IoT Event Based Assignment Algorithm for Parking Control

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Introduction

With the increasing number of vehicles in the world, the supply-demand problem of parking spaces has become more relevant than ever. In traditional parking lots and structures, drivers circle around until they find an available parking spot. Current research has explored the use of sensors to identify available parking spaces. This Internet of Things (IoT) approach to efficient parking has been widely explored and is implemented in select parking structures. However, in the age of information, entire parking systems can be more efficient with data. In this regard, considering additional also IoT provided information from the drivers can increase overall parking system efficiency.

What is the Internet of Things

The network of physical devices, such as cellular phones, appliances, vehicles, and electronics such as sensors and actuators, which can communicate with one another through network connectivity and are able to exchange data.

Broader Research Questions

How can spots in a parking lot most efficiently be allocated if external (IoT provided data) about the person who is about to park is available?

What is the trade off between single user efficiency and the overall system's efficiency?

Could incentivising parking be a means of getting users to park further?

What regulation schemes can be put in place to ensure a user parks in a specific location?

Algorithm Design

The algorithm was devised first by determining possible input data collected from vehicles entering the specific parking lot.

Next, considering the objective of this algorithm, variables were defined:

General variables:

- occupancy of entering vehicle
- cost of a vehicle entering the parking lot
- time of day
- length of stay
- walking distance from car to exit
- status of the passenger: [Elderly/Pregnant/Disabled]

Considering these variables, a score is calculated for each vehicle indicating the "Walk-Cost Factor" of the vehicle. The factor is used for prioritizing the cars in the optimization algorithm.

Similarly, there is a cost associated with each specific spot in the lot. Because we quantified the cost associated with the vehicles in the Walk-Cost Factor, the cost per spot was also calculated in terms of walking. This cost is represented as the distance of the spot from the exit.

Optimization Algorithm

There is a cost associated with each car and parking spot pairing. This is represented by:

$$\sum_{i \in A} \sum_{j \in T} C(i,j) x_{ij}$$

Subject to the constraints:

$$\sum_{j \in T} x_{ij} = 1 \text{ for } i \in A,$$

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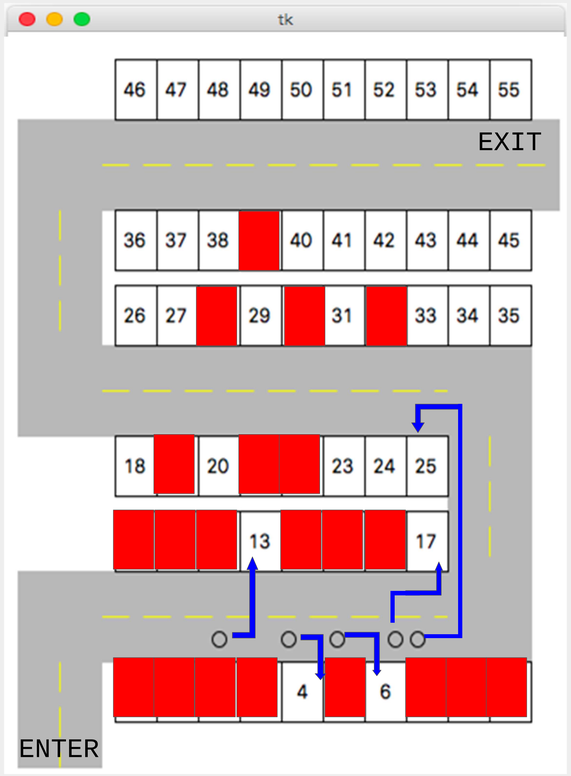
$$x_{ij} \geq 0 \text{ for } i, j \in A, T.$$

The costs are then represented as matrix and the problem is reduced to an assignment problem, or linear programming problem which can be solved using the Hungarian Algorithm.

Event Based Parking Lot Simulation



The simulation works on a set parking lot, as shown above.

The vehicles randomly enter into the parking lot at various speeds and times and have different characteristics. The characteristics of the vehicle are randomly generated and include the number of people in the vehicle, and whether or not someone is pregnant, disabled, or elderly in the vehicle.

Whenever a new vehicle enters into the parking lot, the optimization algorithm is called. The algorithm takes the cars that are still in the lot but have yet to park and the car entering the lot into consideration. When a vehicle exits the lot, the available spots data is also updated.

Once the algorithm runs, it will assign spots to each of the vehicles.

Results

Running the optimization algorithm in a simulation revealed an important feature of this approach to parking efficiency. The simulation showed that this approach directly countered the first-come, first-served paradigm in transportation. As pictured above, the first car into the lot is actually asked to park the furthest away. However, the notion of picking the closer available spots was not challenged.

Conclusion

This research accomplished both creating a smart parking algorithm and creating an event based simulation to see the implementation of this algorithm. Through this simulation it is shown that there are more system-wide efficient approaches to managing parking than the traditional methods which rely on the user and the first-come, first-served paradigm.

Future Work

Future work in this topic would include looking at applications in:

- Different styles of parking lots
- Effect of length of stay on spot allocation
- More complex links between nodes in the lot
- Multiple paths to parking spot
- Shortest path guidance
- Complex arrangements for walking paths and their distances
- Implementing sensor in the parking lot to get real time data of the lot conditions
- Real time negotiated spot pricing

While all of the above topics can be considered with human drivers, the overarching future of research on topics like this is the implementation in autonomous vehicles.

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