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Smart Parking Tying Dynamic Costing Method

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ABSTRACT

The solicitation of smart cities will increase unexpectedly with the rapid increase in IoT infrastructure. Smart City idea notably going up to city lifecycle. Parking is an important part of smart cities yet parking is a difficult process because there isn't a good way to pay for it or find a spot in the existing system. The number of vehicles in our city is increasing day by day due to which there is an immediate need for a good parking system. The focal point of this paper is to manage parking lots by including dynamic costing methods incorporated in a novel iOS apps-based implementation for smart cities' demands, which permits a user or driver to make an option for pricing the desired slot and booking the desired slot based on costing in that lot. That means, that developed iPark proposes innovative costing strategies that permit the making of additional parking profits and the rational ordering of parking transportation through parking lots. This paper additionally focuses on reducing the searching time for determining the parking lot using our proposed method, namely, the booking method. From the results, we can see that our proposed method increases profits as well as utilized resources properly compared to the existing methods.

Keywords: Dynamic Costing Methods; Static Costing Methods; iPark; Smart Billing; Parking Lot

INTRODUCTION

Parking could be an excessive procedure due to the payment or the time and attempt lost. Present revisions have shown that a vehicle is parked for 94.99% of its lifespan besides only on the street for the additional 4.99% (Knack and R. Eckdish 2005). If we carry the United Kingdom in 2018 as an illustration, normally a vehicle was directed 361 hrs. a year as reported by the British National Travel Analysis (Department for Transport 2015) giving roughly 8404 hrs. in which a vehicle would be parked. So where would you park your vehicle for these immense high times? Traveling for parking is obviously the primary difficulty produced by the upsurge of vehicle proprietors universally. Around 30% of traffic is due to the drivers traveling about for parking spots (Donald C. Shoup 2006).

In 2016, research in the Republic of France showed an assessment that seventy million times were consumed each year in the Republic simply in looking for parking which caused the ruin of 7 hundred million € yearly (A. le Fauconnier, E. Gantelet 2006). In 2014, a universal parking analysis by IBM [IBM 2011] mentioned that around 20 minutes are lost in looking for the desired lot. With the above-mentioned figures, we got the conclusion: an enormous amount of global pollution and fuel loss results from people having to travel to find parking (Y. Geng, C. Cassandras 2013). Car park places are organized to be over amply in a few regions and much unlikely to be traced in others. Pricing strategies had acted a significant function in the entire parking disposal for decades (D. Shoup 1997).

LITERATURE REVIEW

The parking mart can be governed by utilizing costing methods. The usage of the inadequate parking size in high-need regions might be enhanced by employing a more effective dealing of the parking demand over the application of costing methods (O. Cats, C. Zhang & A. Nissan 2016). Parking methods do not simply disturb the parking resource usage, it likewise precisely disturbs the overall transportation flow. For example, low-cost parking guides to a rise in transportation jamming, since it makes a financial inducement for parkers to travel for the finite available parking resources (Y. Geng, C. Cassandras 2013). A mathematical examination given by Zhou (J. Zhou 2014), exposed that raising the on-roadway parking charges that are low-cost to an optimum line will decrease the number of hunters, also disheartening people from parking their vehicles on the road.

Costing-oriented PBM methods consider diverse parking costing strategies, e.g., in the form of compromise (J. Zhou 2014; S. Chou 2008; C. Li 2004; W. Longfei 2009; L. Yang 2009; S. Hashimoto 2013), costing variation (G. Yan,

W. Yang, D. Rawat, S. Olariu 2011), or dynamic costing (D. Mackowski; Y. Bai, Y. Ouyang 2015). Costing conciliation is generally achieved by using a smart agent scheme (S. DeLoach 2001), where agents are the deputy of the parkers and the vehicle parks. With conciliation, the agents interrelate through a conversation, interchange bids, assess other agents' bids, and then revise their plans up to all agents reach a suitable promise (D. Ndumu, J. Collis, H. Nwana, & L. Lee 1998. Conciliation approaches are typically formed on game theory or subjective by natural humanoid activities.

