Vehicle Surveillance and Recognition Technologies

Nivedita P R,
Graduate Student,
School of Computer Science and Engineering,
Vellore Institute of Technology Chennai.

Akshaya S,
Graduate Student,
School of Computer Science and Engineering,
Vellore Institute of Technology Chennai.

Nithyashree S,
Graduate Student,
School of Computer Science and Engineering,
Vellore Institute of Technology Chennai.

Vallidevi Krishnamurthy,
Associate Professor,
School of Computer Science and Engineering,
Vellore Institute of Technology Chennai.

ABSTRACT

In this article, a novel license plate recognition (LPR) algorithm is introduced, designed to operate effectively in challenging environments. This algorithm incorporates an innovative shadow removal technique and character recognition approach. It includes advanced methods for addressing issues like image misalignment and grayscale enhancement. Notably, it employs support vector machine (SVM) integration for character recognition, with a distinctive focus on analyzing entire character strings rather than individual characters. This algorithm demonstrates robustness in the face of various factors such as lighting variations, viewing angles, plate positions, sizes, and plate colours. Through extensive testing with 9,026 images, it achieves an impressive 93.54% success rate for LPR, even under complex conditions. It excels in precisely locating and segmenting license plates and delivering high recognition performance for numerals, Kana characters, and addresses.

Furthermore, this paper presents a comprehensive vehicle license plate recognition (LPR) solution, adaptable for diverse applications encompassing access control (AC), law enforcement (LE), and road patrol (RP). This solution is structured around three key modules: plate detection, character segmentation, and recognition. For plate detection, it leverages edge clustering, while feature segmentation is performed using the MSER detector. The character recognition component introduces a two-layer classifier, incorporating a unique zero class. Through rigorous testing and comparison, this system outperforms previous methods in character recognition, showcasing its effectiveness.

Additionally, the paper conducts an evaluation of two distinct feature extraction methods, the Gabor wavelet transform and the Pyramidal Histogram of Oriented Gradients (PHOG), within the context of image-based vehicle type recognition. The classification scheme is thoughtfully designed, employing cascade classifiers with holdout capability to manage ambiguous samples. Ensembles, which include various classifiers like k-nearest neighbours (kNN), multi-layer perceptrons (MLP), support vector machines (SVM), and random forests, enhance the reliability of the classification process. Notably, a second group of base MLPs is coordinated by an ensemble learning method known as rotation forest (RF). The study demonstrates the method's effectiveness using over 600 images representing 21 different car and minivan brands. It achieves an accuracy rate of 98.65% with a low rejection rate of 2.5%, underscoring its potential for real-world applications.

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

This paper presents a random multi-class vehicle classification system. based on the rear view of the car. The system classifies vehicles into one of four classes using a set of taillight characteristics and vehicle size, processed by a hybrid dynamic Bayesian network. The system was tested on a database of 169 videos and achieved high classification accuracy.

This article presents a vehicle detection technique for a smart traffic monitoring system. The system uses similar features to Haar, a machine learning-based method, to detect cars in real-time CCTV footage. This technique is effective and fast in detecting cars and can help avoid collisions between them.

[19] The paper describes a system that uses RFID technology to locate missing entities, such as people with Alzheimer's disease, using a large network of vehicles parked in urban areas. RFID readers and antennas are placed in parked vehicles, while passive RFID tags are worn by the missing person. If an entity is reported missing, the system will be activated and parked vehicles will attempt to locate the entity and send relevant information to the management center. The system was tested using a microscopic transport simulation software package. It showed promising results, detecting up to 98% of homeless people in need of help in less than 30 minutes in Dublin city centre.

TRACKER Network (UK) Ltd has received consent from all 51 UK police forces to use their system to track and locate stolen vehicles. The system operates on a small transponder fitted to the vehicles, and when a TRACKER-equipped vehicle is reported stolen, the central computer sends a signal to activate the locator signal. Police in patrol cars equipped with tracking computers can detect signals and recover stolen vehicles during routine patrols. The system has received type approval for all of its components and has secured a national broadcast and dedicated radio frequency agreement.

