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Smart Parking with Prediction of Available Spots: A Proposed Approach

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Abstract: ***Parking is the most common and can be an extremely inconvenient thing in our day - to - day life. Every citizen faces this problem at least one time a day. In crowded megacities such as New York, LA, Washington D. C., people face excessive difficulty in finding the right place to park. Because of so much population of the vehicles in the city, there is not much space available for park and also might not enough obtainable space at your preferred destination. In megacities, there is no satisfactory parking space management system available in addition parking cost is outrageous. In this paper, a solution is proposed for the prediction of parking spots and parking spot management with the security of the parking area. Computer vision is the main solution that works on an open - source algorithm to sense the car at the defined space in the parking area. Computer vision might be handier on other solutions too such as parking monitoring, vehicle security, accident avoidance, and parking cost management. A brief discussion over the topic is charted in this document.***

Keywords: IoT, Computer Vision, Smart Parking, License Plate Recognition

1. Introduction

From the emerging era, vehicles are being used for a long - time span, and from that time traffic congestion caused by vehicles is a rattling problem at a large scale and it has been escalating exponentially. People face this problem in day - to - day life at least a time a day to find the right parking places, in particular malls, workplaces, restaurants, hospitals, and many other places. Many circumstances are causing this problem such as the growth rate of population and with that purchasing more cars than earlier.

With modernization, people prefer to live in the city and it is growing rapidly. A report [1] states that since 1950 there has been an increase in population that prefer to live in the city and blooming more swiftly. In 1950, 79% of the population were living in cities of the UK, almost four - fifth and predicted up to 92% of them will be living in urban areas by 2030. As well as China's population of urban areas were 13% to 40% in 1950 - 2005 and is predicted to rise to 60% by 2030. With this rate of urbanization, there will be a need for vehicles more than ever. Which would affect the quality of life and traffic will lead to the necessity of parking area as well. Moreover, people prefer personal cars for personal use all around the globe. There is a huge growth in cars ratio over inhabitants in all countries from past few years. In Mumbai, vehicle count went up to 56% from past 5 years. A survey [6] elucidates the number of vehicles over 1000 people and gives information about different countries. Iceland is at its peak which has the most registered vehicles over 1000 inhabitants, as per the record of the year 2016 Iceland had 914 vehicles per 1000 people. Other than that Greece had only 275 vehicles in 1990 and increased to 877 vehicles per 1000 inhabitants in 2016.

It shows a huge amount of growth in the population of cars all over the world. In many big cities, there is an average of 600 cars per 1000 people around the world. The increment in cars population led to another problem that is the time consumption need to find the right and convenient place to park a vehicle. A report [7] reveals that cars are parked 95% of the time in the cities, which is the most impactable major of lack of parking space.

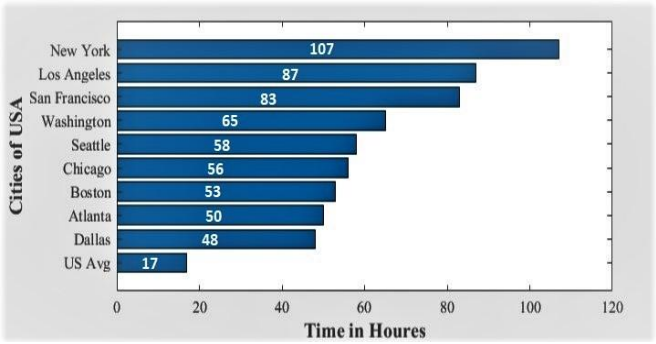


Figure 1: Avg. time taken per year for searching parking spot

Figure 1 shows data about time US drivers have wasted while searching the correct parking spot during the whole year. Data show of the top 10 US cities are the most time - consuming cities of whole US where driving can be very expensive and time consuming. Driver of many other cities avoid to drive during most of the time because of the lack of the parking spot and time consumed by this process every day.

