

IoT Based Advanced Automated Four-Wheeler Parking System and Parking Slot Booking

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ABSTRACT: Without Four Wheelers or Cars we cannot imagine our lives nowadays. They are the backbone of modern-day transport. The demand for cars has increased tremendously in the past 5-10 years. This has led to another major problem in our modern society and our modern lifestyle, we are running out of places to park our cars. It is not the problem of one or two societies or some metropolitan cities but all the countries across the globe. In some cities, people are forced to park the cars outside their house thus blocking some parts of the road. This paper focuses on the parking system which is designed in such a way that it can be easily installed in malls or parking for the whole society, office.

KEYWORDS: IoT, Parking System, Real Time, Automated, Spring, Hydraulic System

I. INTRODUCTION

Cars are one of the most widely used means of transport throughout the world. The developed nations like the United States, Australia, Canada, and many others have been using cars from the very beginning. Even the powerhouse of the automobile manufacturer Germany was in the race too. Out of the mammoth variety of vehicles, here in this paper, the major focus of our concern would be on passenger cars.

The first car ever made was in the year 1908 [12]. It was the beginning of a new era. It was going to change the mode of transportation at an alarming rate. The first mass production of cars was started back in the year of 1913 [6] and since then there was no looking back. Following this commencement of production, the demand not only of passenger cars but also of the commercial cars has been increasing gradually.

Today over 1.2 billion cars are running on roads [13]. But the situation was completely different in the past 10-15 years. According to one source, there were only 58 million vehicles produced worldwide in the year 2000 [11]. But in the year 2018, the number increased to 96 million [11].

The Indian Subcontinent has also seen a rapid increase in the demand for cars. According to one survey, the number of cars per 1000 inhabitants was 22 in the year 2005 [9]. In the year 2016, the number of registered vehicles in India sold by the Indian automobile manufacturers was 25.6 million. In the year 2018-19, the number of cars manufactured by Indian manufacturers rose to 30.92 million [7]. However, this number has been decreased by 13% from the year 2018-19 due to a slowdown in the industry [7].

So far, we have discussed the numbers regarding an increase in the production and sale of passenger cars. But is there enough space to park so many cars. The answer is NO. The situation is worse in some parts of India. Due to the modernized lifestyle, we are running out of space to build a new building. So, there is no question about building a separate parking place. Not in some parts but in most of the cities across the country, people are forced to park their cars outside their houses, which blocks some parts of the road, conveniently, leading to the next problem that is traffic collision and in the worst-case scenario accidents.

II. RELATED WORK

Here, we will be focusing on other studies done on the automated parking system and also on the systems currently being used in the world[1]. The parking system in the world can be categorized in the following ways: Vision-based method, Sensor-based method, automated or Smart parking system [4]. Further-more the Smart parking system is

further classified into the following ways: Parking Guidance and Information System (PGIS), transit-based information system, smart payment system, E-parking, and automated parking [2].

III. NEED FOR PARKING SPACE

Due to modernization in lifestyle, the demand for modern products, especially cars is increasing. There has been a tremendous increase in the manufacture and sale of cars in the last 15-20 years. But with an increase in the number of cars, the question arises: Is there enough space to park these many cars? The answer is clear that there is not enough place. So, which are the places where people generally park their cars? People owning private bungalows, have garages in it and park their cars in it. But there is a dearth of people who own bungalows. Most of the people live in apartments and have limited parking place. In India, people park their vehicles outside their homes, which instigates further problems.

IV. WHY AUTOMATED PARKING SYSTEM

Time is the most paramount and precious thing in the whole world. But in today's modern world there is a scarcity of it. Everyone wants the things to be done by just one press of a button. So why should the car parking lag behind in this race? The automated parking system will save time as well as provide safety to the car.

V. PERFORMANCE METRICES / PARAMETERS CONSIDERED

To implement this system various considerations are to be made. These are the parameters that are to be considered by both the system manufacturer and the customer.

- Manual Walking Distance

It is the distance that is calculated from the point where the customer left his car in the parking area to the point of retrace. Point of retrace is the point or place where there is either staircase or an elevator, or in other simple words it is the entry place of the workplace.

This distance should be as minimum as possible. The major contributing factor for this is the design and placement of the parking system. The location should be ideal.

