Vehicle Surveillance and Recognition Technologies

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ABSTRACT

[6] This paper proposes a licence plate recognition (LPR) algorithm in complex environments using a novel shadow removal technique and character recognition algorithms. The algorithm includes improved techniques for image tilt correction and grey enhancement and uses support vector machine (SVM) integration for character recognition. In SVM integration, character features are extracted from the elastic mesh, and the entire address character string is taken as the object of study instead of a single character. The algorithm is robust to variations in illumination, view angle, position, size, and colour of licence plates. The algorithm was tested with 9026 images and achieved a success rate of 93.54% for LPR in various complex conditions, with adequately located and segmented licence plates and high performance for numerals, Kana, and address recognition.

This paper proposes a solution for vehicle licence plate recognition (LPR) that can be adjusted for different applications such as access control (AC), law enforcement (LE), and road patrol (RP). The solution consists of three modules for plate detection, character segmentation, and recognition. Edge clustering for plate detection and MSER detector for character segmentation is used. The proposed bilayer classifier with an additional null class is proven to be better than previous methods for character recognition.

[29] This paper compares the effectiveness of two feature extraction methods, the Gabor wavelet transforms and Pyramid Histogram of Oriented Gradients (PHOG), for vehicle-type recognition based on images. A classification scheme is proposed using cascade classifier ensembles with a reject option to handle ambiguous samples. The ensembles consist of several classifiers, including k-nearest neighbours (kNNs), multiple-layer perceptrons (MLPs), support vector machines (SVMs), and random forest. A second ensemble composed of base MLPs coordinated by an ensemble meta-learning method called rotation forest (RF) is used to enhance classification reliability. The proposed approach is demonstrated to be effective using over 600 images from 21 makes of cars and vans with a 98.65% accuracy rate and a 2.5% rejection rate, showing promising potential for real-world applications.

Fig 1: Monitor traffic violations with video analytics
[www.briefcam.com]

This paper presents a stochastic multiclass vehicle classification system based on the rear-side view of the vehicle. The system classifies a vehicle into one of four classes using a feature set of tail light and vehicle dimensions, which is processed by a hybrid dynamic Bayesian network. The system is tested on a database of 169 videos and achieves high classification accuracy.

The paper presents a vehicle detection technique for intelligent traffic surveillance systems. The system uses Haar-like features, a machine learning-based method, for detecting cars in real-time CCTV footage. The technique is effective and fast in detecting cars and can help in avoiding collisions between them.

[19] The paper describes a system that uses RFID technology to locate missing entities, such as people with Alzheimer's, by utilising the extensive networks of parked vehicles in urban areas. RFID readers and antennas are placed in parked vehicles, while RFID passive tags are carried by the missing person. If an entity is reported missing, the system is activated, and parked vehicles attempt to locate the missing entity, sending useful information back to the administration centre. The system is tested using a microscopic traffic simulation package. It shows promising results, detecting a wandering person in need up to 98% of the time within a 30-minute time frame in the heart of Dublin city centre.

TRACKER Network (UK) Ltd has obtained the agreement of all 51 Police Forces in Great Britain to use their stolen vehicle tracking and recovery system. The system is based on a small transponder fitted to vehicles, and when a stolen vehicle equipped with a TRACKER unit is reported, a central computer transmits a signal to activate its tracking signal. Police officers in patrol cars fitted with tracking computers can detect the signal and recover the stolen vehicle during normal patrol activities. The system has been granted type approval for all its components and has secured a dedicated radio frequency and a nationwide transmission agreement.

The article discusses the potential benefits of using automated visual surveillance, which involves using surveillance cameras to detect events in real time and take appropriate action. The framework of a video surveillance system includes modelling environments, motion detection, object classification, tracking, behaviour understanding, and fusion of information from multiple cameras. Despite recent progress in computer vision, there are still major technical challenges to be overcome before reliable automated video surveillance can be achieved. The paper analyses the feasibility and challenges of combining motion analysis, behaviour analysis, and biometrics to identify known suspects, anomaly detection, and understanding behaviour.

[1] This paper discusses the concern of the theft of parked cars in parking lots and the use of CCTV cameras for detection. However, non-automated human monitoring can lead to errors or lapses. The paper presents an automated way of detecting vehicle theft using the Canny Edge Detection [13] method to detect movement and notify security personnel or parking lot operators. The method proves to be efficient and useful.

The paper discusses the importance of tracking vehicles on the road and identifies the use of Automatic License Plate Recognition (ALPR) as a solution. ALPR can be used to extract the contents of the number plate from CCTV camera images using MATLAB image processing tools. The paper proposes the use of Adaptive Histogram Equalization (AHE), Active Contour Method, Optical Character Recognition (OCR), and Deep Neural Networks (DNN) for accurate identification of licence plate numbers. The DNN is used for classification and extracting alphanumeric characters to compare with a predefined table in an MYSQL server to change the status accordingly. This system can be used for surveillance in toll operations and gated communities

The article describes a new approach for detecting and searching vehicles in crowded surveillance scenes, using large-scale indexing and feature selection. The method can detect multiple vehicle types and handle occlusions, with minimal manual labelling. Fine-grained attributes are extracted and stored in a database for future searches. The approach is shown to be effective in realistic urban surveillance settings and runs efficiently on a laptop computer.

