Smart Parking Systems: A Comprehensive Review Using Machine Learning

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Abstract:- *The rapid growth in population has led to substantial traffic bottlenecks in recent transportation systems. In the age of Internet of Things (IoT) and smart city ecosystems, smart parking and relevant innovative solutions are necessary towards more sustainable future cities. In this study, machine learning techniques are utilized to construct an automated system for detecting free parking lots from camera photos. This framework was created as part of this effort. We overview the enabling technologies and sensors which have been commonly used in the literature. We emphasize the importance of data reliability, security, privacy, and other critical design factors in such systems.*
Keyword – Automated System, Smart Car Parking, Machine Learning, Internet-of-Things (IoT).

I. Introduction

The management of existing transportation networks and road infrastructure is an area of focus for a number of nations as they try to improve traffic flows, mobility, and safety in their respective nations. Intelligent Transportation Systems (ITS) are a notion that has developed as a direct result of these incentives. ITS, or Intelligent Transport Systems, are cutting-edge applications that may be deployed in transportation and infrastructure to facilitate the interchange of information between different frameworks with the purpose of improving efficiency, safety, and environmental performance. Speed cameras, variable messages. Basic management systems, navigation systems, and traffic control systems signs are all examples of ITS technologies. More advanced applications that combine live information and feedback from other sources, such as parking reservation systems (PRS) and parking guidance and information (PGI) systems, are examples of ITS technologies that are on a higher technological level.
Parking has been the primary issue facing shopping malls, event halls, and other public buildings in recent years. The reason for this is because there is an inadequate amount of parking spaceIn today's world, the number of vehicles owned by a family is typically greater than the number of people who make up that family[1]. Because of this, parking is difficult, and it also extends the amount of time that is required to park the car, which results in an increase in the amount of gasoline that is consumed by the vehicle.

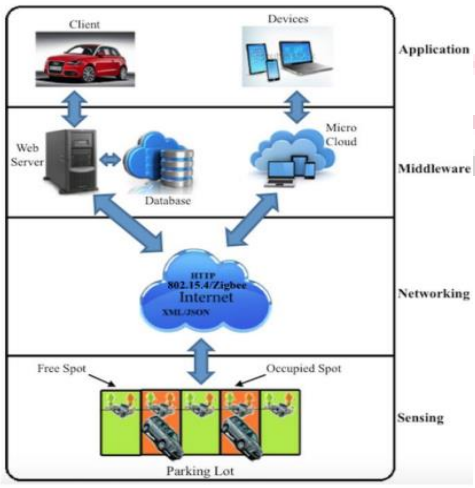

Figure 1 Smart parking system architecture [4]

The challenge of finding parking for such automobiles is one of the main considerations that need to be taken into account in accounting. The process of acquiring parking information has utilized a wide array of car detectors of varying types[2].The inductive loop, acoustic sensor, infrared sensor, and ultrasonic sensor are the most common types of sensors utilized in these vehicle detectors. It has been suggested that the information in the car parking field be gathered utilizing a system that makes use of video camera sensor technology. However, the sensor of a video camera is susceptible to damage from inclement weather and operation throughout the night. In addition to this, it is costly and has the potential to produce a significant volume of data that may be challenging to send over a wireless network [3]. The wireless sensors are nonetheless invasive since they are either buried beneath the asphalt of each parking lot or affixed to its surface.

II. RELATED WORK

L.Hu et al. [1] propose a novel unified method of automated object detection for urban surveillance systems. We use this novel method to determine and pick out the highest energy frequency areas of the images from the digital camera imaging sensors, that is, either to pick the vehicle license plates or the vehicles out from the images. Our proposed method can not only help to detect object vehicles rapidly and accurately, but also can be used to reduce big data volume needed to be stored in urban surveillance systems.

M.Mohamad et al. [2] aims to provide a novel method based on fuzzy primal-dual method of multipliers (PDMM) to manage the optimal energy scheduling problem in the smart grids. The proposed smart grid is constructed of different components such as generators, wind park and storage devices as two of the most profitable and applicable energy sources in the power grids. The simulation results on the IEEE 24-bus test system indicate that the proposed stochastic distributed energy management framework yields an error of less than 0.018% compared to the centralized approach.

Ammad et al. [3] proposed framework adds additional two layers in the existing IoT-fog-cloud architecture - sensors-based energy-efficient hardware layer and policy layer, to monitor the energy consumption and to enable the energy-aware decision making. Initially, the main sources of energy consumption in an IoT-enabled smart environment are identified. To validate the proposed framework, four case studies are considered - smart parking, smart hospital specifically ICU, smart agriculture and smart airport. Simulations are conducted using iFogsim toolkit and results show that a significant amount of energy can be conserved by employing the proposed framework.

Y.Zhang et al.[4]propose a smart VFC system, by combining both PVA and smart parking. The proposed allocation rule maximizes the aggregate utility of the smart vehicles and the proposed payment rule guarantees incentive compatibility, individual rationality, and budget balance. The simulation results confirm the win-win performance enhancement to the fog node controller, the smart vehicles, and the parking places from the proposed design.

R.Khan et al.[5] aims to ensure the continued power supply to the consumers during outages and peak hours from the stored energy in the batteries of electric vehicles (EVs). The first objective function is formulated to maximize the energy output from the EVs-batteries during blackouts or to minimize the energy not supplied (ENS) to the consumers, whereas the second objective function minimizes the losses of the distribution system. Simulation results show that PL of EVs could be employed as a power source during the islanded and grid-connected mode for improvement of reliability in the power systems.

