



**S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT
& RESEARCH, NAGPUR.**

(An Autonomous Institute, Affiliated to RTMNU, Nagpur)



DEPARTMENT OF EMERGING TECHNOLOGIES (AI&ML and AI&DS)

"Become an excellent center for Emerging Technologies in Computer Science to create competent professionals"

A

Literature Survey

On

"Smart and Effective Real-Time Management of Street Parking"

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**S. B. JAIN INSTITUTE OF TECHNOLOGY, MANAGEMENT &
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**(AN AUTONOMOUS INSTITUTION AFFILIATED TO RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY,
NAAC ACCREDITED WITH 'A' GRADE)**

Introduction

Efficient management of street parking is essential for ensuring smooth traffic flow, optimizing the utilization of available space, and enhancing the overall urban mobility experience. However, traditional approaches to parking management often lead to congestion, frustration among drivers, and inefficient use of valuable urban space. To address these challenges, smart technologies and realtime management systems have emerged as promising solutions.

This document aims to inspire cities to adopt a smart and effective real-time management system for street parking. By leveraging advanced sensors, data analytics, mobile applications, and dynamic pricing mechanisms, cities can revolutionize their parking management strategies, making them more efficient, user-friendly, and sustainable.

The project titled "Smart and Effective Real-Time Management of Street Parking" aims to utilize advanced technology, specifically artificial intelligence and real-time data processing, to optimize the management of street parking spaces. Grounded in the realm of urban mobility, this project focuses on leveraging computer vision techniques within the field of smart parking management. The primary goal is to develop a system capable of accurately detecting and classifying available parking spaces on city streets in real-time.

The anticipated outcomes of this project include the development of a reliable and efficient parking management system that can enhance urban mobility and reduce traffic congestion. By accurately identifying available parking spaces in real-time, this system can provide drivers with up-to-date information on parking availability, guiding them to vacant spots and minimizing unnecessary traffic circulation.

Literature Review

Paper 1

Title: Smart Parking Management System

Author: Amol Pomaji^{1*}, Suraj Boinwad², Shrikant Wankhede³, Pushpendra Singh⁴, Bhagyashree Dhakulkar

Year: 2019

Summary: In this paper, Smart Parking Management System (SPMS) is used to book parking slots without any great effort by the user using an android device. The user can check the status of parking area and book the parking slot in advance. This will result in overcoming many problems which are being created due to the bad management of the traffic. Mobile computing has proven as the best area of work for researchers in the areas of database and data management so this application is applied in Android Mobile OS. This application is utilized by can be applied nook and corner due to its easy usage and effectiveness.

Paper 2

Title: Smart Parking System for a Truly Smart City in-line with Smart Cities Technology

Author: Challa Harish, Twinkle Twinkle, Sanchari Mandal, Priya Rani Lakra

Year: 2023

Summary: The project entitled "THE SMART PARKING SYSTEM" presents an IOT based smart parking system which provides an optimal solution for the parking problem in metropolitan cities. Due to rapid increase

in vehicle density especially during the peak hours of the day it is difficult task for the users to find the parking space to park their vehicles. This study proposes a smart parking system based on Arduino components and mobile application.

Paper 3

Title: Smart Parking System Based on Embedded System and Sensor Network

Author: Faiz Ibrahim Shaikh, Pratik Nirnay Jadhav, Saideep Pradeep Bandarkar, Omkar Pradip Kulkarni

Year: 2016

Summary: Locating a parking space in central city areas, especially during the peak hours, is cumbersome for drivers. The issue arises from not having the knowledge of where the available spaces may be at the time, even if known, many vehicles may seek very limited parking spaces to cause severe traffic congestion. In this paper the design and implementation with a prototype of Reservation-based Smart Parking System (RSPS) that permits drivers to effectively locate and withhold the vacant parking spaces in mentioned.

Paper 4

Title: Smart parking systems and sensors: A survey

Author: G. Revathi, V.R.Sarma Dhulipala

Year:2012

Summary: In this paper, we explore the concept of smart parking system and their categories. The classifications of various existing systems are explained. Parking system handles various technologies, and the categories of those techniques are given. The functions of nodes in wireless sensor networks are classified. Various approaches and researches are made to overcome the difficulties of parking area. As a result, many systems and technologies are developed for parking. The categories of various systems .