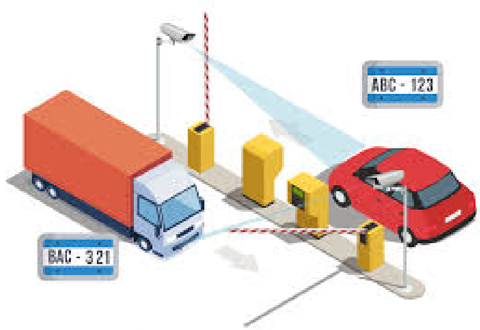

Fig 2: Automatic Number Plate Recognition (ANPR) with barrier gate
[www.vdttechnology.com]

[7] This article discusses the importance of situational awareness in security and the challenges of achieving it across multiple scales of space and time. Smart video surveillance systems have the potential to enhance situational awareness, but the component technologies are currently evolving in isolation. To achieve comprehensive situational awareness, multiscale, spatiotemporal tracking is necessary, which can be achieved through real-time video analysis, active cameras, multiple object models, and long-term pattern analysis.
The article discusses the potential benefits of using automated visual surveillance, which involves using surveillance cameras to detect events in real time and take appropriate action. The framework of a video surveillance system includes modelling environments, motion detection, object classification, tracking, behaviour understanding, and fusion of information from multiple cameras. Despite recent progress in computer vision, there are still major technical challenges to be overcome before reliable automated video surveillance can be achieved. The paper analyses the feasibility and challenges of combining motion analysis, behaviour analysis, and biometrics to identify known suspects, anomaly detection, and understanding behaviour.
Existing methods for vehicle re-identification mainly focus on generic appearance, neglecting unique identities. According to "PROVID", a deep-learning-based approach to PROgressive Vehicle re-identification, vehicle re-id is treated as two specific progressive search processes: coarse-to-fine search and near-to-distant search. The first search process filters a vehicle's appearance attributes and then exploits the Siamese Neural Network for licence plate verification. The latter retrieves vehicles in a human-like manner, by searching from near to far away cameras and from close to distant times. Data for the research has been collected from VeRi-776, the largest dataset of vehicles with diverse attributes and high recurrence rates. It also has sufficient licence plates and spatiotemporal labels. A comprehensive evaluation of the VeRi-776 shows that this approach outperforms the state-of-the-art methods by 9.28 % improvements in mAP and 10.94% in HIT@1.

This paper proposes a vision-based vehicle detection and counting system. A new high-definition highway vehicle dataset with a total of 57,290 annotated instances in 11,129 images is published in this study. Compared with the existing public datasets, the proposed dataset contains annotated tiny objects in the image, which provides the complete data foundation for vehicle detection based on deep learning. In the proposed vehicle detection and counting system, the highway road surface in the image is first extracted and divided into a remote area and a proximal area by a newly proposed segmentation method.
Then, the above two areas are placed into the YOLOv3 network to detect the type and location of the vehicle. Finally, the vehicle trajectories are obtained by the ORB algorithm, which can be used to judge the driving direction of the vehicle and obtain the number of different vehicles. Several highway surveillance videos based on different scenes are used to verify the proposed methods. This method can provide higher detection accuracy, especially for the detection of small vehicle objects.

The use of CCTV cameras for monitoring population movements and preventing crime has become popular worldwide, and their effectiveness is being studied. In Gaborone, Botswana, CCTV cameras were installed in 2018, and their geographic placement was assessed in light of the Situational Crime Prevention theory. In Batangas City, a study was conducted to determine the effectiveness of CCTV cameras in preventing crimes against persons and property, and it was found that CCTV cameras were highly effective in recording scenes and identifying suspicious characters. The article also discusses the importance of security systems based on video motion detection, which provides volumetric and perimeter protection but has a high false alarm rate. We describe an optoelectronic information processing system that is capable of real-time vehicle navigation and target acquisition. The system uses a holographic database, based on the DuPont HRF-150 photopolymer, to perform the desired tasks. The architecture and the performance of the system are discussed in detail.

[13] Anomaly detection is an important part of an Intelligent Transportation System, and this study uses image processing and machine learning techniques to detect anomalies in vehicle movements. Images are captured using CCTV cameras from the front and rear sides of the vehicle, and multiple consecutive frames are acquired for motion detection. Features such as edges and licence plate corner locations are extracted for

tracking purposes, and the direction of the traffic flow is obtained from a trained classifier model. The proposed method is evaluated on a public highway and promising detection results are achieved.

Car make and model recognition (CMMR) is an important part of intelligent transport systems and can be used when licencing plate numbers cannot be identified or fake number plates are used. However, existing CMMR methods are designed to be used only in the daytime when most car features can be easily seen. This paper presents a one-class classifier ensemble designed to identify car make and model at night by using available rear-view features. The majority vote from the support vector machine, decision tree, and k-nearest neighbours is applied to verify a target model in the classification process. The experiments on 421 car make and models captured under limited lighting conditions at night show the classification accuracy rate at about 93%.

This system uses video surveillance as it comes as the most economical technique for monitoring road traffic. The problems in existing methods are occlusions and variable light conditions.

Also, recent research on Indian roads proved that current image processing systems show a 55% median error in vehicle count. The proposed system looks into both day and nighttime conditions to monitor traffic. Also, it provides vehicle classification, traffic density,

vehicle count, licence plate detection and Incident detection. The proposed system implements a 2-lines algorithm and vehicle classification using Kalman filter for daytime and headlight-based detection for night time which helps in the successful tracking of vehicles.

[8] Licence plate detection uses Edge detection, Gaussian Analysis, Feature extraction and character recognition which makes it robust to detect licence plates in both day and night conditions. The median error was reduced to 11% by the use of the 2-lines algorithm. Vehicle classification using Kalman filters gives 82% accuracy. The proposed system will give a median error of less than 10% and an accuracy of more than 90% in counting and classifying vehicles.

