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Intelligent Parking Management System (PMS) based on Video Analytics

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Abstract—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 has arisen. In this paper, various existing Parking Management System (PMS) are reviewed and compared and an intelligent PMS based on Video Analytics is proposed.

Keywords— PMS, Video Analytics, Image Processing, Multi-camera, camera calibration.

I. INTRODUCTION

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 as shown in Fig 1, which can be helpful for searching a vacant parking facility along with its proper guidance and management.

Fig: Intelligent Parking Management System

A. Video Analytics

Video analytics refers to the efficiency of automatically analysing video to find out the temporal and spatial events. This covers a number of spheres such as health care, retail, entertainment, automotive transport, smoke detection, safety & security. It is a recent technology need in various domains. It is used in CCTV system either distributed in the cameras (at the edge) or centralized on dedicated processing systems. Other functionalities such as identification, behavioural analysis or other forms of situation awareness can be built based on the internal representation that VA generates in the

machine. Video analytics is a part of computer vision and subsequently of artificially intelligence. Computer vision belongs to the inter disciplined category which reveals the way through which computers can gain access to high level understanding from digital images and videos. It also includes various tasks such as acquiring, processing, analyzing and understanding digital images. In order to produce numerical or symbolic information in the forms of decisions, it extracts the high dimensional data from the real world. Therefore computer vision deals with the theory behind artificial systems that extracts information from images. The image data can acquire various shapes such as video sequences, views from multiple cameras, or multi-dimensional data from media scanner.

Video analytics is defined as computer vision based surveillance algorithms and systems to extract contextual information from video. It primarily aims at aiding human operators for observing video data. It helps in facilitating online and post-event detection of events of interest. This can prove to be highly beneficial for traffic management due to availability of additional data. Video analytics makes the things more feasible for systems and people by lessening the huge amount of information subsumed in video. Video analytics surveillance systems analyse the captured video and by tagging it with appropriate labels which makes the resulting data more productive. It also helps in decreasing the work load of the staff to a great extent by assimilating video analytics into network cameras and thus creating a versatile video surveillance system. Through video analytics also an operator can use the surveillance system ardently, receiving early warnings about situations that could constitute potential risks. Video analytics can be beneficial for business intelligence purposes, for example, to determine the behaviour of customers and enhance customer experience.

Applications performing these analyses are referred to as Video Content Analysis (VCA) or more commonly Video Analytics (VA). They range from video motion detection and audio detection to more advanced systems, including camera tampering detection, people counting etc. Video analytics propounds a number of advantages, such as efficacious use of staff, decreased costs for storage and servers, and rapid access to stored video. Video analytics also serves in delivering a more targeted and specified information which helps in enhancing the business value.

B. Multi-camera video analytics

Since the view of a single camera is finite and limited by scene structures. In order to monitor a wide parking area, video streams from multiple cameras have to be used. In this regard, various challenges faced in multi-camera environment needs to be addressed thoroughly.

1) The major challenge of a multi-camera video analytical system is how to associate the targets (parked vehicles) detected in different individual cameras.
2) The second problem is that the precision of the pairs of matching points is usually unknown. The precision of a point measures the sensitivity of the accuracy of the map matching location with respect to the accuracy of the view location. For example, at one location in the camera image plane, one pixel movement away from that location may cause 100 pixels of movement away from its original corresponding location on the map. This means the precision of this pair of matching points is low. When we calibrate the camera view onto the map, we minimize the distance between these pairs of matching points. Assigning higher weight to points with higher precision improves calibration performance.

Some key computer vision technologies used in multi-camera video analytical system:

1) Multi-camera calibration will map different camera views to a single coordinate system. It is a key pre-step for multi-camera based analysis.
2) The topology of a camera network will identify whether camera views are overlapped or spatially adjacent and describes the transition time of objects between camera views.
3) Object identification is to match two image regions observed in different camera views and recognize whether they belong to the same object or not.

II. LITERATURE REVIEW

Liu et.al [1] provides and discusses the theory and application of intelligent video systems and analytics. The video system architectures, analytic methods and tasks have been highlighted. The importance of the role that intelligent video systems and analytics play is clearly illustrated. Various applications of intelligent video system can be found in a variety of domains such as transportation and surveillance. Research directions are also discussed and outlined in order to know what is important to achieve the goals of intelligent video systems and analytics.

Kharusi et.al [2], propose an intelligent system for parking space detection based on image processing technique. The proposed system captures and processes the images of parking lot and produces the information of the empty car parking spaces. Then the processed information is used by the driver to find an available car park.

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. A rounded brown image at each parking lot is identified as a reference on image detection. The process of detecting image has been used as a reference to make it efficient enough as compared to the use of a moving object. 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.