Paper 5

Title: Deep Texture Manifold for Ground Terrain Recognition

Author: Jia Xue 1 Hang Zhang 1,2 Kristin Dana 1

Year:2018

Summary : The paper introduces a texture network called Deep Encoding Pooling Network (DEP) designed for ground terrain recognition, a crucial task for tasks like robot or vehicular control and outdoor localization. DEP integrates orderless texture details and local spatial information in its architecture, surpassing existing methods in performance. The evaluation is conducted using the GTOS database, containing over 30,000 images of 40 classes of ground terrain, and a new dataset called GTOS-mobile, consisting of 81 videos of 31 classes of ground terrain. The network demonstrates excellent performance on both GTOS-mobile and more general databases like MINC and DTD. Additionally, the paper introduces DEPmanifold, a texture manifold built by leveraging discriminant features learned from DEP. DEPmanifold learns a parametric distribution in feature space in a supervised manner, enabling the representation of distance relationships among classes and addressing ambiguous class boundaries.

Paper 6

Title: An Algorithm of Parking Planning for Smart Parking System

Author: Xuejian Zhao, Kui Zhao, Feng Ha

Year:2017

Summary : The paper addresses the pressing issue of parking problems caused by the increasing number of vehicles worldwide, particularly in China. With nearly one billion private cars in China by 2013, the scarcity of parking resources poses a significant challenge, exemplified by Beijing's ratio of private cars to parking spaces. To mitigate this problem, the paper proposes a method for parking planning within the framework of a smart parking system. The proposed method transforms the parking planning problem into a linear assignment problem, where vehicles are considered as jobs and parking spaces as agents. The distances between vehicles and parking spaces serve as costs for agents performing jobs. An algorithm is designed to solve this assignment problem efficiently, providing timely and effective guidance for vehicles in a real-time smart parking system.

Paper 7

Title: e-Parking System in Corporate Parking Systems by Implementing Optical Character Recognition

Author: William Sunjaya, Juan Haryanto, Justin Kristian, Derwin Suhartono

Year:2021

Summary: The paper discusses the role of automated parking systems in minimizing direct human contact and enhancing health and safety protocols amidst the COVID-19 pandemic. It highlights how Optical Character Recognition (OCR) technology, specifically using Tesseract and OpenCV, can be leveraged to create touchless parking systems in offices and corporations. These systems offer faster and more efficient parking processes, particularly crucial in environments with a high risk of virus transmission. The algorithm achieves an accuracy rate of 73.75%, precision of 82.54%, recall of 83.87%, and an F1 score of 83.2%. By implementing OCR, the paper suggests that general security can be enhanced, safety protocols can be improved, and the reliance on physical parking receipts can be reduced, leading to increased efficiency in parking systems.

Paper 8

Title: Vehicle Number Plate Identification Using Template Matching Algorithm for Automatic Parking System

Author: Asih Setiyorini, Ika P. N. Purnama, Jayanti Y. Sari, Mutmainnah Muchtar, Edward Ngii

Year: 2019

Summary: The research addresses the inefficiency and error-proneness of manual parking systems in Indonesia by proposing an automatic parking system utilizing digital image processing methods, specifically template matching algorithms. These algorithms aid in analyzing character images on vehicle number plates by mapping pixel intensities, calculating errors, and identifying minimum error values. The template matching algorithm offers advantages such as processing data in matrix form, resulting in less complex computations and shorter processing times, which align well with the requirements of an automatic parking system handling large datasets. System testing involving 160 datasets of vehicle number plates demonstrates promising results, with the highest accuracy reaching 91.7% and an average processing time of 13.7 seconds. This suggests that the proposed automatic parking system effectively addresses the limitations of manual parking systems, offering improved efficiency and accuracy in recording vehicle number plates.

Paper 9

Title: Parking Slot Markings Recognition for Automatic Parking Assist System

Author: Ho Gi Jung; Dong Suk Kim; Pal Joo Yoon; Jaihie Kim

Year: 2006

Summary: This paper describes a monocular vision based parking-slot-markings recognition algorithm, which is used to automate the target position selection of automatic parking assist system. Peak-pair detection and clustering in Hough space recognize marking lines. Specially, one-dimensional filter in Hough space is designed to utilize a priori knowledge about the characteristics of marking lines in bird's eye view edge image. Modified distance between point and line-segment is used to distinguish guideline from recognized marking line-segments. Once the guideline is successfully recognized, T-shape template matching easily recognizes dividing marking line-segments. Experiments show that proposed algorithm successfully recognizes parking slots even when adjacent vehicles occlude parking-slot-markings severely.