- Traffic Density

As the name suggests it will indicate the current scenario of the traffic to the administrator as well as a person who is currently monitoring the system. This will help him to further monitor the parking system, it will also help in identifying the failure (if any) in the system.

- Incomplete Payment

This is the additional parameter considered. Nowadays no one does such kind of thing, but an additional security measure is always a better option. So, when the user wishes to empty the parking slot then he will follow the procedure and will eventually come to the payment option. The gates which are installed in the parking system will not open until the user has completed the payment. This is the additional security measure. If someone tries also to take the chance of free parking, he will not be able to escape the system with his vehicle.

VI. CHALLENGES

This section tells us about the challenges which were faced while designing the system. Also, while in real-time implementation these might be faced by the administrator.

- Wait Time

This is one of the major challenges faced. No one likes to wait for anything, so how can one wait for parking space that too in the automated parking system. It signifies the time which is required until the next parking slot will be available. The display board will display “No more parking slots currently available” when all the slots are full.

- User Verification

When the parking slot is allocated to the user it is necessary to check that the right person gets the right parking slot. There will be more than one user currently in the parking area, so the administrator has to make sure that the registered person gets his slot. So, when the car enters the parking premises the camera on the gate captures the number of the car and the administrator verifies it after it the display board will show the location of his parking slot and how he should get there. Now only the gates which are required will open after he enters the OTP which he will receive on his device.

- Fake Booking

The user has to book his parking slot through his mobile phone. So, the chances of fake bookings are very high. Some users may select the slot and may not come to the parking system. To avoid such kind of issues, there is a pre-defined timer in the app after the user selects the slot for parking, then the auto pre-set timer will start and will automatically cancel the slot if the user does not verify himself in the desired time.

VII. PROPOSED METHODOLOGY

The working of this model is divided into 4 parts: Parking Slot booking through mobile phone, User Verification (at the parking entry gate), Parking of vehicle at the booked slot, Payment.

1. Parking Slot booking through Mobile Phone

Let's discuss the working of Parking Slot booking through mobile phone. To access the parking system, you will be needing the mobile application of the parking system. Once the application is downloaded and installed on your mobile phone, then you can easily register yourself in the system. After successful registration, you will be directed to logging in to the screen. Input your username and password to log in. Once you are logged in, you can see the different options available, but you need to click/ select the “book slot” option to book your parking slot. Then you will be asked to fill in your details that are Name of the person: the person who is booking the slot, Vehicle number: needed for verification at the entry gate and the mobile number: needed for the OTP verification. After filling all the details successfully, you will be displayed the message “Your slot number is _____, You need to verify yourself at the entry gate.” This is done so that the fake booking is not possible.

2. User Verification

Now let's look at the working of User Verification (at the parking entry gate). Once the user vehicle comes at the entry gate then CCTV located at the entry gate will scan the vehicle number and then send the OTP on the mobile number. Once the OTP is verified successfully then the slot number will be displayed. Also, the slot number selected by the user and the way to reach it will be displayed on the screen located at the entry gate.

3. Parking of Vehicle at booked slot

Let's look at the working of Parking the vehicle at the selected slot. As we have in the last parts how the slot number will be allotted to the user and how the way to reach there will be shown. So, before detailing into the whole system working let's understand the different parts which this system comprises. So, this whole system is divided into 3 sub-assemblies. The Base unit, Middle unit, and the Moving unit.

3.1 Base Unit

As the name suggests the Base unit is the main base for the whole parking system assembly. On it the parking slots are constructed, they are arranged in such a way that every other slot is 90 degrees to each other and they are arranged in a 360-degree circle. The height is not specific, it is selected by the person or company who is installing it. The height which we are talking about here is about the total height of the parking slots and not the individual height of the parking slot. The individual height of the parking slot is fixed as the height of the vehicles is also fixed. In this system, we have placed the parking slots on the slot support. It is done because we are using spring as the main moving component and after the full compression the spring cannot be further compressed. So, we have to calculate the solid length of the spring, and then considering the factor of safety, we have to build the slot support accordingly and then place the parking slot on it. The middle unit is then placed very carefully in the center of the parking slots. It has the main component spring which is used for lifting the cars and putting the cars in their respective slots and vice-versa. The middle unit also has its separate base, it is given to give buckle free movement of the spring and to reduce the tension on the spring. The moving unit is the unit that is used for moving the car carrying a plate in any direction and to park the cars in the slots and to bring back the cars from the slots also.