The article discusses the potential benefits of using automated visual surveillance, including the use of surveillance cameras to detect events in real time and take appropriate action. The structure of a video surveillance system comprises components like environmental modelling, motion sensing, object categorization, tracking, behavioural comprehension, and amalgamation of information from multiple cameras. While there have been notable strides in computer vision, there remain significant technical hurdles to address before trustworthy automated video surveillance can be put into practical use. This paper assesses the viability and obstacles in integrating motion analysis, behavioural analysis, and biometric methods for tasks such as recognizing known individuals, spotting irregularities, and comprehending behavioural patterns.

[1] This article addresses concerns about the theft of cars parked in parking lots and the use of CCTV cameras for detection. However, non-automated human monitoring can lead to errors or failures. This article presents an automatic vehicle theft detection method using the Canny Edge detection method [13] to detect motion and alert security personnel or parking lot operators. This method proved effective and useful.

The article discusses the importance of tracking vehicles on the road and identifies the use of automatic license plate recognition (ALPR) systems as a solution. ALPR can be used to extract license plate content from CCTV camera images using MATLAB image processing tools. This article proposes to use adaptive histogram equalization (AHE), active contour method, optical character recognition (OCR) and deep neural network (DNN) to accurately recognize license plates. DNN is used to classify and extract alphanumeric characters to compare with a predefined table in the MYSQL server to modify the state accordingly. This system can be used to monitor road tolls and urban closures.

The paper describes a new approach for vehicle detection and retrieval in crowded surveillance scenes using large-scale feature selection and indexing. This method can detect a wide range of vehicles and clear blockages with minimal manual labelling. Detailed attributes are extracted and stored in the database for later retrieval. This approach is effective for real-world urban surveillance and works well on laptops.

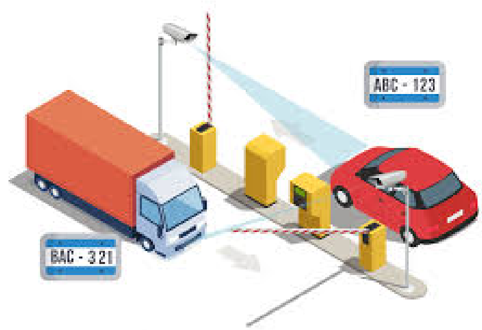

Fig 2: Automatic Number Plate Recognition (ANPR) with barrier gate
[www.vdttechnology.com]

[7] This article discusses the importance of situational awareness in security and the challenges of achieving it at different spatial and temporal scales. Smart video surveillance systems have the potential to improve situational awareness, but the technologies within them are currently being developed independently. Achieving comprehensive situational awareness requires multi-scale spatiotemporal surveillance, which can be achieved through real-time video analytics, active cameras, multi-object modelling, and pattern analytics long-term.

The article discusses the potential benefits of using automated visual surveillance, including the use of surveillance cameras to detect events in real time and take appropriate action. The framework of a video surveillance system includes environment modelling, motion detection, object classification, tracking, behaviour understanding, and multi-camera information fusion. Despite recent advances in computer vision, there are still major technical challenges to overcome before reliable automated video surveillance can be deployed. This article analyzes the feasibility and challenges of combining motion analysis, behavioural analysis, and biometrics to identify known suspects, detect anomalies, and understand behaviour.

Current vehicle re-identification methods mainly focus on general appearance while ignoring unique identifying characteristics. According to “PROVID”, a deep learning method for PROGRESSIVE media re-identification, media re-identification is considered as two specific progressive search processes:

coarse to fine search and neighbourhood search. The search process first filters the vehicle's physical attributes and then uses a Siamese neural network to check the license plate. It searches for vehicles just like humans, using near and far cameras as well as near and far times. The research data is collected from VeRi-776, the largest dataset of vehicles with diverse properties and high repetition rate. It also has all the license plates and space-time stickers. A comprehensive evaluation of VeRi-776 shows that the method outperforms state-of-the-art methods with a 9.28% improvement in mAP and a 10.94% improvement in HIT@1.

This research introduces a vision-based system for detecting and tallying vehicles. It accompanies this work with a newly established high-resolution dataset for road vehicles, encompassing 57,290 instances annotated across 11,129 images. Distinguishing itself from current public datasets, this new resource includes annotations for small objects within images, making it a robust foundation for vehicle detection driven by deep learning. In the proposed vehicle detection and counting system, the image's highway surface undergoes initial extraction and is subsequently partitioned into far and near regions through an innovative segmentation method put forth in this study.

