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Harnessing Intelligence in Implementing Smart Parking Systems Integrated with Interactive Guidance System in Distinctive Shindagha Historical Neighborhood to Enhance and Regulate Mass Experiences

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Harnessing Intelligence in Implementing Smart Parking Systems Integrated with Interactive Guidance System in Distinctive Shindagha Historical Neighborhood to Enhance and Regulate Mass Experiences

by

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Abstract

Under the light of the importance of finding smart solutions for cities strategic issues and in conjunction with the broad race for urban development in order to provide the best living environment and the most appropriate tourist destination, Mobility Management occupies the first place among these issues. Due to the variation in the urban fabric of cities, especially the old historical neighborhoods that are unique in their nature, composition, and conditions for their preservation, challenges related to mobility management raised in these critical areas. Therefore, in this study, we present a smart suggestion to solve the problem of providing smart parking system in Shindagha Historical District in Dubai, that has recently been revived to be the largest open museum in world. This project includes the provision of a smart parking system, studied thoughtfully across the urban and logistical conditions, determinants of urban fabric with respecting the identity of this region, which is linked to a smart tourism guidance system based on a live data platform derived from the museums and facilities that exist in this neighborhood. Moreover, this project contains a smart proposal of current public parking, in order to provide smooth and fast parking in areas with reducing the needed time to find a parking. The proposed solution will be a source of income for the city in the parking management sector. The objectives of the proposed study revolve around shortening the time spent to find a parking in the crowded areas, limiting traffic congestion, planning dynamic path of vehicle movement, reducing unnecessary energy consumption, reducing environmental pollution and gases emissions, maximizing the exploitation of the resources and facilities available in it, and organizing the movement of masses under conditions maintaining security and safety, as proposed models have been suggested for the studied area, with consideration of suitability of the design to the main purpose of the solution, best methods of construction, logistical elements and special conditions. Data have been drawn from the relevant official authorities in Dubai and according to a work methodology based on algorithms of possible occurrences, estimated queue lengths in transport impact analysis and SWOT analysis, in order to evaluate the effectiveness of those proposed smart solutions to lead to the best, smartest and most sustainable model for managing parking lots and masses congestions in such distinctive neighborhoods.

Keywords:

Conveyor Track Multi-story car parking, Automated car parking, Monitoring and controlling public car parking, Smart Public car parking, Smart Reserved car parking, Smart parking application, Smart Parking, Parking Management, parking system, Guidance system,, Mobility Constrains, Distinctive Areas, Cities Parking Solutions.

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Chapter 1

1.1 Background

Figure 1- Historical Area in Dubai, UAE, (Halcrow,2015)

In the led of global development, technology and digital transformation in all aspects of life, the historic Al Shindagha neighborhood in Dubai has been revived to be the largest open museum in the world that contains various sophisticated museums that conveys the originality of the past through the latest technologies' trends. There is no doubt that this historical urban will witness a mass turnout of visitors and tourists, especially in the tourist seasons every year. This makes it face an important strategic problem that needs a smart solution in lane with the conditions imposed

by the nature of the historical regions. The main problem is the urgent need to find an optimal solution of Parking system with maximum capacity to reduce the expected congestion and time required to find a parking lot there, which contributes reducing environmental pollution and increases the masses happiness to enjoy a unique, organized and easy-to-access experience.

It is worth noting that this problem at the present time is no longer difficult to solve in normal cases, as many solutions and options have been applied to create cars parking systems in highly crowded areas, but in our case and referring to the studied area, which is unique and have a high privacy as it is an ancient historical urban, there are many factors that made the presence of parking cars in it is a strategic problem that needs an ideal solution. These factors include the following:

Firstly: The geographical nature of the region – as shown in Figure(1) which is presenting the historical area in Dubai (Halcrow,2015) including Shindagha District that extends along Dubai Creek on one side and is limited to logistical and historical determinants on the other side, represented in the Shindagha Tunnel, which had built since 1975 to link the two sections of Dubai, which are Deira and Bur, and Rashid Port which was the first port established in Dubai and the main reason behind its renaissance. All of these constrains made the availability for implementing a multi-story car parking is very limited, in addition, the ancient historical buildings that are forming the privacy and importance of this area, as it was inhabited by the original inhabitants and mainly by the Ruler Family.

Secondly: The global conditions for preserving the urban heritage: as according to the conditions of the UNESCO World Heritage Centre, exactly in the Operational Guidelines booklet for the Implementation of the World Heritage Convention, closure II (The World Heritage List), in Outstanding Universal Value part, guideline number 53. Nominations presented to the Committee shall demonstrate the full commitment of the State Party to preserve the heritage concerned, within its means. Such commitment shall take the form of appropriate policy, legal, scientific, technical, administrative and financial measures adopted and proposed to protect the property and its Outstanding Universal Value [1] . So, it’s not permissible to change the original fabric of the

historical areas in order not to lose their true value, and this made it very difficult to add any facility that affects the value of the historical area.

Thirdly: The presence of several obstacles hindering the establishment of traditional, intuitive solutions for multi-story car parking in a crowded area where:

- The location of the area along Dubai creek makes it impossible to dig under it to create a multi- story or an underground car parking, as is the case in other areas in the city
- The passage of the Dubai metro line beside the historical area, which prevents the possibility of drilling and building underground parking from this side, and also limits the possibility of building parking over the ground due to the risk that may occur during the construction work of parking over the metro line.
- Governmental controls that occurred from the use of traditional solutions to provide parking for the area, as that Roads and Transport Authority in Dubai is implementing a huge logistical project which is Creek Panorama Bridge, that is a bridge linking Deira and Bur Dubai passes above the Shindagha tunnel to alleviate the congestion in the tunnel at peak hours and solve the mobility problem between the two sockets of the city, which prevents the exploitation of any land from the side of this project.

Based on the foregoing, the need arose to find an optimal solution for a parking system and according to the fact that Dubai is one of the most important smart cities in world, it is important to consider that the optimal solution must be the smartest and most sustainable one as well. Therefore, we will present in this study a smart multi-story car parking system in such distinctive areas and a smart monitoring and reserving system for public car parking spaces. As those proposed systems to be linked to a smart tourist guidance system that improves visitor's experiences and enhances public safety in these areas due to the importance of that in any public services, with the aim of keeping pace with modernity and intelligence that Dubai aspires to in all fields and services provided to masses of visitors and residents.

1.2 Statement of problem

Under difficulties that masses of tourist areas face in obtaining parking for their vehicles, especially in critical areas with high privacy and special conditions such like historical districts, a raised problem of the need of providing a car parking system in Shindagha historical neighborhood in Dubai , which has been revived to be the largest open museum in the world, that will make it the main destination for millions of visitors annually specially after the official opening of Expo 2020 that took place in October 2021, to help the largest number of masses to facilitate parking for their vehicles in the least time and as close as possible to the area with considering the constrains on this distinctive area, in order to provide the best visiting experience for visitors and to let them enjoy the region at the highest level of well-being and modernity.

1.3 Project goals

Since the emergence of the problem of providing a parking system solution among a distinctive crowded area with visitors all over the year and with high privacy and certain conditions imposed on businesses that take place in it, such as Shindagha Historical Neighborhood in Dubai, This study has been built, for an integrated project of providing the best solutions for a smart multi-story car parking system designed according to the privacy of the studied area with integration to an intelligent tourist guidance system and a smart pre-booking system for public parking spaces in order to provide residents and visitors the fastest and easiest way that guarantee having a parking to their vehicles, without wasting their time and efforts on that, and as it can be applied on all over the city of Dubai.

The main goal of the project is: To enhance and regulate different masses experiences and to increase the turnout of the studied historical district by some main objectives like:

- Facilitating masses movement and providing best facilities of car parking, and guidance to the landmarks in the area without needing a huge number of tour guides unless in some special cases such like school groups.
- Abbreviating the time needed to get a car parking in such congested areas.

- Preserving masses health in accordance with global trends to maintain security and safety after the global Covid 19 pandemic, whose repercussions still remain list till this day.
- Promoting the highest capacity on parking that can be provided in the same area in such that acritical areas.

1.4 Methodology

According to the type of problem that need to be solved and types of collected Data, the study have been built on different kinds of analysis techniques, which have been identified as the following:

1. In terms of qualitative analysis:
    - A master plan analysis for the current situation and Location, to determine the best appropriate location for implementing the proposed multi-story car parking.
    - A SWOT analysis on the proposed solutions for implementing a sufficient, easy and smart car parking systems in the studied area, in addition to the traditional car parking systems implemented in this area and even any smart new solution that recently used or under studies around the world, in order to keep pace with the development of cap parking solutions worldwide and ensure of implementing the best in Dubai. Accordingly, this technique of analysis has been used to compare the Strengths, Weaknesses, Opportunities and Threats for each system in comparison to each other that helped in figuring out why the proposed solution in this study is the best.

2. In terms of quantitative analysis:
    - A transport impact study analysis has been done, in order to evaluate whether the proposed solutions are appropriate for the studied area and what type of transportation improvements may be needed besides, to

maintain a satisfactory level of service, provide the highest capacity for parking lots and minimize cars queue length as much as attempting to fade it away.

1.5 Limitations of the Study

The determinants of studies vary according to the area in which the study is conducted, the time required to provide the required data, the extent to which data is available to students, the extent of the privacy and sensitivity of the required data and many more factors. As this study required organizational and administrative data and masterplans for distinctive urban areas with high privacy, it was necessary to accept some conditions that ensure the prohibition of publishing or disposing of these data for purposes other than the study. This was the only determinant that confronted this study, and it was managed by pledging not to publish data evidence and not to use it outside the framework of this study.

Chapter 2 – Literature Review

2.1 Introduction

This chapter presents the research that was carried out in the various smart parking systems and technologies used in. In fact, many related research and articles were reviewed, but the closest ones to the proposed system in this study were selected and been explained in detail below.

2.2 Detailed Literature Review

1. In the Scholarly journal [2] that titled A Smart Parking Solution Architecture Based on LoRaWAN and Kubernetes, by Jhonattan J Barriga, that published in 2020, presented a research in the engineering of a smart parking solution, the author explained about a smart parking solution using magnetic long-range sensors under (LoRaWAN Protocol) and a special software system consists from three main components (Raw Data Bridge, A Parser data component and Logic component for processing payloads before its storage in the MQ server). This software linked with a mobile application that transmits live data, to make the application works as a platform for reserving a parking lot. The solution proposed by the author is characterized by the fact that he chose magnetic sensors that are able to work in all extreme weather conditions. This research gave an extensive idea about the mechanism of the smart system in smart parking, best types of sensors that can be used for this purpose, the differences between them and the efficiency of each type.