Faheem et.al [5] laid out the overall concepts of different intelligent parking services in this philosophy. The economic viability of the various parking methods have been outlined in this research. Different problems arising out of the current existing parking methods have been discussed. The problems arising are the non-availability of reliable, moderns and efficient parking system. Further the problems have been sorted out by exercising different modern techniques such as Expert Systems, wireless sensor based, fuzzy based, GPS based, the parking related problems can be reduced by using Vehicular communication details and Vision based details.

Aalsalem et.al [6] establishes a simple and smart vehicle parking monitoring system called CAMPUSSENSE. The CampusSense was designed for JAZAN UNIVERSITY, where the total staff, faculty members and students were facing problems in the available university car parking slots. The proposed system design included automation of existing manual parking system with efficient and effective use of parking slots. This significantly reduced the frustration of the car parking by all the members in the available car parking slots of the university.

Rizwan et.al [7] proposes a secure parking framework based on video analytics for human activity recognition and user interaction through smartphone application. Machine learning algorithms for human activity recognition using smart camera were used. Algorithms were used to process the parking lot video to extract meanings form human activities while mobile phone application was used to communicate with the user. Image registration algorithm marked incoming and leaving vehicles to keep track of available parking bins. Activities happening in the parking area e.g. human-vehicle interaction, human-human interaction, parking, entering and exiting the parking lot were recognized using support vector machine classification on space time features representation of the scene. In order to train and test the activity identification algorithm real world video dataset VIRAT (1.0) were used. Video analytics algorithms were embedded into smart camera hardware. Video backup was maintained at backend surveillance server.

Vanessa et.al [8], 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.

Gupta [9] 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.

Zheng Xu et.al [10] discusses the architecture for next generation public security system. Both front and backend patterns were taken into consideration to address the problems by the redundant construction of current security information system. Considering the various options of resource consolidation of different IT resources, it provided single computing and storage environment for complex data applications for example data mining etc. Under this strategy the proper utilization of resources and efficiency in tasks was achieved through computing of data storage, retrieval from heterogeneous data.

Jamkhandikar et.al [11] 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.

Prasad et.al [12] proposes a technique for identifying a moving object in a video clip of stationary background for real time content based multimedia communication systems. An object of interest is identified. Both background elimination and background registration techniques are used to identify dynamic objects. Post processing techniques are applied to reduce the noise. Method of least squares is used for the background elimination to compare the accuracies of the current algorithm with the already existing algorithms. The background registration method uses background subtraction. It improves the adaptive background mixture model and makes the system learn faster and more accurately. It also adapt effectively to changing environments.

Catherine Wah [13] presents a technique for identifying vacant spaces in parking lots under severe vehicular occlusion. She presented a method for monitoring vacancies in parking lots using a stereo camera system to create a 3D reconstruction of the scene, which enables to determine the vacancy status of a particular parking space under vehicular occlusion.

Carlos Gálvez et.al [14] proposes a method for estimating the dimensions of non-delimited free parking areas by using a static surveillance camera. The core of this work is the temporal analysis of the video frames to detect the occupancy variation of the parking areas. Two techniques are combined: background subtraction using a mixture of Gaussians to detect and track vehicles and the creation of a transience map to detect the parking and leaving of vehicles.

Diana Delibaltov et.al [15] proposes a novel image processing method for marked parking lot occupancy detection from lamp-post camera views. The primary contributions of this work are (i) a semi-manual method to determine the layout of a parking lot using user marker lines, and infer the three dimensional arrangement, (ii) a segmentation algorithm to perform vehicle/background discrimination, and (iii) an occupancy determination algorithm using vehicle volume modeling and probabilistic summation.

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	DESCRIPTION	METHODS USED	GAP/LIMITATIONS
Tang et.al [8]	Presents intelligent car parking system	Wireless sensor networks (WSN)	Expensive to deploy wireless sensor network and its gateway
Qing Tian et.al [3]	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
Al-Kharusi et.al [2]	Proposes an intelligent system for parking space detection	Image processing techniques	-Single camera is used -Limitations in different weather conditions like rainy, cloudy and sunny weather
Rizwan et.al [7]	Proposes secure parking framework	Machine learning algorithms and support vector machine classification	-Single camera is used -Claim: Accuracy rate 73 -91 %.
Carlos Gálvez et.al [14]	Propose a method for estimating the dimensions of non-delimited free parking areas	background subtraction and a transience map	-Single camera is used -Results were satisfactory, with FN rates below 27% and a maximum of 2 FP (on parking and leaving detection) -Limitations under poor illumination conditions, especially at night
Diana Delibaltov et.al [15]	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	-Single lamp post camera views -Claim-accuracy is close to 80%
Catherine Wah [13]	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.

III. METHODOLOGY

Finding a vacant parking lot, especially in urban areas, is time-consuming and, thus, not satisfying for potential visitors or customers. Efficient car-park routing systems could support drivers to get an optimal parking lot immediately. The primary objective of this research work is to design a real-time optimized Parking Management System based on video analytics in multi-camera environment, which will be helpful to allocate vehicles with the available 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 lot. It also eliminates the need of human assistant guiding people where to park.