Subsequently, these two regions are incorporated into the YOLOv3 grid to ascertain the type and position of the vehicles. To conclude, the ORB algorithm is employed to collect information about vehicle trajectories, including their direction and the count of distinct vehicles. The effectiveness of these proposed techniques is validated through the examination of various road surveillance videos in diverse settings. Notably, this method excels in terms of detection accuracy, particularly when it comes to identifying small vehicle objects.

CCTV cameras have gained widespread use for monitoring and crime prevention on a global scale, prompting extensive research into their efficacy. In 2018, the installation of CCTV cameras in Gaborone, Botswana, was accompanied by a study that evaluated their geographic placement in alignment with the situational theory of crime prevention. Similarly, an investigation was carried out in Batangas City to gauge the effectiveness of CCTV cameras in deterring crimes related to individuals and property. CCTV cameras are lauded for their proficiency in capturing events and recognizing individuals displaying suspicious behaviour. The article also delves into the significance of security systems founded on video motion detection, which extend protection across volumetric and perimeter dimensions, albeit suffering from relatively high false alarm rates. An optoelectronic information processing system is also presented, capable of facilitating real-time vehicle navigation and target acquisition. This system harnesses a hologram database employing DuPont HRF-150 photopolymer to execute these functions, with a detailed exposition of the system's architecture and operational performance.

[13] Anomaly detection is an important part of intelligent transportation systems, and this research uses image processing and machine learning techniques to detect anomalies in vehicle movements. Images are recorded by surveillance cameras from the front and rear of the vehicle and multiple consecutive images are taken to detect movement. Features such as license plate edges and corner positions are extracted for tracking purposes, and traffic flow direction is obtained from the trained classification model. The proposed method is evaluated on public roads and promising detection results are obtained.

Car make and model recognition (CMMR) plays a significant role in intelligent transportation systems, especially in scenarios where license plates are unreadable or counterfeit. However, existing CMMR methods are typically tailored for daytime use when vehicle details are readily visible. This research introduces a one-class classifier explicitly engineered for nighttime car make and model identification, utilizing observable rear-view features. The classification process involves validating the target model by aggregating the majority vote from support vector machines, decision trees, and k-nearest neighbours. Testing was conducted on 421 vehicles and their models photographed in low-light nighttime conditions, yielding a classification accuracy of approximately 93%.

This system uses video surveillance because it is the most economical technique for monitoring road traffic. The problem with current methods is clogging and changing light conditions.

Recent research on Indian roads also found that current image-processing systems have an average error of 55% in vehicle counts. The proposed system monitors day and night conditions for traffic monitoring. It also provides vehicle classification, traffic density, vehicle count, license plate detection, and incident detection. The proposed system implements a 2-stream algorithm and classifies vehicles using a Kalman filter for detection during the day and headlight-based detection at night, contributing to successful vehicle tracking.

License plate detection employs techniques like edge detection, Gaussian analysis, feature extraction, and character recognition, making it highly effective for detecting license plates in various lighting conditions, including nighttime. The introduction of the 2-line algorithm has notably reduced the average error rate to 11%. In the realm of vehicle classification, the application of the Kalman filter yields an accuracy rate of 82%. The system proposed in this context is expected to achieve significant improvements, aiming for an average error rate of less than 10% and a classification accuracy of over 90% in the tasks of vehicle counting and classification.

