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SMART PARKING SOLUTIONS FOR SMART CITIES BASED ON WIRELESS SENSOR NETWORKS

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ABSTRACT

Urban commuting has become a nightmare for a common man who travels to and from work daily in a city. The traffic gets even worse on weekends, as almost half the road is occupied by cars searching for parking. To avoid these problems, recently many new technologies have been developed that help in solving the parking problems to a great extent using RFID technology, GSM, and QR code. In this survey paper, we discuss and analysis various smart parking solutions that are used to locate available parking space with the help of sensors. This saves customer's time as well as minimizes wastage of fuel. This is done with the help of robotics and a lot of software programming. The growth in low-cost, low-power sensing and communication technologies is creating a pervasive network infrastructure called the Internet of Things (IoT), which enables a wide range of physical objects and environments to be monitored in fine spatial and temporal detail. There has been growing interest in the IoT for realising smart cities, in order to maximise the productivity and reliability of urban infrastructure, such as minimising road congestion and making better use of the limited car parking facilities. Some methodological framework for multiple steps ahead parking availability prediction includes the probability a free space to continue being free in subsequent time intervals, and the short-term parking occupancy prediction in selected regions of an urban road network.

KEYWORDS: RFID technology, GSM, QR Code, parking sensors, Internet of Things.

INTRODUCTION

Parking availability prediction is among the most important factors affecting both private car based trip decisions and traffic conditions in urban areas. Drivers' decisions are temporally dependent, implying that they are influenced by past experience, as well as real-time (on road) perceptions. Parking is such a case where prior knowledge on possible prevailing conditions (e.g. difficulty in finding a parking space, off-street parking costs, and so on) affects drivers' parking decisions. At the same time, vehicles in search of free parking spaces negatively impact traffic conditions and the environment.

In this context, parking information provision is a research area of particular interest, since modern communication technologies offer alternative ways of delivering information to travellers in a timely and effective manner. First, they significantly increase the probability of finding free parking spaces and mitigate frustration of those drivers/visitors unfamiliar with the city center. They are supposed to decrease queues in front of parking garages and decrease total vehicle-miles travelled (particularly in the city center).

Additionally, they help road users to optimize their trips and, thus, improve vehicles' energy consumption and decrease emissions. The usefulness of such predictive parking information is straightforwardly understood.

If all drivers act without information and make "uninformed" choices, they will probably resort to similar optimal decisions leading to induced long waiting times, queues and increased parking circling. To avoid this statistical and

computational intelligence methods are developed and a methodology that can be used for multiple steps ahead on street parking prediction in "smart" urban areas.

Let us take a look at example of a regular road on a weekend evening, suppose the road consists of three lanes of traffic flow, it is often found that only two lanes actually have moving traffic, whereas one lane is blocked, or moving very slowly. The reason behind that is simple, the leftmost lane often consists of drivers looking for a spot to park their respective cars, seemingly, a third of the entire road is not moving because of this. Due to this, the moving traffic suffers and it takes them a longer time to get from one point to another. When the car is parked in a large or multi storied parking lot, it can be difficult for the user to find their vehicle again, after parking it hours before.

1.1. PARKING SYSTEM USING RFID TECHNOLOGY

RFID is a well-known technology which provides wireless data transmission through wireless sensor. Figure 1 shows the RFID [15] sensor detects the vehicle occupying the parking, it can log where exactly the vehicle in parked, including the floor and number of parking, for example, P1/ Lot-86

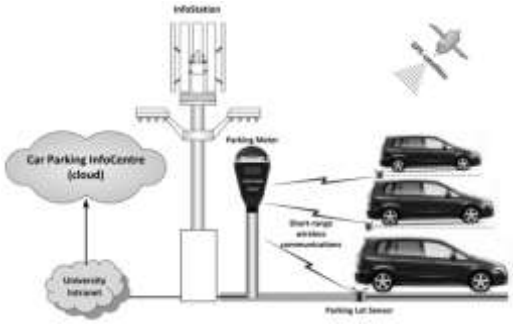

Figure 1. Parking scenario using RFID

The system explained in this paper ill have the ability to compute sense and interact with the physical environment in detail, leading to generation of huge amounts of data [16]. In order to efficiently manage the critical infrastructure and services of a city, these need to evolve into a 'smart city'. This requires intelligent sensors to be deployed in the parking lots for monitoring the occupancy as well as intelligent data processing to gain practical insights from the vast amount of data collected.

