January 2020

Directing users to an available parking spot at an optimal location near the destination

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ABSTRACT

High demand for parking generated by the large numbers of people simultaneously looking for parking within the same area often makes it tedious and difficult to find a parking spot, leading to delays and frustration. Individual drivers typically attempt to find a parking spot closest to an event venue. Finding a parking spot via such an approach requires luck and timing. Many drivers tend to overestimate their luck, thus adding to congestion and wasting more time in the process of finding a parking space. To address these issues, this disclosure describes techniques that use real-time information on available parking spaces to direct drivers to an optimal parking spot in the vicinity of their destination. The state of the system is monitored and updated in real-time to predict the availability of parking spaces with high accuracy.

KEYWORDS

- Parking guidance
- Parking assistance
- Navigation
- Driving directions
- Maps
- Large events

BACKGROUND

Major events, such as concerts, sports events, etc. often draw large crowds to the location of the event. Many of the attendees drive to the location and need to park their vehicles in the vicinity. The high demand for parking generated by the large numbers of people attending the

event often makes it tedious and difficult to find a parking spot, leading to delays and frustration. Individual drivers typically attempt to find a parking spot closest to the event venue. Such an approach involves driving to parking areas closest to the venue and progressively moving farther until an available parking space is found, all the while navigating within and around traffic that includes other drivers that are attempting to do the same. Finding a parking spot via such an approach relies on luck and timing. Many drivers tend to overestimate their luck, thus adding to congestion and wasting more time in the process of finding a parking space.

In an effort to reduce the problems of finding parking, some publicly available services allow drivers to visualize available parking options on a map of the vicinity of the venue. However, providing a dynamically updated map of available parking spaces in the vicinity can be challenging since event-related traffic patterns are highly non-linear, thus causing the state of the system to change rapidly close to the start of the event.

Some services that display available parking spaces additionally include the ability to prepay for parking before arrival, if available at the venue. However, when the available parking options are free or pay-on-arrival, drivers still need to arrive early to maximize the chances of a parking space being open or rely on luck.

DESCRIPTION

This disclosure describes techniques to use real-time information on available parking spaces to direct drivers to an optimal parking spot in the vicinity of their destination. If the driver permits, the techniques can be integrated within the driver's navigation application that provides driving directions.

The approach involves identifying a parking facility that is highly likely to be available at the time of the driver's arrival. With permission from the driver, the estimated time of arrival in

the vicinity of the destination is calculated based on factors such as the driver's current location, the chosen route, current traffic conditions, etc.

The predicted availability of parking spaces is obtained from a trained machine learning model. To that end, the model is provided one or more of the following inputs:

- A static model of the system (if available) based on prior events at the same venue: Such a model can include relevant information such as event types, event durations, times of day, days of the week, etc.
- Dynamic estimates of the current state of the system in terms of deviations from the static model: Such estimates can be obtained from driver information, such as number of drivers and their estimated times of arrivals of the drivers, etc., obtained with permission from the drivers.
- Current state of the parking facilities in the vicinity: The state of available parking spaces in nearby parking facilities can be estimated based on one or more of the following:
    a. Counts obtained from parking facilities, such as garages, that have the capability to determine if a parking space is vacant or occupied, e.g., based on permanently installed sensors.
    b. Counts obtained from parking facilities that detect parking spot occupancy for one-off occasions, such as large events, by deploying temporary sensors, such as laser sensors.
    c. Availability information provided by human operators and/or event organizers via suitable mechanisms, such as an app.

d. Output from a trained machine learning model that indicates whether a parking facility is fully occupied based on traffic patterns, such as slowdowns, go-arounds, etc. within and near the facility.

In case of major events that attract large crowds, the arrival of vehicles at the venue does not follow a Poisson process. Instead, the rate of vehicle arrival changes dynamically, with slow ramp up followed by a sustained peak and usually a fast drop. Therefore, predicting the availability of parking spaces with high fidelity and accuracy requires the state of the system to be monitored and updated in real-time. Such real-time operation further involves periodically checking the probability that a target parking space would be available at the time of the driver's arrival. If the probability falls below a threshold, a different parking spot with high likelihood of being available at the time of arrival is selected instead.

Users can access the system via a maps or navigation application used to obtain driving directions. If the vicinity of the user's destination has parking guidance enabled at that time, the user can request the application to help find a suitable parking space near the destination by selecting the corresponding option within the navigation menu. The system, as described herein, provides driving directions directing the user to an available parking space in the vicinity of the destination. With the user's permission, the available parking space is chosen to minimize the total time required to drive to the destination, park the car, and walk to the venue.

Alternatively, or in addition, users can indicate whether the selection of parking spot is to be performed taking into account the time required after an event to walk back to the parking spot and drive away. Such an option can be useful for large events that involve nearly all of the attendees attempting to leave the venue at the same time when the event ends. Taking into account the time required to leave after an event may result in the user being recommended a

parking spot farther away from the venue, e.g., closer to the venue exit, even when spaces closer to the venue are available.

Further, the users can specify additional criteria regarding the type of parking space needed, e.g., a handicapped parking space, a parking space of at least a particular size, etc. Such cases can be handled by modeling the system as a multi-class queuing network with users with specific needs, e.g., disabled users, being provided a dedicated swim lane.