Chou et al. S. Chou, S. Lin & C. Li 2004) suggested a PBM depends on dynamic parking conciliation and direction utilizing an agent-oriented system. In S. Chou, S. Lin & C. Li 2004), the driver agent usages the mother conciliation algorithm with the vehicle parks agents to deal. The driver agent's requesting cost is fixed depending on a margin of lowest and highest cost and the conciliation hour. The requesting cost is always reviewed after the respondent's price, up to a conciliation decision is fixed. Besides, the vehicle park agent usages the respondent conciliation algorithm to deal, discard or admit offers. When a vehicle park agent gets an offer from a parker agent, it will calculate the parking vacancy plus costing from the resource databank. Related to the parker's agent prices, there is a margin for the smallest and highest prices a vehicle park agent might reply to inside them. It is computed depending on the definite resource cost, an hour of daylight, plus vehicle park usage, to keep a definite revenue threshold. The conciliation method is parallel to the humanoid conciliation method, such that the purchaser agent initiates with the smallest price, and the merchant agent replies with the highest price, then one and the other sides review their price to make a suitable promise. When the agents set a parking cost, the parker is booked this parking slot and the scheme permits path navigation to the vehicle park utilizing a Geographic Info Scheme (GIS) supported gadget and Van Info Communication Scheme (VICS) in the parker's vehicle.

Longfei et al. (W. Longfei, C. Hong & L. Yangi 2009) suggested a related scheme (S. Chou, S. Lin & C. Li 2004), though they have categorized the vehicle park agents of related town areas to a solo parking info supply core (PISC) which links with separate PISCs and parkers' agents over a wi-fi net. This design decreases the usual communication transportation and interconnecting hours to a big range. Further, they have suggested diverse conciliation algorithms between the parkers' agents and vehicle parks agents, such that agents offer their private cost range depending on the projected cost and the dissimilar end's primary cost. The primary prices of the two parties are projected depending on the parking request. Costing conciliation might also be completed utilizing bargain to book parkers to parking resources. Hashimoto et al. (S. Hashimoto, R. Kanamori & T. Ito 2013) suggested a booking method that is booking oriented, at which there is an interim for the booking request method, and parkers should need to record their request before the time limit at which the scheme will assign the slot depends on the maximum price. The interim for every booking request method is determined by the parking admin for all parking time areas. Such as, the parking admin determines the booking request interim 8:30 to 9:00 for the 9:00 to 10:00 time area. This method uniquely tries to increase the profits for parking admins. A different method to a costing-oriented PBM scheme is the cost difference.

Yan et al. (2011) familiarized a smart parking scheme that designs the parking procedure as a birth-death stochastic method. They have classified a parking spot either as a low-cost rank or corporate rank. The low-cost rank parking spots are usually inexpensive than corporate ones, besides they are the spots with lower grades than those of corporate ones, for example, remote from the entrances. Past, dynamic costing might also be used in costing-oriented PBM schemes. Mackowski et al. (D. Mackowski, Y. Bai & Y. Ouyang 2015) implemented a dynamic costing design for a smart parking booking scheme which commits to decreasing the parkers' traveling times and transportation jamming in demanding city hubs and definitely affects the native financial system.

The design uses the actual time data of parking requests as well as parking vacancies to revise the costing of parking spots consequently (D. Mackowski, Y. Bai & Y. Ouyang 2015). The goal of the design is to keep a usage ratio for parking spots per block to eighty-five percent. This is gained by changing the cost like this: when the parking request is high, the cost is higher, plus when the parking request is reduced, the cost is dropped. The idea of deciding the usage level at eighty-five percent by dynamic costing was initially announced by Shoup et al.([Donald C. Shoup 2006), to decrease the traveling time for inexpensive on-roadway parking regions as depicted in his paper. Following, this idea directed to the improvement of San Francisco Park (SFPark) (2015) in San Francisco. The goal is to reduce transportation jamming by vigorously altering costs depending on sensor ancient information.

Popular SFPark, where sensors have been installed on the pitch to collect parking info that is kept in a databank and refined periodically. Conforming to ancient data, the costs are bigger and reduced relative to the anticipated usage. Although vigorously varying parking fees shall equilibrium the grant and request for parking and enhance total usage, it depends on ancient information and figures which might not be precisely adequate to have an accurate result. Therefore, Mackowski et al. (D. Mackowski, Y. Bai & Y. Ouyang 2015) offered a different parking scheme to conquer these shortfalls by utilizing actual time parking information rather than ancient data.