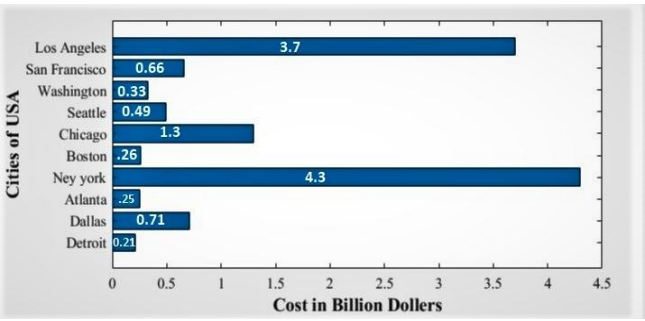


Figure 2: Cost per year in US cities (in billion)

On top of that, another major problem is parking cost. As per the report [2], traffic in the U. S. costs around 72.7 billion USD per year on parking search as the US has the most expensive cities in the world. Figure 2 shows the total expanse drivers experience per year while searching for parking space that time consumed fuel, time, and parking charges in top 10 cities of the USA. INRIX [2] also reposted that Americans spend more than $20 million annually on parking overpaying. A report [5] says that a driver spent an average of 17 hours per year looking for an appropriate parking spot and this hunt of parking spot driver waste around $345 per year according to INRIX, Driver spent almost 20 minutes extra searching equitable parking spots during the regular day and more time during holidays and weekends. They surveyed 60, 000 US drivers from them 63 percent said they avoided driving around cities due to parking challenges. A study [5], shows that 30% of drivers are looking for parking space around the city which causes pollution, traffic, and waste of fuel. It is also shown that there are plenty of parking spaces available in that particular area but inefficient use of parking area and lack of information about that location can be a vital reason for parking congestion and traffic. To solve these types of problems, many attempts were made using modern technologies in particular IoT, machine learning, and AI. According to a study [3], the total market worldwide IoT market was worth around 388 billion US dollars in 2030 and it is forecast to rise more than one trillion dollars. In 2021 revenue from the AI and ML market was expected to reach 327.5 billion dollars and is predicted a rapid growth and to reach more than half a trillion dollars by 2024 [4].

Conventional systems used detectors like ultrasonic sensors or RFID at the entry and exit points to keep track of parking spot availability. In this paper, a system is proposed for smart parking management and parking spot prediction using these two technologies, IoT and Deep Learning. The proposed system uses smart cameras and an IoT board for smart parking technology. Computer vision technology will be advantageous for security purposes of the parking areas and will be also helpful to identify the owner of the vehicle by recognition of license plate. In order to recognize with image processing, a convolutional neural network (CNN) will be used with the state - of - the - art algorithm. Image classification and object detection is the crucial implementation of the CNN network. During the whole period calculation for parking cost and parking spot will be managed by the computer vision and machine learning algorithm with hi - end edge device as conventional decision - making system cannot handle the enormous amount of data efficiently and rapidly. Using this system parking space will be calculated and shown to the application. The application will have all features like parking spot selection, navigation, reservation, or renting spot for time - span in addition app will also show prediction for parking place. This will make parking cost payment very easy and efficient as you will be paying only for those hours you have parked for. With time data for the system will be enormous and handling that will be very difficult so a normal database system will not work for this scenario. In this paper different approach distinct is used for this data handling so distributed database system will be used for data security, fast processing, and manipulating. The cost will be calculated by the system and deducted from your account or wallet automatically if the auto - pay system is initiated. All defined processes and control will be handled using a smartphone application or web application. In addition system for parking security and safety using computer vision and machine learning algorithms is Proposed. Using license plate recognition system, known data of license plate will be initiated into the system and the gate will be open for those recognized vehicles only. It will give security with precision.

This paper is organized further as follows. The related work is presented in section II, section III is for proposed algorithm. The result is reported in section IV. Section V is the conclusion at the end of the paper.

