Destination Coyote Kitchen

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Background

"The best way of getting to Coyote Kitchen" has many different interpretations. For the purpose of building a model that is useful and realistic to an individual or group in search of a way to Coyote Kitchen, the goal is assumed to be:

> *Given unique circumstances, what is the best mode of transportation to Coyote Kitchen?*

Circumstances

For brevity of discussion, the request by an individual or a group for a way to Coyote Kitchen will be referred to as a "way request" (WR). The circumstances of a WR that are factored into the model developed below are identified as:

- L - The Location[1],
- G - The Group size,
- B - The transportation Budget, in U.S. Dollars,
- A_S - The time of a WR in hours after midnight,
- A_E - The very latest the group wishes to arrive in hours after midnight,
- Q - The price of a Beeper[2] person in the group,
- R - The walking speed, in Miles per Hour, of the slowest walker in the group,
- N - The number of cars necessary to transport the group,
- G_i - The gas mileage, in Miles per Gallon, of car i,
- P - The price of Gasoline per Gallon in U.S. Dollars.

It is assumed that all of this data can be collected before the time of a WR. Additionally, some data required to implement this model, specified in the development section, is easiest to obtain online.

Ways

There are four modes of transportation that are possible results of a given input to the model:

- Walking
- Driving the fastest route
- Driving the shortest route
- Hiring a Beeper to drive the group

There is a Cost, C_i, and a Time, T_i, associated with each (i = WALK, FAST, SHORT, BEEP).

For the purpose of developing a stable model, Appalcart has been disregarded as a possible mode of transportation to avoid the unpredictable factors of annual schedule amendments and bus overflow.

[1] An address suffices. This is explained later in the Development section.

[2] Beeper is a ride sharing service, similar to Uber, that charges users of the service per person.

Since it varies drastically, this model assumes that the traffic levels allow for driving to be done at the speed limit of each road.

It is assumed that only one transportation method will be used throughout the trip, utilizing roads and paths appropriate for the method, by all members of the group.

Development

To quantify what it means for a way to be "best", the consideration of priority must be made. Does the group prioritize time or cost? This model makes no assumptions as to this priority, and the individual(s) implementing this model may decide.

The cost C_i and time T_i must be determined for each possible way i. Each depends on distance traveled by way of that method.

Determining distance traveled by each method is not as simple as using the longitude and latitude of a starting location and of Coyote Kitchen and using the Pythagorean Theorem for straight line distance. Similarly, time spent driving depends on speed limits. Determining optimal and appropriate roads and paths to the destination requires algorithms and data that are beyond the scope of the development of this model.

With this said, it is entirely possible to utilize return values from the free and open-source Open Directions Application Programming Interface (API) available from MapQuest. Using two addresses, road and speed limit data, a geographical information system and algorithms, this API returns a shortest driving distance and time, a fastest driving distance and time, and a walkable distance. Any API that provides these values for optimal routes that utilize roads appropriate to each transportation method (the roads must have a sidewalk to be walked, for example) can be substituted for this API. Google's Directions API is another example.

These algorithms and their data are the same used by the MapQuest and Google Maps engines, respectively. Without knowledge of JSON or XML scripting and interacting with an API, one who wishes to utilize this model could simply use one of these user friendly websites to obtain these values.

The values of distances, in Miles, of the most optimal and appropriate paths of each transportation method will be denoted D_i, associated with each route (i = WALK, FAST, SHORT).

Determining Cost C_i

Walking

Walking is free.

$$C_{\text{WALK}} = 0$$

Driving the Fastest Route

The cost of driving the fastest route can be determined by summing the price of the cost of taking each car. Each of the N cars has a unique gas milage, G_i, but all share the distance D_{FAST} and the price per gallon of gas P. The cost of each car can be determined by dividing the distance by the gas mileage, yielding the gallons used, and multiplying by the price per gallon. Therefore:

$$C_{\text{FAST}} = \sum_{i=1}^{N} \frac{D_{\text{FAST}}}{G_i} P = D_{\text{FAST}} P \sum_{i=1}^{N} \frac{1}{G_i}$$

Driving the Shortest Route

Similarly, determining the cost of the shortest route:

$$C_{\text{SHORT}} = \sum_{i=1}^{N} \frac{D_{\text{SHORT}}}{G_i} P = D_{\text{SHORT}} P \sum_{i=1}^{N} \frac{1}{G_i}$$

It is clear that the shortest route will always be the same as the price of the fastest route or *cheaper*, but it may not meet the time constraint $A_S + T_i \leq A_E$.

Hiring a Beeper

The cost of hiring a beeper is simply the number of people in the group G multiplied by the cost per member of the group Q.

$$C_{\text{BEEP}} = G \cdot Q$$

Determining Time T_i

Walking

The time for the group to walk the distance D_{WALK} is determined by the speed of the slowest walker R. Dividing the distance in miles by the miles per hours gives the time:

$$T_{\text{WALK}} = \frac{D_{\text{WALK}}}{R}$$

Driving the Fastest Route

This value is returned directly from the API as T_{FAST}.

Driving the Shortest Route

This value is returned directly from the API as T_{SHORT}.

Beeping

Since the distance traveled is not detrimental to the cost of Beeping, it is logical to always utilize the fastest driving route when Beeping. Thus the time of beeping is the same as the time of driving the fastest route; $T_{\text{BEEP}} = T_{\text{FAST}}$.

Results

If the priority is cost, the way i with minimum cost C_i such that the conditions of the budget B and the latest ending time A_E are met is given by:.

$$i \mid C_i = \min(C_k),\, k \in \{j \mid (C_j \leq B \land A_S + T_j \leq A_E)\}$$

If the priority is time, the way i with minimum time T_i such that the conditions of the budget B and the latest ending time A_E are met is given by:

$$i \mid T_i = \min(T_k),\, k \in \{j \mid (C_j \leq B \land A_S + T_j \leq A_E)\}$$

In either case:

$$i, j, k \in \{\text{WALK, FAST, SHORT, BEEP}\}$$

$$C_{\text{WALK}} = 0$$

$$C_{\text{FAST}} = \sum_{i=1}^{N} \frac{D_{\text{FAST}}}{G_i} P = D_{\text{FAST}} P \sum_{i=1}^{N} \frac{1}{G_i}$$

$$C_{\text{SHORT}} = \sum_{i=1}^{N} \frac{D_{\text{SHORT}}}{G_i} P = D_{\text{SHORT}} P \sum_{i=1}^{N} \frac{1}{G_i}$$

$$C_{\text{BEEP}} = G \cdot Q$$

$$T_{\text{WALK}} = \frac{D_{\text{WALK}}}{R}$$

Where T_{FAST} and T_{SHORT} are given directly from an API or application that utilizes an API, and $T_{\text{BEEP}} = T_{\text{FAST}}$.

Discussion

A major benefit of this model is that it could be easily implemented as a useful web or mobile application. Applications like Google Maps only provide a friendly, graphical interface to time and distance data. This model facilitates an application that goes a step further and provides the optimal cost or time decision given realistic, everyday circumstances.

Such an application could be improved by removing the assumptions this model makes that (1) all members of the group will take the same transport method and that (2) the same transport method will be taken throughout the entirety of the trip. Additionally, it would be most useful if it allowed for more destinations than just Coyote Kitchen.

References

"Open Directions API." MapQuest, 2018, https://developer.mapquest.com/documentation/open/directions-api/route/get/. Accessed 11 February 2019.