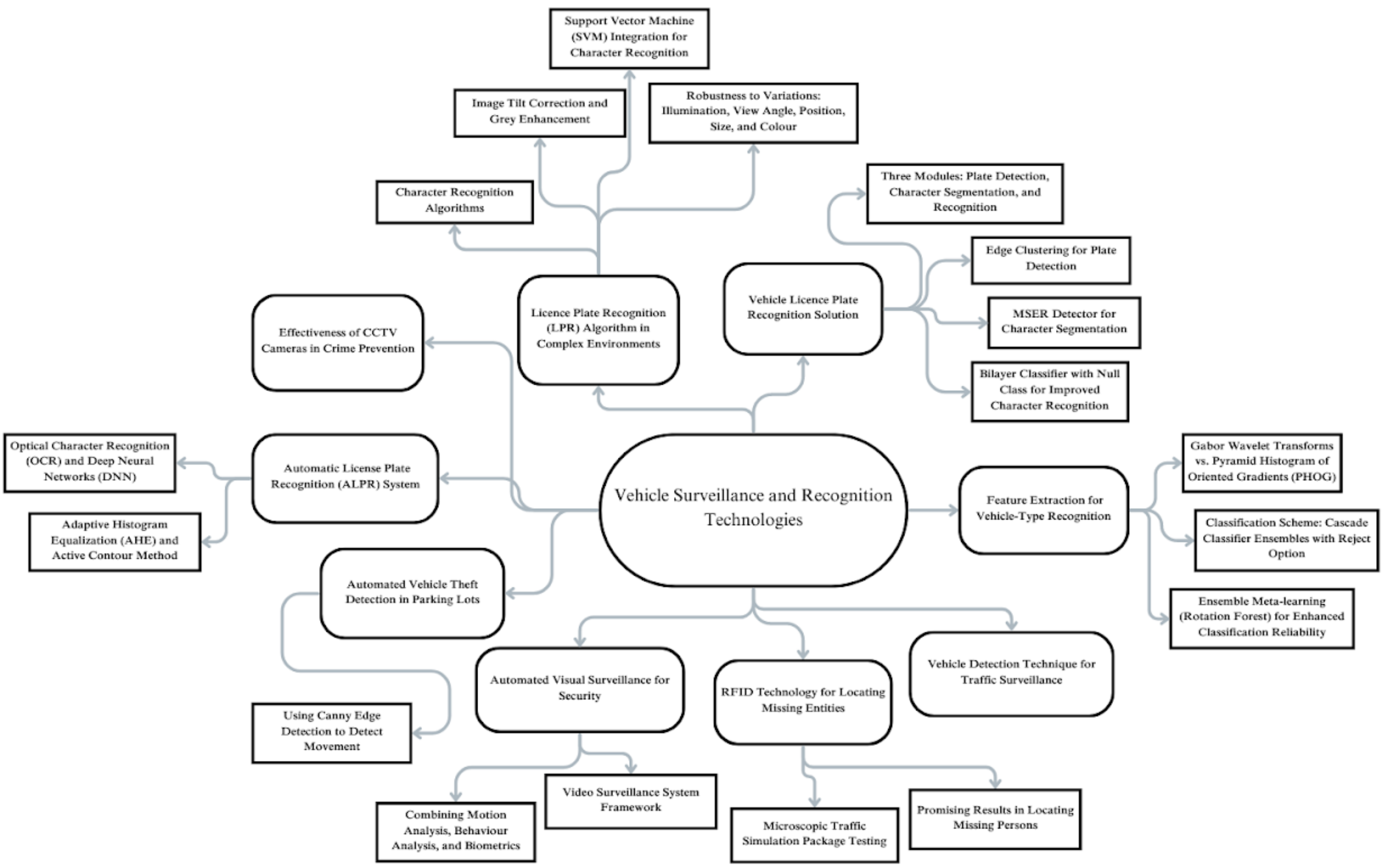

Fig 3: A Mind Map of the Review Paper

INTRODUCTION

Challenges of licence plate recognition (LPR) due to the diversity of plate formats and nonuniform outdoor illumination conditions during image acquisition. A typical LPR system includes four parts: obtaining an image of the vehicle, licence plate localization and segmentation, character segmentation and standardisation, and character recognition. The paper discusses various methods of licence plate localization and highlights their disadvantages, including sensitivity to brightness and longer processing time. The paper emphasises the importance of accurate licence plate localization for the overall system's efficiency.

This article also discusses various techniques for licence plate recognition (LPR), including character segmentation and recognition. Most of these techniques only process a single line of characters and limited types of characters, such as English and numerals. The article presents a solution for image disturbance resulting from uneven illumination and various outdoor conditions and a character recognition algorithm using support vector machines. The system achieved an overall performance of 93.54% and processed numerals, English, Chinese, and Kana characters. The article presents novel contributions, such as a shadow removal method and character feature extraction methods for Chinese characters.

The variables considered in vehicle licence plate recognition (LPR) include illumination, camera viewpoint, and distance from the camera to the plate. However, few studies discuss the variation scope of each variable in different LPR applications and their impact on the solution. For instance, in a fixed-camera scenario, plates' orientation and size may only have marginal differences, whereas, in patrolling vehicles, each variable would have a large variation scope. The variation scope in each variable differs depending on the application.

Applications with larger variation scopes in their variables require more advanced processing and computational power compared to applications with fewer variation scopes. Applying methods developed for one application type to another type is inefficient, as a method designed for one application may not work for another due to different variation scopes in the variables.

This paper introduces the first version of the application-oriented licence plate (AOLP) benchmark database, which has 2049 images categorised into three subsets, and each subset offers a good scope of samples to represent one of the three major applications. All samples were collected in Taiwan, from various locations, times, traffic, and weather conditions.

The paper proposes an application-oriented approach for LPR, consisting of three modules for plate detection, character segmentation, and recognition. Novelty exists in each module, including clustering for plate detection, maximally stable extreme region (MSER) for character segmentation, and a bilayer classifier with a null class for character recognition. The proposed solution is validated using competitive methods, and the performance of each module is compared.

The paper discusses the importance of vision-based vehicle make-and-model recognition (MMR) in various applications, such as vehicle surveillance for high-security areas and identifying blacklisted vehicles. The increasing demand for security awareness and the widespread use of surveillance cameras have made vehicle identification and classification technologies more relevant in recent years. Image-based vehicle recognition is a challenging task due to various issues, including the expanding number of vehicle models, similarities between certain models, and variability in the obtained vehicle images. While most studies have focused on broad vehicle classification, recent research has used advanced machine learning algorithms to classify vehicles into a limited number of fine classes using features such as edge-based features, oriented-contour point models, and transform-based image features. Efficient and robust vehicle make-and-model recognition (MMR) methods are still a challenging research problem. Vision-based vehicle-type recognition requires a multiclass classification framework, which involves feature representation and classification. The Pyramid Histogram of Oriented Gradients (PHOG) edge descriptor and Gabor filter have shown promise for efficient image feature description. PHOG calculates gradient direction and magnitude for each pixel in an image and bins these gradients by direction weighted with magnitude. Gabor filtering is multiresolution and multi-orientation, measuring local spatial frequencies and has shown distortion tolerance performance in various image processing tasks.