Paper 10

Title: Robust parking occupancy monitoring system using random forests

Author: Woon Cho; Seokmok Park; Min-jae Kim; Sangpil Han; Minseo Kim; Taewoo Kim; Jaewoong Kim; Joonki Paik

Year: 2018

Summary: The paper addresses the need for efficient parking management systems in large buildings due to the increasing number of vehicles. It introduces a parking occupancy monitoring system capable of automatically determining whether a parking space is occupied or empty. Several challenges exist in parking areas, such as diverse car models, occlusions, moving objects, trash, and camera lens distortion, which complicate vehicle detection. To overcome these challenges, the paper proposes a part-based and machine learning-based vehicle detection algorithm. This approach aims to address the complexities of parking environments by leveraging both part-based analysis and machine learning techniques. The authors demonstrate the effectiveness of their method on a large indoor parking lot dataset containing various obstacles mentioned earlier.

Paper 11

Title: Research on Obstacle Avoidance and Trajectory Planning Strategy of Automatic Parking System

Author: Yao Cenglin

Year: 2020

Summary: The paper describes the establishment of a mathematical model based on the motion characteristics of vehicles during parking, along with the development of an inequality algorithm derived from obstacle avoidance rules. The feasibility of the model is then validated through MATLAB simulation of a trajectory planning algorithm. During the scene setup phase, a scenario involving common longitudinal parking with obstacles obstructing the parking trajectory is simulated. The simulation involves setting the vehicle speed to a constant low speed and utilizing the algorithm model to control the steering wheel angle at various time points to simulate the trajectory. The simulation results demonstrate the practicality and effectiveness of the algorithm for the specific scene under consideration. This suggests that the proposed mathematical model and inequality algorithm successfully enable trajectory planning for parking scenarios, particularly in the presence of obstacles, validating their real-world applicability.

Paper 12

Title: Project of an Intelligent Recommender System for Parking Vehicles in Smart Cities

Author: Yuriy Pankiv; Nataliia Kunanets; Olga Artemenko; Nataliia Veretennikova; Ruslan Nebesnyi

Year: 2021

Summary: The paper emphasizes the critical role of parking in transportation systems, highlighting that it is often the first impression people have when arriving at a destination. Convenient and affordable parking is seen as welcoming, while inadequate or expensive parking can lead to dissatisfaction and potentially relocation. Insufficient parking spaces can pose problems for both motorists and city residents. The lack of proper parking planning in new construction projects is attributed to various factors such as reluctance to address the issue, lack of information, or ineffective analysis. This results in many modern projects facing parking-related challenges. To address this issue, the paper proposes an intellectual recommender system for public transport parking. This system analyzes the area, processes user statistics, and generates recommendations regarding parking needs or possibilities for a project. Such a system, if developed and refined, could significantly contribute to designing more efficient cities. The proposed system utilizes location analysis and statistical data (e.g., population, car ownership rates, availability of parking locations, work patterns) to advise on the required number of parking spaces in a specific area. This information can guide decision-making processes, such as adjusting the number of parking spaces, planning regional development according to parking requirements, redirecting traffic, or implementing alternative transportation modes to reduce congestion.

Paper 13

Title: Automatic Parking System Performance Testing Based on Indoor Positioning System

Author: Zhuo Kaimin; Chen Tao; Jiang Zhuofan; Zhang Yue; Wang Xu

Year: 2023

Summary: The paper introduces an automatic parking system designed to assist drivers and alleviate the psychological pressure associated with parking. To enhance the accuracy and success rate of the system across different parking space types, the paper proposes a performance testing method based on indoor positioning systems. This method aims to comprehensively evaluate various indicators of automatic parking performance. Utilizing the proposed testing method, the paper conducts real vehicle tests in typical parking scenarios to verify the accuracy, efficiency, and convenience of the approach. By selecting a vehicle equipped with an automatic parking system for these tests, the paper aims to provide technical support for the development and validation of automatic parking systems. The paper underscores the importance of accurate and efficient automatic parking systems and presents a systematic approach to evaluate and analyze their performance, thereby contributing to the advancement of automated parking technology.