2. Related Work

a) Computer Vision

Z. Razak [24] represented an image processing model for detect for available space by threshold technique where the system compares between the background and newly incoming image since an incoming object will change the value of the background image pixel and if the change is above the set threshold, the space is set as occupied. Parking spot detection can be also managed and spotted with machine learning and computer vision technologies. As these technologies are capable of handling multiple steady and moving objects it can be very handful to operate with them. Parking management at outdoor environment can be difficult cause of weather conditions such as storms, rain, fog that can affect on the performance of the result. Fraifer and fernström [8] have proposed a parking system functioning with CCTV cameras for monitoring the parking area and capturing video which interconnected to the system and analyzed through computer vision algorithm. That algorithm determines the space is available or not in the parking spot. This information is sent to the server for updating the database. After that driver can see the status and find the appropriate space through smartphone. In computer vision technology shadows and lights can affect the result of the output. In [9] Imen et al proposed a vision - based new approach for detection of vacant space with a combined method of SURF algorithm and adaptive background subtraction for foreground object detection. Another real - time space detection system can be developed with a convolutional neural network (CNN). The system can be trained to determine occupied and free parking space. In [10] authors have suggested an architecture that utilizes a deep Convolutional Neural Network (CNN) for detection of vacant and occupied parking slots. They have elucidated the testing of this system with large labeled datasets of parking spots. Authors have used three - level architecture first one is visual nodes for capturing the live feed, second is the server for datasets, event handler, a detection module, and the end - user interface for mobile apps and web apps.

b) RFID and WSN

Among many widely used technologies, Radio Frequency Identification (RFID) was used for the development of smart parking systems many times over the years. Mainetti et al [11] has used RFID and WSN (Wireless Sensor Network) technologies for the development of smart parking. Authors

have integrated RFID, WSN, and NFC (Near Field Communication) and also included payment systems through NFC technology with IDA - Pay [12]. RFID and WSN allow drivers to allocate the parking slot in advance and pay for that spot at the location. The driver can pay with all available smart payment systems such as debit/credit card, smartphone or dedicated smart card without any hesitation of security. In another study from the previous author of [12] has also proposed this system [13], where authors have proposed SPS (Smart Parking System) using UHF RFID and IEEE 802.15.4 wireless sensors network. This system can verify the occupancy of the parking spot and can inform the driver about that location if space is available via software or smartphone application. For this architecture authors have no mathematical equations and also not implemented for large parking areas. They have given only theoretical ideas about the system. Hsu et al [14] proposedarchitecture with the parking guiding system. Firstly, a spot can be reserved via smartphone using internet. As soon as the vehicle enters the premises, parking splot will be displayed on a miniature map using wireless transmission for vehicles by the DSRC (dedicated short - range communication) protocol. An Inertial navigation system (INS) is dedicated to guiding the vehicle to the reserved parking area.

c) IoT and Devices

Yu et al [15], has introduced IoT based smart parking system with the addition of an e - payment service for a convenient and hassle - free parking experience. In this model, they have utilized Arduino with JAVA codded and raspberry pi with python codded to receive data through Wi - Fi. They have used ultrasonic sensors for the recognition of vehicles. LED is used to illustrate the state of the space. The payment will be initiated at the leaving moment from the parking with QR code, user can pay via popular payment methods. Thangam et al [17] has represented SRS reservation using raspberry pi and cameras for recognition of a person's face and number plate using morphology - based [18] detection of license plate. The authors have not performed any practical with live parking area and have not given any mathematical explanation for the architecture.

3. Proposed Algorithm

a) Model

In this paper, the proposed architecture relies on a Computer vision algorithm, all procedures are following a setup of recognition to calculate the fees and send invoice to the client's phone. A client can pay via popular payment methods or can arrange an auto pay method using the smartphone application. There will be no onsite payment to reduce hassle. The application will help to select a location other than that it will show you preference according to your daily routine.