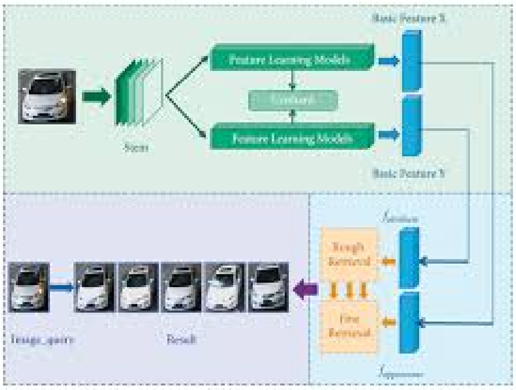

Fig 4: Vehicle re-identification system based on appearance features [www.hindawi.com]

This paper also discusses different machine learning algorithms that can be used for the vehicle-type recognition task, including neural networks, support vector machines, random forest, and ensemble classifiers. Ensemble classifiers integrate multiple component classifiers for a single task, and examples include bagging, AdaBoost, random subspace, and rotation forest. Rotation forest is a new technique that enhances diversity among component classifiers while maintaining their accuracy by applying PCA to randomly split feature subsets. It has been shown to perform better than several other ensemble methods on benchmark classification datasets. The accuracy of image classification has been the primary focus in most studies, but in scenarios like surveillance, reliability in classifier design is more important, and reject options can help abstain from uncertain classifications. However, reliable classification is a less studied topic due to the difficulty in determining the reliability of a classification for a specific instance.

This article proposes a classification scheme with a rejection option for vehicle-type recognition. The system is composed of two ensembles, with the first-stage ensemble consisting of eight classifiers, and the second-stage ensemble consisting of an RF ensemble of MLPs. The rejection option improves the reliability of classification and leaves the control of classification accuracy to human judgement. The proposed system reduces the error rate by controlling the accuracy-rejection tradeoff. Vehicle classification is a crucial task in transportation systems, parking optimization, law enforcement, and autonomous navigation. Vision-based methods are commonly used to detect and classify vehicles using external physical features. However, designing an effective and robust automatic vehicle classification system that works in real-world conditions is challenging due to problems such as occlusion, object tracking, shadows, rotation, and lack of colour invariance.

Feature-based methods, such as the scale-invariant feature transform (SIFT), are commonly used for object classification as they provide pose invariance and resilience to appearance change and local deformation. However, feature extraction can be limited when dealing with low-resolution images in real-world conditions. This paper presents a multiclass vehicle classification system using a hybrid dynamic Bayesian network (HDBN) that classifies a vehicle into one of four classes based on its direct rear-side view. The system uses low-level features such as height, width, and angle, which are computationally inexpensive and do not require high-resolution or close-up images. The proposed approach aims to overcome the limitations of feature-based methods in dealing with low-resolution images in real-world conditions.

[16] The paper discusses the need for an automated traffic surveillance system to address problems like traffic congestion and accidents. The first step in traffic surveillance is recognizing vehicles in surveillance video cameras, which is a challenging task. The paper proposes a system that uses Haar-like features for automatic car detection from CCTV cameras placed at the top of traffic signals. Vehicle detection and counting are crucial to reducing traffic congestion and increasing security. The passage suggests using a network of parked cars with RFID technology as a service delivery platform for detecting missing entities, particularly for high-risk groups such as those with dementia or disabilities. The system involves parked cars with RFID readers, an administrative centre, and a missing entity with an RFID tag. When an alarm is raised, the parked cars attempt to locate the missing entity and send information back to the administrative centre. The system is demonstrated with a use case of locating a missing Alzheimer's patient and validated using a microscopic traffic simulation package.

Fig 5: Automatic vehicle counting system
[www.indiamart.com]

The article discusses the increasing need for visual surveillance systems in homeland security applications to detect abnormal behaviour and hostile intent, and identify human subjects. Visual surveillance technologies such as CCD cameras, thermal cameras, and night vision devices are widely used, and the processing framework of an automated visual surveillance system includes motion/object detection, object tracking, behaviour and activity analysis and understanding, person identification, and camera handoff and data fusion. The article also highlights the challenges of creating a single general-purpose surveillance system due to difficulties in object detection, tracking, and identification from video problems. The review paper aims to provide a general understanding of the theoretical and practical perspectives involved in visual surveillance systems and potential challenges for those considering implementing or integrating such systems.

This paper discusses the importance of security and surveillance through CCTV in detecting intrusion or other unwanted phenomena. Real-time image processing is an optimal solution for this purpose. Object tracking in video surveillance systems is widely used by security agencies for real-time monitoring and detection of potential security threats. The paper focuses on edge detection, particularly the Canny Edge Detection method, which is used for object classification and detection in complex videos. A proposed computational model is suggested for detecting moving objects in parking lots using several video cameras. The monitor will give a notification if any movement is detected after the video footage is processed to avoid human error.

The article describes the importance of an attendance monitoring system for vehicles in organisations and educational institutions. The traditional manual marking of attendance is cumbersome and can be exploited, but an automated system makes it easier and more secure. The system has two processes, automatic and manual, with the automated system being more valuable for ensuring compliance and regulation proof of attendance. The article highlights the benefits of an automated vehicle attendance monitoring system in making the process simpler, elegant, and regulation-compliant.

The article describes a system for automatic vehicle search in urban surveillance videos based on semantic attributes. The system allows users to search for vehicles based on attributes such as colour, size, length, width, height, speed, direction of travel, date/time, and location. The system is robust to challenging urban environments and supports large-scale data indexing. The article proposes a novel vehicle detection method that uses co-training, synthetic occlusion generation, and deformable shape/aspect ratio sliding windows to handle occlusions and multiple vehicle types. Once vehicles are detected and tracked, attributes are extracted and ingested into a database for future searches. The system provides an end-to-end solution for vehicle retrieval based on semantic attributes, including a robust detection/tracking approach for capturing vehicles in crowded scenes.