METHODOLOGY

PROPOSED SYSTEM

Figure 1 graphically shows our proposed system. From the figure, we see that our proposed system has four main components: Admin, Parking Apps, Pricing Engine, and Parking lot.

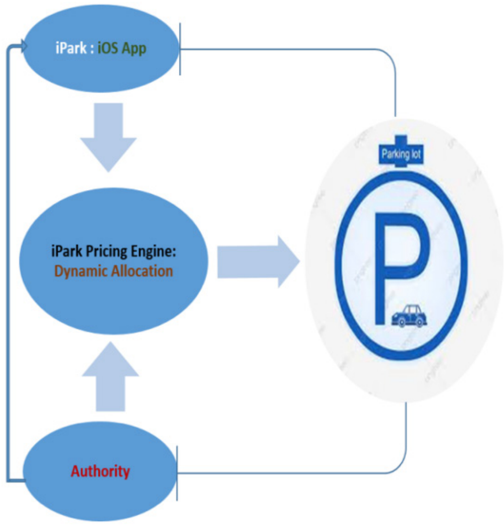

FIGURE 1. Proposed parking system

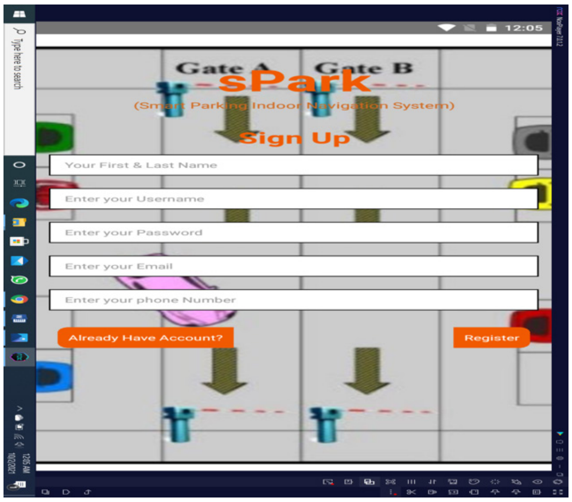

FIGURE 2. Registration Interface

The parking admin controls the parking lot with the help of implemented iOS parking apps. The parking apps are designed according to following the dynamic costing methods, which is the main focal point of our proposal. With the help of the dynamic costing method, we can see that our proposal can gain a lot of advantages over the existing system, especially gain more profits when compared to existing static costing methods.

Different segments of our proposal are discussed here one by one:

iPark: iOS App: This segment is used by the user and admin to properly utilize the parking lot. With the help of this developed app, a user can book and access his booked slot within the specified time period. Users can enjoy the dynamic costing facility while using this app because the app is designed following the dynamic costing method which is discussed underneath and this costing method is the main focal point of our proposal. In the result section, we see that the dynamic costing methods gains are very high when compared to the existing static costing method. The different parts of our developed apps are given below:

REGISTRATION INTERFACE

The registration interface is designed for user/driver registration purposes. Before, used the system a user/driver must need to register in the system using this interface. When all the required fields are fill-up then a user/driver get the user's name and password for later use the system.

LOGIN INTERFACE

The login interface is designed for driver verification. It is intended to avoid illegal practices in the smart car parking app. Figure 3 displays the login interface. The driver can enter the account utilizing the user's name and password if he/she has registered already, if not, the user can register using the above interface.

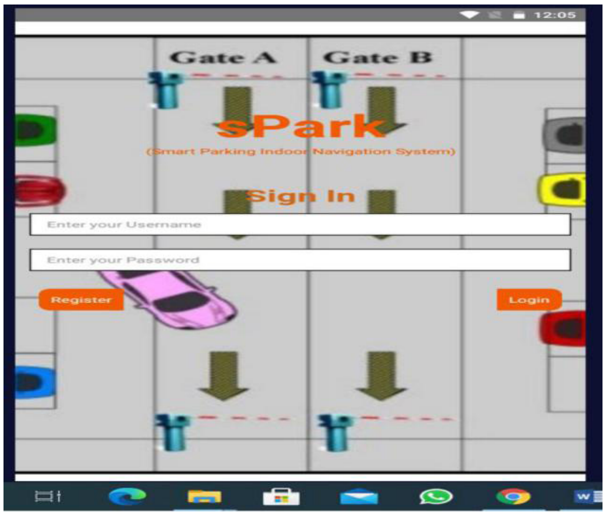

FIGURE 3. Login Interface

SELECTING THE VACANT SLOT INTERFACE

This interface as presented in Figure 4 shows all vacant spaces for choice.