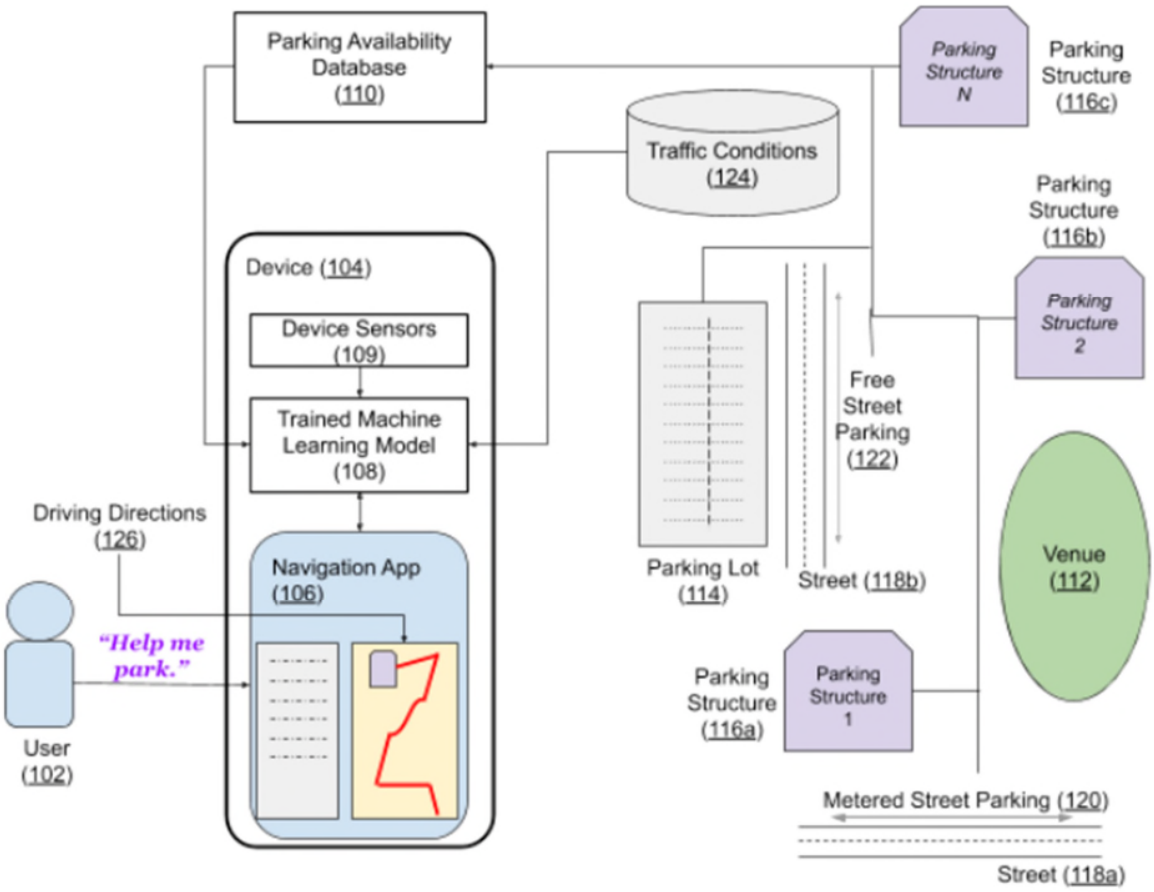

Fig. 1: Provision of directions to parking spot near a venue

Fig. 1 illustrates a user (102) that is driving to an event being held at a venue (112). The user seeks driving directions to the venue from a navigation app (106) on the user's device (104), e.g., a smartphone, in-car navigation system, etc. The user further seeks parking assistance and

requests to be directed to a parking spot that would be available when the user arrives at the venue.

With user permission, the user's input as well as relevant information from the device sensors, such as the user's location, is provided as input to a trained machine learning model (108). The model receives further input from a database of parking spaces (110) indicating available parking spots in the vicinity of the venue. The database is continually updated with parking space occupancy information from the various parking options near the venue, including but not limited to parking structures (116a-c), parking lots (114), streets (118a) with metered street parking (120), streets (118b) with free street parking (122), etc. In addition, with permission from the relevant parties, the model is provided with information regarding current and projected traffic conditions (124) in the vicinity of the venue.

Based on these various inputs, the model identifies a suitable parking spot near the venue that is likely to be available when the user is projected to reach the venue. The directions within the navigation app then direct the user to the spot. If dynamic updates in the parking and traffic patterns indicate that the currently chosen spot is likely to be occupied when the user arrives, another likely available spot is selected and the directions are updated accordingly.

With permission of the relevant parties, the operation of the system can be enhanced by obtaining relevant data, such as traffic and parking patterns, in the vicinities of various venues that hold events. If the relevant parties permit, such data can be appropriately labeled and used to refine static models of the system and/or be provided training data to train machine learning models.

Dynamic information about parking spot occupancy can be obtained from parking facilities via an application programming interface (API) or any other suitable mechanism. The

threshold value of probability below which a parking space is considered no longer likely to be available upon the user's arrival can be specified by the system developers, set dynamically at run time, or chosen by the users.

The techniques described in this disclosure can be integrated within any kind of navigation application including apps included on mobile devices, systems embedded within vehicles, etc. Moreover, the parking spot prediction system can be accessed via other suitable mechanisms such as an API. The system serves to enhance the functionality and utility of navigation applications and reduce the time, effort, and frustration of finding an optimal parking spot, e.g., during events that draw large crowds.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable collection of user information (e.g., information about a user's social network, social actions or activities, profession, a user's preferences, or a user's current location), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user, or a user's geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes techniques that use real-time information on available parking spaces to direct drivers to an optimal parking spot in the vicinity of their destination. The

approach involves selecting a parking facility that is highly likely to be available at the time of the driver's arrival by using a trained machine learning model. The state of the system is monitored and updated in real-time to predict the availability of parking spaces with high accuracy. Such real-time operation further involves periodically checking the probability that the target parking space would be available at the time of the driver's arrival and updating the recommended space if the probability falls below a threshold.