Ensuring security at public access facilities is a complex challenge, and video surveillance systems are currently used to provide footage for human operators and forensic investigation. However, human attention is not always reliable and manually searching through large collections of footage can be tedious and error-prone. Automatic video analysis technologies, such as multiscale tracking, can aid in real-time threat detection and forensic investigation. The article discusses the state-of-the-art video analysis technologies, component technologies for a smart surveillance system, and future directions

The article discusses the increasing need for visual surveillance systems in homeland security applications to detect abnormal behaviour and hostile intent, and identify human subjects. Visual surveillance technologies such as CCD cameras, thermal cameras, and night vision devices are widely used, and the processing framework of an automated visual surveillance system includes motion/object detection, object tracking, behaviour and activity analysis and understanding, person identification, and camera handoff and data fusion. The article also highlights the challenges of creating a single general-purpose surveillance system due to

difficulties in object detection, tracking, and identification from video problems. The review paper aims to provide a general understanding of the theoretical and practical perspectives involved in visual surveillance systems and potential challenges for those considering implementing or integrating such systems. Focuses in the computer vision research field are detection, classification and pose estimation. The task of vehicle Re-Id is, given a probe vehicle image, to search in a database for images that contain the same vehicles captured by multiple cameras. Its applications are found in various fields like video surveillance, intelligent transportation and urban computing. If we want to find a suspect vehicle in a huge amount of surveillance videos, we can first filter out a large number of vehicles by appearance such as colours, shapes and types, to narrow down the search space. Then, the licence plate is utilised to accurately identify the suspects. Furthermore, the search scope is expanded from near cameras to far away, and the search period is extended from close time to distance. Therefore, spatiotemporal information can also provide great assistance.

However, using appearance-based approaches only can't give optimal results due to the large intra-instance differences of the same vehicle in different cameras and subtle inter-instance differences between different vehicles in the same views. Furthermore, due to the varied illuminations, angles, and resolutions, conventional licence plate identification systems may not work in unrestricted surveillance settings. Moreover, the recognition of licence plates is a multi-step, sophisticated process that involves plate detection, segmentation, shape adjustment and character recognition. Effective utilisation of licence plate information in unconstrained traffic still remains a challenge.

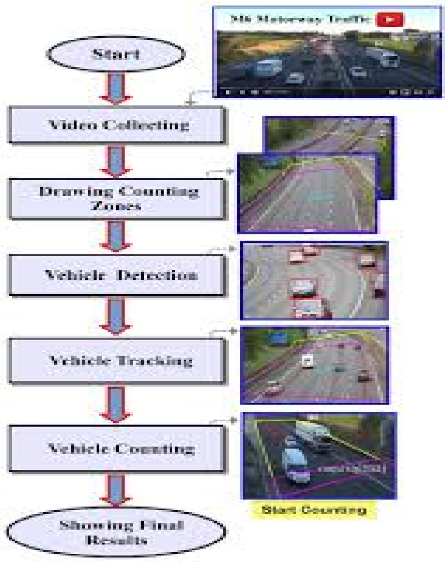

Fig 6: Main workflow of the vehicle counting approach
[www.researchgate.net]

For appearance-based coarse filtering, we adopt the fusion model of low-level and high-level features to find similar vehicles. For the licence number plate, instead of accurately recognizing the characters of the licence plate, we just need to verify whether two plate images belong to the same vehicle. Therefore, a Siamese neural network is trained with large numbers of plate images for licence plate verification. At last, a spatiotemporal relation model is utilised to re-rank vehicles to further improve the final results of vehicle Re-Id.

Generally, at a high viewing angle, a more distant road surface can be considered. The object size of the vehicle changes greatly at this viewing angle, and the detection accuracy of a small object far away from the road is low. In the face of complex camera scenes, it is essential to effectively solve the above problems and further apply them. This article focuses on the above issues to propose a viable solution and applies the vehicle detection results to multi-object tracking and vehicle counting.

[14] The article discusses the use of CCTV cameras as a modern policing strategy to prevent crime. Traditional policing methods have little impact on crime reduction, so many countries have modernised their policing strategies through technology, such as CCTV cameras. The article explores the use of CCTV cameras in Gaborone City, Botswana and assesses their geographic placement in light of the principles of Situational Crime Prevention theory. The article also describes the two major functions of modern CCTV systems, which are video information and security, and explains the differences between conventional and IP cameras.

This paper presents a memory-based rather than a model-based approach to navigation using holographic data storage. Optical image processing is well suited for optical implementation due to its inherent 2-D parallelism optics. Optical data storage offers high storage capacity and fast parallel access to the stored information. Systems that combine holographic storage with correlation can produce up to 30,000 correlations/s ~an input image updated at 30 Hz correlated against 1000 stored templates. An experimental vehicle navigation system uses optical correlation to direct a vehicle along a predefined trajectory. The vehicle uses only visual input to perform this task, with a CCD camera recording the observed visual scene as the vehicle is manually driven along the desired trajectory. Sequential still frames from this video are then selected to be "way-points" and stored in the holographic database.

Anomaly detection is an important problem for Intelligent Transportation Systems (ITS). Vehicles moving in the wrong direction pose a major risk for other drivers, and if anomalies in vehicles' direction of movement are detected accurately in real-time, the risk of accidents can be decreased significantly. Traditional methods such as road sensors may not provide accurate results in congested lanes, and image processing-based solutions are more reliable with the advantage of increased compatibility and ease of maintenance. In this paper, a novel vehicle flow detection method is presented, using light curtain information to detect vehicles through dedicated lanes, CCTV cameras to capture images of the vehicle from both ends and combining image processing with machine learning techniques to calculate each vehicle's direction of flow.

