Technical Disclosure Commons

Defensive Publications Series

August 2020

Estimating Wait Times and Determining Optimal Routes at Retail Outlets

N/A

Follow this and additional works at: https://www.tdcommons.org/dpubs_series

Recommended Citation
N/A, "Estimating Wait Times and Determining Optimal Routes at Retail Outlets", Technical Disclosure Commons, (August 07, 2020)
https://www.tdcommons.org/dpubs_series/3504

This work is licensed under a Creative Commons Attribution 4.0 License.
This Article is brought to you for free and open access by Technical Disclosure Commons. It has been accepted for inclusion in Defensive Publications Series by an authorized administrator of Technical Disclosure Commons.

Estimating Wait Times and Determining Optimal Routes at Retail Outlets

ABSTRACT

Making a purchase at a grocery store or waiting for a table at a restaurant often entails waiting in a line. While stores are overcrowded at certain times or on certain days, at other times, stores can be relatively empty. This situation is worsened under pandemic conditions: for example, the outbreak of the Covid-19 disease has necessitated the closure of many businesses and enforcement of a six-feet social distance between customers of those businesses that are open. Longer wait times are inconvenient and put people at greater risk of exposure.

This disclosure describes techniques that enable customers to estimate wait times at retail outlets or businesses; recommend or schedule a store and/or a timeslot that reduces or eliminates waiting time; and, based on a customer's shopping list and the distribution of people within a store, compute a route that improves social distancing while reducing the duration of time spent at the store.

KEYWORDS

- Retail outlet
- Supermarket
- Grocery store
- Queuing delay
- Wait time
- Social distancing
- Radar sensor
- Computer vision
- Activity heatmap
- Cartography
- Simultaneous localization and mapping (SLAM)

BACKGROUND

Making a purchase at a grocery store or waiting for a table at a restaurant often entails waiting in a line. While stores are overcrowded at certain times or on certain days, at other times, stores can be relatively empty. This situation is worsened under pandemic conditions: for example, the outbreak of the Covid-19 disease has necessitated the closure of many businesses and enforcement of a six-feet social distance between customers of those businesses that are open. Customers now generally experience longer wait times, and, due to social distancing, queues have grown physically longer, often snaking outside the business into the parking lot or onto the street. Longer wait times are inconvenient and put people at greater risk of exposure. Longer wait times can be somewhat alleviated by scheduling appointments; however, in the case of walk-up businesses like grocery stores, this is not always practical.

Although stores often maintain information relating to the distribution of people indoors using equipment such as people counters, cameras, computer-vision modules, etc., such information is not generally public. Although the distribution of people can be publicly determined by global or local, e.g., WiFi hotspot or cellular-base-station based positioning systems, such information is of insufficient granularity and not real time. The number of people in a store at a given hour may thus be known on average, but not their instantaneous distributions within the store, nor the existence of a line extending outside the store, nor if such a line obeys social distancing protocols. Also, currently unknown are the average times spent by a customer waiting in a line outside a store, in aisles within the store, at check-out counters, etc. Although stores maintain information relating to product location, such information is not generally public, and if it is, e.g., in the form of aisle signs, it is of insufficient granularity.