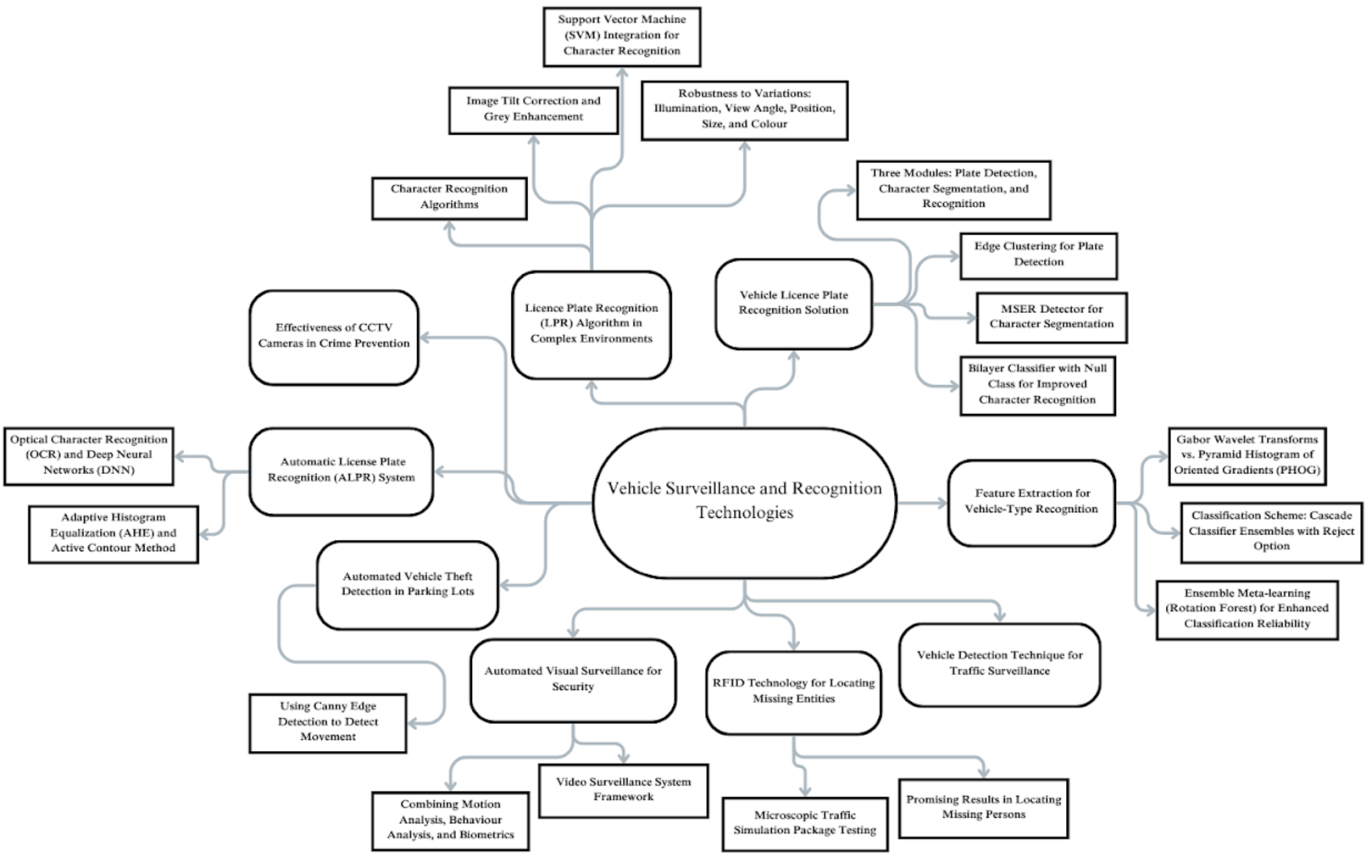

Fig 3: A Mind Map of the Review Paper

INTRODUCTION

License Plate Recognition (LPR) systems face significant challenges due to the diversity of license plate formats and the nonuniform outdoor illumination conditions during image acquisition. A typical LPR system comprises four components: image acquisition, license plate localization and segmentation, character segmentation and standardisation, and character recognition. This article discusses various license plate localization methods, highlighting their drawbacks, such as sensitivity to brightness and longer processing times. It underscores the critical role of accurate license plate localization for overall system efficiency.

The article also explores various LPR techniques, including character segmentation and recognition. Many existing techniques process only a single line of characters and a limited range of characters like English letters and numerals. The paper presents a solution to address image disturbances caused by uneven illumination and diverse outdoor conditions, along with a character recognition algorithm based on support vector machines. The system achieved an impressive overall performance of 93.54% and handled numerals, English, Chinese, and Kana characters. Noteworthy contributions include a shadow removal method and character feature extraction methods for Chinese characters.

In the realm of vehicle license plate recognition, several variables come into play, including illumination, camera viewpoint, and distance from the camera to the plate. However, few studies delve into the scope of variation for each variable in different LPR applications and their respective impacts. For instance, in a fixed-camera scenario, plates may exhibit only marginal differences in orientation and size, whereas in patrolling vehicles, each variable could vary significantly. The variation scope for each variable depends on the specific application.