2. As for Article [3], that titled parking requirement eases in historic area: palm harbor has plenty of spots, study finds, by Tampa Bay, published in 2013, presented how the Restaurants and office buildings in Palm Harbor's historic downtown reduced their number of off-street parking spaces in response an analysis had been done by King Engineering, which tracked down that at its pinnacle, just 49% of 642 public and private parking spots in

the midtown region were being used. This small article concluded with a quote that is relevant to our study:'' In a historic district that prides itself on being walkable, the idea is to avoid "giant parking lots and seas of parking," Sandra Gorman of King Engineering.

3. The research [4] titled A study on smart parking guidance algorithm, by John Ho-Shin, published in 2014 as a transport research in Transportation Research and Emerging Technologies field, where the author addressed the study of an algorithm of smart guidance for car parking, where he inserted a mechanism for linking smart guidance in parking spaces with phones or any other smart devices to deliver data to serve the driver. Also, he dealt with the practices of many scientists, experts and engineers who worked on this algorithm of guidance, and then explained the components of the intelligent parking system proposed by him. This research helped in linking scientific concepts with practical plans for the intelligent systems programming mechanism in parking and addressed an overall flow chart of smart parking guidance system as shown in the Figure (6) below.

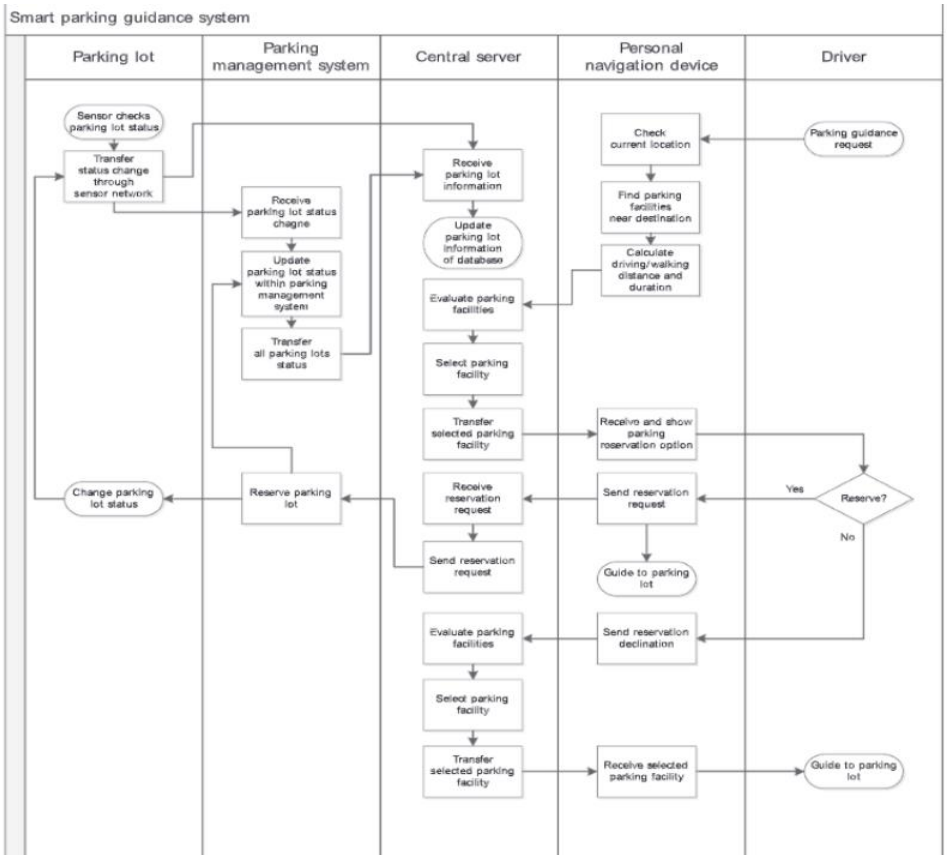

Figure 2- Flow chart of smart parking guidance system, [4]

4. In the journal article [5] titled progress, mobility and urban regeneration in a traditional neighborhood: El Encino, Mexico, by Alejandro Acosta Collazo through ProQuest Digital Library in 2017,constitutes a research database for articles and research related to computer science, electronics and electrical engineering, in which presented the urban image of El Encino as a combination of the factory facades, parking lots and historic buildings. This article is useful as it talked about a historical urban and how factories got in volved in it, in a way of interpreting how to reuse historical buildings with preserving their privacy concept.

5. As for article [6] titled Deep Learning-Based Mobile Application Design for Smart Parking, by H. CANLI, published through IEEEXPLORE library in 2021, the author presented a mechanism for using deep learning with long-term memory (LSTM) to predict parking needs. The author had proposed a LSTM model for predicting the occupancy rate of Parking space as shown in Figure (7) below. This article considered as a summary of how to harness technology (IOT) to serve the community in terms of mobility and parking management.

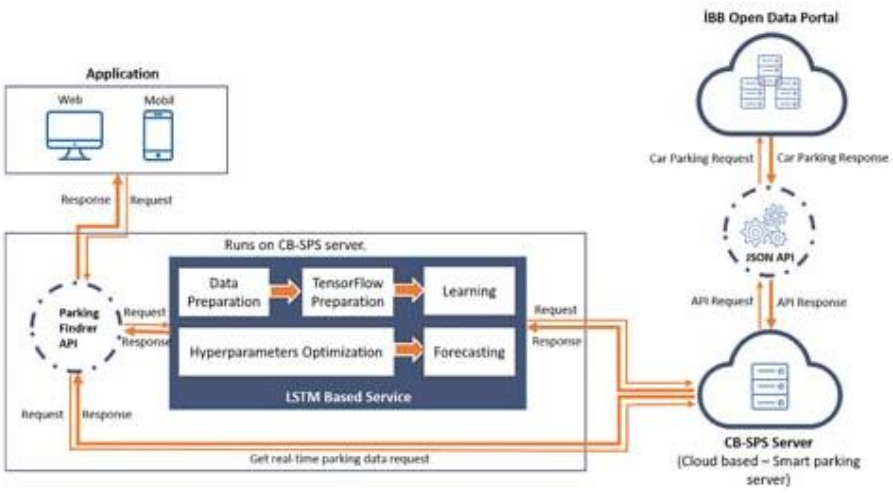

Figure 3- LSTM Model of predicting Parks Occupancy ratio, [6]

6. In article [7] titled New "Smart Parking" System Based on Resource Allocation and Reservations, by Yanfeng Geng, published in 2013, the author proposed a "smart parking" system for an urban environment by simulating an optimal parking space according to

current condition information while ensuring that the driver does not cost more than his current cost value. Based on the simulation results, the proposed system reduces the average time to find a parking space and the cost of parking, while the total parking capacity is used more efficiently.

7. In the Journal [8] titled From smart parking towards autonomous valet parking: A survey, challenges and future Works, by Kezhi Wang, published in 2021, the author summarized the current parking solutions from traditional parking to smart parking, as he suggested plans for valet parking, in addition to classifying parking mechanisms and discussing future directions for the parking system. This article is a reference for improving traditional parking according to the general situation with high density of vehicles and how to design a booking system.

8. As for article [9] titled A Survey of Smart Parking Solutions, by Trista Lin, published in 2017, the author has surveyed the numerous previous literature regarding smart parking solutions from both academic and business perspectives. The author presented a comprehensive classification of parking systems and deduced from them an intelligent parking system in three stages: information collection, system deployment, and service deployment. He also explained solutions to the current parking difficulties from a technical point of view. This article serves as a comprehensive guide to the development of car parking systems.

9. On the other hand, Article [10] titled IoT Smart Parking System Based on the Visual-Aided Smart Vehicle Presence Sensor: SPIN-V, by Luque-Vega, published in 2020, the author presented a SEI-UVM solution, which is an integrated solution for smart mobility that was implemented in the outdoor car parking of a university campus in Mexico with the aim of reducing searching time for car parking at peak times. The proposed solution is divided into three main blocks: SPIN-V sensor works as a device to recognize license plate text as text and not as image or video, A mobile application, and A monitoring center (OBNiSE) to manage the status of parking spaces that must be consumed by the mobile application.

10. In Article [11] titled Parking Management for Smart Growth, by Richard W. Willson an expert in the Department of Urban and Regional Planning at Cal Poly in Ponoma, published on the global platform 'ProQuest E-book Central' in 2015, the author dealt with the mechanism of adapting parking management to the development and growth of cities. The author is a university professor and an expert in the field of city planning, so he highlighted the best practices and strategies followed in the field of parking management and how they were applied. This book learned in how to create a parking management strategy as it presented kinds of Strategic Parking Management according to kinds of Smart Growth as shown in Table (1).

Smart Growth Objective	*Strategic Parking Management*
Housing and transportation choices near jobs, shops, and schools to support local economies and protect the environment.	Parking management enables compact development by reducing the aggregate parking supply and land consumed by parking. It makes construction of infill housing more economically feasible.
Beautiful, safe, affordable neighborhoods with schools and shops nearby that have easy and low-cost ways to get around for all.	Parking management avoids the visual and environmental impacts of excess parking. It allows for compact development, reducing the distance between destinations. It improves the case for mixed-use development and the development of alternative travel modes.
Healthy communities with strong local businesses and jobs that pay well.	Parking management reduces expenditures on parking supply through shared parking. It allows for economic development in parking-constrained areas through more efficient use of the existing parking supply.

Table 1- Strategic Parking Management Kinds according to kinds of Smart Growth, [13]

11. As for Journal [12] titled What's that garage for? Private parking and on-street parking in a high-density urban residential neighbourhood, by JoachimScheiner, published as a journal in Transport Geography magazine in 2020, in which it discussed the importance of establishing parking and the difference between public and private parking in smart urban areas. In this article, the author presented a solution for the problem of providing adequate parking spaces in a crowded residential area characterized by an acute shortage of parking although that the city administration generally tolerates illegal parking in the same time. In addition, a constrain given that the willingness to pay for parking is very low and the level Residents' satisfaction with parking is very low. Thus, the solution

was to impose policies at the regional level, which is summarized in: Firstly, establishing a parking policy that depends mainly on the level of implementation relaying on the residential current urban, Secondly, establishing a policy for parking charges according to how much the residents can affords.