CMMR is an interesting research topic in intelligent transport systems (ITS). It can be used to improve the accuracy and reliability of car identification by providing more information about manufacturers, models, shapes, and colours. It can also be used to detect suspected or blacklisted cars, or unknown licence plates, via CCTV cameras. Previous studies have developed solutions to the problem during the daytime, but there are also methods designed to identify car makes and models at night. This paper presents a new CMMR method for scenes under limited lighting conditions or at night. It uses new feature selection methods and a one-classifier ensemble to recognize a vehicle of interest. The authors propose that a vehicle's features should be captured from the rearview, where features are less prone to brightness and glare. A genetic algorithm is then applied to select the most optimal subset of features for the recognition process.

Intelligent Traffic Systems solve problems like incident detection, traffic monitoring, traffic rules violations, live traffic updates and automated traffic signalling. Intelligent traffic system management and better access to real-time information along with historical information helps commuters to plan their route. It can also help to reduce congestion. Loop detectors, video cameras and mobile sensors like GPS can be used for traffic monitoring. Loop detectors and GPS involve high installation costs and high maintenance costs. On the other hand, installing video cameras and monitoring traffic using them is a better option as it doesn't require high installation and maintenance costs and no personal cost for the commuters.

Existing approaches for motion detection in traffic surveillance systems can be divided broadly into three categories: temporal difference, optical flow, and background subtraction. Although the temporal difference approach is adaptive to environmental changes, they are often used in incomplete detection of the shapes of moving objects. The optical flow approach is employed to detect moving objects by using the projected motion in the image plane with proper approximation. Unfortunately, these methods inevitably result in the generation of noise and excess computational burden. The background subtraction approach is widely used for the detection of moving objects due to its ability to accomplish accurate detection of moving objects while exhibiting only moderate computational complexity. This is achieved by comparing the differences between pixel features of the current image and those of the reference background model of the previous image.

In this method, the foreground pixels in frame N are calculated by subtracting the background frame from it. The density of frame N is calculated by the ratio of foreground pixels to total pixels in the frame. The background frame is manually selected as a frame containing no vehicles to serve as the template, where any pixel differences indicate a vehicle. This simple intuitive method gave disastrous results because of a particular characteristic of buses in Bengaluru. Bengaluru buses have a grey cover on their roofs as protection from heat and rain. Online image searches revealed similar characteristics of buses in other Indian cities. This grey colour is almost the same as that of the road, and therefore using background subtraction does not detect a vehicle. So we propose to implement a 2-line algorithm which solves this problem.

Also, it is seen that the methodologies used for daytime conditions are not applicable for nighttime or bad lighting conditions so it is proposed to have two different approaches for day and night respectively. Most of the features employed for vehicle detection, such as colour, shadows, edges and motion information, are difficult or impossible to extract in dark or nighttime situations. Hence, the aforementioned methods are inadequate in dark or nighttime traffic conditions. In contrast to daytime traffic environments, headlights and rear lights become the salient features of moving vehicles in nighttime traffic conditions. However, nighttime traffic conditions are complicated and chaotic, with many potential light sources that are not vehicle headlights, such as traffic lights, street lights and reflections from vehicle headlights. The proposed algorithm, including headlight segmentation, headlight pairing and headlight tracking, does not rely on the performance of a lane detection algorithm. First, pixels of headlights are extracted from the captured image sequences using the thresholding method. Second, the pixels of the headlights are grouped and labelled to obtain characteristics of the related components. The locations and sizes of the related components are employed for headlight pairings. A related component of the headlight is indicated by an enclosure within a bounding box. Finally, the bounding boxes are tracked by a tracking procedure to detect vehicles.

CONCLUSION

The proposed licence plate recognition algorithm is designed for a specific country but can be adapted for use with licence plates from other countries. The improved binary algorithm can be adapted to other surrounding schemes, and the OCR technique for numerals, Roman letters, and Chinese characters can be used for similarly constituted licence plates and other applications.

The paper's contributions are the introduction of the AOLP database with three subsets and an LPR solution with adjustable settings for different applications.

From the experimental study, we can conclude that:

1. Different applications are better tackled by the solution with compatible settings to guarantee efficiency and performance
2. Each module and the overall proposed solution are competitive with existing approaches.

The proposed DBN system for vehicle classification outperforms well-known classifiers such as kNN, LDA and SVM. The system also proved that high classification accuracy can be achieved using simple features. It is also stated that future work will include converting the current model to an incremental online learning model, stochastic vehicle make and model identification and adaptive DBN structure learning for classification purposes.

The paper discusses a machine learning-based technique for detecting vehicles using Haar cascades in video frames. It presents different vision-based vehicle detection systems and explains how Haar cascades can detect cars in rapidly changing environments. The experimental results show that the technique has an accuracy of over 90% in counting vehicles. With decreasing costs of sensors, processors, and CCTV cameras, and increasing image resolution, the field is expected to see continuous growth.

The paper proposes a system for locating missing entities using RFID-based techniques and networks of connected parked vehicles as a service delivery platform. The system is highly automated and demonstrated through a use case of a missing Alzheimer's patient. Future research is suggested to optimise system parameters, guarantee the quality of service, and explore energy management algorithms for the parked vehicle component. Additionally, the authors propose incorporating dynamic parking models and vehicle-in-the-loop platforms to increase realism and explore tracking missing entities.

The article discusses the advancements in visual surveillance systems, particularly in behaviour and event analysis, for detecting human and/or other object behaviours. The focus has shifted from low-level functions such as motion detection and segmentation to more complex scene analysis. Advanced behaviour/event analysis systems use pattern discovery to define new behaviours/events and present them to specialists for confirmation. The article reviews the developments and challenges in combining object tracking, motion analysis, behaviour analysis, and biometrics for standoff human subject identification and behaviour understanding. The purpose of the paper is to provide insight into visual surveillance systems from a big-picture perspective, reviewing existing works to understand the stages involved in a general visual surveillance system, how to detect and analyse behaviour and intent, and how to approach the challenge.