Applications with larger variation scopes in their variables necessitate more advanced processing and computational power compared to those with narrower scopes. Attempting to apply methods developed for one application to another is inefficient since a method designed for one application may not be suitable for another due to differing variation scopes in the variables.

This paper introduces the Application-Oriented License Plate (AOLP) benchmark database, featuring 2049 images categorized into three subsets, each representing one of the three major applications. All samples were collected in Taiwan, spanning various locations, times, traffic conditions, and weather.

The paper proposes an application-oriented approach to LPR, comprising three modules for plate detection, character segmentation, and recognition. Each module introduces novelty, 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 rigorously validated against competitive methods, and the performance of each module is thoroughly compared.

Additionally, the article discusses the significance of vision-based vehicle make-and-model recognition (MMR) in various applications, such as vehicle surveillance in high-security areas and identifying blacklisted vehicles. The rising demand for security awareness and the widespread use of surveillance cameras has amplified the relevance of vehicle identification and classification technologies. Image-based vehicle recognition poses challenges due to the increasing number of vehicle models, similarities between certain models, and variations in obtained vehicle images.

While most studies have concentrated on broad vehicle classification, recent research has leveraged advanced machine learning algorithms to classify vehicles into fine-grained classes using features like edge-based features, oriented-contour point models, and transform-based image features. Developing efficient and robust vehicle make-and-model recognition methods remains a complex research problem. Vision-based vehicle-type recognition necessitates a multiclass classification framework involving feature representation and classification. Promising techniques include the Pyramid Histogram of Oriented Gradients (PHOG) edge descriptor and Gabor filter, which excel in efficient image feature description by calculating gradient direction and magnitude for each pixel and employing Gabor filtering for multiresolution and multi-orientation measurement of local spatial frequencies, demonstrating distortion tolerance in various image processing tasks.

This article also discusses various machine learning algorithms that can be used for the task of vehicle type recognition, including neural networks, support vector machines, random forests, and ensemble classification. The ensemble classifier integrates multiple component classifiers for a single task, and examples include bagging, AdaBoost, random subspace, and rotation forests. Rotated forests are a new technique that improves the diversity among component classifiers while preserving their accuracy by applying PCA to randomly divide object subsets. It has been shown to perform better than several other aggregation methods on benchmark classification datasets. Image classification accuracy is the primary goal of most research, but in situations such as surveillance, the reliability of the classification design is more important, and discarding options can help avoid uncertain classifications. However, reliable classification is a little-studied topic due to the difficulty of determining the reliability of the classification for a specific case.

This article proposes a classification system with elimination options to identify vehicle types. The system consists of two sets, with the first stage set consisting of eight classifiers and the second stage set consisting of one MLP RF set. The opt-out option improves classification reliability and leaves human control over classification accuracy. The proposed system reduces the error rate by controlling the trade-off between rejection precision. Vehicle classification is an important task in traffic systems, parking optimization, law enforcement, and automated navigation. Vision-based methods commonly detect and classify vehicles using external physical characteristics. However, designing an efficient and robust automatic vehicle classification system that works in real-world conditions is challenging due to issues such as occlusion, object tracking, shadowing, rotation, and lack of colour constancy.

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

[16] The article discusses the need for an automated traffic monitoring system to solve problems such as traffic congestion and accidents. The first step in traffic monitoring is vehicle identification in surveillance cameras, which is a difficult task. The article proposes a system that uses a Haar-like feature to automatically detect cars from CCTV cameras placed on top of traffic lights. Vehicle detection and counting are essential to reduce traffic congestion and increase safety. The passage proposes using a network of parked cars with RFID technology as a service delivery platform to detect missing entities, especially for high-risk groups such as people with dementia or disability. The system includes parked cars equipped with RFID readers, an administrative centre, and a defunct entity with an RFID tag. When the alert is triggered, parked cars will attempt to locate the missing entity and send the information back to the administrative centre. The system is illustrated with a use case of locating a missing and confirmed Alzheimer's patient using a micro traffic simulation package.