3.2 Middle Unit

The middle unit and the moving unit are both operated by the hydraulic system. The middle unit is operated first followed by a moving unit. Both these units can be operated simultaneously but it is avoided to save the cost in the hydraulic system.

3.3 Moving Unit

Once the user reaches the main parking system, he will find there the car carrying a plate. The user has to place his car there and on the computerized touchpad has to enter the slot number assigned to him. As soon as the touchpad will read the correct slot number it will send it to the hydraulic system to further operate the middle unit and the moving unit. As soon the hydraulic system receives the signal it will move the spring to the desired height as the spring reaches the desired height it will stop the movement of the middle unit and the movement of the moving unit will start. The car carrying plate which is the main component of the moving unit and the carrier of the car will align itself properly in front of the desired parking slot of the user. After proper alignment, the sliding plate which is attached to the car carrying plate will move forward further in the slot and will detach from the car carrying plate after it has reached completion in the parking slot. The sliding plate and the car carrying plate is attached by the help of sliders.

4. Payments

Finally, let's look at the working of the last part that is payments. When the user has finished his work and wishes to empty his parking slot, then he has to click on the empty slot button on the touchpad. As soon as he clicks on the button the car carrying plate will come near the slot and align itself accordingly. After it has successfully aligned the sliders will attach with the car carrying plate and then it will bring the car back to the basement. After the car has returned to the basement the parking system exit gate will not open until the user has completed the payment. Now to complete the payment the user has to open the mobile application of our parking system and click on the payment button on the home screen. After clicking it the various payment gateway options available to us are visible and available to choose for payment. The various gateway available to us are Cash, Card, Wallet, and PayPal. When the Cash option is selected the user is obliged to pay only by Cash at the main exit gate. When the Card option is selected the user will be re-directed to the gateway page of the bank. The system supports all Credit and Debit cards. When the user clicks on the Wallet the user will be re-directed to the payment gateway of the respective wallet from which he wishes to pay. When the user selects the PayPal option, he will be directed to the PayPal payment gateway. After the successful payment, the "Payment Success" message will be displayed and the gates will be opened. If the user has selected Cash as the payment option, then the "Please pay your cash at the exit gate" message will be displayed and the parking system gate will open.

VIII. COMPONENTS REQUIRED

Let us look at the different components which were used in the making of this parking system. We will be looking at the different sub-assemblies also.

Firstly, we will look at the sub-assemblies which are used in this system.

1. Base Unit

As the name suggests this unit is the main base of the whole parking system. There will be a total of 4 such units, which will be arranged in the circular pattern such that they are exactly 90 degrees to each other. These are the following components which are used in the base unit:

1.1 Base

This component is the main base of the whole parking system. It will be made of mild steel so that it can carry the weight of the system and also resist shock and vibrations if any.

1.2 Slot support

It is a specially designed component. It is designed according to the solid height of the spring. It is also made of mild steel.

1.3 Slot

It is the main parking slot. It will be fixed in size according to the size of vehicles. It will also be made of mild steel.

2. Middle Unit

This unit is used for the movement of the car from the ground to the desired height of the respective parking slot. This unit will be located in the exact center of the circular pattern of the base unit. These are the components which are used in this unit:

2.1 Middle unit Base

According to the base unit, this unit will also have a solid base. But instead of the regular rectangular or square base, this base will be circular. It will be made of mild steel as it is playing the main role in lifting the car. It also has the slot having a diameter equal to that of the spring in case if spring buckles.

2.2 Spring

It is the most important component in this parking system. The role of spring is that it has to expand or contract and adjust itself to the desired height and also have to maintain that height. The wire which is used for making spring is ASTM A228 (Music Wire).

2.3 Middle unit Top Plate

The main purpose of this component is to provide support for spring and to avoid the buckling effect in the spring. Additionally, it provides extra support to the moving unit which is directly attached to it. It is made of mild steel.

3. Moving Unit

After the movement of the middle unit stops the movement of this unit starts. It will then park the car in the slot.