H.Canli et al.[6] a deep learning and cloud-based new mobile smart parking application was developed to minimize the problem of searching for parking spaces. Within the application, a service has been developed based on deep learning with Long short-term memory (LSTM) to predict the parking space. With the real-time car parking data collected in the city of Istanbul in Turkey, high accuracy results were obtained. The results have confirmed the high accuracy and reliability that was promised.

Z.Cai et al.[7] a dual-lens millimeter wave (MMW) radar antenna is designed for a smart parking system in the context of the Internet of Things (IoT). In addition, a dielectric rod lens is used to correct beam direction and maintain a wide beamwidth in order to overcome received energy loss due to scattering of the car chassis. The measured gain is 15.8 dBi for the transmitting antenna and 7.9 dBi for the receiving antenna, and the 3-dB beamwidth is approximately 65°. The system measurement results show that the proposed antenna has stable measurement effect and is suitable for the MMW radar smart parking system.

Sheetal et al.[8] propose a novel multi-objective grey wolf optimization technique for node localization with an objective to minimize a localization error. Two objective functions are considered for distance and geometric topology constraints. The proposed algorithm is compared with other node localization algorithms. Our algorithm outperforms the existing algorithms. The result shows that localization error is reduced up to 17% in comparison with the other algorithms. The proposed algorithm is computationally efficient due to the choice of fast converging parameters.

M.Badar et al.[9] propose a blockchain-based smart parking system with privacy preservation and reputation management. In our system, a consortium blockchain is created by different parking lots to run the parking system securely and transparently, where the parking offers are recorded on a shared and immutable ledger. Our evaluations

demonstrate that our smart parking system is secure and capable of preserving drivers' privacy with low communication, computation, and storage overheads.

M.Echarri et al.[10] describes the development of a decentralized low-latency smart parking system: from its conception, design and theoretical simulation, to its empirical validation.a decentralized database and fog computing gateways, whose performance is evaluated in terms of response latency and processing rate. Results show that the proposed system is able to deliver information to the drivers fast, with no need for relying on remote servers.

III. Smart Parking Systems and Classifications

Smart parking systems are categorized into various categories in which each of them has a different purpose and use different technologies in detecting vehicles. Smart parking systems benefit both the drivers and the operators. Smart parking enables several attractive services such as the smart payment/reservation, which can substantially enhance the experience of both drivers and operators.[5] Moreover, the smart parking system helps in preventing the unauthorized vehicular usage, as it increases the security measures on parking lots. Furthermore, SPS can play a significant role in providing a clean and green environment by minimizing the vehicle emissions via decremented delays in finding the vacant parking spot. Smart parking system (SPS) architectures commonly consist of several layers based on their functionalities .Firstly, the sensing layer, which is the backbone of the smart parking system, and it is responsible for detecting the presence and/or absence of a vehicle in an area using different sensing technologies. These technologies are mostly comprised of receivers, transmitters, and anchors. Secondly, the network layer, and it is the communication segment of the system, which is responsible for exchanging messages between transmitters/receivers and the anchors. Thirdly, the middleware layer, which is the processing layer of any SPS in which intelligent and sophisticated algorithms are utilized to process the real-time data. It also acts as a data storage, as well as, the link between the end users requesting services from the lower layers. [6]

IV. Approaches to smart parking system

Detailed analysis and comparison of the technology methods or approaches used by various SPSs have been provided in this section.

4.1. Wireless Sensor Network (WSN) based SPS

WSN can be defined as a network of wirelessly connected sensor nodes that are spatially dispersed and are dedicated to monitoring different environmental aspects such as sound, temperature, pressure, etc

4.2. Multi-agent system (MAS) based SPS

To develop SPS, various researchers have deployed MAS due to its effectiveness in both closed or indoor and outdoor or open parking lot areas.

4.3. Computer vision/image processing based SPS

Computer vision/Image processing based SPS uses different types of camera networks to use image data to extract different information such as parking lot occupancy status , license plate recognition (LPR) and face recognition for billing, security issues, and to provide road traffic congestion report.

4.4. Vehicular Ad-Hoc network (VANET) based SPS

VANET is based on the Mobile Ad Hoc Network (MANET), where a wireless network of mobile devices is used. SPS utilizing VANET has three main components: Parking Side Unit (PSU), Road Side Unit (RSU), and On-Board Unit (OBU).

4.5. Internet of Things (IoT) based SPS

IoT is the buzzing technology of the current era, where all devices are interconnected with one another through the internet. Every device interconnected with the internet possesses an unique identifier (UID).

4.6. Machine learning (ML) based SPS

ML is a subset of AI that provides a system the ability to learn and improve on a particular task from the datasets or experiences without explicitly programming the system. A machine learning-based SPS analyses the parking lot of data to extract the parking lot status.

4.7. Deep learning (DL) based SPS

DL is a subset of ML and a function of AI which mimics the human brain in terms of data processing and feature extraction to make decisions.

4.8. Neural Network (NN) based SPS

NN is a combination of algorithms that extracts features and underlying relationships from sets of data through a process that mimics human brain function.

V. Conclusion

This paper provides review on smart parking systems deployed by different researchers. The paper systematically talks about different approaches taken by the researchers to develop their smart parking system and their suitability for different parking lots. The paper also provides information about different smart parking sensors and their usage for different conditions. Moreover, classification of SPS as per user interfaces, networking technologies, computational approaches, and services have been provided. As per comprehensive review and analysis conducted in this research, it

can be observed that multi-approach based SPS will dominate in future smart cities where the IoT will work as the backbone.

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