The paper presents an automated system for identifying possible vehicle theft through moving object detection. The goal is to reduce vehicle theft from parking lots, especially during the night. The paper proposes using an edge detection technique for optimal performance in vehicle theft prevention due to its accuracy and cost-effectiveness. The system for extracting characters from licence plates and updating the status based on a comparison with a predefined table achieves 100% accuracy. This makes it a valuable tool for monitoring campus vehicles and keeping track of their status. The article presents an end-to-end system for vehicle retrieval based on fine-grained attributes, which includes a novel detection/tracking approach for capturing vehicles in challenging urban environments. The system is robust to crowded scenes and environmental factors, and a comprehensive quantitative analysis was performed using real surveillance data. Future work includes exploiting the vehicle dataset to learn a generic vehicle detector, adding more feature planes to generate a larger feature pool, and developing large-scale online adaptation methods.

Fig 7: Stolen vehicle tracking system| Anti-theft solution
[www.faststeamtech.com]

[13] This article discusses how smart surveillance systems can enhance situation awareness by transforming video surveillance from a data acquisition tool to an information and intelligence acquisition system. Real-time video analysis allows for higher-resolution information acquisition, while long-term operation provides spatiotemporal context for analysing information. As these systems continue to evolve, they will be integrated with other sensing devices and space information, providing a rich mechanism for maintaining situational awareness. The article discusses the advancements in visual surveillance systems, particularly in behaviour and event analysis, for detecting human and/or other object behaviours. The focus has shifted from low-level functions such as motion detection and segmentation to more complex scene analysis. Advanced behaviour/event analysis systems use pattern discovery to define new behaviours/events and present them to specialists for confirmation. The article reviews the developments and challenges in combining object tracking, motion analysis, behaviour analysis, and biometrics for standoff human subject identification and behaviour understanding. The purpose of the paper is to provide insight into visual surveillance systems from a big-picture perspective, reviewing existing works to understand the stages involved in a general visual surveillance system, how to detect and analyse behaviour and intent, and how to approach the challenge.

In this paper, a deep learning-based progressive vehicle Re-Id approach, which employs the deep CNN to extract the appearance attributes as the coarse filter, and Siamese neural network-based licence plate verification as the fine search is proposed. Furthermore, the spatiotemporal relations of the vehicle in real-world urban surveillance is investigated and combined into the proposed method. To facilitate the research, one of the largest vehicle Re-Id datasets from urban surveillance videos with diverse vehicle attributes, sufficient licence plates, and accurate spatiotemporal information was built. The experimental results verified that the proposed vehicle detection and tracking method for highway surveillance video scenes has good performance and practicability. Compared with the traditional method of monitoring vehicle traffic by hardware, the method of this paper is low in cost and high in stability and does not require large-scale construction or installation work on existing monitoring equipment. According to the research reported in this paper, the surveillance camera can be further calibrated to obtain the internal and external parameters of the camera. The position information of the vehicle trajectory is thereby converted from the image coordinate system to the world coordinate system. The vehicle speed can be calculated based on the calibration result of the camera. Combined with the presented vehicle detection and tracking methods, abnormal parking events and traffic jam events can be detected to obtain more abundant traffic information. The methodology and results of the vehicle detection and counting system provided in this analysis will become important references for European transport studies.

The paper evaluates the placement of public surveillance cameras in Gaborone and surrounding areas and applies the Situational Crime Prevention theory. It finds that many cameras are not placed in grey zones, lack warning labels in the Setswana language, and that privacy concerns could be used as an excuse by offenders. However, there is enough lighting around the cameras to strengthen their effectiveness. The paper calls for further study to evaluate the effectiveness of CCTV cameras and establish a monitoring system for public safety. The study finds CCTV cameras effective in preventing traffic violations, crimes against property, and crimes against persons. Eye-to-eye checkers and 3D software can enhance their accuracy. The optical correlator system shown in this paper was able to guide a vehicle through a preprogrammed path and automatically recognize and track targets in real-time. Up to 1000 holograms were stored at a single location using the DuPont 100-mm-thick photopolymer and up to 10,000 holograms have been stored in photorefractive crystals. This capacity can enable an entire building or campus to be mapped for autonomous vehicle navigation, a number of targets stored from all possible perspectives, scales, and elevations for automatic target recognition and tracking, and more clever use of the correlation peaks, improvements in the control algorithm, and optimised correlation templates can further increase the capability of the system.

This study presents a vehicle flow detection approach to detect traffic anomalies, using optical flow estimation and machine learning technique k-nearest neighbour. Results from public motorway tests showed that it can detect vehicles travelling opposite the traffic flow, but requires dedicated cameras for each lane. Future research subjects include detection via a single camera, detection of different types of anomalies, and detection of humans passing by.CMMR is an important topic for developing intelligent transport systems, but it is difficult to recognize under limited lighting conditions due to missing features. This paper proposes a method to recognize CMM at night by using the salient features of the car rearview. The proposed method is robust and can deal with many missing features, with an average correct recognition of 93.8%. Future work will involve finding more robust features of distinguishable features with respect to improving classification accuracy.

The title "Vehicle Surveillance and Recognition Technology" reflects a focus on studying and developing technologies related to monitoring, identifying, and analyzing vehicles in various contexts. This field encompasses a range of topics related to surveillance, security, transportation, and computer vision.

REFERENCES

[1] Shammi, S., Islam, S., Rahman, H. A., & Zaman, H. U. (2018, February). An automated way of vehicle theft detection in parking facilities by identifying moving vehicles in CCTV video stream. In *2018 International Conference on Communication, Computing and Internet of Things (IC3IoT)* (pp. 36-41). IEEE.

[2] Nemade, B. (2016). Automatic traffic surveillance using video tracking. *Procedia Computer Science*, *79*, 402-409.

[3] Choudhury, S., Chattopadhyay, S. P., & Hazra, T. K. (2017, August). Vehicle detection and counting using haar feature-based classifier. In *2017 8th annual industrial automation and electromechanical engineering conference (IEMECON)* (pp. 106-109). IEEE.

[4] Wu, G., Wu, Y., Jiao, L., Wang, Y. F., & Chang, E. Y. (2003, November). Multi-camera spatio-temporal fusion and biased sequence-data learning for security surveillance. In *Proceedings of the eleventh ACM international conference on Multimedia* (pp. 528-538).

