

**A Data-Driven Tool for Smart Parking Management**  
**System**

**Project/Thesis ID. 2023: E2022**

**BE Electrical Engineering 2020**

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## **Certification**

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This is to certify that Muhammad Suhaib Salman, 200768, Muhammad Khizer Shahid, 200722 and Aarsal Farooq, 200728 have successfully completed the final project **A Data-Driven Tool for Smart Parking Management System** at the **Air University Islamabad**, to fulfill the partial requirement of the degree **Electrical Engineering (Electronics)**.

**Project Supervisor**

Dr. Ashfaq Ahmed

Assistant Professor

**Chairman**

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**A Data-Driven Tool for Smart Parking Management System**

Sustainable Development Goals

(Please tick the relevant SDG(s) linked with FYDP)

SDG No	Description of SDG	SDG No	Description of SDG
SDG 1	No Poverty	SDG 9 ✓	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger	SDG 10	Reduced Inequalities
SDG 3	Good Health and Well Being	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals



## A Data-Driven Tool for Smart Parking Management System

Range of Complex Problem Solving			
	Attribute	Complex Problem	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	
7	Consequences	Have significant consequences in a range of contexts.	
8	Interdependence	Are high level problems including many component parts or sub-problems	
Range of Complex Problem Activities			
	Attribute	Complex Activities	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).	
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	

## **Abstract**

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This project introduces a pioneering approach aimed at alleviating challenges in big city parking lots by leveraging machine learning and deep learning methodologies. The primary objectives encompass identifying critical factors contributing to congestion in urban parking spaces and devising an innovative, data-driven software architecture dedicated to efficient vehicle management. Through the utilization of advanced image recognition powered by machine learning and deep neural networks, the system facilitates real-time analysis of video footage from parking lots. By accurately detecting and monitoring parking space availability, this technology aims to mitigate frustrations and time wastage commonly experienced by vehicle drivers. Moreover, the system prioritizes safety concerns by ensuring the well-being of both vehicles and individuals within parking lots. The proposed solution, integrating cutting-edge technologies, offers a promising avenue towards enhancing parking management practices in large urban settings while safeguarding human health and parking infrastructure integrity.

## Undertaking

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I certify that the project **A Data-Driven Tool for Smart Parking Management System** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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Muhammad Suhaib Salman

200768

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## **Acknowledgement**

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We truly acknowledge the cooperation and help make by Dr Ashfaq Ahmed, Assistant Professor of Air University Islamabad. He has been a constant source of guidance throughout the course of this project.

We are also thankful to our friends and families whose silent support led us to complete our project.

## List of Tables

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<b>S. No.</b>	<b>Elapsed time since start of the project</b>	<b>Milestone</b>	<b>Deliverable</b>
<b>1.</b>	End of June 2023	Investigation of Parking lot management related data	Dataset
<b>2.</b>	End of July 2023	Investigation and Implementation of pre-data processing methods	Pre-processed Dataset
<b>3.</b>	End of December 2023	Investigation, architectural design and implementation of machine learning methods for classification	Data-driven tool for: (i) vehicle detection. (ii) parking space detection, and (iii) vehicle plate detection.
<b>4.</b>	End of February 2024	Investigation and software implementation of optimization methods	Smart Parking Management System
<b>5.</b>	End of April 2024	Research article write-up and submission	Research Article



## Chapter 1 : Introduction

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In recent years, parking management has undergone a significant transformation with the introduction of Smart Parking Systems. These innovative systems leverage modern technology to streamline the parking experience, making it simpler and more efficient for both drivers and parking lot operators. Smart Parking Systems are designed to address various challenges encountered in traditional parking setups, offering solutions that enhance convenience, safety, and monitoring capabilities within parking facilities.

