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Research paper

A machine learning technique for detecting outdoor parking

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Abstract

In recent years, it has been observed that it becomes time-consuming and cumbersome job to find a vacant parking lot, especially in urban areas. Thus, it makes difficult for potential visitors or customers to search a vacant space for parking their vehicles and keeps on revolving round the parking area which not only increases frustration level but also wastes time and energy. In order to get an optimal parking lot immediately, there is a requirement of an efficient car-park routing systems. Current systems detecting vacant parking lots are either based on very expensive sensor based technology; or based on video based technologies which do not consider various weather conditions like sunny, cloudy and rainy weather. In the proposed work, a hybrid model is designed for detecting outdoor parking which detects the empty spaces available in the parking lots and the spaces/ slots getting vacant in the real-time scenario. This model is based on training, validating and testing the images (dataset) collected from various heights and angles of different parking areas stored in the repository. In this research, more advanced feature extractors and machine learning algorithms are evaluated in order to find the vacant parking lots in the outdoor park-ing areas.

Keywords: *Parking Management System; Video Analytics; Image Processing; Feature Extraction; Machine Learning; Hybrid Model.*

1. Introduction

This era has witnessed a rapid augmentation in the vehicle ownership with the advancement of highway and mechanization. The densely populated areas in various towns and cities are undergoing some major problems due to lack of parking spaces resulting in lack of convenient services for the vehicle users during their driving trips. Therefore the significant problems confronted are rise in traffic congestion, difficulty in searching parking spaces, longer travel lines which is highly degrading the quality of life and also lowering the levels of accessibility. Considering all these aspects, the urgent need of promoting intelligent parking management system as shown in Fig.1 [1] has arisen.



Fig. 1: Image of Outdoor Parking Lot.

1.1. Parking management system

At present, it is noticed that there is no systematic system for the existing car parks. These car parks are quite inefficient and manually managed. Most of the time people are confronted with the difficulty in getting a suitable parking space on which vehicle users wasted a lot of their time. The problem of non availability is mostly seen in the urban areas where the number of vehicles is higher. The biggest reason for these unproductive circumstances happens to be the lack of implementing new technologies. The objective of this work is to devise a parking system with the help of image processing techniques rather than using sensor base. To abate the cost of sensor and hassle of wiring, an integrated image processing approach should be developed for an intelligent parking system. Owing to the rapid industrialization, rise in population, slow advancements in urban areas and mismanaged parking facilities, a lot of obstacles related to the parking are emerging day by day. There is an urgent requirement for a safe, resourceful, efficacious and a convincing system which can be helpful for searching a vacant parking facility along with its proper guidance and management.

It is really strenuous to find an empty space in parking lots of big metropolitan areas which makes this task more challenging. It takes lots of time and money to find the vacant parking lots. Moreover, it makes a considerable contribution in polluting the environment with CO_2 emissions. Image based systems are surveyed on a large scale and proved to be a good solution for large and outdoor parking lots for reducing the cost of installation of thousands of sensors.

2. Literature review

Paulo et.al [1] introduces and provides a new parking lot dataset consists of 695,899 images. These images were captured from two parking lots from three different camera views. The main focus of capturing these existing images were to collect a large amount of repository of images under different climatic conditions like sunny, rainy and overcast periods. The main advantage and application of providing such a huge collection of images is the ability to evalu-

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ate different classification techniques. It is otherwise very challenging in the present real time scenario. The main challenges are the presence of shadows, over-exposition to sunlight, low light in rainy days, difference in perspective, and so on.

Kharusi et.al [2], proposes an intelligent parking space detection system based on image processing technique in which images were captured and processed to provide the information of the empty car parking spaces. This information is used by the drivers to find the available parking lots.

Qing Tian et.al [3] introduces the intelligent parking management system based on LPR (License plate recognition). LPR provides the right vehicle information, LP Number, LP Color, car type and access time of vehicle .Video streaming frame by frame of the vehicle has been designed to get the best information with high speed. The information stored in the database is user friendly and helped administrators to operate easily and accurately. The LPR model helped in achieving the high success rate of 95 % almost when applied to real time implementation.