The article discusses the growing need for visual surveillance systems in homeland security applications to detect anomalous behaviour and hostile intent as well as identify human subjects. Visual surveillance technologies such as CCD cameras, thermal cameras and night vision devices are widely used, and the processing framework of automatic visual surveillance systems includes motion/object detection, object tracking, analysis and understanding of behaviour and activity, and human recognition. The article also highlights the challenges in creating a single general-purpose surveillance system due to difficulties in detecting, tracking, and identifying objects due to video glitches. The review article aims to provide a general understanding of the theoretical and practical perspectives related to visual surveillance systems and the potential challenges for those considering implementing or integrating such systems.

This article discusses the importance of security and video surveillance in detecting intrusions or other unwanted phenomena. Real-time image processing is the 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 article focuses on edge detection, especially the Canny Edge detection method, which is used to classify and detect objects in complex videos. A computational model is proposed to detect moving objects in parking lots using multiple cameras. The screen will provide a notification if motion is detected after processing the video footage to avoid human error. The article describes the importance of vehicle movement control systems in organizations and educational establishments. Traditional manual timekeeping is tedious and can be exploited, but automated systems make timekeeping easier and safer. The system has two processes, automatic and manual, with the automatic system being more useful in ensuring compliance and proving the presence of the regulator. The article highlights the benefits of automated vehicle presence monitoring systems by making the process simpler, more refined, and regulatory compliant.

This article describes an automatic vehicle search system 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, the direction of travel, date/time and location. The system is robust in harsh urban environments and supports large-scale data indexing. The paper proposes a new vehicle detection method that uses co-training, synthetic occlusion, and shape/aspect deformable sliding windows to handle occlusions and multiple vehicle types. Once vehicles are detected and tracked, attributes are extracted and put into a database for future research. The system provides a comprehensive solution for vehicle retrieval based on semantic attributes, including a robust detection/tracking method for capturing vehicles in crowded scenes. Ensuring the security of public access facilities is a complex challenge and video surveillance systems are currently being used to provide footage for operators and forensic investigators. However, human attention is not always reliable, and manually searching large footage collections can be tedious and error-prone. Automated video analytics technologies, such as multi-scale tracking, can facilitate real-time threat detection and forensic investigation. The article discusses advanced video analytics technologies, component technologies for smart surveillance systems, and future directions.

Research areas in the field of computer vision are detection, classification, and pose estimation. Vehicle Re-Id's mission is to provide a vehicle image probe to search a database of images containing similar vehicles captured by multiple cameras. Its applications are found in various fields such as video surveillance, smart transportation, and urban computing. If we want to find a suspicious vehicle in a large number of surveillance videos, we can first filter a large number of vehicles by appearance, such as colour, shape, and type, to narrow down search space. The license plate number was then used to positively identify the suspect. In addition, the search range is expanded from near to far cameras, and the search period is extended from near to far times. Therefore, spatio-temporal information can also be of great help.

However, using approaches based solely on appearance cannot yield optimal results due to large differences between instances of the same vehicle in different cameras and small differences between versions between different media in the same view. Additionally, due to different lighting, angles, and resolutions, conventional license plate recognition systems may not work in an unconstrained surveillance context. In addition, license plate recognition is a complex multi-step process including detection, segmentation, shape adjustment, and character recognition. Effective use of license plate information when participating in unrestricted traffic remains a challenge. For appearance-based coarse filtering, we apply a low-level and high-level feature aggregation model to find similar vehicles. For license plates, instead of accurately identifying license plate characters, you just need to check whether the 2 license plate images belong to the same vehicle or not. Therefore, the Siamese neural network is trained with a large number of license plate images to verify license plates. Finally, the spatio-temporal relationship model is used to reclassify the vehicles to further improve the final vehicle Re-Id result.

Generally, a further path can be considered from a high perspective. The size of the vehicle object changes significantly under this perspective, and the detection accuracy of small objects far from the road is low. Faced with complex scenes, it is essential to effectively solve the above problems and apply them further. This article focuses on the above issues to propose feasible solutions and apply vehicle detection results to multi-object vehicle tracking and counting.

[14] The article discusses the use of CCTV as a modern police strategy to prevent crime. Traditional policing methods have little impact on crime reduction, which is why many countries have modernised their policing strategies with technologies such as CCTV. The article explores the use of CCTV cameras in the city of Gaborone, Botswana, and evaluates their geographical location based on the principles of situational crime prevention theory. The article also describes the two main functions of modern video surveillance systems, which are video information and security, and explains the difference between conventional cameras and IP cameras.