FIGURE 4. Selecting Parking Slot

The slots are recognized in dissimilar shades. The blue slots are for booked parking; the grey slots show slots accessible for parking. The interface likewise shows the adjacent structures. After the choice, the client can continue to press their 4-digit operational puzzle with the attached keypad. In the wake of choosing a slot, a dialog is shown which contains data with respect to how long the parking is saved.

The reserved time for booked slot interfaces is demonstrated in Figure 4. Using this interface, a user notified his/her booked slot time prior to end. In this application, we pick the time booked for a slot as 15 minutes.

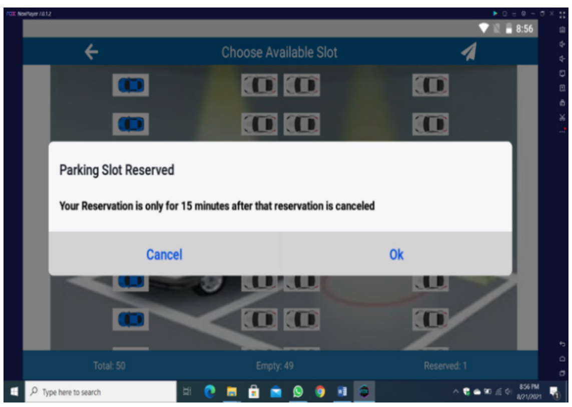

FIGURE 5. Interface for notifying reservation time

iPark Pricing Engine: Dynamic Allocation

The parking admin that owns the parking resources (parking spots) gathers instantaneous parking info to decide the parking costs and circulate them to the parkers to aid them to make bookings with the help of our developed iOS apps' iPark. From the viewpoint of parking admin, the dynamic costing method is for creating better profits and resource utilization from the parking facility, associating facility variation for parkers with diverse necessities and finances, and decreasing the traffic looking for parking. In different circumstances, parkers want to know parking info from parking prices and guarantee the best service.

For gain these policy objectives, the composition of dynamic costing is broken down into the cost of usage (p_u), statistical cost (p_s), and congestion cost (p_c). Mainly, the usage cost is decided by the instantaneous status of parking spot targeting for indicating instantaneous parking status as well as growing the profits; the statistical cost is weighed by the ancient cost, that serves operators with a suitable cost for their booking time span as well as decreases the possible transportation of parking looking; finally, the congestion cost returns the congestion in immediate prospect, plus avoids the unexpected upsurge of the parking request. The two, usage cost and congestion cost are calculated intermittently, while t is an interval, on demand, the cost of statistics is computed. The parking cost p is denoted as follows:

$$p = \beta_u p_u + \beta_s p_s + \beta_c p_c \tag{1}$$

Where β_u, β_s, β_c denotes the diverse weights for dissimilar cost modules. Mark that the joint parking cost p is the avg. cost for the entire booking period.

Usage Cost: Resource consumption determines the cost of use, unambiguously the unavailable car park spots, along with operators' possible requests. The usage cost (p_u) is fixed such that it can exploit the profits, parallel to numerous prices of parking admin linked with real-time status of the resource. Assumed a private parking spot having J parking slots, the cost of use throughout i^{th} span of time is p_u^i, which is restricted by the total of users requesting parking. The costing choice is to find the optimum revenue:

$$\max_{p_u^i} \left[\sum_{i}^{I} (x^i p_u^i - f(j^i, J)) \right] \tag{2}$$

$$\text{s.t: } x^i, j^i \leq J$$

Where x^i denotes the entire request for parking spots with cost p_u^i throughout i^{th} slots of time, I is the entire slots of time, and f(j^i, J) represent the function of parking price related with unavailable car park slots j^i and entire parking slots J.

Conferring to the utility function of operators defined upstairs, operators' choice of their parking spots depends on the walking length and parking cost. Nevertheless, since operators calculate walking distance provisionally based on their individual proficiency and other unpredicted aspects, the parking admin cannot acquire these activities from the operators. So, we just consider that the overall request x^i for parking spots with cost p_u^i is decided by the cost, which could be denoted as

$$x^i = \frac{C^i}{\delta^i p_u^i} \tag{3}$$

Where C^i denotes the entire number of operators whose financial plans are greater than p_u^i and δ^i is the constraint of preference to demand a parking spot with cost p_u^i.