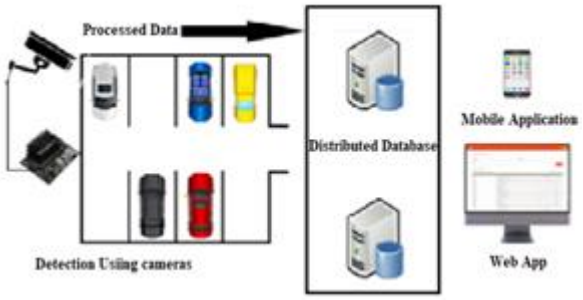
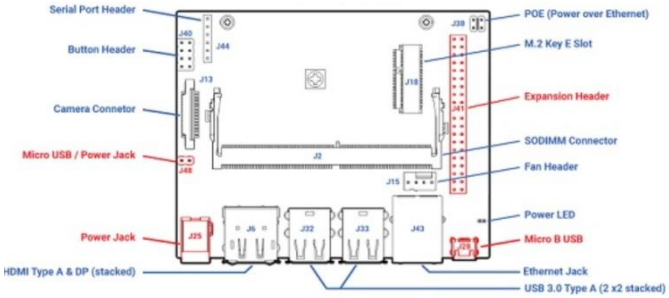


Figure 3: Representation of the model

Here this framework is divided into three layers for sake of understanding, first one is physical and detection layer, second one is communication or datacenter layer, third is application layer.

b) Hardware and Detection Layer

At the foundation or a hardware layer mentioned as the physical layer where all detection and calculation on the live feed and recognition work take place, cameras with high - definition quality will be used for higher frame rate and lucid image so that advanced and splendid recognition over frames can be done. What is more an edge device will be used for running the OS and deep learning algorithm on it. There are wide range of devices that can be used for the system development of object detection and recognition for instance, Raspberry pi 3B, Google coral Dev board, Intel neural compute stick, NVIDIA jetson nano. For object detection, architecture requires certain deep learning models to run on edge devices with higher frame rates to work smoothly and update the database quickly as fast as possible. For these requirements, all edge devices need to have such definite specifications on board to train models, for instance, multi - core CPU, great clock speed, dedicated GPU, etc. Multiple cores and high processing speed are keys for model training as it has enormous amount of data and images that need to be processed; In addition, the device should be able to run on popular frameworks for instance Tensorflow, Keras, Pytourch, etc. NVIDIA Jetson Nano [19] has acquired all these necessary requirements in it. Jerson Nano can run wide range of advanced networks, including all popular ML frameworks such as Tensorflow, PyTorch, Caffe/Caffe2, MXnet, darknet etc. These frameworks can be used to develop new machines and complicated AI models with robust capabilities like image processing, image segmentation, video enhancement, and analytics. In [19], it is shown that Jetson Nano comparing to all other edge devices, performs more efficiently and supports all frameworks while on the flip side, other devices support only some of them. In addition, Nano not only works with these frameworks but also gives effective results and detects with higher framerate and HD resolution. This board runs officially on the OS called linux4Tegra which is actually a version of Ubuntu 18.04 that's designed to run on Nvidia's hardware. Having Linux as OS gives benefits to use other popular apps such as LibreOffice, visual studio code, etc.



(a)

(b)

Figure 4: (a) Carrier board for Jetson Nano (b) NVIDIA Jetson Nano module

Board Specification

Nvidia Jetson Nano comes with Maxwell GPU with 128 - cores for display and computing multiple frameworks and detection concurrently. It comes with two different models 4 GB or 2 GB of RAM variant. It works over Quad - core ARM A57[at]1.43 GHz CPU. For its operating system, it needs a microSD card with 5V micro - USB connector J28 power input. Jetson Nano must get a minimum of 4.75V to operate but there are also other options for Nano. If there are more require more than 2A, e. g., for peripherals attached to the carrier board or complicated task that requires high performance, with connecting J48 power select pins that disable power supply of micro - USB pin and enable 5V - 4A via J25 power jack to get more power. USB - powered Jetson cannot work continuously under heavy workload other than less performance. For its benchmark performance, it requires an external power source 5V & 4A. Carrier board consumes around 0.5W at 2A and 1.25W at 4A.