3.1 Moving unit Base Plate

It will be used as the base for this unit. It is attached to the middle unit top plate with the help of pillars. It is made of mild steel.

3.2 Bend

It is used as a connector for the base plate and the support plate. It also acts as a protection for the hydraulic system wires. It is made of material EN-8.

3.3 Moving unit Support Plate

This is the extra component in this unit. It is provided for stability and ease of movement of the car carrying a plate. It will be made of material mild steel.

3.4 Pillar

As mentioned earlier they are used to connect one component to another. They are specially designed because in this system they are used for movement purposes. They are made of material EN-8.

3.5 Car carrying plate

This component is used for carrying the car and then the slider which is attached to it is used to park it in the slot. It is also made of mild steel.

4. Car Lifting Unit

As mentioned earlier in the methodology section, the spring is used in this system and due to the solid length parameter, the spring cannot come to the bottom till the base so we have added another unit to take the car from the base till the minimum height the spring can reach. The components which are used in this system are Rod, Slider, Pillar, Car carrying plate, Car lifting unit support plate. Some of the components are used in the previous sub-assemblies also, so we will not be discussing them here.

4.1 Rod

This component is the main part of this unit. It is made of material EN-8. It is having the rounded cut section for the slider to slide into it.

4.2 Slider

It is a specially designed component. For having the additional support and stability it has been provided with the external extruded slot and it has been directly connected with the support plate. It is made of material EN-8.

4.3 Car lifting unit support plate

The design of this component is exactly similar to the moving unit support plate. The only difference is that this component is having the slot for the external extruded slot of the slider to fit in. It is made of material mild steel.

Now let us look at the remaining components which are used in the system.

1. Base

This component is the main base of the whole parking system. It is made of mild steel material. If the user wants to make the base firmer, he can also make it concrete.

2. Gate

The role of this component in this system is similar to its role in the real-life that is to allow and exit of the car in the parking system. It will be made of material EN-8.



3. Car

The car model which is used here is not an actual model, but the rough sketch where-in the actual car is being able to be demonstrated properly. The only thing which is taken into consideration is that the actual dimensions of the car are being scaled down to the ratio of 1:10.

IX. CALCULATIONS

The main calculations which were made are for spring which is used in the middle unit. There are different types of springs available in the market but for this system, we are using compression spring because of the following three major advantages. Firstly, they resist the movement of the components. Secondly, they come back in the original position when they are stretched but they will stay in their stretched position until there is pressure on them. The third last advantage is they provide consistent pressure.

There are also different types of compression springs available. But we are using Open and Grounded type. In this type the ends of compression spring are open and they are ground so they can easily make contact with another surface without any interference.

While designing the system some of the calculations were made. But before actually describing the calculations first we have to understand the basic parameters used in the formulas.

Spring Outer Diameter	OD
Spring Inner Diameter	ID
Spring means Diameter	D
Wire Diameter	d
Pitch	p
Spring Free Length	L _f
Spring Solid Length	L _s
Total number of coils	n _t
Active coils	n _a
Solid Height	L _{solid}
Free Length	L _{free}
Wire Length	L _{wire}

Before directly going into the formulas, we need to understand that there are some pre-defined parameters. These are the parameters without which the design and the calculation are not possible. The pre-defined parameters are:

- Wire diameter: 16mm
- Free Length: 550mm
- Number of Coils: 22
- Outside Diameter: 52mm
- The wire used for spring is Music Wire ASTM A228

Now the formulas which were used and how the data was calculated using it.

Spring Mean Diameter (D):

$$D = OD - d$$

$$D = 52\text{mm} - 16\text{mm} = 36\text{mm}$$

Spring Index (C):

$$C = D/d$$

$$C = 36\text{mm}/16\text{mm} = 2.25$$

It is a very important factor in spring design. It is very important to understand the value to keep for spring index. This factor also helps to understand the coil stiffness and also how stressed the spring is. The ideal value of the spring index is between 6 to 12. If the spring index is below 4 and above 25 then the spring is very difficult to manufacture and also the spring might buckle. That is the spring bends laterally instead of a decrease in length.

Wahl Factor (K_w):

$$K_w = \frac{4C-1}{4C-4} + \frac{0.615}{C} = 1.873$$

Solid Length (L_{solid}):

$$L_{solid} = n_t \times d = 22 \times 16\text{mm} = 352\text{mm}$$

Solid Length is the length of the spring beyond which the compression in spring is not possible.

