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IOT- BASED SMART VERTICAL PARKING SYSTEM

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ABSTRACT: Urban areas worldwide are facing increasing challenges related to parking congestion and space limitations. This project deals with developing an IoT based smart Vertical Parking system. This system also reduces the excess use of land space which is very less in our urban cities. By incorporating IoT technology, vertical parking offers enhanced efficiency and convenience for both vehicle owners and city planners. Urbanization and the ever-increasing number of vehicles on the street have made a pressing issue. This project is aimed to develop a prototype of the portable car parking system for parking cars within a large parking area. This paper explores the deployment of IoT-based vertical parking systems as a novel approach to address these urban challenges. It outlines the system design, data collection, and its potential impact on urban mobility. The paper concludes with a discussion on the benefits and future prospects of this technology. The driver can check the availability of parking space online in the web app and can book a space. More advantages for the green energy vehicles as they can also be get charged in this facility. The portable system is working with solar power so that it can be moved to another locations during festivals and conferences to address the parking issues. This innovative idea is developed in relation with the OMAN Vision 2040 to have smart cities equipped with modern technologies.

1. INTRODUCTION

The life in urban living have lot of challenges, especially when everyone has more than one vehicle, innovative solutions are imperative to address the growing challenges of limited space, environmental sustainability, and the increasing demand for electric vehicles.

Finding a parking space in most metropolitan regions, especially during the rush hours, is difficult for drivers. Difficulty arises from not knowing where the available spaces may be at that time traffic congestion may occur. The number of cars is expanding day by day. An average, people spent 20 minutes to find a suitable parking for the car. This results in the disruption of the traffic and sometimes in the movement of people. This is due to the weak planning and not thinking of solutions to keep pace with the large increase in the number of vehicles, and most people park the car for long times without thinking. Drivers looking for parking space is a major cause of traffic congestion and accounts for 30%.

Our groundbreaking innovative idea that combines efficiency and eco-friendliness is the Solar-Powered Vertical Parking System with Electrical Charging have a lot of features for the fast living world. Urban areas are witnessing a surge in population and vehicular traffic, resulting in a dire need for smart parking solutions. The solar-powered vertical parking system presents an ingenious approach to maximize parking capacity while harnessing clean energy from the sun. This not only optimizes land usage but also reduces the overall footprint of parking facilities. The system is equipped with solar panels on its exterior surfaces, harvesting sunlight to generate clean and sustainable energy. This integration not only powers the parking facility but also contributes surplus energy to the grid, promoting a renewable energy ecosystem. Recognizing the rise of electric vehicles (EVs), the vertical parking system framework joins state-of-the-art electrical charging stations. The system employs advanced automation to efficiently maneuver and park vehicles. Through the use of sensors,cameraand smart technology, the parking process becomes swift, reducing the time spent searching for parking spaces and minimizing traffic congestion.

A recent survey performed by the International Parking Institute [12] reflects an increase in the number of innovative ideas related to parking systems. At present there are certain parking systems [13] that claim to citizens of delivering real time information about available parking spaces. Such systems require efficient sensors to be deployed in the parking areas for monitoring the occupancy as well as quick data processing units to gain practical insights from data collected over various sources.

The aim of this project is to improve space utilization, streamline traffic flow, and provide an improved user experience. These objectives focus on optimizing parking space availability, reducing congestion, and offering convenient features such as real-time space availability updates, user-friendly reservation systems, and enhanced security. The integration of IoT technology also supports data-driven decision-making, predictive maintenance, and sustainability, ensuring that vertical parking facilities are efficient, safe, and environmentally responsible while seamlessly integrating with the local community.

Specific objectives of the project as follows

1. Enhanced User Experience: Improve the convenience and ease of finding and using parking spaces.
2. Improved security: Enhance safety and security for both vehicles and users in parking structures.
3. Data-Driven Management: Utilize information analytics for better decision-making and efficient facility management.

Benefits and Impact

•Reduced Congestion: The real-time parking information enables drivers to quickly locate available spaces, reducing the time spent driving in search of parking.

•Environmental Benefits: Reduced congestion leads to lower fuel consumption and, consequently, decreased emissions.

•Space Optimization: The system ensures optimal utilization of parking facilities, reducing the need for further urban expansion.

As per the VISION 2040 of OMAN Smart and sustainable cities are to be built with advanced IT infrastructure. This project is designed to develop a solution to reduce parking congestion and space limitations. This system also reduces the excess use of land space which is very less in our urban cities.

2. Project Description

Implementing a project like "Smart Vertical Parking" can bring about numerous benefits and improvements to urban mobility and parking solutions. Smart Vertical Parking" is an innovative project concept that aims to address urban parking challenges by utilizing vertical space efficiently. Here's why I empathize with the idea:

1. **Urban Congestion Relief**: Smart Vertical Parking can significantly reduce the on-street parking demand by utilizing vertical space more efficiently. This, in turn, can help alleviate traffic congestion and make campus/city life more convenient for residents and visitors. Mainly in our UTAS during the morning time.