Unlike conventional parking systems, Smart Parking Systems provide real-time assistance to drivers by guiding them to available parking spaces promptly. Additionally, these systems empower parking operators by enabling them to monitor parking occupancy levels in real time and ensure adherence to payment regulations. This modern approach not only aids drivers in finding parking spots more easily but also assists parking authorities in managing parking facilities more effectively.

The distinctive feature of Smart Parking Systems lies in their ability to tackle common urban parking issues. These systems address concerns like traffic congestion, bolstering security measures, and enhancing surveillance within parking lots. By utilizing camera-based technology coupled with advanced algorithms, these systems accurately identify unoccupied parking spaces, minimizing the stress and time consumption often associated with finding parking in bustling urban areas.

Within the realm of Smart Parking Systems, diverse technological implementations exist, ranging from ground sensor technology to counter-based systems and camera-based solutions. Among these variations, systems employing camera-based technology, especially those incorporating machine learning techniques, stand out for their versatility and effectiveness in addressing the multifaceted challenges encountered in modern parking management.

## Chapter 2 : Scope

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The project's scope encompasses the development and implementation of a Smart Parking Management System, leveraging state-of-the-art technology to address the pressing challenges faced in contemporary parking infrastructure. The primary objectives revolve around improving the efficiency and functionality of parking facilities in urban environments, with a particular focus on the following high-priority areas:

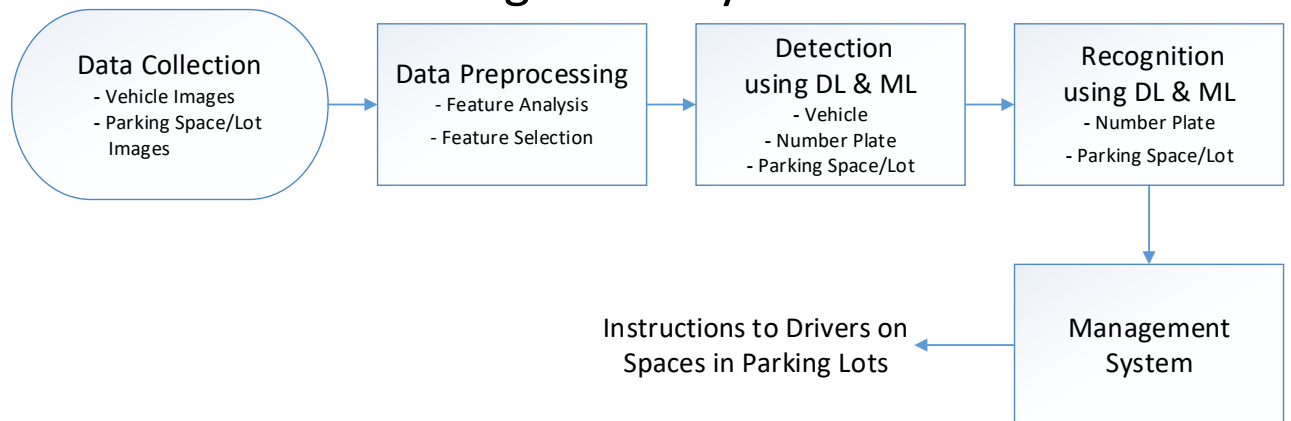
1. **Real-Time Guidance and Occupancy Monitoring:** The system aims to provide drivers with real-time guidance to available parking spots using image recognition technology. Simultaneously, it enables parking facility operators to monitor parking occupancy levels dynamically, ensuring effective space utilization.
2. **Traffic Congestion Mitigation:** Addressing traffic congestion within parking lots is a significant focus. The system will utilize advanced algorithms to streamline parking, reducing congestion and optimizing traffic flow within parking premises.
3. **Enhanced Security and Surveillance:** Implementing camera-based technology and machine learning algorithms will bolster security measures in parking lots, ensuring a safer environment for vehicles and individuals. This includes monitoring for any suspicious activities or incidents within the parking facility.
4. **Minimization of Driver Frustration:** By accurately identifying available parking spaces and providing real-time guidance to drivers, the system seeks to minimize frustration and time wastage often experienced while searching for parking.
5. **Integration of Advanced Technology:** The project emphasizes the integration of cutting-edge technology, such as machine learning and deep learning algorithms, especially within camera-based image recognition systems. This integration will play a crucial role in accurately identifying parking spaces and optimizing system performance.

