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Smart Parking System: a Review

Ragy Samir, Ayman Al-Ahwal, Islam A.M. El-Maddah and Hossam E. Abdelmunim

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Smart Parking System: A Review

Ragy Samir[1], Ayman Al-Ahwal[2], Islam A.M. El-Maddah[1], Hossam E. Abdelmunim[1]

[1] Computer and Systems Engineering Department, Ain Shams University, Cairo, Egypt
[2] Communication and Electronics Department, Pyramids Higher Institute for Engineering and Technology, Cairo, Egypt

Abstract: Parking a vehicle in congested areas is a common problem in many parts of the world, causing overcrowding and pollution. Due to the fast growth in vehicle density, particularly during rush hours of the day, it is very hard for people to find a parking space for their vehicles. Smart parking sensors and technology assist drivers in locating available parking spots, boosting parking efficiency. The smart parking system proposed is covering an onsite deployment of a slot module that observes and notifies the availability of each parking spot on time. Due to reduced cost and tolerance to changing environmental circumstances, this paper reviews the literature on the use of smart parking sensors, technologies, and applications and recommends a combination of machine vision and embedded systems ideal for open parking lots.

Keywords: Smart parking system, Computer Vision, Parking lot, Embedded Systems.

1 Introduction

In densely populated regions, such as cities, the supply of parking spots is frequently fewer than the availability of vehicles, resulting in a parking space shortage. According to IBM Global Parking Survey, 30% to 50 % of drivers hunt for free parking spaces in congested areas across the world [1], vehicles take between 3.5 and 14 minutes to find a parking place, which leads to frustration for drivers, accidents, wasted time, congestion, and air pollution. Many times, in large parking slots, the driver tends to forget where they parked their car, so people waste their time and energy looking for their cars' parking. Smart parking is one of the Internet of Things (IoT) applications. IoT technology first appeared in 1999. The smart parking sector is growing and developing new solutions regularly. Smart parking solutions are one of the most fundamental and important requirements of smart cities that improve the safety of parked vehicles [2].

Many existing methods employ sensors to determine whether the space is occupied or not. That helps a driver to park his car faster and more securely and to find his car quickly. In the year 2019, according to the CEIC "Census and Economic Information Center" [3], the Number of Registered Vehicles IN EGYPT was reported at 7,806,052 vehicles registered in Dec 2019. Statistics show that the number of registered cars is increasing every year, this increase is approximately linear. With smart parking, drivers can adjust their travel schedules without wasting time driving around the city in vain if they have real-time information on parking availability. The smart parking system can use information and communication technologies to help drivers find empty parking spaces quickly and effectively. The advantages of deploying smart parking systems for cities include a reduction in the time it takes for drivers to find a parking spot, a reduction in pollution, fuel consumption, and traffic congestion through smart parking apps, and an increase in the number of people who use public transportation, and, most importantly, an increase in city revenues from parking fees [4].

This paper aims to review smart parking systems which use a wide range of available technologies like the Internet of Things, and Computer Vision based on deep learning algorithms. The paper is organized as follows: Section 2 will discuss related work of smart parking. Section 3 analyzes the algorithms of machine-vision-based deep learning algorithms. Section 4 concludes.

2 Related Works

An initial search was carried out on academic scholars of Google, and based on the result of this search, a refined search was carried out in databases, IEEE, Springer, Elsevier, Taylor and Francis, and Google Books. The Keywords used are intelligent parking sensors, technologies, smart parking systems, wireless parking systems, online parking, parking efficiency, and outdoor parking systems.

There are four principal levels of the smart parking system (SPS) [5]. The first is the detecting layer, which contains sensor devices placed in the parking lot. The second is the networking layer for communication between the transmitter and the receiver. Third, the middleware layer is utilizing intelligent algorithms and efficient visualization technology. Finally, the application layer offers various services to users. There are three types of sensor devices [5], First, slave devices, also known as "receivers," are placed on parking spots to detect presence/absence. Second, master devices, also known as "transmitters," are tasked with collecting sensor readings from their connected slave devices and transmitting these readings to a gateway for further processing. Finally, the "anchor" devices, are used as repeaters to increase wireless sensor coverage of the parking for efficient routing.