R. Yusnita et.al [4] designs an intelligent parking space detection system based on the Image processing technique. The concept of this analysis has been using of image processing technique rather than using sensor based technology. This approach of using integrated image processing has been far better in implementation and cost wise as comparing the sensor based one as wiring hassles and cost of sensor is not is involved.

Rizwan et.al [5] proposes a framework for parking based on video analytics. It is used for human activity recognition and user interaction through smartphone application. It is implemented using Machine learning algorithms. Algorithms are deployed for processing the parking lot video to extract meanings form human activities whereas mobile phone application was used to communicate with the user. To mark incoming and leaving vehicles, Image registration algorithm is used which keeps track of available parking bins. Real world video dataset VIRAT (1.0) is used for training and testing the activity identification algorithm.

Vanessa et.al [6], proposes an efficient car parking system based on WSN (wireless network sensor) for. This has been executed by deploying sensor to the car park field and each parking lot has been equipped with the sensor node. The node detects and monitors the occupancy of parking lots. The sensor node sends the latest status of parking lot and further sends the detail to the deployed sensor network and its gateway. The detail is accessed by the people managing the complete parking system. They are helped in accessing the information regarding vacant parking lots, security and statistical data. The system has been implemented using CROSS BOW MOTES.

Catherine Wah [7] presents an approach to identify vacant spaces in parking lots captured under extreme vehicular occlusion. She presented a technique using a stereo camera system for monitoring vacancies in parking lots to create a 3D reconstruction of the scene.

Carlos Gálvez et.al [8] proposes a technique for approximation the dimensions of non-delimited free parking areas. For this, static surveillance camera is used. This work is essentially based on the temporal analysis of the video frames to detect the occupancy variation of the parking areas. Two techniques are mutually joint: background subtraction and Transience map.

Diana Delibaltov et.al [9] proposes an efficient image processing method for occupancy detection of marked parking lot from lamp-post camera views.

Gupta [10] intends to have the detailed massive information analytic applications and its shortfalls. Further it tried to explore the different arenas that would get pleasure from the massive knowledge of application with respect to real time.

Jing Li et. al [13] develops the real time video copy detection system using HADOOP platform. Two copy detection system algorithm were introduced based on Brightness Sequence firstly & TIRI-DCT secondly. The two results were compared and was concluded that HADOOP platform improved the significant efficiency of the video copy detection. It played the significant role in video tracking and retrieving the data on real time basis.

Banaei, et.al [14] introduces HADOOP framework, a distributed data processing model for the big volume of data. The large volume data has been in the cases of MULTIMEDIA process. It catered the requirements for processing of large data storage. With HADOOP large images have been process by defining infinite set of computing nodes with required infrastructure. All this has been taken care of in this paper.

Natarajan et.al [15] proposes a real-time traffic analytics system. Road accidents can be automatically detected from live video streams. Nearby hospitals and highway rescue teams will be alerted by this system when accidents occur. It also provides detection of road congestion and automatically broadcasts alternative route information. Apache Hadoop is used to implement this system and analysis results are stored in Hive.

Parida et.al [21] combines statistical assumptions with the identification of moving objects acquired in the processing of the frames. For background subtraction, the proposed approach extracts gray color information to improve object segmentation. An AVI file is used and it is decomposed into R, G and B components. After that it detects the moving objects. Matlab is used for its implementation.

Jamkhandikar et.al [24] presents a framework for efficient detection and tracking of an object in real time using color feature. In order to analyze the motion of object is chaotic or not, a tracking algorithm is developed. Several stages are used for automatic tracking of object. These are image capturing, image processing, time series extraction and analysis. Euclidian filter is proposed since it has the advantages of being used in dynamic images. The color image is converted into gray, because gray images requires less time in processing.

2.1. Research gap

A brief summary is given below to clearly depict the research gap in various researchers' work done on designing PMS.