12. In the study [13] titled Real-Time Optimal Scheduling of a Group of Elevators in a Multi-Story Robotic Fully-Automated Parking Structure, by Jayanta K.Debnath, published in 2015, proposed a mechanism for distributing the car parking layer on different levels according to the current parking occupancy of the facility and determines the work sequence of the elevator once the pickup and retrieval of cars is determined. The study reports the following result: In the stationary case of time-constant arrival rate and average parking duration, a greedy strategy is used to fill the positions.

13. In the research [14] titled Online operations strategies for automated multistory parking facilities, by YinengWang, published in 2021, which presented a model to simulate a real-time scheduling system for a fully automated multi-story car park structure intended for large metro areas, in which each lift is assumed to be designed to transport a single vehicle between floors and during the rush hour period. Morning. The scope of the study covered 4 to 20 floors to include 400 parking spaces on each floor according to the assumed customer arrival rate and average service rate modeled using the MATLAB environment. Performance metrics were monitored for average customer wait times, elevator service, and maximum customer wait times. Simulation results show that the proposed design facilitates acceptable waiting times and customer service with good elevator utilization rates. The study indicated that the number of proposed elevators would facilitate real-time scheduling with reasonable waiting times for customers. Below Table(2) shows the simulation result table.

Number of Floors	4	6	8	10	12	14	16	18	20
Minimum Number of Elevators	17	25	32	39	45	50	56	60	65
Average Waiting Time (sec)	10.8	11.9	14.7	14.1	15.8	19	20.8	21.6	28.8
Maximum Waiting Time (sec)	65.9	68.4	111.5	49.4	50.0	131.4	204.3	143.1	269.0
Average Scheduling Time (sec)	0.1	0.1	0.2	0.2	0.2	0.4	0.4	0.4	0.9
Maximum Scheduling Time (sec)	1.5	2.1	6.1	1.7	5.078	15.7	12.8	14.4	22.8

Table 2- Simulation Result for Waiting Time in Multi-Story Car Parking, [14]

2.3 Smart Parking Development Review

The rapid increase in the population in the world, especially in cities, and consequently the increase in the number of vehicles is a reason behind many mobility issues, due to the dominant culture of people around the acquisition of having a vehicle for each member of the family and even renting a car while touring in a city instead of using public transportation, it is expected after a few years to a growing problem of the lack of sufficient parking spaces for the preparation of vehicles will raise up in the transport sector, especially in the tourist areas due to the influx of visitors to it at the same time. Moreover, it is important to remember that this problem currently exists, so it can be reduced if cities be prepared well, by implementing an innovative smart and safe solutions. Today, to find a parking for your car as soon as possible and as close as possible to the intended destination is a challenge, thus it becomes a mandatory for urban planners in all over the world, to plan sustainable parking solutions, especially if cities tied by many constraints within its surrounding urban and logistical fabric.

Ancient historical regions around the world that have a unique peculiarity due to that they are areas under the responsibility of preserving their original nature in order to preserve their historical value, are one of the main regions in cities that face the problem of providing sufficient and easy parking for visitors. In the same time, they are subject to some restrictions that limit the possibilities of applying traditional solutions of parking that used in other areas. Therefore, this study was conducted, to deal with the solution of the problem of providing the smartest car parking in one of distinctive historical areas called Shindagha Historical District located in the city of Dubai in the United Arab Emirates.

Governments and companies tended to find the most appropriate solutions to solve the problem of the need for a parking place in crowded areas, especially in crowded, tourist and commercial areas. One of the most striking effects was to reduce carbon dioxide emissions and reduce energy sources consumption, as it is mentioned by one of the studies that were conducted by experts in transportation security systems in Los Angeles that cars which are waiting for getting

a parking in one of the business districts in Los Angeles produced about 730 tons of carbon dioxide and burning about 47 thousand gallons of gas, in addition to the financial fines, which were imposed daily on those who park their cars in unauthorized areas. [15]

Accordingly, and with the development of technology, the concepts of defining areas designated for parking have changed, as the traditional solution was to allocate a plot of land to accommodate a specific number of cars according to the area of this possible land, which resulted in loosing large areas for parking operations in the vicinity of commercial or tourist areas or even in the middle of cities where is supposed to be used for other commercial purposes. The greater of having congestion, the greater of need to widen the area of the land, and this is a great financial loss in addition to the difficulty of finding cars after parking due to the huge number of cars in the same land. This problem was solved by numbering the parking with letters and numbers and coloring them in specific colors to help drivers find their cars faster.

Over time, this idea developed, and the implementation mechanism changed to become underground, where basements for car parking are made wherever possible. This solution helped reduce land loss and improve its use. With the development of technology with internet of things applications and algorithms usage, this solution was developed, and parking became equipped with systems that calculated number of cars entering and exiting the parking and vacancy durations in the parking, this helped in informing the driver from outside about the possibility of finding a parking of his car inside. This system enabled stakeholders and governments to collect funds from smart parking as a result of the service provided to visitors and how it facilitates their movement and raise the level of their happiness in their visit experience which they came for. This solution is the most widespread in the world, whether in the streets or in commercial or tourist areas.

With time and according to critical cases in which it is not possible to establish a car parking on the surface of the ground or even to build a parking under the surface of the earth due to the nature of the area and the surrounding restrictions such as (river, sea, tunnel, metro line,

underground water) and so on, so It is imperative to find more sustainable and smart solutions to suit these cases, and this is the main goal of this study.

Beyond searching and investigating, parking solutions became more dynamic, such like multi-story parking, 2-story parking movable system and others which used to park cars for long periods, for example at the airport, the traveler parked his car to keep it until his return. As for the mechanism of applying technology to create smart systems for parking lots. Through research, four technological solutions were applied till this day, to create a smart system in parking spaces, which are:

1. wired sensor based shown in Figure (2): A system that uses ultrasonic sensors at each lot of the parking that connected with wires to carry their signal to the server. This system is the most used system although that it costs highly. [16]

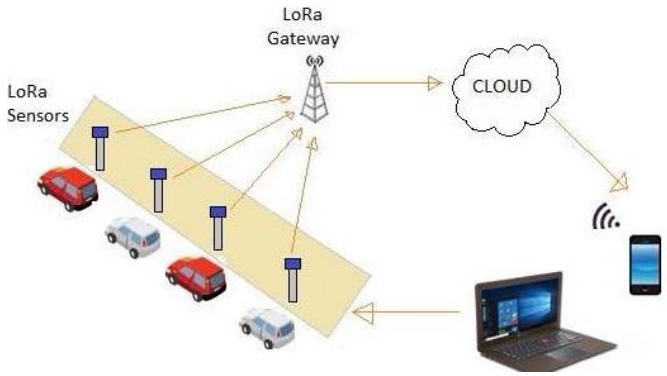

Figure 4- Wired Sensor Based Technology, [16]

2. Wireless Based shown in Figure (3): It is an advanced system from the previous system in that the sensors used in it are connected wirelessly to control unit. They are also sensitive to sound, light and temperature, but it is considered as an expensive system due to the need for data processing units and receiving and sending devices. [16]

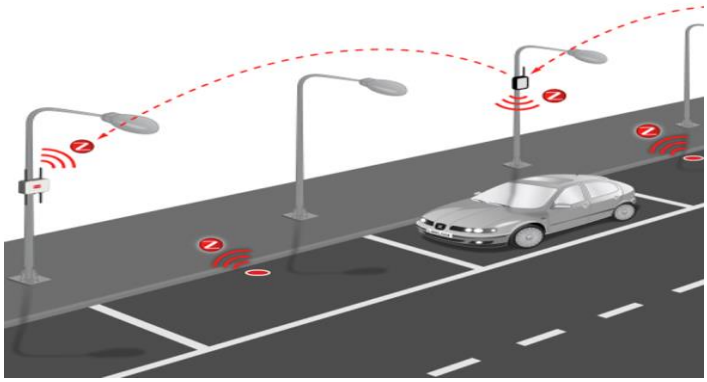

Figure 5- Wireless Sensor Based Technology, [16]

3. Image Based shown in Figure (4): It is a system based on cameras to record photos for cars whether when enter or exit. This system is the most common. When the vehicle arrives at the parking gate, the sensor automatically records the vehicle number plate and stores it in the database, and by sequentially entering and exiting vehicles, parking availability is automatically updated. [16]

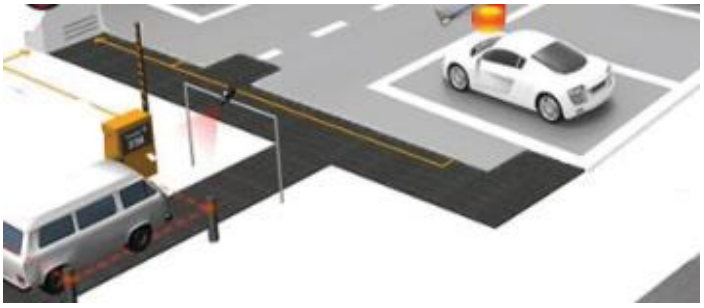

Figure 6- Image Sensor Based Technology, [16]

4. Counter based (parking meter) shown in Figure (5): Counter-based systems consist of sensors placed at the entrance and exit point of the parking, this system only gives information about the total number of vacant parking lots without guiding to the exact location of the vacant parking spaces and this is actually its defect, Thus, this kind of systems is not effective for on-street and residential parking lots. [16]

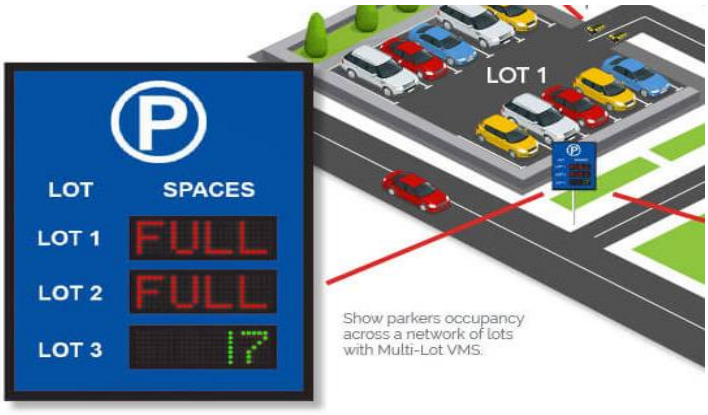

Figure 7- Counter Sensor Based Technology, [16]

Intensive research had been done over references from scientific journals, international articles, books and reliable scientific platforms that search for a solution to the same problem, whether in terms of possible solutions to provide smart parking around the world or even in terms of the privacy of the studied area and similar regions around the world and how transport was managed in it. In addition, reviews on studies dealt with programming smart parking systems and their mechanism of operation was a must, in order to become familiar with and see all the systems and technology used around the world to manage car parking and study how it is possible to create a system combines more than one technology.