The smart parking system's components are classified into three different categories [6]. Firstly, counter-based systems use sensors to count vehicles entering and exiting a parking area; so it's useful for parking to detect the available slots inside the parking. The disadvantage of this system is not to guide the driver to the exact parking space available so it will be good to use as part of a smart parking system, not the main components and it is not suitable for outdoor parking. Secondly, sensor-based systems use sensors installed in each parking space, such as ultrasonic sensors or IR sensors. It can guide the driver to the exact parking space and is suitable for outdoor parking. The disadvantage is so expensive to install; as it requires many sensors per parking slot to cover the entire parking lot. The third one is the image and video-based systems (vision-based). This system can use current CCTV cameras, which are less expensive to install, and are a good option for outdoor parking lots. This system requires a large amount of data to be transmitted over a wireless network, so it can be used to detect many slots as camera wide-angle detection will be effective for huge smart parking and can be used in outdoor parking lots.

In 2016, Huayu Zhou, and Zhihua Li [7] determined how the vehicle will occupy the parking spot. The presence of a car is detected using RFID sensors. The system must be able to alert drivers regarding a parking spot being occupied after a car has been recognized. The disadvantage of [7] is the parking spot will only be identified at close range; because there is no other sensor to search for parking slots from a far place.

In paper [8] Dharmini Kanteti presented a smart parking algorithm that includes the use of IoT devices for vehicle detection, software that works with OCR, Arduino as a microcontroller, and Raspberry Pi to interface all the parking spots using the algorithm. A CMOS sensor detects the license plate of a car, the data is matched to a database, and the user is allocated to the right parking place. The ultrasonic sensors are triggered, and the timer starts when the user reaches a designated rotary parking slot. When the user gets down, he should provide the details of the smart card, which will ensure that the user got down as well as assist him in exiting the parking lot. However, the disadvantage is if all the parking spots are full, the user will be unable to park the car after arriving at the parking lot. In addition, the amount of hardware employed in the presented proposal significantly raises the cost of installation.

The article focuses on improving vehicle detection transmission [9]. Authors propose IoT smart parking consists of three layers. First, the IoT parking layer includes the ESP32 module and camera. Second, the fog layer includes LoRa and Wi-Fi, and finally, the cloud layer includes the cloud server. The paper's proposed plan merely offers information about parking locations only. So, it does not include security elements if the car is taken. Furthermore, when it comes to scaling applications to the industrial level, IBM Watson is not very cost-effective.

Meenaloshini provides a smart parking model in paper [10] that used an IoT device to detect the car in a parking area by using IR sensors. The disadvantage is that if there are any other things other than the vehicle, for example, a person standing in the parking spot, they will be detected as occupied.

At [11] highlighted some of the advantages of using a vision-based system over a sensor-based coverage hundreds of parking spaces can be covered by a single captured image. Also, the cost compared to sensor-based systems, installation, and maintenance costs are lower. So, versatility; images obtained can be used for a variety of purposes, including surveillance. So, the most useful and efficient system for smart parking is based on embedded computer vision. So, the rest of this paper will focus on the vision-based smart parking system.

3 Vision-based parking system

Many researchers solving the smart parking system with artificial intelligence based on images using artificial vision. So, it's mandatory to avoid issues with using a vision-based system by using three approaches [11]. First, image quality must be good quality to be processed for object recognition tasks. Insufficient lighting at night and adverse weather conditions, such as rainy or foggy weather, have an impact on the quality. Second, Occlusions, which are the captured images, are sometimes obstructed by the surrounding objects, such as trees, buildings, and object shadows. Third, Classification problems based on image classification systems have proliferated over the years and are maturing.