Table 1: Comparison of Various Parking Management System (PMS)

Author & Year	Paper Title	Journal / Conference	Description	Methods Used	Gap/Limitations
Paulo et.al [1], 2015	PKLot – A robust dataset for parking lot classification	Expert Systems with Applications, www.elsevier.com/locate/eswa	Introduced a new parking lot dataset composed of 695,899 images captured from two parking lots with three different camera views	Texture-based descriptors for classification of Parking spaces.	The best result achieved by the texture-based classifier was about 89%.
Rizwan et.al [7], 2015	Video Analytics Framework for Automated Parking	Technical Journal, University of Engineering and Technology (UET) Taxila	Proposes secure parking framework	Machine learning algorithms and support vector machine classification	-Claim: Accuracy rate 73 -91 %.
Carlos Gálvez et.al [35], 2015	Vacant parking area estimation through background subtraction and transience	The Institution of Engineering and Technology (IET) Journals	Propose a method for estimating the dimensions of non-delimited free parking areas	background subtraction and a transience map	-Limitations under poor illumination conditions, especially at night

Al-Kharusi et.al [2], 2014	map analysis Intelligent Parking Management System Based on Image Processing	World Journal of Engineering and Technology	Proposes an intelligent system for parking space detection	Image processing techniques	-Limitations in different weather conditions like rainy, cloudy and sunny weather
Diana Delibaltov et.al [36], 2013	Parking Lot Occupancy Determination from Lamp Post Camera Images	16th International IEEE Conference on Intelligent Transportation Systems	Propose a image processing method for marked parking lot occupancy detection from lamp-post camera views	segmentation algorithm and vehicle volume modeling and probabilistic summation	-Claim-accuracy is close to 80%
Yusnita et.al [4]. 2012	Intelligent Parking Space Detection System Based on Image Processing	International Journal of Innovation, Management and Technology	present an intelligent system for parking space detection based on image processing technique	integrated image processing approach	-various weather conditions are not considered.
Qing Tian et.al [3], 2014	Design of Intelligent Parking Management System Based on License Plate Recognition	Journal of Multimedia	Presents an intelligent parking management system	LPR (License Plate Recognition) through video streaming	-No analysis, Only vehicle information, such as LP number, LP color, car type stored in system database -Claim: can achieve high correct rate at 95%
Catherine Wah [34], 2015	An Implementation of Vacant Parking Space Detection System	International Journal of Advance Engineering and Research Development	Presents a technique for identifying vacant spaces in parking lots	Video-based parking space detection system.	- challenging to detect parking space in an indoor parking area. -The system performance can be further improved in night time.
Tang et.al [8], 2006	An Intelligent Car Park Management System based on Wireless Sensor Networks	1st International Symposium on Pervasive Computing and Applications	Presents WSN-based Intelligent car parking system. Wireless sensor nodes are deployed to the parking lots to monitor and detect the occupation status of the parking lots	Wireless sensor networks (WSN), prototype of the system using the crossbow motes products and the extended Crossbow XMesh networks architecture	- Expensive to deploy wireless sensor network and its gateway

Some authors have proposed and presented Parking Management system (PMS) based on wireless sensor networks which is expensive to deploy. Some other's research work presented image processing and machine learning techniques to detect outdoor parking lot availability but they have the following limitations/Challenges: Limitations under various weather conditions like rainy, cloudy, foggy and sunny weather as shown in Fig 2. [1].



Fig. 2: Parking Lot in Various Weather Conditions (A) Sunny, (B) Rainy and (C) Foggy

Limitations under poor illumination conditions, especially at night as shown in Fig. 3. [1].



Fig. 3: Parking Lot in Dim Light I.E. Night.

Accuracy range claimed by authors using various techniques is approximately 80-95%.
To overcome the limitations under various weather conditions like sunny, rainy and cloudy, a framework for Parking lot detection using hybrid model is proposed. Now a days, locating and detecting vacant parking area needs high attention. So it is desired to work in this field which gives rise to a new research topic.