Spring Pitch:

$$\text{Pitch} = \frac{L_{free}}{n_t} = \frac{550\text{mm}}{22} = 25\text{mm}$$

X. FIGURES AND DATA

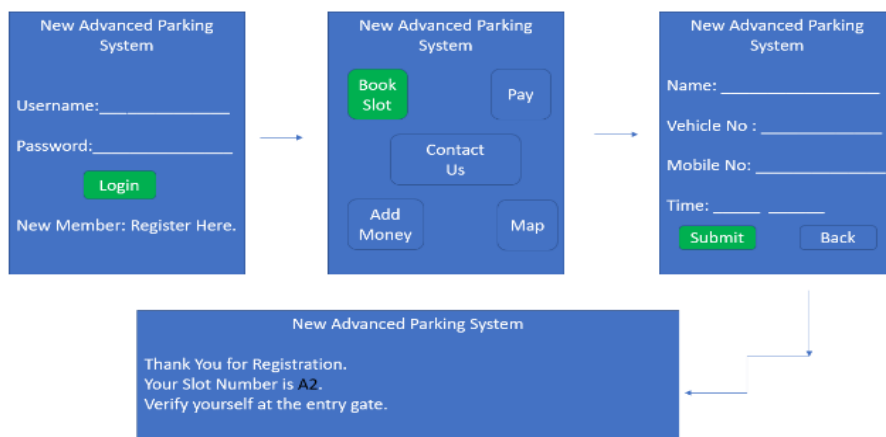


Figure 1: Steps for booking a parking slot through mobile phone

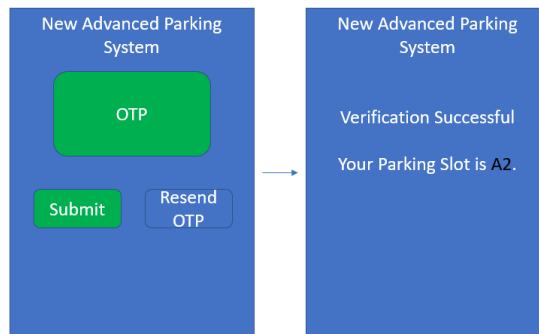


Figure 2: steps for verifying the user at the parking entry gate

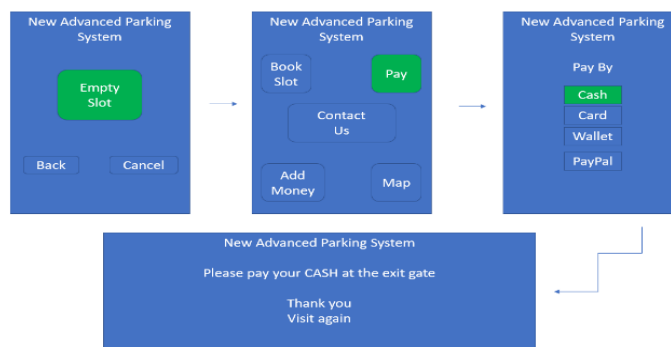


Figure 3: Steps for payments

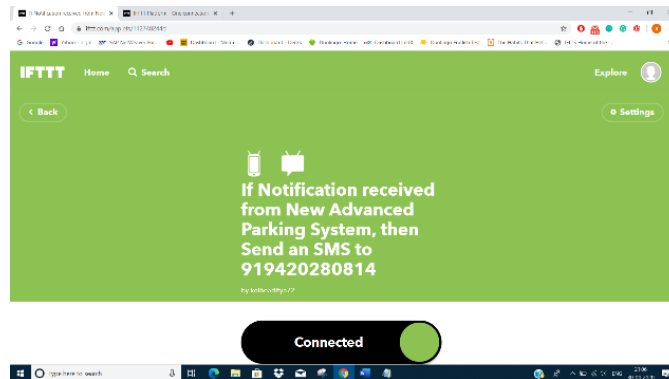


Figure 4: System connected to the cloud service IFTTT

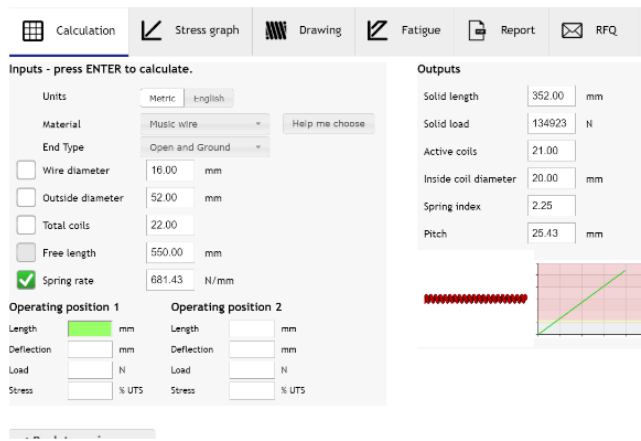


Figure 5: Spring parameters

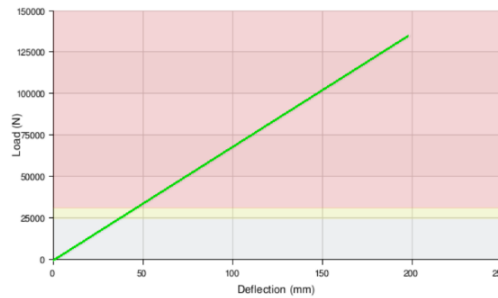


Figure 6: Load vs Deviation graph for spring for given parameters

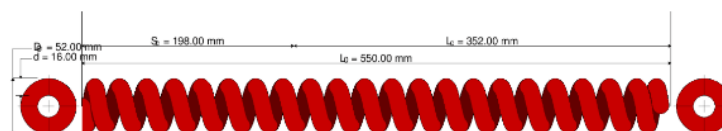


Figure 7: Spring Design

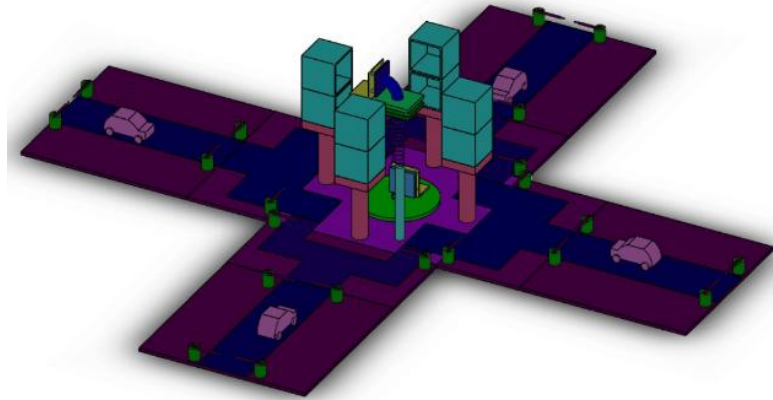


Figure 8: Actual Parking System in CAD Model view

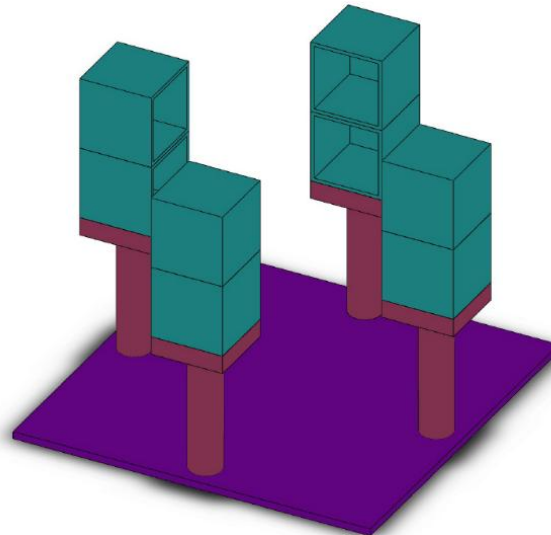


Figure 9: Base unit CAD model view

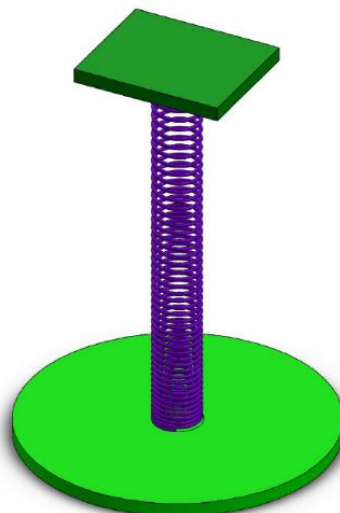


Figure 10: Middle unit CAD model view

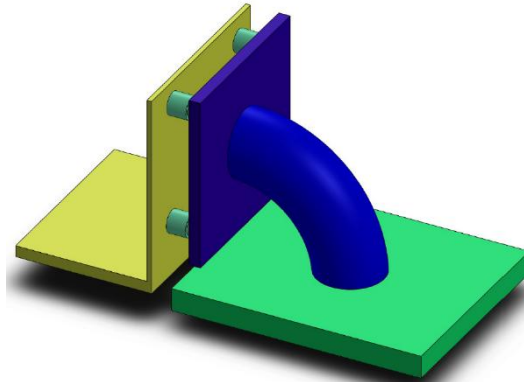


Figure 11: Moving Unit CAD model view

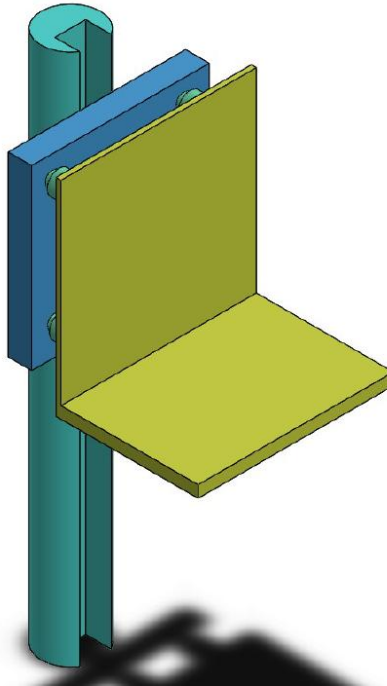