2.4 Findings of Literature Review

In conclusion, as a final outcome from literature review that mentioned previously, most of the published studies on sites and platforms talked about the smart parking system from a technical perspective based on sensors solutions. As for the studies that dealt with creating a car parking system from a planning concept with applying technologies, were mostly for residential or commercial areas, rather than historical areas. Also, its common in historical areas to apply traditional car parking solutions whenever they had enough spaces designated for car parking, capable of accommodating the number of visitors, while there are many important historical areas that existed in city centers and which until now have not been found the best solution to the problem of providing a sufficient car parking for visitors, regardless of how smart this solution is.

Therefore, this study presents the smartest solutions of creating an advanced smart parking system that can be applied in high privacy and critical urban areas, by establishing a conveyor track multi-story car parking with a capacity that is compatible with the number of visitors. In addition to that it presents how to link the proposed parking system to a smart tourism guidance system, that helps in controlling visitors choices of pavilions visits in accordance to museum pavilions capacity, in order to maintain security and safety due to the need that topped the whole world after the repercussions of the Covid-19 pandemic and the extent of the importance of preserving safety in the presence of any unexpected force- megere situation, to give a solution that is compatible with the visions and aspirations of smart cities and serves tourist areas, and to make Dubai an emulated example in the field of integrating mobility management with smart technology and smart guidance system.

Chapter 3- Project Description

3.1 Introduction

Under difficulties that masses of tourist areas face in obtaining parking for their vehicles, especially in critical areas with high privacy and special conditions such like historical urbans, a raised problem of the need of providing a car parking system in Shindagha historical neighborhood in Dubai shown in the Figure (8) below , which has been revived to be the largest open museum in the world, making it one of the main destination for massive numbers of visitors annually after it is officially opened in conjunction with the Expo 2020 which launched in October 2021, to help the largest number of masses to facilitate parking for their vehicles in the least time and as close as possible to the area with considering the constrains on this distinctive area, which resulting providing the best visiting experience for visitors and to let them enjoy the region at the highest level of Wellbeing and modernity.

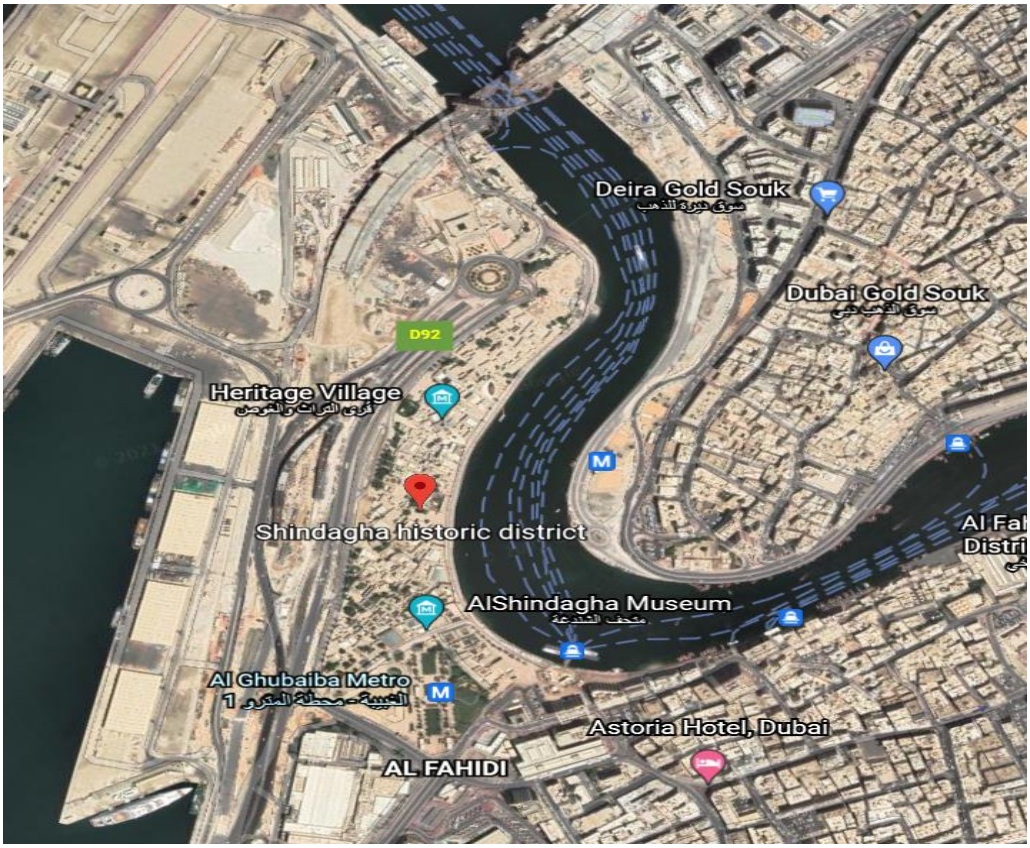

Figure 8- Shindagha historical neighborhood in Dubai, (Dubai Municipality GIS Center,2021)

3.2 Statement of the Three parking management solutions

This study consists of proposing Three main solutions for the mobility management in Al Shindagha Historical District as the following:

A. Smart Conveyor Track Multi-Story Car Parking

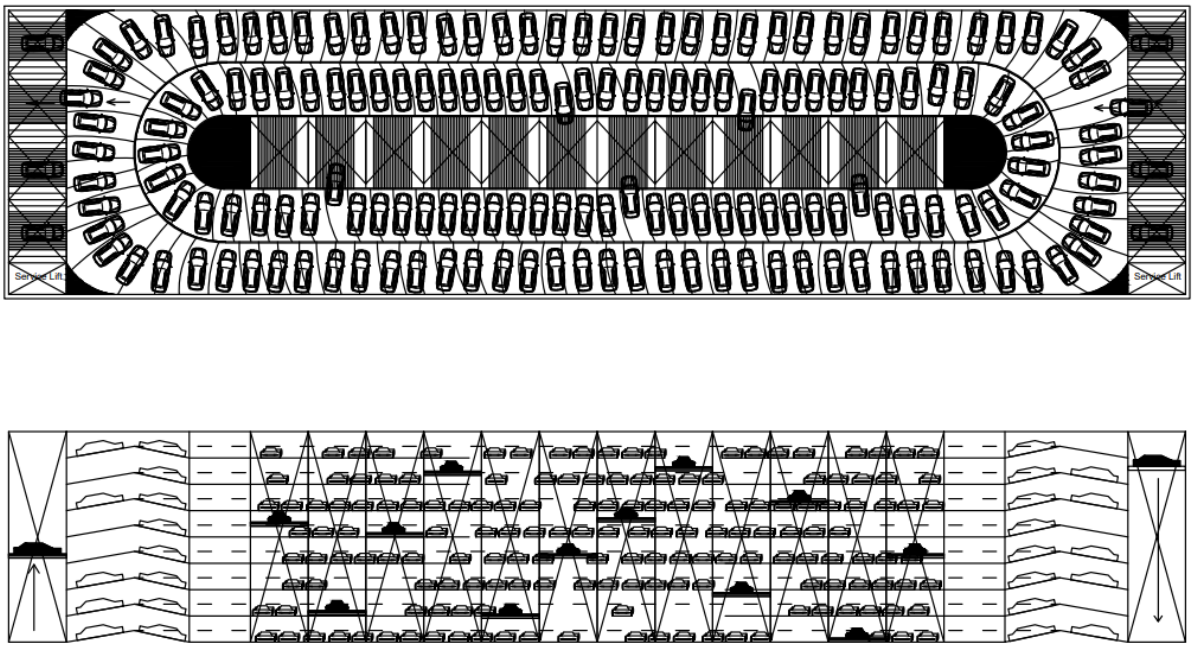

Figure 9 - Proposed Smart Conveyor Track Multi- Story Car Parking

The smart track automated multi-story car parking has been proposed to park cars automatically through a self-mechanical system without the owner effort. Visitors supposed to drop their cars in an automated lift that carries out the cars within the building stories, then a programmed driven tracks work as conveyors that carry cars as soon as they reach the entrance of the building, to park cars in the closest possible position. Figure (9) presents a proposal for the smart system. This smart system is linked to an application in which the car owner can follow the movement of his car in the building and how it conveys through smart tracks, which gives him an indicator about the most appropriate time to request his car according to his tour journey, as the system must be sited for estimating the needed time to pick up the car. The proposed parking idea is inspired by baggage track

at airports as shown in Figure (10), that showing both the traditional and advanced conveyor systems, where the track conveys and spins baggage and moves them until their owner picks them up. This is the basic principle in the idea of the proposed smart attitude, which aims to:

- Reducing the time that visitor spends to get a suitable parking for his car.
- Reducing the time that takes a visitor to walk from the parking lot to the intended destinations - especially when no available car parking close to the destination or spreads over a large area.
- Reducing traffic congestion, issues and inconveniences that occur in parking spaces while parking the cars.
- Maintaining the privacy of the car owner as no need to use the traditional valet parking anymore, as this proposal is one of the most prominent innovative solutions convenient to the repercussions of the Covid-19 pandemic, in which valet parking service was banned to prevent the spread of disease among population.

Figure 10- Baggage Conveyor Tracks, (Google,2021)

The proposed parking system is an innovative version of robotic automated car parking system, which is considered till this day, still under experiment development stage according to the robot's faults potentials studies.

On the other hand, the proposed parking system, which is presenting in this study, is easier to implement as it depends on the principle of algorithms for potential solutions to park the car based on the available places defined by a set of sensors, all on a specific path that works dynamically to convey cars, such like the dynamic conveyor track shown in Figure (11) below.

The potential faults or problems of the proposed parking system in this study are not so complicated and can be fixed simply. These faults may be at the design stage like the designed path is incorrect, and bypassed by making simulation models for it, or faults during the operational stage that are limited to faults in the dynamic path work system.