This paper presents a memory-based navigation approach instead of a model that uses holographic data storage. Optical image processing is well suited to optical implementations due to its inherent 2D parallel optical properties. Optical data storage provides high storage capacity and fast parallel access to stored information. Systems that combine holographic storage with correlation can produce up to 30,000 correlations/second ~ an input image updated at 30 Hz correlates to 1,000 stored samples. An experimental vehicle positioning system uses optical correlation to steer the vehicle along a predetermined trajectory. The vehicle uses only visual input to perform this task, with a CCD camera recording the observed landscape while the vehicle is driven manually along the desired path. Consecutive still frames from this video are then selected as “reference points” and stored in a holographic database.

Anomaly detection is an important issue for intelligent transportation systems (ITS). Vehicles travelling in the wrong direction pose a great risk to other drivers, and if abnormalities in the vehicle's direction of travel are accurately detected in real-time, the risk of an accident can be significantly reduced. 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 new vehicle flow detection method is presented, using light curtain information to detect vehicles on reserved lanes, CCTV cameras to record images of vehicles from both ends and combined processing. Image data processing with machine learning techniques to calculate the traffic flow direction of each vehicle. CMMR is an interesting research topic in intelligent transportation systems (ITS). It can be used to improve the accuracy and reliability of car identification by providing additional information about the manufacturer, model, shape and colour. It can also be used to detect suspicious or blacklisted vehicles or unknown license plates through CCTV cameras. Previous research has developed solutions to this problem during the day, but there are also methods designed to identify vehicle makes and models at night. This paper presents a new CMMR method for scenes in limited lighting conditions or at night. It uses novel feature selection methods and a unique classifier to identify vehicles of interest. The authors propose that vehicle characteristics be recorded from the rearview mirror, where characteristics are less affected by brightness and glare. Then, a genetic algorithm is applied to select the most optimal subset of features for the recognition process.

Smart traffic systems solve problems such as incident detection, traffic monitoring, violations of traffic rules, live traffic updates and automatic traffic signals. Smart traffic system management and better access to real-time and historical information help commuters plan their routes. This can also help reduce traffic congestion. Loop detectors, video cameras, and mobile sensors such as GPS can be used to monitor traffic. Loop detectors and GPS have high installation and maintenance costs. On the other hand, installing video cameras and monitoring traffic using them is a better option as it does not require high installation and maintenance costs nor does it have personal costs for commuters.

Current methods for motion detection in traffic monitoring systems can be divided into three categories: time difference, optical flow, and background subtraction. Although the temporal difference approach can adapt to environmental changes, it is often used to incompletely detect the shape of moving objects. The optical flow method is used to detect moving objects using projected motion in the image plane with appropriate approximation. Unfortunately, these methods will inevitably create noise and excessive computational load. Background subtraction is widely used for moving object detection due to its ability to accurately detect moving objects while having only moderate computational complexity. This is achieved by comparing the difference between the pixel characteristics of the current image and the characteristics of the reference background model of the previous image.

In this method, the number of foreground pixels of image N is calculated by subtracting the background image. Image density N is calculated as the ratio between the foreground pixels and the total number of pixels in the image. The background frame was hand-selected as a vehicle-free frame to model, with any pixel difference representing a vehicle. This simple and intuitive method yields disastrous results due to a peculiar characteristic of Bangalore buses. Buses in Bengaluru have grey roofs to protect against heat and rain. Online image searches show similar features of buses in other Indian cities. This grey colour is close to the grey colour of the road, so using background subtraction cannot detect the vehicle. Therefore, we propose to implement a 2-stream algorithm to solve this problem. Furthermore, it appears that the methods used for daytime conditions do not apply to nighttime or poor lighting conditions. Therefore, it is proposed to have two different approaches for day and night respectively. Most features used for vehicle detection, such as colour, shadow, edge, and motion information, are difficult or impossible to extract in the dark or at night. Therefore, the methods mentioned above are not suitable for dark or night traffic conditions. Unlike daytime traffic environments, headlights and taillights become the main characteristics of vehicles moving in traffic conditions at night. However, traffic conditions at night are complex and chaotic, there are many potential light sources other than the vehicle's headlights, such as traffic lights, street lights, and reflections from the vehicle's headlights. The proposed algorithm, which includes headlight segmentation, headlight matching, and headlight tracking, is independent of the performance of the lane detection algorithm. First, the headlight pixels are extracted from the captured image sequence using a thresholding method. Second, the headlight pixels are grouped and labelled to obtain the characteristics of the related components. Location and size of relevant parts used to pair the headlight. The relevant part of the headlight is represented by an enclosure inside the bounding box. Finally, the bounding boxes are followed by a tracking process to detect the vehicles.