With the development of sensor technology, many modern cities have been deploying various IoT devices in and around the cities for monitoring. Moreover, wireless in-ground sensors have been installed in parking lots, which record parking events or availability. Cities like San Francisco have made real-time parking information available to the public in order to help people make their decisions about parking. However, in order to efficiently utilise these parking facilities and the real-time data, an automated parking availability prediction mechanism is required. This will help people to plan their trips ahead of time, and therefore save time and traffic congestion in finding available parking spots.

It is used for optimum utilisation of parking space by utilizing vertical space rather than horizontal space. The growing population and the increase in vehicles have made the plots expensive and hence the conventional parking has become non-feasible. Car ramps or car lifts also consume a lot of space therefore mechanized car parking systems prove to be feasible.

1.2. MULTI-CAR PARKING SYSTEM

Multi-level Car parking system used automated car parking which transports cars to different parking levels. It requires less floor space area thus saving on the cost of building. Circular parking system rotates circularly while a rack-pinion mechanism is used to lift the cars to the parking chamber at different levels. Figure 2 shows the Multi-level car parking system (MLCPS) has a number of advantages over the conventional parking system. Some of the advantages of MLCPS are stated below.

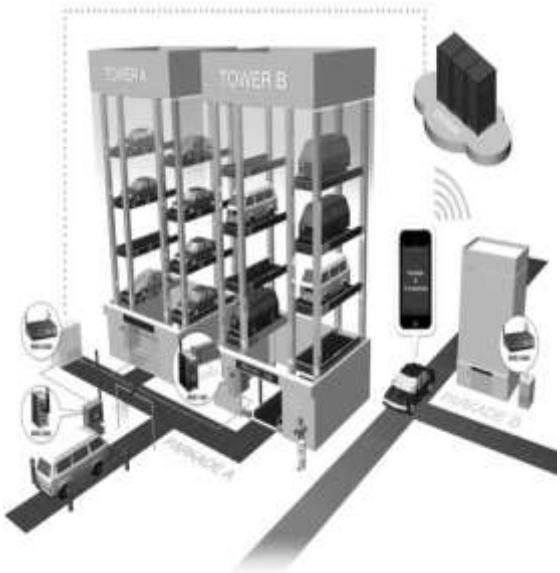

Figure 2. Multi-level car parking system

Parking is made easier with MLCPS as the driver is not made to drive from the parking lot to find free parking space and do not have to park the car in the free parking lot. Even retrieving the car from the parking space does not require the driver. All this saves a lot of time. MLCPS can be used for both public and private use. It is designed to accommodate any number or cars. It makes difference in designing and planning places.

RELATED WORK

Analysing parking data in terms of parking lot availability has received attention in the literature. The main challenges of parking availability prediction are the accuracy of long term prediction, the interaction between the parking lots in an area, and how user behaviours affect the parking availability.

In [1] and [2], a continuous-time Markov model is built to predict the parking availability in an ad hoc network. In [3], a recurrent neural network is used to forecast the time series parking occupancy up to 60 minutes ahead for the area of parking lots in Santander city. They also used a Weibull parametric model to predict the free parking duration, which consists of two functions, a survival function that computes the probability of available parking time in an area that is larger than a specific time, and a hazard function that computes the failure rate.

In [4], Chen et al. presented Generalized Additive Models for availability prediction of shared bike and car parking lots in the centre of Dublin city. The models considered the variables time of day, time of year, day type, weather, temperature, humidity and the past 2 steps of data, and chose these variables with corresponding functions based on the prediction type (short, medium and long term predictions). They predicted the waiting time utilising an exponential distribution of inter-arrival time.

In [5], Beheshti et al. introduced a hybrid model consisting of a Markov chain Monte Carlo (MCMC) approach with an agent-based model, which generates the proposed distribution for MCMC, for parking and traffic prediction around the University of Central Florida. Moreover, they used Metropolis- Hastings to make the training of MCMC more practical. These previous works have focused on prediction models based only on one of the cites. Further,

they have focused on a single model for prediction, ignoring any comparative analysis on finding the model that performs better with a given time horizon of prediction. In this paper, we focus on the analysis of three non-parametric models with three different time-series feature sets on datasets from Melbourne and San Francisco.

METHODOLOGY

Analysing parking data in terms of predicting parking lot availability has received attention in the literature. The main challenges of parking availability prediction are the accuracy of long term prediction, the interaction between the parking lots in an area, and how user behaviours affect the parking availability.

Smart Parking System using Wireless Sensor Networks [6] uses sensors which are cost effective and they detect if a car is present or absent in particular parking space i.e. real-time parking space availability. Additionally, the sensors also give information like the car parking time and also the health status. Besides displaying the availability status at various locations which has strategic importance, they also provide the information such as slot allocation, car park timing, and information about billing and directional assistance to the driver's mobile phone via SMS. The SMS feature is used because the number of mobile phone users is very large and the use of SMS also saves cost incurred in printing parking bills and thus saves paper too. The smart parking system which uses sensors is highly energy efficient and cost effective as it uses only a single sensor.