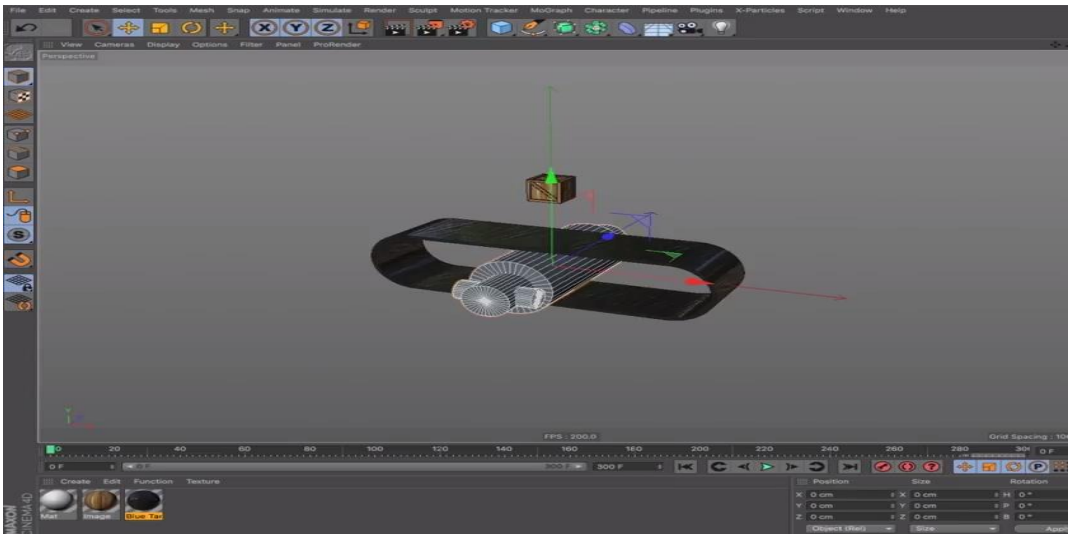

Figure 11- dynamic conveyor track, (Dubai, 2021)

B. Smart tour guide application

The smart multi-story building will be linked through an application in accordance to the marine taxi trips that will transport visitors to Al Shindagha historical district without the need to wait for the marine taxi to arrive. In addition, this application will also be available as smart guidance service to plan his trip and determine the available and not crowded places, in other words, the visitor will be able to know each of museums pavilions, and the smart guidance system will present the best visit proposals that shorten his standing in waiting queues or being exposed to huge crowding in museums pavilions, which became undesirable after the pandemic that imposed social distancing to maintain safety and prevent the spread of disease among population. Figure (12) below presents a proposed interface of the smart interactive guidance application.

Figure 12- Smart Interactive Guidance Application, (Dubai Municipality,2021)

C. Smart public parking pre-booking system

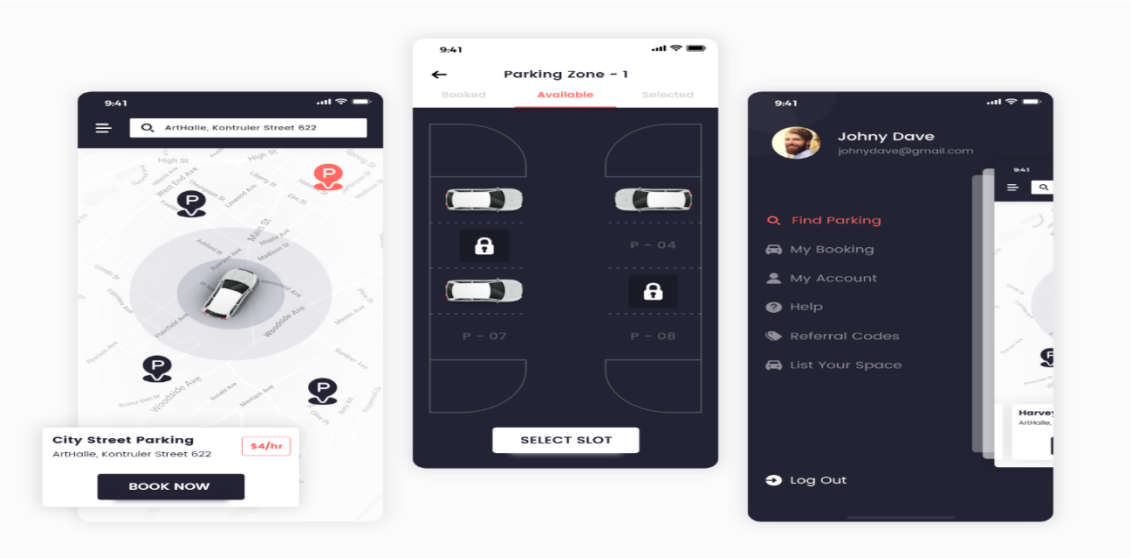

Figure 13- Proposal for an interface of a pre-booking application

Based on extensive research and looking at best practices for on-street parking, a new smart solution to exploit the current open spaces intended to be parking lots for cars, which was not possible for implementing a multi-story car parking for the reasons mentioned previously in this study. Thinking in an innovative way, this study proposed a smart system for on-street cars parking as follows: The proposed system supposed to link on-street parking lots to a geographic information system such like (Google maps) through an application, to allow users to reserve on-street parking lots for their cars in advance, so that the user can view the map of the available parking lots and choose the closest parking to his desired destination, then reserve it for a maximum approximate period that has been determined to be 30 minutes before the arrival time according to the studies of on-street parking demand as mentioned in the literature review of this study. The pre-booking proposed system to be by car plat number exclusively, that ca be recognized using image based sensors distributed in streets, in order to ensure that the driver the reserved parking lot is for a specific car not person so the overall system can be controlled effectively, while it can be applied for all on-street parking over Dubai with applying penalties hen drivers do not comply with this system. Figure (13) shows a proposal for an interface of a pre-booking application that can be named as this study case as : Smart Shindagha Tour and Park Application.

The thing remains in this application proposal is to activate it to distinguish the reserved parking from the available ones for users who do not register in the application or who do not wish to pay for reserving a parking lot before their arrival. Thus, the needed technology that is proposed in this study is simply as follows: To place an image based lighting sensor at each parking lot so that it lights up in red if it is reserved and lights up in green if it is still vacant, whether for application users or even for other drivers, knowing that these sensors must be connected to the application by a cloud database, so that it presents the parking lot vacancy situation to the application regardless of how it is vacated (either by pre-booking or by an external user). This technology efficient and do not require a high application budget, in addition to the fact that the proposed application must be linked with a Geographic Information System for acquiring open parking data through cameras and sensors scattered all over the streets of Dubai, which can monitor the

smallest details inside the vehicles, so there is no doubt that it is able to monitor live on-street parking lots vacancies and then transfer it to the application. Figure (14) shows a proposal for the booking presentation technology that have been explained previously.

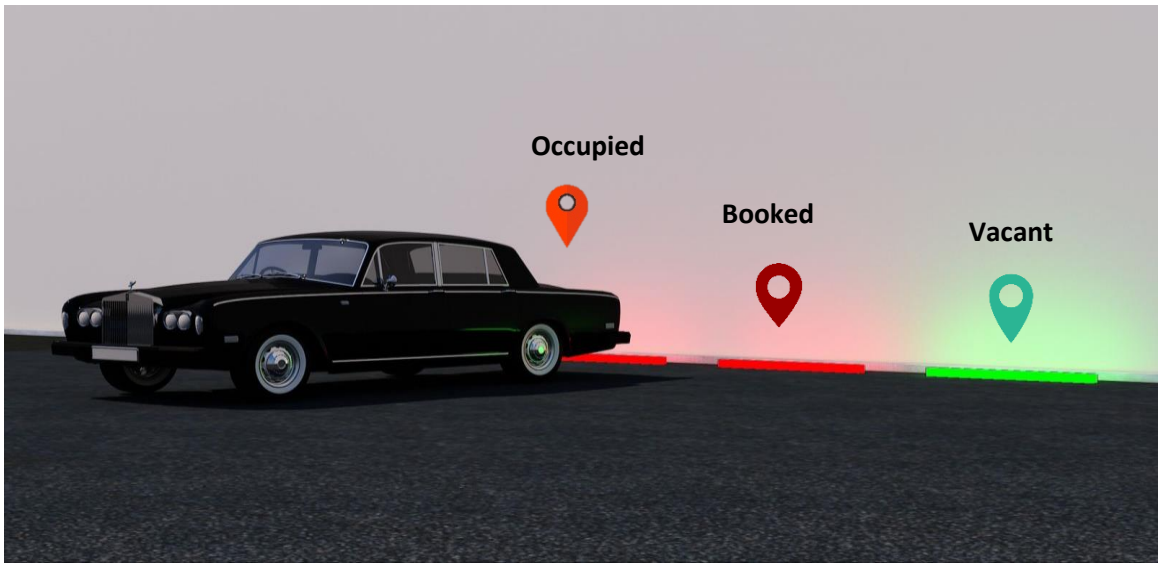

Figure 14- Proposal of Booking Presentation Technology by Image Based and Lighting Sensors

3.3 Sources of Data

Based on proposed solutions to solve a global strategic problem that may encountered in any archaeological or heritage area or even any region with similar privacy in the world, the needed data have been classified confidential as it has been collected after pledging not to publish due to its sensitivity. Therefore, collecting data requires communication with tow government authorities in Dubai as follows:

1. Roads and Transport Authority in Dubai for requesting masterplans of the Right Off-Way for Dubai metro station in the Shindagha area and the plans for the Creek Panorama Bridge that is under construction, in order to see the logistical restrictions imposed on the area in which leaded to implement only traditional solutions to serve the area with parking spaces for the expected number of visitors. In fact, the requested data was prohibited to be published due to its sensitivity, so

it had been allowed only to review it without getting a copy able to be published. Thus, best lands choices were determined accordingly and well explained in Current situation and location analysis – Chapter4 in this study, in order to implement the proposed solutions for car parking systems in this study.

2. Dubai Municipality which is the responsible authority in Dubai for managing all developing projects in the city, as coordination and communications held with each of:
    a) Architectural Heritage and Antiquities Department: The responsible department of implementing the Shindagha Museum project for reviving the historical Shindagha area and improving an impressive masterplan since 2015. Thus, the study of the final masterplan of Shindagha museum project had been provided by AHAD.
    b) Geographic Information Systems Center that provided all geospatial maps of the studied area and logistical area plans.