Represent the primary cost of parking facilities with the lowermost usage by p_{basic}. φ^i is used for fixing the primary cost depend on the live status of a parking spot, the service cost could be calculated such as $p_u^i = \varphi^i p_{basic} / (1 - \sigma^i)$ where is the utilization of precise parking spots. The operational request connected through σ^i is $C^i / \delta^i p_u^i\ (1 - \sigma^i)$.

As a result, it is possible to write Equation (2) as

$$\max_{p_u^i}\left[\sum_i^I \left(\frac{c^i}{\delta^i p_u^i} p_u^i - f(j^i, J)\right)\right], \quad p_u^i = \frac{\varphi^i p_{basic}}{(1-\sigma^i)} \tag{4}$$

$$\text{s.t.} \quad \frac{C^i}{\delta^i p_u^i (1-\sigma^i)} \le J, \qquad \varphi^i \le 1$$

The Lagrangian's best-case scenario is like represented by

$$\max_{p_u^i}\left[\sum_i^I \left(\frac{C^i}{\delta^i} + \lambda\left(J - \frac{C^i}{\delta^i \varphi^i p_{basic}}\right) - f(j^i, J)\right)\right] \tag{5}$$

The optimum solution is

$$p_u^i = \frac{C^i}{\delta^i J (1-\sigma^i)} \tag{6}$$

Statistical Cost: The statistical cost is agreed to anticipate the parking cost above the present time period. If a parker books a parking slot throughout the forthcoming time periods, the parking admin will enforce an opportunity price by stripping other parkers of the chance to be acknowledged to usage those parking spots. Nevertheless, the active usage costing cannot properly return the opportunity price in the coming. In this circumstance, the parking admin ought to offer a different rationale price to foresee upcoming parking costs, rather than encasing resources at the present usage cost. Because the entire transportation streams are periodic, the parking environments are equally varying. As a result, the historical info supplied by the parking admin is a dominant tool to foresee the parking cost above forthcoming time periods. Hence the statistical cost (p_S^i) of parking booking service is represented like so

$$p_s^i = \frac{\sum_i^{I'} \left[ñ\, p_u^{i_{avg}} + (1-ñ) p_u^{i_{(k-1)}} \right]}{I'} \tag{7}$$

where p_S^i is the cost of statistics for the i^{th} slots of time throughout the present span of time k^{th} (we usage 24 hrs. works as 1 span of time that comprises of I slots of time), I' is the whole slot of time that operator books, $p_u^{i_{avg}}$ is the avg. cost of use at the i^{th} slot of time in all last spans, $p_u^{i(k-1)}$ is the cost of usage at i^{th} slot of time throughout the last $(k-1)^{th}$ span of time, finally, ϱ is a weight constraint.

On supplying operators with this statistical cost, the parking admins let operators gain the forthcoming parking cost that might avoid probable congestion. At a similar time, as the statistical cost can guess the forthcoming usage cost, this better rational cost permits the parking admins to upsurge the profits as well as operators' allowances.

Congestion Cost: To escape numerous operators requesting a few parking spots and lessen the traffic bottleneck produced by parking seeking, we recommend a supplementary cost module that is congestion-susceptible to boost operators to equilibrium their parking choices in addition to decreasing congestion. The blockings measured are transportation bottleneck and parking bottleneck. Since the traffic congestion cannot be precisely detected by the parking sensor, and numerous traffic jams are not created to search for parking, we only emphasize the increasing ratio of parking unavailability to understand the traffic state. If the transportation searching for parking spots provides input to transportation bottlenecks, the degree of parking unavailability ought to increase radically in a small time. In addition, when the vacant parking spots are smaller than a precise ratio, it will reason for parking blocking and clashes if enormous operators demand these spots. As a result, two types of congestion costing are reflected: costing when the gain ratio of unavailability passes a precise threshold and costing while the parking unavailability touches a definite mark. Both costing is measured iteratively to avoid the cost being extremely oscillating. This type of variation in cost, growing when the grant is under operators' request and reducing when the grant overdose operators' request, can control the correlation of grant and request to touch definite symmetry.

