *The Perfect Weekend in Portland, Oregon*. Travel + Leisure. Retrieved December 5, 2021, from <https://www.travelandleisure.com/weekend-getaways/ideal-weekend-portland-oregon>.
2. Payne, K., Kumari, K., Huddleston, L., & Hassan, R. (2018). Minimizing Commute Distance for Small Groups: A Linear Programming Approach.
3. Hunley, B., Mohnike, C., Bailey, P., Shrikhande, R., & Stahl, T. (2019). Route Optimization using R: Completing the McMenamins Passport.
4. Bell, J. (2012). The Traveling Salesman Problem (TSP) Applied to Willamette Dental's Technology Equipment Deployment.
5. "Google Maps." Google Maps Oregon, <https://www.google.com/maps/place/Oregon/@44.1044175,-123.0397108,6z/data=!4m5!3m4!1s0x54936e7c9b9f6a55:0x7d4c65db7a0bb876!8m2!3d43.8041334!4d-120.5542012>. Accessed 4 Dec. 2021.
6. "Travel Alerts - Travel Oregon." Travel Oregon, <https://traveloregon.com/travel-alerts/>. Accessed 4 Dec. 2021.
7. Portland, Travel. "Portland, Oregon - The Official City Guide." The Official Guide to Portland, Travel Portland, 6 Sept. 2019, <https://www.travelportland.com/>.
8. Sawik, T. (2016). A note on the Miller-tucker-zemlin model for the asymmetric traveling salesman problem. *Bulletin of the Polish Academy of Sciences Technical Sciences*, 64(3), 517–520. <https://doi.org/10.1515/bpasts-2016-0057>