3.4 Expected Results and deliverables

Every project supposed to have expected results and deliverables. Deliverables are outcomes of analysis and works done during the lifetime of the study, thus in this study, three main proposed solutions for enhancing parking management and the tourist experience in the Shindagha area, were investigated to reach to the accompanying deliverables:

1. A Study of smart parking management in a distinctive area
2. A developed solution for Smart car parking Facility
3. A new of its kind integrated Guidance System for tourist areas
4. A Framework parking solution which can be applied on other distinctive areas in Dubai and worldwide.

While results that supposed to be figured out after processing deliverables, can be concluded into:

1. A sophisticated smart multi-story car parking facility with a capacity of about minimum 1000 cars serving a distinctive historical tourist area.
2. A dynamic tourist guide system that is applicable anywhere in the world
3. A smart pre-booking system for public parking spaces that can be applied in all over Dubai city and can be circulated in all over the world.

3.5 Expected Proposed Solutions Budget

The overall budget of project divided into two main categories:

- Budget for the study and design of the project: In the case of this study, No funds were needed for collecting required data from government authorities, as open data are available for public through Dubai government authorities websites, while sensitive data allowed to be available only for review and not to be published as what happened with this study data. In addition, in both cases data are free of charge for academic researchers.
- Budget of implementing the proposed systems: Since those proposed solutions supposed to be submitted to Roads and Transport Authority in Dubai (RTA) to work on its implementation, and therefore the implementation will take place through the budget of Dubai government. The cost of implementation needs an economic feasibility study according to the specifications of building materials, needed hydraulic systems, sensors, applications of IOT and many other parts that have wide range of values. On the other hand, in the phase of study, it had been designed a 3D simulation to help in clarifying the concept of the conveyor track system and to reflect the calculations that had been done to count the capacity of each floor in the multi-story parking and how this number of cars is allocating the gross floor area for each floor. Figure (21) in chapter 4 of this study, shows the 2D proposed system design, in accordance to the calculations clarification in the same chapter.

On a next step, a tender must be launched through RTA, that must match the specifications and the periods required for implementing a smart conveyor track multi-story car parking, a pre-booking system for public on-street parking lots and a smart guidance system integrated with the smart parking systems in the area. Consequently, an in-depth study of the project needed, and many authorities in Dubai government have to cooperate to work on that.

Chapter 4- Project Analysis

4.1 Master plan Analysis- Current situation and Location

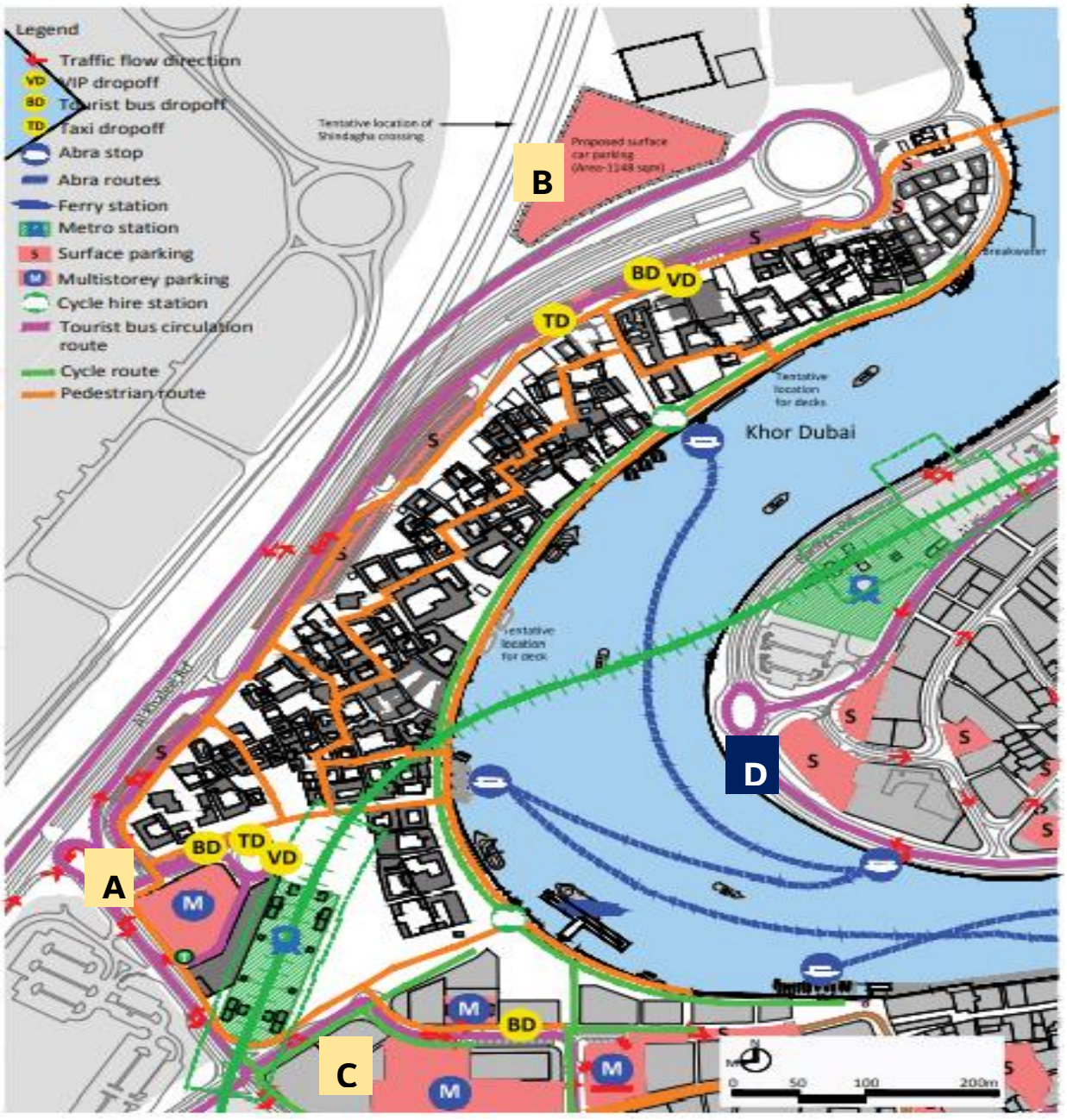

Figure 15- Shindagha Master Plan, (Halcrow,2015)

Determinants of implementing a multi-story car parking in the Shindagha area and the solutions proposed by Halcrow - consultant of Shindagha masterplan in 2015, have been analyzed in this study to reach to the following:

1- As shown in the Figure(15) of the studied area, and according to the forementioned analysis of the studied area and lessons learned from the literature review for the similar and related studies and articles, Its found that Block (A) which was allocated as a multi-story car parking area in Shindagha district, is not allowed neither not appropriate for establishing the multi-story car parking due to the metro station right off-way allocation, as the metro station block occupies an underground area which limits the possibility of implementing any building within the metro campus perimeter in the Shindagha District, whether above or below the earth surface referring to Roads and Transport Authority restricted activities list. [17]

Figure 16- Block B of Proposed Multi-Story Car Parking, (Halcrow,2015)

2- As shown above in the Figure (16) of the studied area, the block (B) of land proposed by Halcrow in the other side of the shindagha museum and beside the Shindagha roundabout as it will be an area adjacent to the 295-meter under-construction bridge, by BESIX international company, which called Shindagha Bridge that will arise 15.5 meter above the Dubai creek level. This Bridge designed to consist of six lanes in each direction in addition to a pedestrian crossing that supposed to link Deira Dubai with Bur Dubai and continue along AL Khaleej road till Jumeirah area. [18]. Figure (17) below, shows the Shindagha Bridge Proposal design as announced by BESIX and RTA.

Figure 17- Shindagha Bridge Proposal Design, (BESIX,2018)

3- As shown in the Figure (16), The proposed parking surface (C) from the side of Al Nahda Street and allocated as a private parking surface, is not suitable for a multi-story car parking, that it lies within the metro station right off-way area, therefore it had been allocated by RTA as a surface parking area with limited capacity as shown in Figure (18).

Figure 18- Block C of Proposed Multi-Story Car Parking, (Halcrow, 2015)

The previous analysis concluded the reasons behind not getting an no objection certificate from the Roads and Transport Authority on the proposals submitted by Halcrow. Thus, a new vision has been discussed in this study with consideration of the importance of Al Shindagha and Al-Ras areas as historical and tourists' areas in Dubai. Referring to the Figure (15), that shows the new proposed location (D), that lies in Al Ras area opposite of Shindagha area, on the other side of Dubai Creek, suits to be allocated as a multi-story car parking that serves both the Al Shindagha and Al Ras areas, according to the restrictions of RTA and affection plan of Dubai metro. To be clear and ensure that location (D) is suitable for implementing the multi-story car parking which proposed in this study and presenting the smooth and infatuate accessibility to the location with the ability to be linked with Al Shindagha area. Figure (19) below, explains the Proposed visitors journey between Al Ghubaiba marine station and the proposed new marine station in Al Ras, to reach specifically at the platform located as close as possible to the visitor center.