Paper 14

Title: On-Street and Off-Street Parking Availability Prediction Using Multivariate Spatiotemporal Models

Author: Tooraj Rajabioun; Petros A. Ioannou

Year: 2015

Summary: The paper addresses the growing importance of Parking Guidance and Information (PGI) systems within intelligent transportation systems, driven by increasing connectivity between vehicles and infrastructure. A significant challenge in developing effective PGI systems lies in the unpredictable nature of parking

availability in both on-street and off-street parking facilities. A reliable PGI system must accurately predict parking availability at the time of arrival. To tackle this challenge, the paper examines parking availability data in a major city and proposes a multivariate autoregressive model. This model accounts for both temporal and spatial correlations in parking availability data and enables accurate prediction of parking availability. The predicted availability is then used to recommend parking locations with the highest likelihood of having at least one spot available at the estimated time of arrival. The effectiveness of the proposed approach is demonstrated using real-time parking data from areas in San Francisco and Los Angeles. Overall, the paper presents a promising solution for improving the accuracy and reliability of PGI systems, thus enhancing the overall efficiency of urban transportation.

Paper 15

Title: Development of a Data-Driven On-Street Parking Information System Using Enhanced Parking Features

Author: Syrus Gomari; Rohith Domakuntla; Christoph Knoth; Constantinos Antoniou

Year: 2023

Summary: The paper addresses the issue of congestion in urban areas by proposing improvements to On-Street Parking Information (OSPI) systems. Current systems primarily rely on costly manual observations to maintain accuracy. The paper introduces enhancements to these systems by incorporating vehicle parked-in and parked-out events alongside traditional location-based features. These parking events (PEs) are used to develop dynamic features that allow the OSPI system to adapt to changes in parking availability. Additionally, a Parking Behavior Change Detection (PBCD) model is developed as a supplementary component to identify potential updates to the parking map based on detected changes in parking behavior. The evaluation of the proposed OSPI system demonstrates its effectiveness, with the availability prediction model performing comparably to state-of-the-art models despite its simpler but more adaptive features. The foundational temporal and aggregated spatial parking capacity features are shown to be highly beneficial, while the PE-based features improve the system's ability to capture variances and adapt to disruptions automatically. The paper concludes that a reliable OSPI system can be achieved using predominantly PE-based features alongside aggregated parking capacity features. This methodology enables the development of more accurate and adaptive OSPI systems, ultimately contributing to the reduction of congestion in urban areas.

Paper 16

Title: Implementation of a Parking State Machine on Vision-Based Auto Parking Systems for Perpendicular Parking Scenarios

Author: Saeid Sedighi; Duong-Van Nguyen; Klaus-Dieter Kuhnert

Year: 2019

Summary: The paper addresses the increasing interest in autonomous parking, which is considered a key subset of autonomous driving. While autonomous driving technology is advancing, autonomous parking is viewed as more practical for immediate implementation in the automotive industry. However, current autonomous parking solutions often require multiple maneuvers and considerable time to park, particularly in challenging traffic conditions. To address this issue, the paper presents a parking strategy for vision-based autonomous parking systems. The proposed method aims to enable the ego-vehicle to complete its parking with a minimal number of maneuvers, typically one to three. Experimental results demonstrate that the proposed method significantly reduces the number of maneuvers and time required for parking. Remarkably, the method achieves a success rate of over 95% in parking even in heavy traffic flows within parking areas.

Moreover, the paper asserts that the proposed method is lightweight and efficient for real-time applications, making it suitable for practical implementation in autonomous parking systems. Overall, the paper highlights

the effectiveness and efficiency of the proposed parking strategy, contributing to the advancement of autonomous parking technology.

Paper 17

Title: Real-time Electric Vehicle Classification for Electric Charging and Parking System Using Pre-trained Convolutional Neural Network

Author: Yian Seo,Kyung-shik Shin

Year: 2019

Summary: The paper discusses the application of deep learning, specifically Convolutional Neural Networks (CNNs), for vehicle image classification in the context of electric vehicle parking and charging systems. It identifies diverse purposes for vehicle image classification, such as real-time vehicle recognition, license plate character recognition, logo identification, and color classification. The focus of the paper is on categorizing electric vehicle model images based on electric vehicle types and classifying each image using CNNs. The proposed model aims to support the optimization problem of charging equipment installation and usage by recognizing the electric vehicle type in real-time at the entrance of parking or charging systems. This allows for directing each vehicle to the appropriate parking and charging area, as different electric vehicles require different charging methods and equipment. The model is built using transfer learning, where a pre-trained network with a large dataset is fine-tuned with the specific electric vehicle type dataset. The paper conducts 10-fold experiments and achieves a final test accuracy of 77.6%. The paper presents a practical application of deep learning in optimizing electric vehicle parking and charging systems, demonstrating the potential for improving efficiency and user experience in electric vehicle infrastructure.