Figure 12: car lifting unit CAD model view

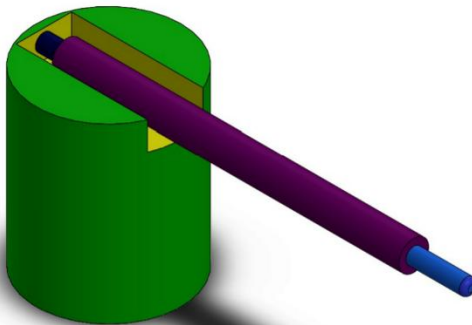


Figure 13: Gate CAD model view

BOM Table			
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	base with road		4
2	car		4
3	gate		24
4	base 3		4
5	connecting road 2		2
6	connecting road 1		2
7	middle unit base		1
8	Spring		1
9	middle unit top plate		1
10	pillar		15
11	moving unit support plate		1
12	car carrying plate		2
13	bend		1
14	moving unit base plate		1
15	base		1
16	slot 1		8
17	slot support		4
18	rod		1
19	slider		1
20	car lifting unit support plate		1

Figure 14: Bill of Material (indicated the total number and quantity of components used)

XI. CONCLUSION

This paper has introduced us to the smart and advanced method for vehicle parking. Due to the rapid growth in the population, the demand for luxuries has also increased tremendously, and one of them is the car. But due to the continuous growth in the population, the land area is decreasing and so also the space for parking the vehicles. This system proposes the proper way for parking of the vehicles. As the saying goes, The more the merrier; the fewer, the better fair. Here the more number of vehicles can be parked in the same place with the fewer requirement of the place.

XII. ADVANTAGES

- 1) More number of vehicles can be parked in the same place.
- 2) The Space requirement for this system is very less compared to conventional parking.
- 3) There is more security to the vehicles in this parking system.
- 4) Once the system is installed there is very little maintenance.

XIII. APPLICATIONS

- 1) Malls, Movie theatres parking
- 2) Office parking
- 3) Bus, Railways and other transport parking
- 4) It can be used as the common parking for the Apartment or the whole Society itself.
- 5) Can also be used as private parking
- 6) If an individual wishes he can use it to for personal parking

XIV. FUTURE SCOPE

According to one report, over 1.2 billion cars are running on the road. The number is already very high. There is no proper arrangement for their parking. The number of cars will be increasing, so there is a need for the proper arrangement, which can not only park more vehicles but also the space required for it will also be less.