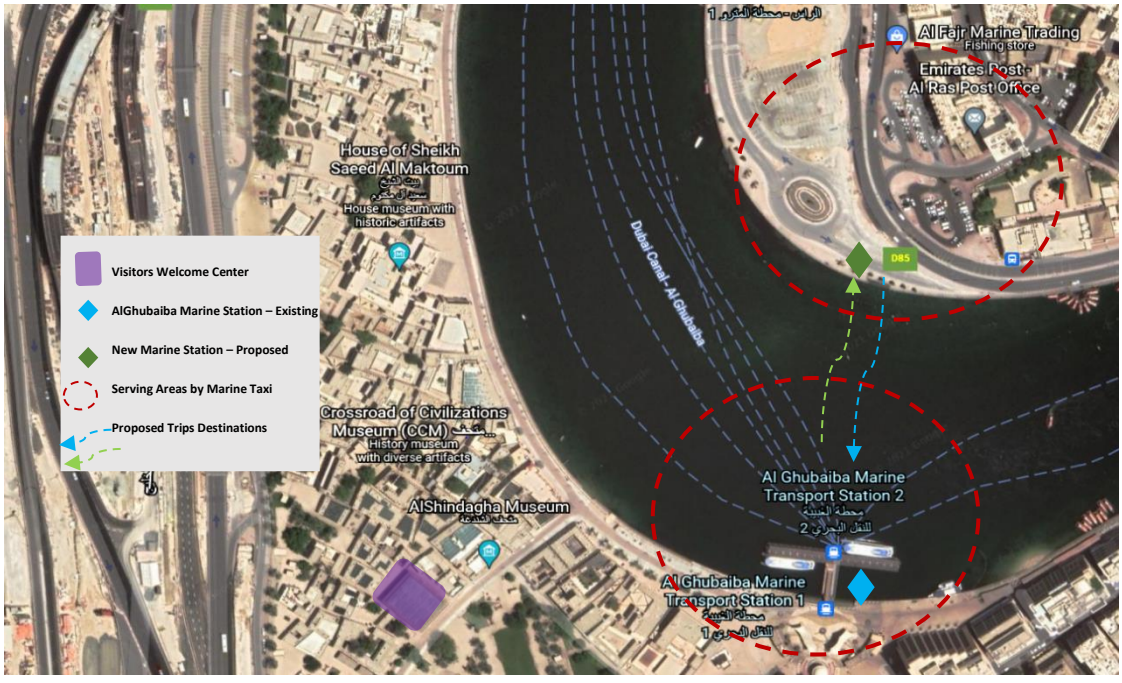

Figure 19- Proposed Visitors Journey Between Al Ras Area and Shindagha Area through Marine Taxi

4.2 Qualitative Analysis: SWOT Analysis

This study identified that although the idea of an authentic historic district in proximity to the creek is attractive for tourists and the area has a good number of heritage and cultural assets, the current situation of the transportation services and facilities are relatively need improvement in providing a world class experience for tourists and residents. As a first Phase of finding a smart parking and guidance solution, a SWOT analysis is a mandatory to figure out the strengths and weaknesses of the potential solutions.

The strengths and weaknesses of the existing parking situation in relation to the proposed parking management solutions, and the opportunities and threats of implementing these solutions are summarized as follows:

Strengths

1. Authentic district and its proximity to the creek which make the studied area attractive for visitors.
2. High concentration of historical and heritage buildings which means having a very high value assets that need proper controlling and monitoring systems.
3. Rich and interesting history which means that the area is an attractive destination for residents and tourists, that means high visits density expected.
4. Creek based experiences, such as Abra ride and marine taxi tour with viewing the loading and unloading of commercial goods at the wharfage which considered as available transportation options through the two sides of Dubai creek.
5. The strategic location of Al Shindagha area and its surrounding infrastructure, which facilitates access to the area by more than one means of transportation and more than one road (Al Shindagha Tunnel, Al Shindagha Bridge, Dubai Creek).
6. Diversity of transportation (Dubai Metro Al Shindagha Station, Al Ghubaiba Marine Taxi Station, Al Shindagha Bus Station).
7. The tourism importance of the area, which will reflect the importance of the proposed smart solutions.

8. The new experience resulting from the application of smart solutions that will facilitate and enhance the visitor's experience, regulate the movement of visitors and help maintain public safety.
9. The proposed smart conveyor track multi-story car parking will be the first of its kind in the world, in the smartest and most modern city in the world, and in its oldest historical area, which links the present with future and enhances the value of the original area due to its service with the highest infrastructure.

Weaknesses

1. Lack of diversity in the guidance solutions in the historical area.
2. Missing paths, and continuous routes between the heritage districts and new museums.
3. The Fact that Al Shindagha area is accessible only for pedestrians.
4. Newly activities in Shindagha which causes confusion in the mobility movement and management and the normal life.
5. Many Constrains in the area facing the ordinary parking management solutions (The Metro line, Dubai Creek, Rashid Port, New Shindagha Bridge, Shindagha Tunnel and the fact of history preservation rules).
6. Lack of available surface car parking in the area that can serve the expected number of visitors.

Opportunities

1. Establishing a smart car parking solution that serves one of the most important tourist areas in the emirate.
2. Organizing pedestrian traffic in the area through smart applications for the Internet of Things.
3. The development taking place in the city of Dubai, which supports creative ideas and innovation, and harnesses the necessary resources for that.
4. The competence of the concerned authorities to work on implementing the proposed solutions.

5. The possibility of making a model of the proposed smart multi-story building in order to simulate the expected reality, discover possible problems, avoid them and improve the idea.
6. The applicability of the proposed solutions to all important tourist sites in Dubai and worldwide.
7. The effectiveness of the proposed solutions in providing additional income to the emirate in terms of pre-booking fees for parking on the roads and parking fees in the smart multi-story car parking.

Threats

1. The need for large areas to construct the traditional multi-story car parking.
2. Limited number of parking spaces available when using open spaces.
3. Poor programming of robots, causing accidents inside the parking building which make this technology not still efficient.
4. Failure to design the lanes of movement through robots in a way that consider the dimensions of rotation and turns and the dimensions of vehicles of all kinds, which causes obstruction to the movement of the vehicle in the building.
5. The problem of calculating the expected weight of vehicles, which causes the problem of lifting the vehicle on robots or even on tracks.
6. Inadequate monitoring and sensor system in the building, which may cause accidents while parking vehicles.
7. Inadequate system database, which may cause confusion in the delivery of vehicles to their owners.
8. Hydraulic failure in vehicle transmission tracks.
9. The absence of an alarm system in the event of a system malfunction.

According to the aforementioned analysis of smart parking solutions and by comparing the weight of each factor of the SWOT analysis parts in accordance to the SWOT matrix review, we concluded to the following:

The proposed solutions have outstanding strengths and high opportunities for implementation, but there are some threats that may appear during, therefore its mandatory to study all of the possible risks and work to find the most appropriate alternatives, often by using the elements of strength to reduce the impact of weaknesses [11].

This analysis leads us to the fact that the proposal to apply smart solutions of parking management in the historical area, which was presented in this study in the form of three smart solutions, is a successful and able to be applied, as it follows the offensive strategy due to the presence of strong opportunities for application and many strengths that will result from its implementation, which will enhance the strength of the proposal in front of the possible threats. Thus, making a simulation model of the proposed solutions, especially the smart conveyor track multi-story parking, will help to bypass the possible threats and will improve the proposal design accordingly, and this is what this study recommends in its last chapter.

4.3 Quantitative Analysis: Transport Impact Study (TIS)

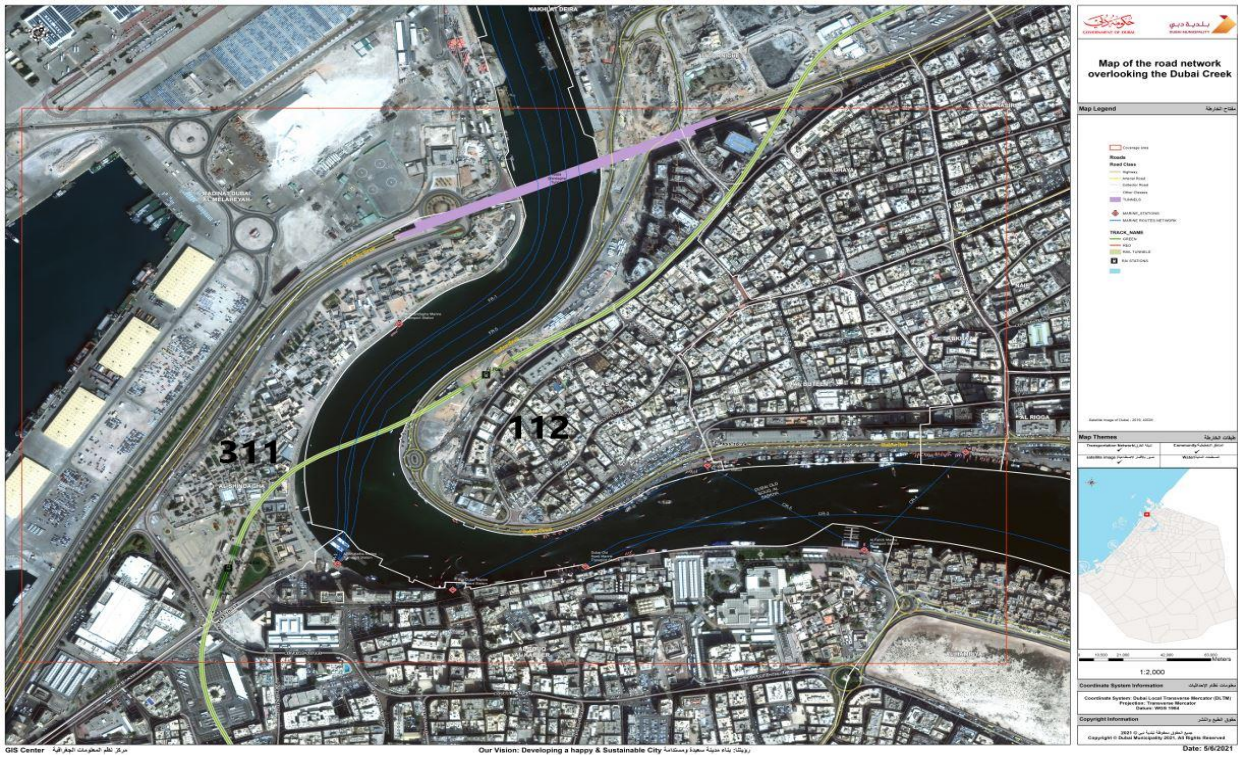

Figure 20- Map of Al-Shindagha area - Land No. 311 and Al Ras Area - Land No.112, (Dubai Municipality,2021)

As this study summarized three main smart proposals for car parking management Shindagha historical district in Dubai, it was a necessary to do a transport impact study analysis, which is usually done when proposing solutions in the field of mobility management. The analysis of the transport impact study is broad research in itself, while that the proposals presented in this study serve the field of car parking management, so the two determinants that most affect the establishment of a smart multi-story car parking in a crowded area were taken which are: Cars queue length and Trips generation. Figure (20) shows us the plot of the study (Al-Shindagha area - Land No. 311) and the proposed land for implementing the proposed smart multi-story parking (Al-Ras area - Land No. 112), while the Table (3) below presents the total number of car parking lots in both areas as Roads and Transport Authority Provides.