Image-based can be further divided into two categories recognition-based and appearance-based [12]. Firstly, recognition-based, which employs an algorithm to detect objects of interest that are vehicles. Secondly, appearance-based (lot detection), which focuses on detecting empty parking spaces, the background subtraction algorithm is the most widely used algorithm. Moreover, there are algorithms also assisted by a series of vision algorithms divided into various approaches to machine vision. Thirdly, Image processing in three dimensions. Fourthly, the Combined technique uses a machine-learning algorithm, and image processing to improve image quality, avoid light variations, and classify image content. Finally, Monitoring techniques to determine the number of parking lots be processed; by estimating the occupancy of the entire parking lot and checking the vehicle's presence in each parking lot, are two types of monitoring that are available.

Also, Choeychuen [12] divided Machine vision-based systems that employ image processing techniques that may be divided into two categories: recognition and appearance. The recognition-based technique for parking space identification will identify automobiles in the parking lot by analyzing their features and categorizing them from the input picture region. This method is exact, but it might be difficult to implement since it requires numerous datasets to be trained under diverse settings to construct the model classifier. The appearance-based technique, on the other hand, determines unoccupied parking spots based on several appearance variables including histogram density of edge orientation from an adaptive backdrop model, masked area, or image removal. During training, this method uses fewer datasets.

At Amato et al. [13]. Deep learning is an artificial intelligence branch aimed at developing strategies that allow computers to master complicated human-level perceptual tasks such as seeing and hearing. Vehicle and pedestrian identification, picture classification, speech recognition, object detection, natural language processing, and other fields all have near-to-human-level accuracy. They also suggested that CNN "Convolution neural network", one of several deep learning algorithms, is an excellent solution for vision tasks. CNN is a convolutional layer that can more accurately describe and differentiate the spatial connection between nearby pixels than typical fully connected layers. The classes in which CNN was trained are the network's ultimate output. The training method for CNN is computationally costly and time-consuming. However, if the network has been trained, the prediction phase is speedy and accurate.

In [13], A CNN classifier-based smart parking system has been built. Two datasets, PKLot and CNRPark, are used, as well as a smart camera. The PKLot dataset is used to train and test the parking lot occupancy detection, whereas CNRPark is utilized at two distinct sites with different angles of view. The suggested system provides a distributed, effective, efficient, and scalable solution for real-time parking occupancy monitoring; because it employs deep CNN, the system is robust to disturbances like partial occlusions and has an excellent generalization characteristic. Also, it just combines Raspberry Pi modules with a smart camera, the classification step only requires a small amount of CPU power. A website is used to offer real-time access to all the cameras installed across the parking lots. After being tested in several places and under varying light circumstances, the experiment result indicates a very good accuracy even under partial occlusions. The test result also reveals that when it comes to predicting parking status across many datasets, CNN has high generalization skills. While, Bin et al. [14] proposed a smart parking system that uses real-time image processing and a camera as the sensor to find parking spaces. The system's structure is made up of image acquisition, image preprocessing, and image detection modules. Real-time pictures with a resolution of at least 640 x 480 pixels are collected during image acquisition. The preprocessing module subsequently computes the pictures. It processes them using the detection technique, such as turning the photos to grayscale. The detecting module is where the real-time decision to identify the state of a parking place is made.

Using an image processing technique and a brown-rounded image drawn at each parking lot, [15] proposed a parking space detection method. The first technique is the initialization module that automatically detects the location of each parking lot. Second, the image acquisition module captures and stores images from a video camera, so it's recommended to use a high-definition camera and avoid any obstacles such as shadows, trees, and buildings. Third, the image segmentation module uses image subtraction to separate the objects from the background, such as converting RGB images to grayscale and thresholding the binary image to differentiate pixel values. Fourth, the image enhancement module involves removing noise and pixels from unrelated objects using a binary morphological function. Finally, image detection modules are the five modules that make up the system.