3. Methodology

The primary objective of the proposed research is to design an optimized Parking Management System based on advance video processing techniques which will be helpful to allocate vehicles with the available outdoor parking slot number at entry point. People need not to get frustrated in finding the vacant parking area by circling round and round the parking lots. It also eliminates the need of human assistant guiding people where to park. The proposed system mainly consists of two phases: Training and Testing Phase as shown in Fig 4:

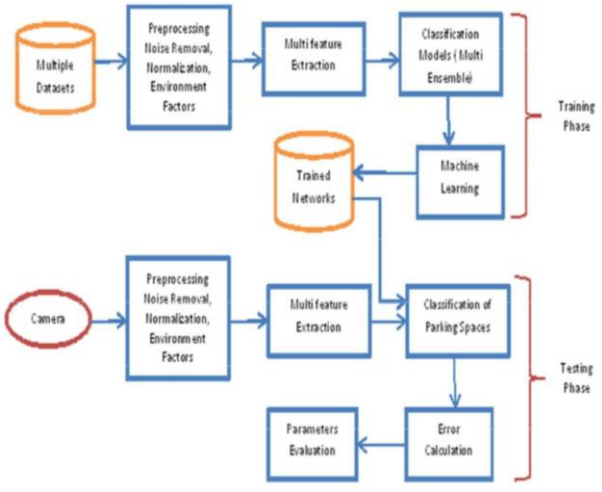


Fig. 4: Proposed Design of Optimized Framework for Outdoor Parking Lot Detection Using Hybrid Ensemble Model.

3.1. Training phase

Multiple Datasets: The first step in the training consists of acquiring multiple images of parking lots using high resolution cameras at various places from different angles and under various weather conditions like sunny, rainy and cloudy. Thus collecting standard dataset of parking lots.
Image preprocessing: Next, Image preprocessing techniques like noise removal, shadow removal, segmentation and normalization will be applied by considering various environment factors. Multi Feature Extraction: After image preprocessing, multiple feature extractors based on color and texture will be applied.
Classification models: Once the Region of Interest has been segmented, next step is to implement and evaluate various existing classification techniques like SVM and neural networks.
Machine learning model: The last step in training phase is to build a hybrid model for machine learning/pattern recognition based techniques.
Finally, the trained networks will be stored and tested in testing phase for detection of vacant parking lots.

3.2. Testing phase

Collecting multiple videos and creating database of the parking lots: The first step in the testing phase consists of collecting and capturing videos of various parking lots from various angles and under different weather conditions. Thus collecting testing database of the parking lots.
Image preprocessing: Once database has been created, next step is to convert frames from Video sequences of parking lots and apply various image preprocessing techniques like noise removal, shadow removal, segmentation and normalization of the images captured in various environmental factors like sunny, rainy and cloudy.
Multi Feature Extraction: After image preprocessing, multiple feature extractors based on color and texture will be applied.
Classification of parking spaces: Using trained networks stored in the training phase, a hybrid model for machine learning will be used for detecting and classifying vacant lots in the parking area.
Error Calculation: Once the system is trained and tested, the difference between the actual and desired output i.e. error will be calculated.
Parameters Evaluation: Based on the error calculated, parameters will be evaluated and adjusted to minimize the errors. This process is called learning.

4. Results

The proposed system is implemented in MATLAB R2016b. Various datasets for parking lots including categories like cloudy, rainy, sunny are studied. As shown in Fig 5 (a) and 5 (b), empty patches and occupied patches dataset for all climate conditions are separated. Various preprocessing tasks like histogram equalization to normalize light conditions due to various impacts like cloudy and sunny climate are performed. Features for dataset like mean, max variance for both RGB and HSV color space are extracted. Finally, as shown in Fig 5 (c) through 5 (h), Scaled conjugate gradient back propagation Neural Network training and testing is implemented over the dataset and various parameters like, confusion matrix, accuracy and ROC plots are checked.

5. Conclusion

The proposed system is expected to provide us with an efficient Parking System which would automate outdoor Parking Management System using hybrid model of existing video processing techniques. Automated Parking Management System would save driver's time to find the vacant parking lots automatically. The proposed work is expected to work satisfactorily with excellent accuracy rates under various weather conditions like sunny, rainy and cloudy.

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