This system fits in this criterion and can be the proper solution for the parking. Not only it can be implemented in the malls and movie theatres but also it can be used for the apartments, societies and also for personal parking itself.

The more development that can be done soon is in the spring.

REFERENCES

1. Muftah Fraifer, Mikael Fernström, "Smart Car Parking System Prototype Utilizing CCTV Nodes - A proof of concept prototype of a novel approach towards IoT-concept based smart parking"
2. M.Y.I. Idris, Y.Y. Leng, E.M. Tamil, N.M. Noor and Z. Razak, "Car Park System: A Review of Smart Parking System and its Technology", Information Technology Journal 8 (2): 101-113, 2009, ISSN 1812-5638
3. Wu He, Gongjun Yan, and Li Da Xu, "Developing Vehicular Data Cloud Services in the IoT Environment", IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 10, NO. 2, MAY 2014
4. Mohit Patil, Rahul Sakore, "Smart Parking System Based on Reservation", International Journal of Scientific Engineering and Research (IJSER), ISSN (Online): 2347-3878, Volume 2 Issue 6, June 2014
5. Supriya Shinde, Ankita Patil, Sumedha Chavan, Sayali Deshmukh, and Subodh Ingleshwar, "IoT based Parking System using Google", International conference on I-SMAC (IoT in Social, Mobile, Analytics, and Cloud), (I-SMAC 2017)
6. Mr. Basavaraju S R, "Automatic Smart Parking System using Internet of Things (IoT)", International Journal of Scientific and Research Publications, Volume 5, Issue 12, December 2015
7. Zhanlin Ji, Ivan Ganchev, Máirtín O'Droma, and Xueji Zhang, "A Cloud-Based Intelligent Car Parking Services for Smart Cities", 2014 IEEE
8. Rosario Salpietro, Luca Bedogni, Marco Di Felice, Luciano Bononi, "Park Here! A Smart Parking System based on Smartphones", Embedded Sensors and Short Range Communication Technologies, 2015 IEEE
9. Abhirup Khanna, Rishi Anand, "IoT based Smart Parking System", 2016 International Conference on Internet of Things and Applications (IOTA) Maharashtra Institute of Technology, Pune, India 22 Jan - 24 Jan 2016
10. Mahendra B M, Dr. Savita Sonoli, Nagaraj Bhat, Raju, Raghu T, "IoT Based Sensor Enabled Smart Car Parking for Advanced Driver Assistance System", 2017 2nd IEEE International Conference On Recent Trends in Electronics Information & Communication Technology (RTEICT), May 19-20, 2017, India
11. Sunil Chouhan, Sandhya P, "INTERNET OF THING BASED CAR PARKING SYSTEM", 2017 The Authors. Published by Innovare Academic Sciences Pvt Ltd. This is an open-access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>) DOI: <http://dx.doi.org/10.22159/ajpr.2017.v10s1.19577>
12. <https://en.wikipedia.org/wiki/Car>
13. <http://www.knowinddedia.net/auto.html>
14. https://en.wikipedia.org/wiki/List_of_countries_by_vehicles_per_capita
15. <https://www.statista.com/statistics/664729/total-number-of-vehicles-india/>
16. https://data.gov.in/catalog/total-number-registered-motor-vehicles-india?filters%5Bfield_catalog_reference%5D=92126&format=json&offset=0&limit=6&sort%5Bcreated%5D=desc
17. <https://www.statista.com/statistics/262747/worldwide-automobile-production-since-2000/>
18. <https://www.statista.com/statistics/281134/number-of-vehicles-in-use-worldwide/>
19. https://www.greencarreports.com/news/1093560_1-2-billion-vehicles-on-worlds-roads-now-2-billion-by-2035-report
20. <https://www.carsguide.com.au/car-advice/how-many-cars-are-there-in-the-world-70629>
21. <https://mechanicbase.com/cars/car-weight>
22. <http://www.advanexusa.com/calculator>
23. <https://www.acxesspring.com/compression-spring-design>
24. <https://www.astmsteel.com/product/en8-carbon-steel-080m40-bs-970/>