DESCRIPTION

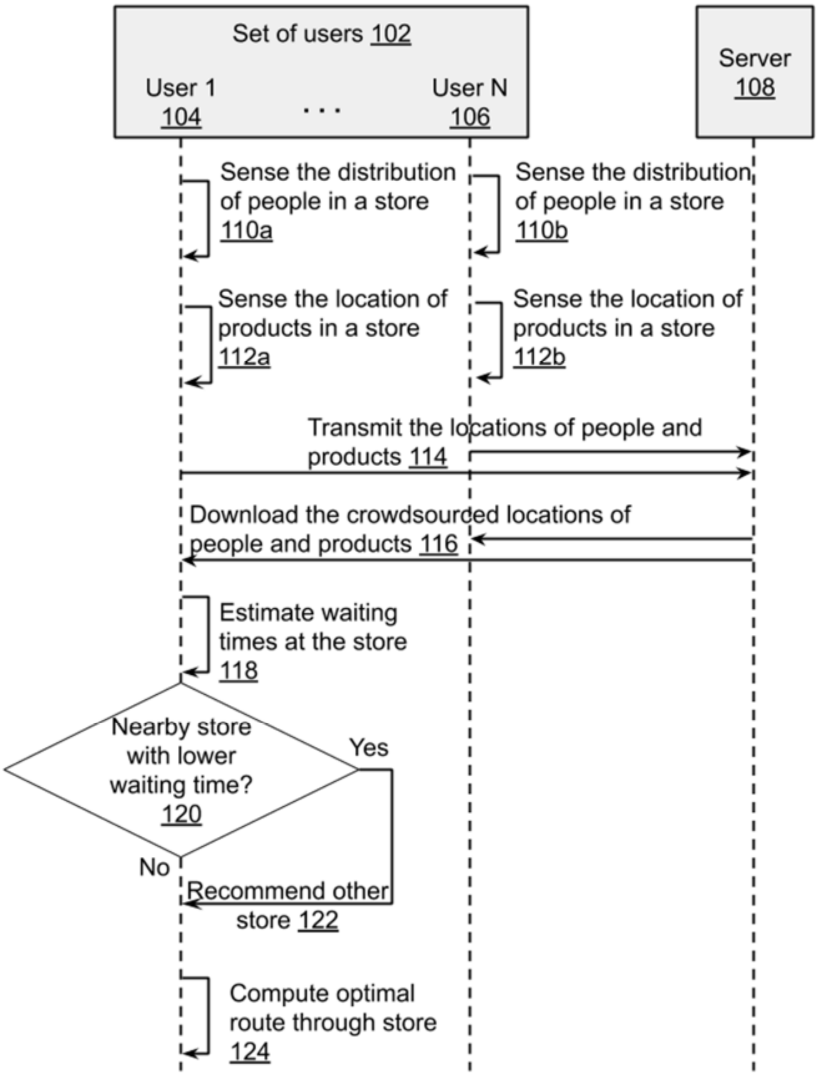

Fig. 1: Estimating wait time and determining optimal routes through stores

As illustrated in Fig. 1, this disclosure describes techniques that enable customers to estimate wait times at retail outlets or businesses; recommend or schedule a store and/or a timeslot that reduces or eliminates waiting times; and, based on a customer's shopping list (obtained with user permission) and the distribution of people within a store, compute a route that improves social distancing while reducing the duration of time spent at the store.

Per the techniques, devices of one or more users (104, 106) of a set of users (102) are used, with user permission, to automatically sense the distribution of people in a store (110a, 110b) and the locations of products in the store (112a, 110b). For example, with user permission, lidar sensors on smartphones, smart glasses, smartwatches, and other wearable or portable devices, can accurately measure elevation data, from which the size, identity, and location of products can be determined with fine granularity. With user permission, lidar and radar sensors on wearable devices can also determine the location and distribution of people in a store.

WiFi signals being reflective off human bodies and transparent to walls, WiFi echoes can be analyzed to determine the distribution of people in a store, or just outside a store. Cameras and computer vision (CV) or augmented-reality (AR) modules on wearable devices can be used to locate, with fine granularity, products within a store. For example, AR/CV modules can readily estimate distances and numbers of people within a landscape using homography or simultaneous localization and mapping (SLAM) techniques.

AR/CV techniques can also automatically detect long lines that extend beyond a store boundary and whether people in a queue or other region are social distancing or not. With user permission, the microphone of a wearable device can measure ambient noise, which is also an indication of the crowdedness or activity level of a location (audio heatmap).

With appropriate permissions from each user, the data generated by lidar, radar, optic, audio, or other sensors on customer devices and/or other store visitors (e.g., delivery-service providers) can be used for the creation of a real-time street-map of a retail outlet. The features of the map include activity heatmaps, and product and people locations.

Additionally, other sources of data such as traffic cameras, public sensors, cellular base station usage data, cameras used to generate pictorial maps of streets, etc., can be used for the creation of a real-time map of a retail outlet. Such a map of retail outlets can be entirely crowdsourced, e.g., generated independently of people-counters, cameras, product-availability databases, computer-vision modules, etc. that may be deployed by the retail outlet to maintain information on people and product distribution.

