

Chapter 3

Smart Parking Safety and Surveillance System Using Computer Vision: Enhancing Urban Security Through In-Vehicle and Multi-View Monitoring

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ABSTRACT

This chapter presents a comprehensive framework for designing a Smart Parking Safety and Surveillance System leveraging computer vision technologies to enhance urban security. The objective is to automate and improve the monitoring of vehicles and pedestrians in parking environments using in-vehicle and multi-view camera systems. The approach employs OpenCV-based modules for pedestrian detection, lane and sign recognition, foreground-background extraction, and multi-camera tracking, integrated through a modular architecture. Sample lab exercises and system simulation demonstrate practical

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applicability. The findings indicate the system's potential to significantly reduce human error, improve vehicle tracking accuracy, and strengthen surveillance coverage in smart cities. The chapter concludes that such vision-enabled systems are integral to modern urban infrastructure, especially when aligned with emerging technologies like IoT and blockchain. The proposed model serves as a scalable foundation for future smart surveillance initiatives.

1. INTRODUCTION

1.1 Context and Need for Intelligent Parking Surveillance

The growth in the rate of urbanization and the increasing population of vehicles have created a vast range of infrastructural and logistical problems in the cities. The most critical issue among them is secure and efficient parking management. Common parking systems that use manual supervision or simple sensor-based occupancy sensors are unable to deal with the multifaceted issues of security, accessibility, surveillance, and real-time responsiveness. With growing complexity in urban infrastructure, the demand for intelligent systems that can automate, monitor, and secure parking facilities has never been greater. Smart parking monitoring systems are an integral part of the larger ecosystem of intelligent transportation systems (ITS) (Grbić & Koch, 2023).

Such systems take advantage of advances in computer vision, Internet of Things (IoT), edge computing, and, more recently, blockchain to enable parking space monitoring automation, violation detection, and pedestrian and vehicle safety. The combined effect of these technologies makes it possible to manage urban parking in an all-encompassing, real-time, and decentralized manner, ultimately leading to improved traffic flow, fuel consumption reduction, safety improvement, and citizen experience enhancement (Suresh Babu, C. V., Thrisha, M., 2025).. These are, however, small-scope implementations that do not leverage full multi-camera vision systems or in-car sensors that can deliver 360-degree coverage and situational awareness. India has a burgeoning urban population and a rising mismatch between the number of vehicles and parking spaces, and it is poised at the threshold of a smart parking revolution. Indian cities, as per a Frost & Sullivan report (2023), are estimated to lose nearly \$22 billion annually in revenue because of inefficient parking systems and traffic congestion (Grbić & Koch, 2023).

1.2 Role of Computer Vision in Smart Urban Systems

Computer vision, as an area of artificial intelligence, has quickly become central to urban systems. Its influence is keenly felt in the context of intelligent parking. Using advanced visual processing, the systems can now automatically calculate vacant parking spots, monitor vehicle entrances and exits, observe pedestrian traffic flow, and carry out license plate recognition at a rate that is superior to that of sensor-based approaches (Grbić & Koch, 2023).

The use of OpenCV (Open-Source Computer Vision Library) has further increased the pace of innovations in this area. OpenCV's extensive collection of tools—such as HOG descriptors for pedestrian detection and background subtraction methods—enables developers and researchers to design and refine real-time surveillance applications with ease. These abilities are complemented by the inclusion of deep learning models such as YOLO (You Only Look Once) and SSD (Single Shot Detector), which support highly accurate object detection even in complex or low-light conditions (OpenCV contributors, 2021).

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