In this proposal, we categorize the congestion grade based on congestion factor l. When the bottleneck factor passes the threshold of definite grade, an extra cost for congestion is accused. The cost of congestion p_c^i through i^{th} time slot is represented on

$$p_c^i = \left\{p_c^{(i-1)} + \xi^l \frac{dr}{di} + \omega^l \frac{(r^i - r_{avg}^i)}{r_{avg}^i}, 0\right\}^+ \quad (8)$$

Where ξ^l and ω^l are the bottleneck constraints to fix the weight conferring the diverse congestion factors l, and r^i and r^i_{avg} denote the usage ratio and average usage ratio during i^{th} time slice.

Throughout the bottleneck, the operators must suffer the additional congestion cost or else choose another parking spot with smaller parking costs. As a result, equation (8) pushes the operator request to the parking spots with smaller usage ratio and low growth ratio. The supplier utilizes the congestion cost when the bottleneck touches a definite grade and fixes the bottleneck cost and grade dynamically conferring to the instantaneous parking info. After the bottleneck is detached, the bottleneck cost is reduced evenly to nil to escape additional bottleneck and cost fluctuation if a different bottleneck is found.

Throughout this segment, we have described a dynamic costing method comprising 3 dissimilar costing modules: usage cost, statistical cost, and congestion cost. The two, usage cost and congestion cost are fixed intermittently in a certain time period. And the live costing info is warehoused in a database for statistical cost and advanced study. In veracity, the operators simply require to learn the overall cost, rather than definite cost modules.

Authority: With the help of developed apps, the parking admin or authority can manage his/her parking lot and make more profit in this way. He/she is the sole authority of the parking lot. The parking admin can simultaneously monitor his/her parking lot by using the developed iOS apps and in this way his/her lots are utilized properly without any kind of pressure. In this way, the utilization of resources is properly handled and the parking admin can earn more and more profits from his/her parking lot, and the users are also satisfied by using the parking lot in their expected way.

SIMULATION RESULTS OF OUR PROPOSAL

Connected to the dynamic costing method, the static costing method is an option for the parking admins. We perform the following simulation to compare the road traffic searching for parking under dynamic and static costing choices that are the names of two dissimilar costing methods from which dynamic costing method is used in our proposed system for calculating parking spots cost and static costing method is used in other existing systems.

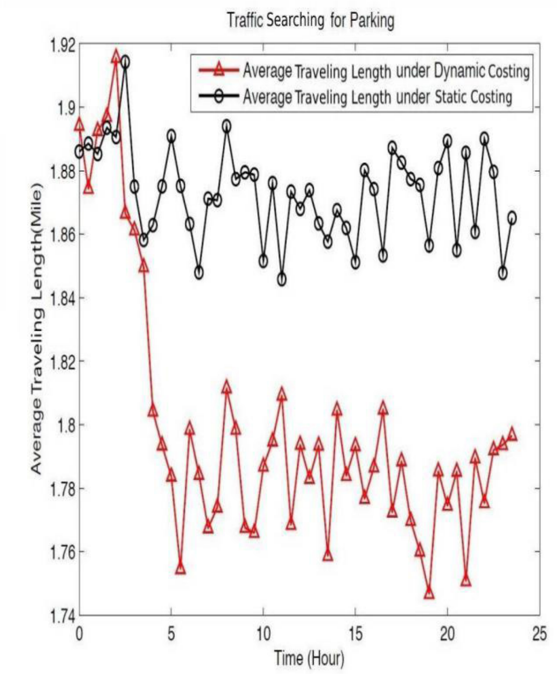

FIGURE 6. Comparison of Travelling Length Covered by Searching for Parking under Dissimilar Costing Methods

Throughout the simulation, both static cost and primary cost of dynamic costing are fixed as default price (¥ 1 for each slot of time). On behalf of the method of dynamic costing, βu, βs, βc are fixed to 0.6, 0.4, and 0.3 that signify the dissimilar weights for diverse cost modules. As displayed in figure 6, by employing the method of dynamic costing, the avg. the traveling length of all operators for parking searching might be decreased.