Parking_area	Community_num	Community_name	Park_spaces_count	Park_spaces_per area
AREA 112	112	AL RAS	1441	**72**
AREA 311	311	AL SHINDAGHA	713	**713**

Table 3- Total number of Car Parking Lots in Al Ras and Al Shindagha areas, (RTA,2021)

4.3.1 Trip Generation Analysis:

Referring to RTA Trip Generation and Parking Rates Manual (DTGPRM) 2013 which has been used to estimate vehicle trips into Shindagha according to land uses, the trip generation calculations for weekdays and weekends accordingly, shown in Table (4) and Table (5). [19] [20]

Weekday Trip Generation									
Proposed Land Uses	AM			NOON			PM		
	In	Out	Total	In	Out	Total	In	Out	Total
Multi Story Car Park	100	43	143	110	83	193	81	69	150
Total (Existing and proposed additional trips) in Both Shindagha and Al Ras Areas	410	198	607	532	532	1064	**622**	492	1114

Table 4- Trip Generation Calculations in Weekdays

Weekend Trip Generation									
Proposed Land Uses	AM			NOON			PM		
	In	Out	Total	In	Out	Total	In	Out	Total
Multi Story Car Park	93	26	119	94	68	162	101	62	163
Total (Existing and proposed additional trips) in Both Shindagha and Al Ras Areas	234	103	336	771	491	1262	**1114**	1079	2256

Table 5- Trip Generation Calculations in Weekends

Analysis Results:

The trip generation calculations conclude to the following:

- The peak of generated trips occurs during the weekend peak evening with an estimated 1,114 trips during this hour.
- According to RTA transaction calculations, each parking space is supposed to attract 60% of all incoming trips at any given time. This equates to 668 vehicles heading towards the on-street parking areas and another 668 vehicles heading towards the multi-story parking.

4.3.2 Queue Length Analysis:

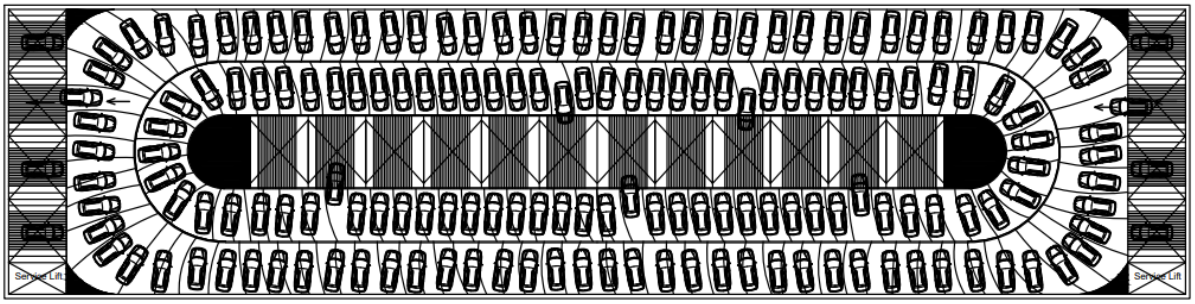

Figure 21- Story Layout of Proposed Smart Conveyor Track Multi- Story Car Parking

Queue length analysis was performed to verify that access to parking areas does not lead to queues on external roads. The two main parking areas are the proposed multi-story car parking and on-street parks (accessed from Al Khaleej Street). The capacity of each of the studied areas is as follows:

1. In the smart conveyor track multi-story parking, the story capacity according to the proposed design which is shown in Figure (21) has been estimated to 144 cars for each story in average. Due to the fact that the proposal shortens the floor height from 5 meters in the traditional multi-story parking to 2.5 meters, so in is the same allowed height in the area, the proposal can consist of twice the number of stories than the traditional one. Thus, we will have 8 stories instead of 4.
2. Each of the stories can accommodate 144 vehicles, assuming that the average length of the vehicle is 5.5 meters. Then, the estimated capacity of the proposed smart conveyor track multi-story parking will be equal to 1152 vehicles.
3. In Shindagha area, 713 vehicles can park on street spaces, according to the data of Roads and Transport Authority.
4. In Al Ras area, according to the data of Roads and Transport Authority, the total number is 1,141 vehicles for the entire region, but as the study covers only part of Al Ras area, then the studied part can cover 72 vehicles as capacity.

As a next step, Queue length for each of parking solutions in each area have been calculated by the following formulas:

Average Queue Length in Vehicles has been calculated using the formula:

Equation 1- Average Length Equation (in Vehicles)

$$E(m)\ \frac{P^2}{1-P}$$

As P = Volume to Capacity ratio of the car park entry

The 95% percentile Queue Length in Vehicles has been calculated using the formula:

Equation 2- 95% Percentile Queue Length Equation (in Vehicles)

$$E(m)\ \frac{P}{1-P}$$

As P = Volume to Capacity ratio of the car park entry

While the results have been transformed in meters as the Average length of car estimated equals 5.5meter as proposed in the design of the smart conveyor track multi story car parking [19] [20]. Table (6) presents the results of the Queue length calculations for both multi story parking and on street car parks.

Queue length analysis							
Access	Volume	Capacity	V/C	Average Queue Length (vehicles)	95%ile Queue Length (vehicle)	*Average Queue Length (m)	*95%ile Queue Length (m)
Multi story parking	668	1152	0.58	0.8	**1.38**	4.4	**7.58**
On-Street parking for Shindagha Area	668	713	0.94	14.73	**15.7**	81.02	**86.42**
On-Street parking for Al Ras Area	668	72	9.28	0.85	**1.44**	4.67	**0.50**

Table 6 - Queue Length Analysis of Parking Spaces among Al Shindagha and Al Ras

**Average length of car estimated =5.5meter*

Analysis Results:

Accordingly, the Queue length analysis concludes to the following:

- For the multi-story car park, there will be an one vehicle in the queue (equivalent to 7.58m) at peak hour. For the on-street parking areas, as the current situation without a multi-story car parking, there will be around 16 vehicles in the queue at peak hour in Shindagha area, with only one vehicle for Al Ras specified area.
- The analysis shows that there will be queues of cars in Shindagha if no new parking solutions have been added to the area.
- Al Ras area seems to have no queue of cars in the current situation, which means its very suitable for implementing the proposed smart conveyor track multi-story car parking, in order to serve both Shindagha and Al Ras areas.
- Shindagha queues can be comfortably accommodated within the proposed smart multi story car parking.
- The studies on the proposed smart multi story parking shows that it is useful and effective in the studied areas.

Chapter 5 Conclusion

5.1 Conclusion

In conclusion, this study employed smartness in serving community in an easy-to-apply and more effective way than the common solutions these days. The study case that was selected, was one of the most complex cases in terms of analyzing the current situation in the region and choosing the possible location to create a smart conveyor track multi-story car parking proposal to serve the important historical area, which will attract millions of visitors in conjunction with the opening of Expo 2020 and the recent announcement of His Highness Sheikh Mohammed bin Rashid Al Maktoum, that Dubai won the bid to host the ICOM 2025 International Museum Conference. This study proposed three ideal solutions for parking management, the first of its kind in the world, to create a multi-story intelligent parking automated through conveyor tracks that pull vehicles which are moving vertically through special elevators designated for this system , as these conveyor tracks convey vehicles horizontally in each story until they are returned to their owners through the special application. The idea here is that tracks are conveying vehicles horizontally not vertically, as is the case in the latest automated multi-story parking systems used in the world, in addition to the fact that the proposed system does not need artificial intelligence mechanisms like robots in order to convey vehicles, which have been distinguished in recent studies and implements of multi-story car parking. Moreover, as this study has also introduced a smart solution that is applicable throughout the city and even all over the world, which is a smart system for pre-booking on street parks, so that it allows the driver to reserve a parking space for his cars before a specific period of time needed to arrive, which guarantees the driver a specific and applicable parking for his vehicle through the applications of Internet of things technology. In addition, the study indicated a mechanism for integrating previous solutions with a smart solution for tourist guides and wayfinding, by linking them through an application so that the visitor can reserve a parking lot for his vehicle, whether in multi-story parking or on street parking lots, as well as using the app for a tour guide that helps him identify the congestion situation in each pavilion of the Shindagha museum and every important area or landmark he may like to visit, so that he organizes his visit without the need to stand in queues or even be exposed to severe crowding, which helps in maintaining the health and safety of visitors, maintaining social distancing and the numbers allowed in each museum according to the repercussions of the covid-19 pandemic and in anticipation of any another new pandemic.

5.2 Recommendations

During the deployment of a smart solution in the field of parking management that considered a critical side in mobility management, urban planners must cooperate and integrate with the studying engineers and designers and spend as much time as possible surveying and examining all possibilities in order to reach the best version of all the proposed solutions. Accordingly, this study recommends modelling the proposed solutions, whether by using technological mechanisms or implementing them on the real ground in miniature, in order to test their effectiveness and make improvements if necessary before it is implemented. This research also recommends considering future work that have been mentioned, in order to continue providing the best service solutions for sensitive and important areas as known as Dubai is in every field of life.

5.3 Future Work

Every study that deals with a smart and new from its kind solution in any field of life supposed to have a future work plan for implementation and development. Thus, in this study which presents smart new solutions in the field of parking management in one of the important crowded areas in the world, which can be applied at the city level as a whole, have a summary of future works to enhance the implement of the proposed solutions and let it serve wider kinds of vehicles and larger group of users. Therefore, the future work after this study has been summarized according to the following steps:

1. Applying a simulation model for trailer running of the proposed solution of smart conveyor track multi-story car parking and the proposed application for smart pre-booking system of on street parking, on the real ground, over a specific period and within a small area, to improve and enhance the proposed design if appointing any malfunctions or problems encountered during the trial run and to trail the implementation effect on the real ground to provide the highest possible quality.

2. Choosing the geographic information system that will feed the application for smart pre-booking on street parking system, trying the proposed solution on a specific area for a

specific period, and drawing results to get out a detailed feasibility study for the estimated costs and expected financial return over years. This step will reflect the valuable of the proposed system and makes Dubai the reference in establishing.

3. Start designing of the smart application and feeding it with the database of Al Shindagha Museums and the most important landmarks in it, in order to replace it with the tourist guide.

4. Studying the use of hologram technology for a tour guide through the smart application, as a kind of improvement and development of the idea.

5. Studying the possibility of implementing a proposal for multi-story car parking for electric vehicles, so that the conveyor track is used to charge the cars while they are park.

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