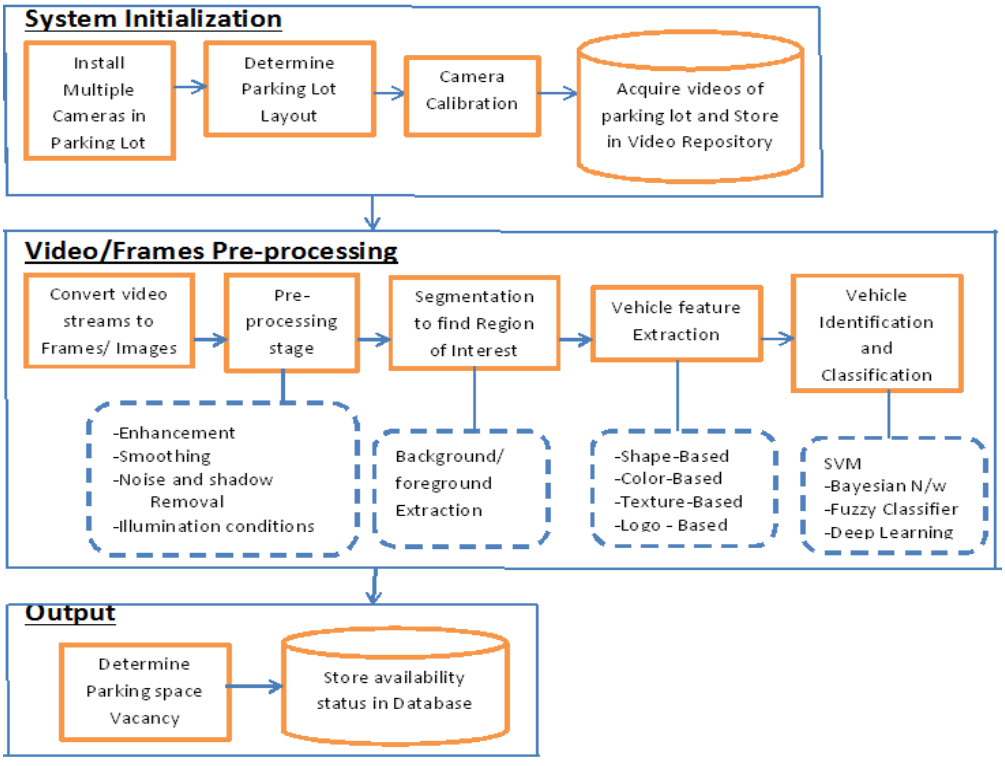

Fig.2: Proposed Design of Parking Management System (PMS) using multi-camera based Real-Time Video Analytics

The proposed system mainly consists of three components as shown in Fig 2:

A. System Initialization

1) The first step consists of installing multiple high resolution cameras at various places at appropriate angles in the parking area.
2) Determine the initial layout of the parking lot: In order to determine the number of vacancies in a parking lot (i.e. how many spaces are available and, more importantly, where they are), it is required to have knowledge about the layout of the parking lot being monitored. So the next step is to detect the marks (lines) of parking space directly from the images of the empty parking lot.
3) Camera Calibration: Camera calibration is the process of estimating intrinsic and/or extrinsic parameters. Intrinsic parameters deal with the camera's internal characteristics, such as, its focal length, skew, distortion, and image center. Extrinsic parameters describe its position and orientation in the world. Knowing intrinsic parameters is an essential step for 3D computer vision, as it allows to estimate the scene's structure in Euclidean space and removes lens distortion.
4) Videos will be acquired and recorded from multiple cameras and captured videos will be stored in the video repository.

B. Video/Frame Pre-processing

1) Video sequences from video repository will be converted into video frames/images and sent to image processing framework.
2) Image processing framework consists of 4 major stages: pre-processing, segmentation, feature extraction and classification which include many existing techniques such as feature extractors (based on color, texture, shape, logo, etc). and machine learning algorithms (Deep learning, SVM, Bayesian Network, Fuzzy classifier, etc). Images will be converted to suitable format i.e. Gray scale, HSV or any other suitable format depending upon the properties extracted.

C. Output

1) The final step is to determine parking space vacancy. Once, video frames are processed and objects (vehicles in this case) are identified and classified in the parking lot, the vacant space cane be detected in parking lot.
2) The final status of parking lot will be stored in the database for User Interface module.

IV. CONCLUSIONS AND FUTURE WORK

In this paper, an intelligent parking management system (PMS) is proposed which is not only limited to handling and processing of video data captured from multiple cameras at wide area parking lot but also involve the analytics of real-time video data (like details of vehicle parked in the parking lot such as number plate recognition, entry and exit time, duration and slot number of parking, type of vehicle, etc) for efficient PMS and decision making. The system can be further enhanced for video surveillance and security purpose to identify any type of unusual event detection. The system can be further improved to detect parking vacancy at unstructured parking areas (outdoor parking).

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