Smart Parking Applications using RFID Technology [7] RFID is a well-known technology which provides wireless data transmission through wireless sensors. Although utility of RFID is known for a long time, it was not utilized to its full potential. Smart parking application which uses RFID technology requires no human intervention and is used for vehicle detection. It can also be used to develop automatic parking fee collection system. This technology helps the drivers to quickly check-in and checkout from the parking lot and also makes the parking secure. The RFID sensor at the entry point helps in avoiding multi check-ins thus avoiding traffic congestion in the parking lot. The RFID technology enables automatic parking fee collection thus saving time of the drivers.

The main components of RFID technology that are used for the purpose are RFID labels, RFID readers, software system and a barrier to control the gate. The transaction management, reporting and operational tasks are controlled by the software used in RFID. A database management system is also used to manage and record the vehicle tracking data and is considered within software requirements.

3.1. CAR PARKING SYSTEM USING GSM AND RFID

Figure 3 shows the Car Parking System using GSM and RFID [8]. The main components which are used are microcontroller, RFID module & GSM module.

Figure 3. Car Parking System using GSM and RFID

The microcontroller is generally interfaced with GSM and RFID module. The GSM technology uses the SMS service to locate the available parking space in a parking lot. The IR sensor which is placed at that parking slot, examines if it is vacant, and if it finds that there is availability, then it sends a confirmation. The SMS contains details like the Parking slot number, allowed Parking period, the tariff for parking which is proportional to the time duration and a security code. The whole process starts with the user when he/she send an SMS to the GSM module which is fixed in the parking lot. After that, the GSM module sends the password and the available parking space number to the driver.

Once it is sent, the counter for reservation time starts automatically. The driver then has to park the vehicle according to slot number that has been provided, taking help from the LED lights placed there. The green LED represents vacant slot. After the vehicle has been parked in the selected spot, the green LED is switches off automatically meaning that the slot has been occupied. The driver then has to use the password which is sent to him for making an entry and exit through the barrier gate. The RFID tag is generally used to authenticate the registered users.

3..1.1. MULTI-LEVEL CAR PARKING SYSTEM USING IMAGE PROCESSING

Multi-level Car Parking System using Image Processing [10] which uses Image processing exercises automated car parking which transports cars to different parking levels. Hence, this car parking system requires less floor space area thus saving on the cost of building. In most cases, a circular parking system is found where the cars are being lifted from the base level. The base rotates circularly while a rack-pinion mechanism is used to lift the cars to the parking chamber at different levels. To lift and place the cars in an empty space is a tedious task and hence robotic arms or gripping mechanism is found in the parking systems.

QR CODE BASED VEHICLE PARKING SYSTEM

QR code based Vehicle Parking System [9] model the important components are the parking zones, the users and the database required for the smart parking system. The management decides the parking tariffs and broadcasts live parking information to vehicle drivers. On receiving parking details, the user chooses a desired parking space and also books a space. Upon confirmation of the parking space, SPSR generates a unique QR code and sends it to the user. As a result, users' parking decisions changes the state of parking resources. The reservation authority distinguishes each user by the unique QR code which the management system has sent to the user at the time of reservation. After the reservation is done, the management updates the data.

4.1. REGRESSION TREE MODEL PARKING SYSTEM

Regression tree [11] is a type of classification tree with the end result of a constant integer value, rather than a class that emerges from using regular classification tree. Mean square error is used for node splitting rather than the conventional system entropy. The interpretation for this model is easy once the data has been input. Along with the ease of use, the missing values need not be left empty in a node, rather we can use the average of the previous and next node of the corresponding level in the tree.

The average values of the corresponding regions are c1 and c2. We need to impose stopping criteria to avoid an endless loop. The node splitting will be repeated till this criteria is met. The size of the tree is an important factor in data prediction. If the tree is too small, it may not reveal the characteristics we require and if it is too large, over fitting is a disadvantage. The stopping criteria we impose can be either of the following:

· Maximum depth
· Maximum leaf nodes
· Minimum samples at the leaf node, etc.

4.2. NEURAL NETWORK MODELS

Figure 4 shows the Neural Network Models for Time Series Prediction [12] Time series modelling is a popular approach for making predictions in transportation problems.

This approach is suitable for analyzing parking occupancy due to the temporal structure of the performance measures of parking systems. A common prediction strategy implemented in transportation problems is based on the autoregressive moving average family of models.