In common, an operator under parking cost of dynamic will choose a parking spot that can give the maximum profit. Inequity, with static costing, every operator cannot learn the associated parking info from the cost and is simply interested in the traveling length. It permits self-centered operators to track the adjacent parking spots to their target without any constraint. As a consequence, the parking spots rush regions are completely unavailable, which vigor part of operators to drive extra and unused their petrol. In different circumstances, the unavailable ratio in adjoining regions is greatly inferior. It additionally originates from the difficulty of load equity. Figure 6 displays that, throughout the early stages, the performance of traveling length is analogous under dynamic and static the two dissimilar methods. After that, with the traffic flow growing, the parking cost is increasing and the congestion cost is accused of avoiding additional jamming. In reply, few operators change their choices from costly parking spots to next at low-priced costs. As per the consequence, the parking request is more balanced throughout all parking spots, causing the decrease of traveling length in comparison with the static costing method.

Profit: We initially analyze the performance of profits improvement under recommended dynamic costing and static costing methods, at dissimilar cost units. Figure 7 illustrates the total profits of all parking spots in the target region conferring to dissimilar costing methods one is static which is incorporated in the existing system and another one is dynamic costing method with a booking-oriented strategy that is incorporated in our system.

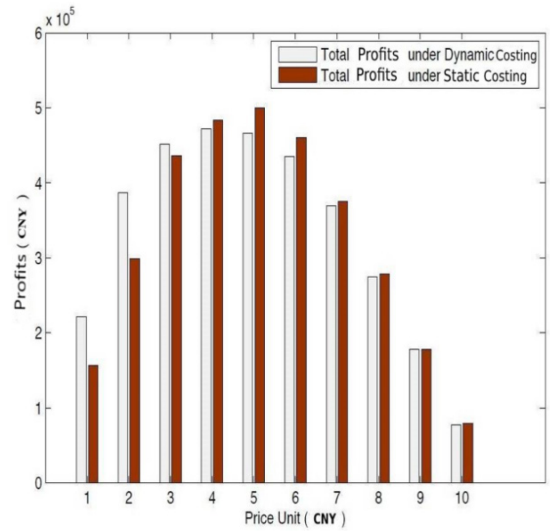

FIGURE 7. Profits Analysis between Dynamic and Static Costing

Note that the cost unit means the primary cost for the dynamic costing method and the single static cost for the static costing method. Depending on dissimilar cost units, both kinds of costing execute contrarily on profits increase. Correlated to static costing, the recommended dynamic costing can increase profits when the primary cost is low. With the growth of primary cost, the profits under dynamic costing become parallel with static cost. Although the biggest profits are smaller than static cost (93.22%), dynamic costing can let additional valued operators with small finances search their anticipated parking spots. Hence the operators' financial plan limitations are under Gaussian distribution, the bigger primary costs will cause better failure on parking finding and transportation blocking. As a result, in the real world, a small cost is more feasible considering the communal well-being, which permits more operators with a minor financial plan to find their parking spots. Herein circumstance, the dynamic costing might gain improved profits, since it can fix parking costs dynamically depending on parking status, besides letting maximum operators be pleased.

In addition, after setting the static cost to gain the maximum profits depending on the distribution of operators' financial plan, finding such a distribution is difficult within the physical realm.

As a result, random choice of static costing is measured as a prospective selection without the info of operators' financial plans. As displayed in figure 8, the profits under random costing rely on the random series. When the scale chosen is short enough, the profits are getting nearly the static cost. By the growth of random scale, the performance of profits development turns into far inferior to recommended dynamic costing and static costing. As a result, this research results confirm that the recommended dynamic costing can modify cost considering live information to gain additional profits and fulfill additional operators than static and random choice costing while the primary cost is low. On the other hand, when the choice range is low enough, the parking admins gain analogous profits under random choice and static cost but giving up the operators' fulfillment.

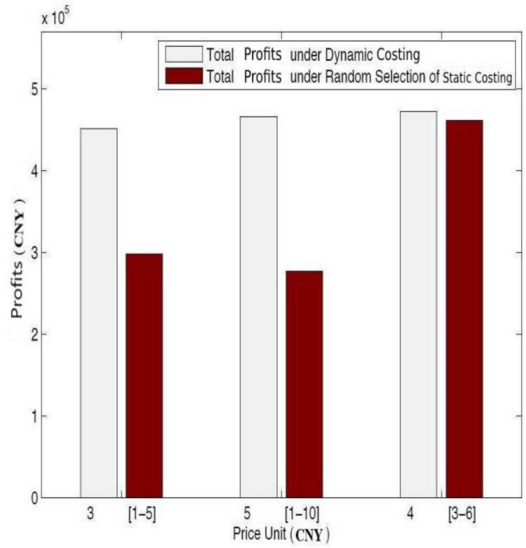

FIGURE 8. Profits Correlation between Dynamic and Random Choice of Static Costing.