2. **Eco-Friendly Approach**: By optimizing parking spaces, the project promotes eco-friendliness. Fewer vehicles circling in front of the campus in search of parking means reduced emissions, contributing to a cleaner and greener urban environment.

3. **Timesaving**: The convenience of a smart vertical parking system can save people precious time, as they won't have to spend excessive time searching for parking spots.
4. **Innovation and Technology**: The integration of smart technology into parking solutions represents a forward-thinking approach to urban planning. It demonstrates a commitment to innovation and a desire to make our campus more advanced and user-friendly.
5. **Space Optimization**: Utilizing vertical space effectively helps make the most of limited urban real estate and for our campus. It maximizes land use, which can be crucial in densely populated cities where space is at a premium.
6. Automated Vertical Parking Towers : Design and build automated vertical parking towers that can efficiently store and retrieve vehicles. Develops a user-friendly smartphone app that allows drivers to reserve parking spots, monitor availability. Enable users to locate their parked vehicle easily using GPS guidance.
7. Security and Safety Measures: Implement a comprehensive security system, access control, and alarm systems, to ensure the safety of both vehicles and users. Integrate smoke and fire detection systems for early fire prevention.

3. Methodology

The core of the vertical parking system lies in its space-efficient and environmentally conscious structural design. The system typically features vertical towers equipped with multiple levels of parking spaces. Each parking bay incorporates a robust framework of steel and aluminum, providing structural integrity while minimizing material usage. The vertical arrangement optimizes land use, making it an ideal solution for densely populated urban areas.

Solar Power Integration: At the heart of the system is the integration of solar panels, harnessing the power of the sun to meet energy demands. The solar panels are strategically placed on the exterior surfaces of the parking towers, maximizing exposure to sunlight throughout the day.

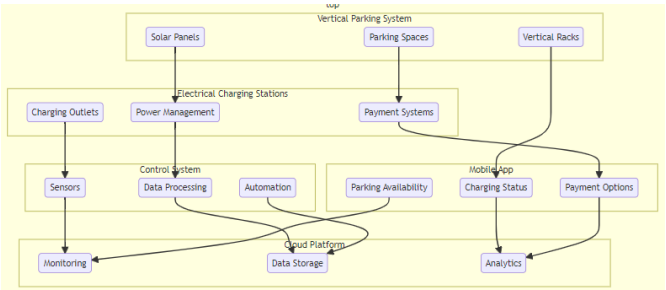
Electrical Charging Infrastructure: To meet the growing demand for electric vehicles (EVs), the parking bays are equipped with state-of-the-art electrical charging infrastructure. Charging stations are strategically positioned within the parking structure, ensuring convenient access for EV owners. This feature aligns with the global shift towards sustainable transportation, promoting the adoption of electric vehicles while addressing concerns about charging accessibility.

Smart Parking Technology: The system incorporates advanced AI camera, sensors and IoT (Internet of Things) technology to facilitate efficient parking management.

Real-time data on parking availability is relayed to users through mobile applications, guiding them to the nearest available spot. Real-Time Space Availability: Provide users with up-to-the-minute information on parking space availability on each floor, reducing the time spent searching for a parking spot.

User Interfaces: Users can access this information through various interfaces such as mobile apps, websites, or electronic displays at the entrance of the parking facility. These interfaces provide real-time information on the availability of parking spaces on each floor.

Environmental Impact Assessment: A comprehensive environmental impact assessment is a crucial component of the methodology. Life cycle assessments, energy payback periods, and carbon footprint analyses are conducted to quantify the system's sustainability.



Block diagram of the Smart vertical parking system

Challenges

4. Related Case Studies

1.Singapore's Green Car Park Initiative: In the heart of the bustling city-state, Singapore has implemented a state-of-the-art vertical parking system equipped with solar panels and electric vehicle charging stations. This initiative not only optimizes land use but also generates clean energy to power the facility. The case study reveals a significant reduction in the carbon footprint of the parking structure, providing valuable insights for other densely populated urban areas[1].

Solar-Powered Vertical Parking System:

At the heart of Singapore's Green Car Park Initiative lies the implementation of solar-powered vertical parking systems. The vertical parking system efficiently utilizes vertical space, enabling the construction of eco-friendly parking facilities in densely populated urban areas[2].

The solar panels integrated into the vertical structures harness renewable energy from the sun, providing a sustainable power source for the entire

parking facility. This not only reduces the carbon footprint associated with energy consumption but also contributes to Singapore's commitment to increasing the share of renewable energy in its overall energy mix[3].