With user permission, Kalman filters can be used to track individuals in the store by tracking the belief state of the location of a person in the store. Kalman filters can track multiple variables associated with an individual, e.g. position, velocity, etc., in a manner similar to self-driving cars, which track and predict the immediate motion of passing or nearby objects such as pedestrians, cars, bikes, etc. As in self-driving cars, the Kalman filter can fuse data from multiple sensors, e.g., radar, laser/lidar, images from cameras, etc. and maintain a probability distribution, e.g., mean (maintained as a multivariate vector), standard deviation (maintained as self- and cross-covariance matrices), etc., regarding how certain the filter is about each variable. The uncertainty typically increases as the object moves, and decreases as measurements are taken.

Extended Kalman filters can be applied to track linear motion, e.g., objects going down a store aisle or turning corners, and unscented Kalman filters can be applied to track non-linear motion, e.g., objects moving in a circle. This tracking process can be assisted by a known map, as in localization. For example, tracking can be performed using knowledge of the layout of the store, since a user's proximity to nearby or known objects, such as the bread aisle, also indicates their location and motion.

User devices of users that provide permission to utilize such techniques transmit data regarding the locations of people and products (114) to a server (108), using techniques such as differential privacy as necessary. A user can download from the server the crowdsourced map of a retail outlet that includes real time activity heatmaps and locations of people and products (116).

Based on factors such as real time and historical crowdsourced locations and numbers of people and products at a store; the activity heat-map correlated with the known hours of operation; the user's shopping list; etc., an estimated waiting time at the store is computed (118). If individual users provide permissions to share their arrival and departure data, wait times can be more precisely calculated. Wait times can also be determined with store-provided information relating to the number of people arriving and departing a given location or store.

A measure of arrival (or service) rate can be obtained by dividing the net number of arrivals, e.g., the number of arrivals less the number of departures, by the average time spent in the store. For example, knowing that one hundred individuals entered a store at 2 PM and fifty left at 3 PM indicates that the store can service on average fifty individuals per hour. A more accurate measure of service rate can be obtained by averaging net arrivals over many samples/days rather than a single per-hour sample.

Similarly, estimated waiting times can be computed for other stores, including nearby stores. If nearby stores are found with lower waiting times or better social distancing practices (120), such a store can be recommended (122) to a user. Similarly, an optimal time slot can be recommended. The user can select a store and/or a time slot based on the recommendations and proceeds towards it. Based on the user's shopping list (if provided by the user) and the real time, crowdsourced locations and tracks of people and products throughout the store, a route through the store is computed (124) that can enable social distancing, e.g., avoiding paths that go through crowded sections or aisles, and reduce the user's duration in the store.

Additionally, mapping, search, virtual assistant, recommendation services, etc., can account for the wait times as estimated above, refined based on the date, time, season, etc., and further refined based on various publicly available news analyzed using natural language processing. For example, negative news can be used to predict a possible short term run on essentials, in which case a recommendation can be provided to a user to avoid going to the store. An expected storm or bout of inclement weather can trigger a recommendation to get basic provisions or emergency supplies, with a visit to the store being timed when the store is relatively less crowded.

The techniques of estimating wait time and optimizing shopping route to ensure social distancing and to reduce in-store duration, as described herein, and information relating to the number of cash registers versus self-checkouts, etc., can be especially valuable for customers who may be more susceptible to disease causing agents (e.g., coronavirus), and for stores that may not have designated elderly hours.

The described techniques can also have other applications, examples of which follow.

- *Planning of product locations*: Retailers such as supermarkets can use people distribution data to plan or re-plan product locations (or other resources) to improve social distancing. The motion of individuals within a store can be used to understand customers' shopping preferences and to analyze/predict their immediate motion/trajectories. For example, it may be determined that users who stop by the bread aisle may be likely to next stop by the deli meats section, or vice-versa. This can prompt a modification to the layout of the store such that the bread and deli meat sections are adjacent to each other. A store can also use such information for targeted advertising, marketing, and other demand or resource-planning purposes.