Now, we conclude from the above simulation results that the recommended dynamic costing method which is incorporated in our system usages the live parking status as operators' feedback, taking benefit of operators' distinguished desires for the development in profits advance, in addition to cares operators' fulfillment, related to the random-cost and static cost strategies.

CONCLUSION

The ease of smart parking methods is somewhat a challenge in the present day. There is no efficient costing method included in today days parking methods. So, the parking lot admin, as well as the user, suffer a lot. This picture of costing methods' emergencies provides rise to innovative results with the aid of an iOS app which is developed by including a dynamic costing method, therefore, handling parking systems excellently. This paper focuses on the emergency of efficient costing method for the parking lots across an isolated city and comes out with an iOS-based secondary cellular application system. The recommended research result provides real-time info about a parking lot and is able to harmonize with the iOS mobile apps, therefore, giving users the likelihood of booking a parking lot and enjoying dynamic costing options residing at a far distance. From the simulation results, we can conclude that this research increases the outcomes in all sectors like resource utilization, searching time, profits, etc. when compared with other existing systems.

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DECLARATION OF COMPETING INTEREST

None

REFERENCES

Knack & R. Eckdish. 2005. Pay as you park. Planning. 71(5).

Department for Transport. 2015. National travel survey England.

Donald C. Shoup. 2006. Cruising for parking. *Transport Policy* 13(6):479–486.

IBM. 2011. IBM global parking survey: Drivers share worldwide parking woes. September.

A. le Fauconnier & E. Gantelet. 2006. The time looking for a parking space: strategies, associated nuisances and stakes of parking management in France. In Proc. European Transport Conference (ETC), September.

Y. Geng & C. Cassandras. 2013. New smart parking system based on resource allocation and reservations. *IEEE Transactions on Intelligent Transportation Systems* 14(3):1129-1139.

D. Shoup. 1997. The high cost of free parking. *Journal of Planning Education and Research* 17(1):3-20.

O. Cats, C. Zhang & A. Nissan. 2016. Survey methodology for measuring parking occupancy: Impacts of an on-street parking pricing scheme in an urban center.. *Transport Policy* 47:55-63.

J. Zhou. 2014. An integrated model of parking pricing and cruising. In Proc. *Safe, Smart, and Sustainable Multimodal Transportation Systems (CICTP*): 3441-3449.

S. Chou, S. Lin & C. Li. 2008. Dynamic parking negotiation and guidance using an agent-based platform. *Expert Systems with Applications* 35(3):805-817.

C. Li, S. Chou & S. Lin. 2004. An agent-based platform for drivers and car parks negotiation. In Proc. *IEEE International Conference on Networking, Sensing and Control* 2: 1038-1043.

W. Longfei, C. Hong & L. Yangi. 2009. Integrating mobile agent with multiagent system for intelligent parking negotiation and guidance. In Proc. 4th IEEE Conference on Industrial Electronics and Applications (ICIEA), pages 1704-1707.

L. Yang, M. Rongguo & W. Longfei. 2009. Intelligent parking negotiation based on agent technology. In Proc. WASE International Conference on Information Engineering (ICIE'09) 2: 265-268.

S. Hashimoto, R. Kanamori & T. Ito. 2013. Auction-based parking reservation system with electricity trading. In Proc. IEEE 15th Conference on Business Informatics (CBI), pages 33-40.

G. Yan, W. Yang, D. Rawat & S. Olariu. 2011. Smartparking: A secure and intelligent parking system. *IEEE Intelligent Transportation Systems Magazine* 3(1):18-30.

D. Mackowski, Y. Bai & Y. Ouyang. 2015. Parking space management via dynamic performance-based pricing.. Transportation Research Part C: Emerging Technologies, 59:66-91.

S. DeLoach. 2001. Analysis and design using mase and agent tool. Technical report DTIC Document.

D. Ndumu, J. Collis, H. Nwana & L. Lee. 1998. The Zeus agent building toolkit. *BT Technology Journal* 16(3)..

San Francisco Municipal Transportation Agency. San francisco park (sfpark), February 2015.