The project scope encompasses the research, design, development, and implementation phases necessary to create a robust and efficient Smart Parking Management System. It involves the deployment of camera-based technology with machine learning capabilities to facilitate real-time guidance for drivers and enhance parking facility management. Moreover, Smart Parking Management System is carried out in collaboration with National Institute of Electronics (NIE) under Ministry of Science & Technology. NIE will implement this project for Civil Aviation Authority.

## Chapter 3 : Methodology

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### Block Diagram For Parking Management System



## Chapter 4 : Benefits

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The implementation of the Smart Parking Management System is poised to bring about a myriad of benefits, encompassing both operational and user-centric advantages:

1. **Reduced Labor Costs:** By automating parking space monitoring and guidance through advanced technology, the system significantly reduces the need for manual intervention, leading to decreased labor costs for parking facility management.
2. **Improved Efficiency and Digital Investment Opportunities:** The system's utilization of modern technologies like machine learning and deep learning not only enhances operational efficiency but also opens doors for further digital investment opportunities within the parking management sector.
3. **Increased Revenue:** Efficient utilization of parking spaces, coupled with streamlined payment compliance, results in increased revenue generation for parking facility operators.
4. **Better Customer Experience:** Providing real-time guidance to drivers and simplifying the parking process enhances the overall experience for customers, reducing frustration and saving time, thus fostering greater satisfaction among users.
5. **Enhanced Safety and Security:** Integrating advanced camera-based technology and machine learning algorithms fortifies security measures within parking lots, ensuring a safer environment for vehicles and visitors, thereby mitigating potential risks and enhancing overall safety.
6. **Integration with Other Systems:** The system's compatibility and integration capabilities with other smart systems create synergies and opportunities for seamless collaboration with adjacent smart city infrastructure, fostering a cohesive and interconnected urban ecosystem.

The amalgamation of these benefits underscores the overarching impact of the Smart Parking Management System. It not only optimizes parking operations, leading to cost reductions and revenue increments but also prioritizes user satisfaction by enhancing safety, efficiency, and the overall parking experience. Moreover, its forward-looking approach aligns with the digital transformation wave, positioning parking management within the realm of future-ready, technology-driven initiatives.

## **Chapter 5 : Conclusion**

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In conclusion, the introduction of a Smart Parking Management System marks a pivotal advancement in modernizing parking infrastructure. This innovative solution, empowered by cutting-edge technologies such as machine learning and deep learning, seeks to revolutionize traditional parking paradigms. By providing real-time guidance to drivers, efficiently managing parking occupancy, and bolstering security measures within parking lots, this system stands as a beacon of transformative change.

The scope of the project underscores its commitment to addressing high-priority areas including traffic congestion mitigation, enhanced safety, improved efficiency, and seamless integration with other smart systems. This multifaceted approach not only aims to streamline parking operations but also strives to elevate the overall user experience.

The project's benefits encompass a spectrum of advantages, ranging from reduced labor costs and increased revenue to a heightened focus on customer satisfaction, safety, and the creation of digital investment opportunities. Through these tangible benefits, the Smart Parking Management System promises to reshape the landscape of parking management, aligning with the trajectory of a technologically-driven future while catering to the evolving needs of urban environments.

In essence, this undertaking signifies a leap forward in modernizing parking infrastructure, paving the way for smarter, more efficient, and user-centric parking solutions that harmoniously integrate with the ever-evolving landscape of smart city initiatives. The convergence of innovation and practicality within the Smart Parking Management System heralds a new era in redefining how we perceive and interact with parking facilities in bustling urban spaces.

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