Camera for detection

The camera is a crucial part of this project for recording and collecting frames for detection with high definition. The camera should have the capability for minimum performance in bad or stormy weather. At night cameras should give better performance in order to detect cars in parking lot for this situation infrared light is a better solution for cameras.

Wireless communication

As Nano module and carrier board do not have a wireless communication device onboard although it has M.2 key E slot for external communication device that can be added for data transmission. Intel 8265AC wireless NIC is specially made for Jetson modules, which works with dual - band connectivity and Wi - Fi protocol 802.11ac which gives more than enough performance. In addition, the carrier board has an inbuilt ethernet port for fast and steady communication and data transfer. This communication power will be used to transfer data from device to database over internet connection through secure transmission.

Detection process

After all setup, this is the most important and difficult process to accomplish. For the detection model, an open - source YOLO framework will be used, which gives state - of - the - art detection with higher framerate. In particular, YOLO v3 [20] will be used for smooth running and handling. Which is an improved model of [21] 'you only look once' object detection model developed by Redmon et al. we can use custom data set for a model which can be made from different sets of images of number plates. For training, Also pre - trained YOLO model can be used for faster results and detected images will be directly used for word detection by OCR (Optical Character Recognition). To use those detected images for word recognition, only a license plate will be needed to extract from the whole image of the front view or back view of the car image frame. These extracted images will be used for the detection of numbers from the plate. For this purpose, PyTesseract is used which is an OCR library of python. In [19] benchmark for YOLO is shown for the Jetson Nano module which is 24 fps recognition, which is an excellent performance small edge device can give.

All this layer will be set up at the entrance and exit of the parking lot for recognition of number plates from the cars. In addition, there may be some user those who have paid in advance or booked parking spot for a long time that will be determined at next level of this model as this data will be sent to multiple databases for timer and calculating the parking fees that will be directly sent to users application as invoice including all information necessary.

c) Communication Layer

This layer is dedicated to data transmission to the database from the edge device and data from databases to the application layer. This layer will work as a medium for the Nano module and user interface device. In this proposed architecture, where first data of license plate will be sent to a cloud database with entry time of vehicle, type of vehicle, which will give a unique id to that license plate and will start the timer for that plate. As soon as car leaves parking exit again recognition will be done and sent to the first database which will stop the timer and send the time taken by the car to the second database which will calculate the price for that car according to the time taken by that vehicle. All this math will use resources as it needs on the cloud which will reduce charges then whole reserved database. There are several examples available for such databases e. g., Google firebase, Azure Database, Amazon RDS. These databases provide service "pay as you go". after this all calculation all data with time of entry and exit and parking fees will be sent to user as invoice page to their smartphone or web application.

d) Application Layer

This layer can be elucidated as a user interface layer as this model will be available to end - users as a smartphone application or web application. We intend to make this

interface with easy to use and attractive UI so every user of any age can use this app. In this app many facilities are included such as pre - booking option, monthly payment or looking for a particular spot at any time. The payment system will notify you as soon as you leave the parking premises by app notification to your phone or if you are using web app, it will send you an SMS that will be containing a link with a secure payment gateway. This payment you can do with popular methods for instance UPI, cards, or payment applications.

In order to use this application or website, there are some steps are involved for authentication of your identity and vehicle that one is using. This precaution is necessary for user identification with that car when it arrives at the parking lot, a slot number of a parking slot and location in mini - map will be shown to the user so the user can find parking space easily. Steps are shown in figure 5 in form of a flow chart in figure 5. Firstly, with login or signup user will enter the main page by giving personal and car information to app. Secondly, the wallet will be set up to use it further for payment purpose. All this setup will lead to a map where you can see and navigate to a place where you want to go by searching that place in a search bar. The app will show available parking locations to users and also suggests nearest parking places for convince. It will show a miniature map of available parking lot with double tap also where you can book that slot in advance it will show other users as occupied spot.