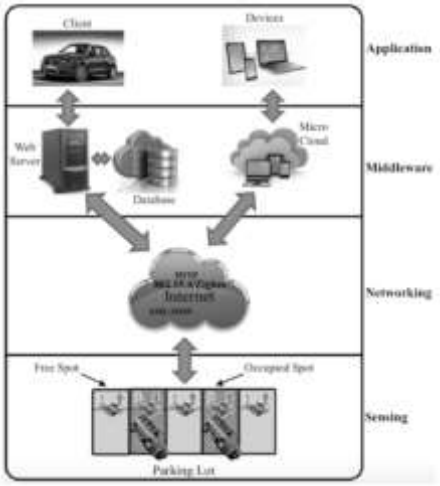

Figure 4. Neural Network Models for Time Series Prediction

These models are relatively straightforward mathematically and easy to produce; however, they are severely constrained by stationarity and linearity, characteristics that most frequently violated in real transportation time series. Treating non-stationarity and nonlinearity may lead to a tedious process without achieving the desired levels of accuracy in predictions and modelling reliability.

Neural 6 Networks (NNs) for time series provides a good alternative, as they relax many of these constraints, and also appear to provide short-term forecasting models that are more adaptable to sudden shifts in the data. A recent study on traffic time series prediction has shown the structural equivalencies between nonlinear univariate and multivariate ARIMA models with exogenous variables and dynamic forms of Multilayer Perceptions. The simplest of all is the NAR(p) structure of order p.

For a time series consideration in a NN framework, the MLP should be modified to account for the time sequence of events under study. This is usually accomplished by adding memory structures in than MLP that retain the effect of past information to the system and use it during learning. The memory is accomplished using local - at an intra neuron level - and global - between neurons of different layers - recurrent connections in a neural network.

The networks with memory usually require cumbersome and slow learning procedures that may not be always stable. To avoid this, static MLPs can be externally modified to represent the temporal characteristics of transportation time series (e.g. parking occupancy) in a manner resembling the common statistical prediction techniques. The introduction of such data inputs in MLPs that are unchanged in their internal structural logic may conceptually approximate very complex and multivariate statistical structures with equal efficiency as classical MLPs.

PARAMETRIC HAZARD-BASED MODEL

Figure 5 shows the Hazard-Based Free Parking Duration Modelling [13] Hazard-based duration modelling deals with the statistical representation of time to event data, a very frequent form of data in transportation problems.

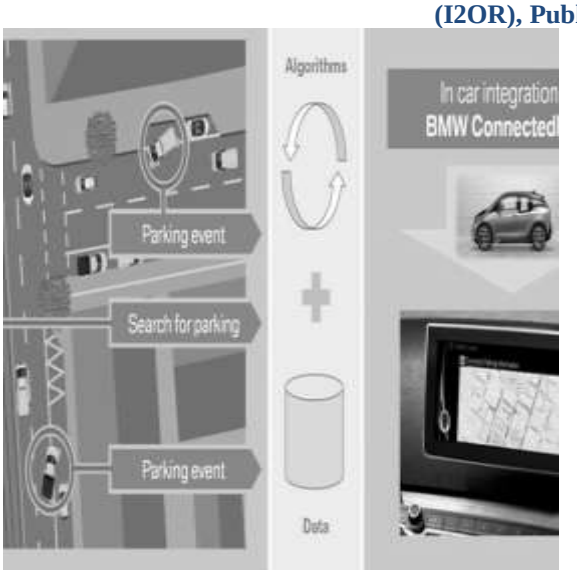

Figure 5. Parametric hazard-based model

A typical example of such transportation data is the time to clear and incident, the time until the end of congested phenomena the time until the end of transit vehicle repair the time to an activity the time to household evacuation under the emergence of a physical disaster the time for a pedestrian to cross a signalized intersection approach the time to vehicle transaction, the time to complete an overtake and so on. Extensive review on the hazard based transportation. Parametric hazard-based modelling is based on two concepts: the survival function and the hazard function.

Parametric hazard based models may have a range of different functional forms aiming at modelling different distributional characteristics.

CONCLUSION

We conclude from the survey and analysis the smart parking solution or under very tender stage in India and people hardly know about the technology. They cannot distinguish between smart parking and automated parking which is already very prevalent in India. However people are willing to accept it as it will solve many problems like space availability, wastage of time, fuel and will also provide security to the vehicle. Large data analyses collected by smart city deployments is an important task to enable intelligent management of the infrastructure that has been monitored using IoT devices. The study reveals that the regression tree, which is the least computational intensive algorithm compared to others. Hence Smart Parking has got a huge potential as many Smart City projects are coming up in India and and a huge investment has already been lined up and enhances further scope for using cost affective, and energy efficient wireless sensor network in smart car parking systems..

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