Zacepins et al. [16] developed a smart parking system that combined video processing and analysis with real-time parking lot monitoring using a machine learning technique. The system's method was to analyze videos and stream them to the public. Decision tree, logistic regression, random forest, linear support vector machine, and radial-basis function support vector machine were among the five main classifier models used by the system. As a result, five classifier models for parking lot occupancy detection are compared. The results show that logistic regression performed better and made more accurate predictions. The classifier model for real-time parking monitoring was then decided to be logistic regression.

An algorithm for a smart parking-lot-management system was proposed in [17]. Starting with processing the image and extracting occupancy information of spots and positions, the algorithm can detect empty parking spaces from aerial images of parking lots. Individual parking spaces, whether occupied or not, are reported by the system. The system uses two approaches to detect cars in parking slots: filled-edge image and dilated-edge image approaches. The filled-edge image performed better in determining the parking spot's vacancy.

Di Mauro et al. used a real-world dataset containing videos from multiple parking spaces to maximize the use of parking spaces in urban areas [18]. They investigated the parking occupancy status of parking lots using two scenarios: stall-based occupancy estimation and stall-free occupancy information. In a stall-based scenario, it is assumed that parking stalls are numbered on the ground where the car is supposed to be parked, whereas in a stall-free scenario, no parking stalls are marked in the parking space. Then, semantic segmentation, and image classification are used to compare the stall-based and stall-free approaches. When the geometry is known, an image classification method is preferred, according to the results. Even so, if the configuration is unknown, an image segmentation method is the best option. The experiments also show that temporal smoothing is effective for improving object detection and image segmentation results, but not for image classification results.

Finally, Trivedi et al. [19] used the Hough transform to develop real-time parking management for a small module. The goal was to detect and identify the status of available parking spaces in real-time. Color enhancement, edge detection, and the Hough transform method are used to create two types of modules for car parking. The two oval modules of the car park are parallel parking with different radii and parking angles with the same radius.

Conclusion

An analysis of existing vision-based smart parking systems reveals that recognizing unoccupied parking spots or cars is dependent on the camera's picture quality. As a result, installing a high-quality camera capable of collecting great night photos and reducing error rates would be costly. However, as compared to sensor-based systems, vision-based systems have lower installation and maintenance costs. As a result, this method is highly recommended for future smart and efficient parking systems based on images applying artificial vision. It is critical to select a strategy and algorithm for a vision-based smart parking system to get the best and most efficient results. Many researchers have been more interested in applying Convolutional Neural Networks classifiers in recent years. CNN is popular because it is more adaptive and has a high generalization ability. The CNN module may be applied to various parking spots with various datasets. When compared to other approaches, LPQ and LBP have the lowest error rates. However, high-quality photos are required to achieve greater accuracy. Many photos are also required to train and test the datasets, reflecting that the time spent developing the classifier will be extended. In comparison, the CNN classifier has a larger error rate than LPQ and LBP [13], the system can suppress noise generated by shadows, light, and partial occlusions that other approaches cannot. As a result, CNN is more efficient for detecting parking slots. Bin et al. [14] shows the disadvantages of sensor-based smart parking systems, such as microwave detection, infrared detection, and ultrasonic detection, in comparison to sensor-based systems. One of them is that the system is not responsive to various climatic changes, limiting its application to indoor parking environments. Another problem is that the system would require

one sensor for each parking place, which would be costly to install and maintain in bigger parking lots. The biggest benefit of implementing a sensor-based system, however, is that the accuracy is really high, but this depends on the sensor selected. Increasing parking consumption and revenue for parking owners, reducing the need to build extra parking infrastructure by guiding drivers to inefficient spaces, lowering operations costs; and implementing a more effective payment process for users by replacing parking rangers with technologies such as automatic number plate recognition (ANPR). This paper analyzed the different vision-based smart parking system strategies for detecting free parking spots using a camera as the sensor. In conclusion, this paper suggests that vision-based smart parking systems outperform sensor-based smart parking systems. It will be the smart parking system of the future, with extremely high precision, reliability, and efficiency. The algorithm of a vision-based system is more adjustable; we don't need to replace the sensor if we want to modify it. This will enhance the accuracy with which parking spots are managed.

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