- *Supply-chain management*: The attention of both customers and businesses can be directed to activity in a normally uncrowded section, or inactivity in a normally busy section. For example, excess activity in a normally uncrowded section, e.g., the dairy section, can be an indication of a run on milk. Lack of activity in a normally busy section can be an indication that the store has run out of the corresponding products. A crowdsourced activity heatmap per the techniques described herein, can be used to determine if shelves are emptying out of products, and if so, which products. Data for such an activity heatmap can be gathered passively as the customers simply walk through the store.
- *Understanding of customer group dynamics*: With user permission, groups or pairs of individuals frequently traveling together through the store can be identified as friends or partnered couples, and their consumer preferences examined. With user permission, lidar and other sensors can be used to identify a vector of unique characteristics such as the size of the shopping cart or basket (or the absence of one), the size/shape/build of the person, voice ID, etc. These can be useful to understand the layout of groups as they travel through the store.
- *Planning store layout to encourage social distancing*: Data relating to the distribution and tracking of people and group dynamics can be used to improve the understanding of whether individuals are complying with social distancing protocols. For example, the data can be used to determine that some spaces, e.g., check-out counters, are simply too small to support adequate compliance with social distancing protocols. Such a determination can enable the store operator to take such action such as admitting fewer individuals into the constrained space; re-working the store layout to enable better compliance with social distancing norms; opening or closing certain entrances or exits; etc.

- *Demand handling*: Sensor data obtained as described herein can be useful to understand the capabilities of a store for handling demand. For example, a store owner can determine if the number of cash registers or self-checkout lanes are high enough that queueing delays are satisfactorily low. Such information can also be presented to users of search, maps, virtual assistant, and recommendation services. For example, a recommendation service can recommend stores with a relatively high number of cash registers, which is indicative of low wait times.
- *Business and city planning*: Knowledge of future wait times and the adherence of users to social distancing protocols can be indicative of high or inelastic demand for particular products, and hence be useful for city planners. Similarly, it may indicate a business opportunity for entrepreneurs. For example, information regarding long wait times for a particular restaurant can prompt a competitor, e.g., a food truck owner, to set up shop there with similar cuisine. A business owner can use wait time statistics to hire more people during busy hours, or use product consumption statistics to appropriately position supply chain resources, e.g., supply trucks, to alleviate periods of excess demand. Alternative or more convenient types of businesses can be established or advertised, e.g., a delivery service at times or in geographies of excess in-store demand. Customers can be steered towards such alternative businesses that even out the demand-time curve by the issuance of discount coupons, etc.
- *Cartography*: Sensor data obtained as described herein can augment map services by extending map views into retail outlets and businesses. To further assist users in planning their trips to retailers and supermarkets to reduce wait times, a map provider can periodically, e.g., once a month, send conventional, backpack-style lidar and/or camera mapping rigs into

buildings, with appropriate permissions from the building owner/tenant. The resulting data can be used to build an inventory for the store. Knowing the inventory can help in meal planning (buy these five items on these shelves to make this meal), providing the user with not only a recipe but a direct map of where to find the items very quickly. Search engines can utilize such data such that when a user searches, e.g., for flowers, results that include a picture of a shelf at a nearby grocery store appears alongside a map and time to reach, an average wait time once the user reaches, and a recommendation of when to leave to reduce wait time can be provided. Additionally, activity heatmaps, generated as described herein, can be analyzed to determine the main types of distinguishable activity going on, e.g., humans walking, cars driving, conversations, etc., thereby discovering, refining, or improving the business hours of an establishment, including detecting businesses that have shut down or new businesses that have opened up.

Further to the descriptions above, a user is provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable the collection of user information (e.g., information about a user's shopping list, store visits, sensor data, 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 is 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 has 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 enable customers to estimate wait times at retail outlets or businesses; recommend or schedule a store and/or a timeslot that reduces or eliminates waiting time; and, based on a customer's shopping list and the distribution of people within a store, compute a route that improves social distancing while reducing the duration of time spent at the store.