Paper 18

Title: Parking Tickets for Privacy-Preserving Pay-by-Phone Parking

Author: Ricard Borges,Francesc Sebé

Year: 2019

Summary: The paper introduces a privacy-preserving pay-by-phone parking system as an alternative to traditional parking meters and mobile payment applications, aiming to maintain the same level of privacy as the traditional paper-based method, even in the presence of internal attackers with access to all information managed by the system servers. The system ensures drivers' privacy without requiring trust in any party involved in the parking process and can tolerate situations where the mobile devices of drivers lose network coverage while their cars are parked, ensuring uninterrupted service. By leveraging mobile technology, the proposed system offers a secure and privacy-preserving solution for parking payments, addressing concerns related to privacy and trust while providing convenience and flexibility to drivers and ensuring the confidentiality of their personal information.

Paper 19

Title: A multi-classifier image based vacant parking detection system

Author: Junzhao Liu; Mohamed Mohandes; Mohamed Deriche

Year: 2013

Summary: The paper addresses the need for smart parking systems to assist drivers in finding available parking spots, especially in rapidly expanding cities with increasing vehicle numbers and parking areas. It highlights four main categories of car parking management systems: counter-based, wired-sensor-based, wireless-sensor-based, and image-based. In this study, the authors focus on developing, implementing, and testing an image-based system for detecting vacant spaces in a parking area. The proposed system utilizes edge detection techniques followed by the combination of edge density, closed contour density, and foreground/background pixel ratio to determine the presence of a car at each parking spot. By combining these features, the authors achieve a robust vacant space detection system at a low computational cost. This approach offers a promising solution for efficiently detecting available parking spaces, contributing to the development of smart parking systems and improving the overall parking experience for drivers.

Paper 20

Title: Semi-autonomous virtual valet parking

Author: Author Arne Suppé, Luis E. Navarro Serment, Aaron Steinfeld

Year: 2010

Summary: The paper addresses challenges faced by wheelchair van users and older drivers in finding suitable parking spots that accommodate their needs for clearance and ease of ingress and egress. Despite regulations specifying parking spots for wheelchair vans, users often encounter problems with clearance for van ramps. Additionally, older drivers may struggle with getting in and out of their vehicles, particularly if neighboring cars block their doors. To address these issues, the paper proposes a method and user interaction for low-cost, short-range parking without a driver in the car. This approach aims to enable ingress and egress without the doors being blocked by neighboring cars, thus improving accessibility and convenience for wheelchair van users and older drivers. By implementing this method, the paper seeks to enhance the parking experience for individuals with mobility challenges, ensuring that they can safely and comfortably access their vehicles without obstruction from neighboring cars. This solution has the potential to significantly improve the quality of life for these individuals by providing them with greater independence and ease of movement.

Paper 21

Title: A cross-domain functional safety approach of System of Systems on example Valet Parking

Author: Thomas Glock; Carl Philipp Hohl; Stefan Otten; Pavel Nefedov; Eric Sax

Year: 2019

Summary: The paper discusses the increasing demand for new assistance functions in autonomous driving, such as valet parking, which involves the vehicle becoming part of the Internet of Things (IoT) and evolving into a Cyber-Physical System (CPS). One of the emerging challenges is the analysis and consideration of functional safety, particularly in the context of valet parking, which involves autonomous parking processes in parking garages. The paper highlights current challenges, including the interaction of systems and distributed functional scopes across various domains such as automotive and industrial automation. These challenges necessitate analysis and evaluation according to relevant standards. To address the challenges of functional safety analysis in a cross-domain System of Systems (SoS), the paper presents an approach. This approach aims to provide a framework for analyzing and evaluating the functional safety of valet parking systems, taking into account the complex interactions and distributed nature of these systems. The paper contributes to advancing understanding and methodologies for ensuring functional safety in the context of autonomous driving and valet parking systems, addressing the complexities inherent in cross-domain SoS.

Book References

Creating a literature review that includes book references specifically focusing on terrain recognition using deep learning entails drawing from a range of texts that cover fundamental theories, methodologies, applications, and case studies in the fields of smart and effective parking management . As of my last update, here are several pivotal books and resources that could serve as essential references for understanding and exploring the nexus and terrain recognition:

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