2. **Oslo's Sustainable Urban Mobility Hub:** Norway's capital, Oslo, has embraced sustainability with a vertical parking system designed to accommodate electric vehicles exclusively. The integration of solar panels on the vertical structure complements the city's commitment to renewable energy. The case study highlights the positive environmental impact, reduced dependence on traditional energy sources, and increased adoption of EVs within the city.[4] Oslo, renowned for its commitment to sustainability, has emerged as a global leader in redefining urban mobility. The city's innovative approach to sustainable transportation includes the development of a cutting-edge Urban Mobility Hub featuring a solar-powered vertical parking system with integrated electrical charging stations[5].

   Solar-Powered Vertical Parking System: The heart of Oslo's innovative mobility hub is the solar-powered vertical parking system. Traditional parking facilities often consume vast horizontal spaces, contributing to urban sprawl and environmental degradation. In contrast, the vertical parking system optimizes vertical space, allowing for more efficient land use[6].

Dubai's Solar Oasis: In the arid landscape of Dubai, a solar-powered vertical parking oasis has emerged as a testament to the city's commitment to smart infrastructure. This case study delves into the incorporation of advanced energy storage systems to ensure uninterrupted charging services, even during periods of low sunlight. The project showcases the adaptability of solar solutions in diverse environmental conditions.

Solar-Powered Vertical Parking System: Dubai's Solar Oasis integrates solar panels into a vertical parking system, transforming traditional parking structures into eco-friendly hubs. The vertical design optimizes space utilization, a critical factor in densely populated urban areas. The solar panels, strategically positioned on the parking facility's facade and roof, harness sunlight to generate clean energy[7].

Renewable Energy Integration: Solar panels are seamlessly integrated into the parking facility's structure, providing a dual benefit of generating electricity while offering shade to parked vehicles[8].

Grid Independence: By relying on solar power, the parking system reduces its dependence on the traditional energy grid, contributing to energy resilience and sustainability[9].

3. Barcelona's Community-Driven Model: Barcelona has taken a community-centric approach by implementing solar-powered vertical parking systems in residential areas. The case study emphasizes the active involvement of local residents in the planning and maintenance of the facility, fostering a sense of ownership and sustainability. The model promotes a decentralized approach to urban mobility solutions[10][11].

Several other cities worldwide have already implemented IoT-Based Vertical Parking systems, reporting reductions in congestion and improvements in air quality. Case studies from these cities serve as valuable examples of the technology's effectiveness.

5.Challenges

While IoT-based vertical parking systems offer immense potential, they also present challenges related to system reliability, data security, and cost. Overcoming these challenges will require ongoing research and development.

Challenges such as system reliability, data security, and costs require ongoing research and development. Moreover, addressing the scalability and integration with existing infrastructure remains a priority.

Space Limitations:

One of the primary challenges faced by vertical parking systems is the utilization of limited space in densely populated urban areas. Designing efficient and space-saving structures that incorporate solar panels while accommodating multiple vehicles demands creative engineering solutions.

Energy Storage and Distribution:

The intermittency of sunlight poses a challenge in harnessing consistent energy. Developing effective energy storage systems, such as advanced batteries, and establishing seamless distribution networks are crucial for ensuring a reliable power supply for electric vehicles.

Technological Integration:

Harmonizing various technologies, such as solar panels, electric vehicle charging infrastructure, and smart parking systems, requires seamless integration. Compatibility issues and the need for standardized protocols must be addressed to create a cohesive and efficient system.

6.Future Prospects

Advancements in Solar Technology:

Ongoing advancements in solar technology, including improvements in efficiency and cost-effectiveness, will contribute to the viability of solar-powered vertical parking systems. Emerging technologies such as transparent solar panels and solar paint could revolutionize the aesthetic and functional aspects of these structures.

Smart Grid Integration:

Integrating solar-powered parking systems into smart grids will enhance their ability to manage energy flows dynamically. This integration allows for better synchronization between energy production, storage, and consumption, maximizing efficiency and minimizing waste.

Incentives and Policies:

Governments and municipalities can play a pivotal role in promoting the adoption of solar-powered vertical parking systems by offering incentives and implementing supportive policies. Subsidies, tax breaks, and regulations favoring sustainable urban infrastructure can accelerate the transition.

Public Awareness and Acceptance:

Educating the public about the environmental and long-term benefits of solar-powered parking systems can generate support and demand. As awareness grows, communities may actively participate in the integration of these systems into their urban landscapes.

7.Results

The paper presents the results and findings:

- Improved parking space availability, leading to reduced congestion.
- Enhanced parking experience for users.
- Increased operational efficiency and cost savings.
- A significant reduction in carbon emissions.

8.Conclusion

In conclusion, IoT-based vertical parking systems represent a viable solution to the urban parking dilemma. These systems have the capacity to enhance parking efficiency, decrease congestion,

and contribute to the development of smarter, more sustainable cities.

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