[5] Kim, B. S., Kim, K. W., & Park, S. T. (2015). The improvement plan for fire response time using big data. *Indian Journal of Science and Technology*, *8*(23), 1.

[6] Felix, A. Y., Jesudoss, A., & Mayan, J. A. (2017, August). Entry and exit monitoring using license plate recognition. In *2017 IEEE international conference on smart technologies and management for computing, communication, controls, energy and materials (ICSTM)* (pp. 227-231). IEEE.

[7] Zakria, Deng, J., Hao, Y., Khokhar, M. S., Kumar, R., Cai, J., ... & Aftab, M. U. (2021). Trends in vehicle re-identification past, present, and future: A comprehensive review. *Mathematics*, *9*(24), 3162.

[8] Ko, T. (2008, October). A survey on behavior analysis in video surveillance for homeland security applications. In *2008 37th IEEE Applied Imagery Pattern Recognition Workshop* (pp. 1-8). IEEE.

[9] Song, H., Liang, H., Li, H., Dai, Z., & Yun, X. (2019). Vision-based vehicle detection and counting system using deep learning in highway scenes. *European Transport Research Review*, *11*(1), 1-16.

[10] Molepo, S. P., Faimau, G., & Mashaka, K. T. (2020). CCTV placement in Gaborone City, Botswana: A critical review through the lens of Situational Crime Prevention theory. *Kriminologija & socijalna integracija: časopis za kriminologiju, penologiju i poremećaje u ponašanju*, *28*(2), 144-163.

[11] Cuevas, Q. D. P., Corachea, J. C. P., Escabel, E. B., & Bautista, M. L. A. (2016). Effectiveness of CCTV cameras installation in crime prevention. *College of Criminology Research Journal*, *7*, 35-48.

[12] Adu-Gyamfi, Y. O., Asare, S. K., Sharma, A., & Titus, T. (2017). Automated vehicle recognition with deep convolutional neural networks. *Transportation Research Record*, *2645*(1), 113-122.

[13] Sarikan, S. S., & Ozbayoglu, A. M. (2018). Anomaly detection in vehicle traffic with image processing and machine learning. *Procedia Computer Science*, *140*, 64-69.

[14] Popov, G. I. Video Motion Detection Algorithm Using Multiple CCTV Cameras.

[15] Boonsim, N., & Prakoonwit, S. (2017). Car make and model recognition under limited lighting conditions at night. *Pattern Analysis and Applications*, *20*, 1195-1207.

[16] Piza, E. L., Welsh, B. C., Farrington, D. P., & Thomas, A. L. (2019). CCTV surveillance for crime prevention: A 40-year systematic review with meta-analysis. *Criminology & public policy*, *18*(1), 135-159.

[17] Welsh, B. C., & Farrington, D. P. (2002). *Crime prevention effects of closed circuit television: a systematic review* (Vol. 252). London: Home Office.

[18] Lu, Y. (2003). Getting away with the stolen vehicle: An investigation of journey-after-crime. *The Professional Geographer*, *55*(4), 422-433.

[19] Griggs, W. M., Verago, R., Naoum-Sawaya, J., Ordonez-Hurtado, R. H., Gilmore, R., & Shorten, R. N. (2018). Localizing missing entities using parked vehicles: An RFID-based system. *IEEE Internet of Things Journal*, *5*(5), 4018-4030.

[20] Wheatley, S. E. (1993, October). Tracker-stolen vehicle recovery system. In *IEE Colloquium on Vehicle Security Systems* (pp. 1-1). IET.

[21] Sathya, V., & Samath, J. A. (2012, October). Implementation of fuzzy logic with high security registration plate (HSRP) for vehicle classification and checking in toll-plaza. In *International Conference on Advanced Information Technology academy and Industry Research collaboration* (pp. 297-306).

[22] Anoop, M. A., Poonkuntran, S., & Karthikeyan, P. (2022). Deep Learning-Based Indian Vehicle Number Plate Detection and Recognition. *Object Detection with Deep Learning Models: Principles and Applications*, 4.

[23] Pu, A., Denkewalter, R., & Psaltis, D. (1997). Real-time vehicle navigation using a holographic memory. *Optical Engineering*, *36*(10), 2737-2746.

[24] Feris, R. S., Siddiquie, B., Petterson, J., Zhai, Y., Datta, A., Brown, L. M., & Pankanti, S. (2011). Large-scale vehicle detection, indexing, and search in urban surveillance videos. *IEEE Transactions on Multimedia*, *14*(1), 28-42.

[25] Wen, Y., Lu, Y., Yan, J., Zhou, Z., von Deneen, K. M., & Shi, P. (2011). An algorithm for license plate recognition applied to intelligent transportation system. *IEEE Transactions on intelligent transportation systems*, *12*(3), 830-845.

[26] Greiffenhagen, M., Comaniciu, D., Niemann, H., & Ramesh, V. (2001). Design, analysis, and engineering of video monitoring systems: An approach and a case study. *Proceedings of the IEEE*, *89*(10), 1498-1517.

[27] Hsu, G. S., Chen, J. C., & Chung, Y. Z. (2012). Application-oriented license plate recognition. *IEEE transactions on vehicular technology*, *62*(2), 552-561.

[28] Zhang, B. (2012). Reliable classification of vehicle types based on cascade classifier ensembles. *IEEE Transactions on intelligent transportation systems*, *14*(1), 322-332.

[29] Psyllos, A., Anagnostopoulos, C. N., & Kayafas, E. (2011). Vehicle model recognition from frontal view image measurements. *Computer Standards & Interfaces*, *33*(2), 142-151.

[30] Kafai, M., & Bhanu, B. (2011). Dynamic Bayesian networks for vehicle classification in video. *IEEE Transactions on Industrial Informatics*, *8*(1), 100-109.

[31] Bhanu, B., & Kafai, M. (2016). *U.S. Patent No. 9,466,000*. Washington, DC: U.S. Patent and Trademark Office.