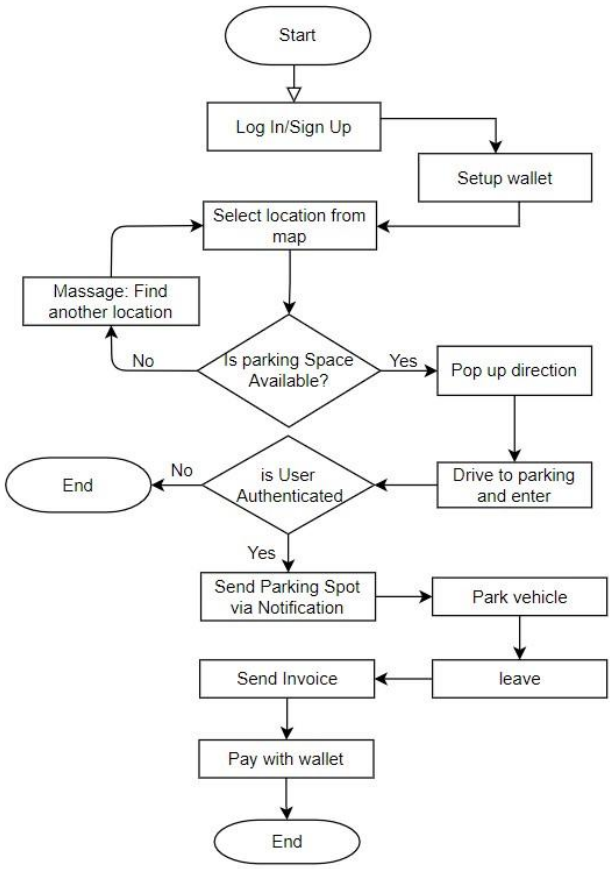


Figure 5: Flowchart of procedure for application usage

After selecting an appropriate spot and location app will pop up to a map view with navigation for a convenient drive to the parking area, as soon as car enters in parking camera will capture the frame and algorithm will determine the license plate number which will be updated on the cloud.

Prediction

Predicting a parking spot for a user when parking is far away, the system will predict the possibility of parking spots from parked vehicles routing with parking time. Firstly, in a trial run of the algorithm will note usually visiting vehicles and will estimate the time of park. After all the measures for a month, an algorithm has all data to determine average time for parked vehicles. It can be assumed that In that average time all vehicles will be altered with the new one. This system is applicable for malls, airports and all busy places. For private buildings and offices, there is no need for this kind of system so far, as they have limited permission for vehicles to enter and park. In public places, this technique might work more efficiently to predict empty parking spots. This algorithm will be used when desired parking area is full and still that is more convenient space for the user.

Furthermore, when the user will try to find a parking spot from the app and search for area or place of destination, a possible ETA will be found from the current location of user and that will be compared with that specific parking spot's average time. If both are more similar then parking algorithm will look for vehicles that have been parked for the ETA and average time for parking.

In addition, If the vehicle is recognized or previously parked more than three or four times then the prediction system with KNN and regression method will be added with prediction system in order to predict when that parked car will leave the premesis and that spot can be set available for upcoming vehicle or user.

4. Conclusion

In this paper, a theoretical approach is proposed during the research for the development of a smart parking system with the smart app for navigation and prediction of empty slots with higher efficiency and smart way.

The main novelty of this proposed architecture is scalability, and more speedy and accurate result to use in real - time world. This main feature is achieved by a high powered module which has more processing power and dedicated GPU for image processing power for image recognition and detection. Used module has the capability of running multiple algorithms concurrently and effectively, it can run deep learning frameworks for classification and normal machine learning algorithms such as linear regression, KNN, K - means, etc for prediction. This will give more effective results than other modules. In addition, all data will be stored in cloud for more availability and scalability as it can be accessed for further processing and cloud will help for further processing of data. User application will be made easy to use with a great interface. After one time setup, this architecture needs less maintenance and handling can be done remotely by SSH connection as module runs over Linux architecture.

Moreover, prediction of parking spot is the main goal of this paper this algorithm is the backbone of this architecture, if that prediction goes wrong user may face many problems and also waste of time.

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