CONCLUSION

The proposed license plate recognition algorithm is designed for a specific country but can be adapted for use with license 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 structured license plates and other applications.

The contribution of the paper is the introduction of an AOLP database with three subsets and an LPR solution with adjustable parameters for different applications.

From empirical research, we can conclude that: Different applications are best addressed with a solution that has compatible settings to ensure efficiency and performance, and each module and overall solution proposed is competitive compared to existing methods.

The proposed DBN system for vehicle classification performs better than well-known classification systems such as kNN, LDA, and SVM. The system also demonstrates 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 recognition of vehicle makes and models, and structural adaptive learning. DBN structure for classification purposes.

The paper discusses a machine learning-based technique to detect vehicles using the Haar layer in video frames. It introduces different vision-based vehicle detection systems and explains how Haar Stunts can detect cars in rapidly changing environments. Experimental results show that this technique has over 90% accuracy in counting vehicles. With the cost of sensors, processors and CCTV cameras decreasing as well as image resolution increasing, this field is expected to continue to grow.

The paper proposes a system for locating missing entities using RFID-based techniques and a network of connected parked vehicles as a service delivery platform. The system is highly automated and is demonstrated through the use case of a missing Alzheimer's disease patient. Future research is proposed to optimize system parameters, ensure service quality, and explore energy management algorithms for parked vehicle components. Additionally, the authors propose to combine dynamic parking models and circular vehicle platforms to increase realism and explore the possibility of tracking missing entities. The article discusses advances in visual surveillance systems, especially in behaviour and event analysis, to detect the behaviour of humans and/or other objects. The focus is now shifting from low-level functions such as motion detection and segmentation to more complex scene analysis. Advanced behaviour/event analysis systems use pattern discovery to identify new behaviours/events and present them to experts for validation. The article reviews the developments and challenges in combining object tracking, motion analysis, behavioural analysis and biometrics for remote human subject recognition and behavioural understanding. The objective of this article is to provide an overview of video surveillance systems from a global perspective, reviewing existing work to understand the steps involved in a common video surveillance system, how to detect and analyze behaviour and intentions as well as approach challenges.

The document presents an automated system to identify possible vehicle theft through the detection of moving objects. The goal is to reduce car theft in parking lots, especially at night. The article proposes to use edge detection technique to achieve optimal effectiveness in preventing vehicle theft thanks to its accuracy and cost-effectiveness. The system extracts license plate characters and updates the status based on comparison with a preset table achieving 100° accuracy. This makes it a valuable tool for monitoring vehicles on campus and tracking their status. The paper presents an end-to-end system for vehicle retrieval based on detailed attributes, including a novel detection/tracking method for vehicle capture in challenging urban environments. The system is robust to crowded scenes and environmental factors, and comprehensive quantitative analysis is performed using real monitoring data. Future work includes leveraging the vehicle dataset to learn a general vehicle detector, adding additional feature plans to create a larger feature set, and developing adaptive methods of online response on a large scale.

[13] This article explains how smart surveillance systems can improve situational awareness by transforming video surveillance from a data-collection tool to an intelligence and information-gathering system. Real-time video analytics enables higher resolution information collection, while long-term activity provides spatio-temporal context for information analysis. As these systems continue to develop, they will be integrated with other sensors and spatial information devices, providing a rich mechanism for maintaining situational awareness. The article discusses advances in visual surveillance systems, especially in behaviour and event analysis, to detect the behaviour of humans and/or other objects. The focus is now shifting from low-level functions such as motion detection and segmentation to more complex scene analysis. Advanced behaviour/event analysis systems use pattern discovery to identify new behaviours/events and present them to experts for validation. The article reviews the developments and challenges in combining object tracking, motion analysis, behavioural analysis and biometrics for remote human subject recognition and behavioural understanding. The objective of this article is to provide an overview of video surveillance systems from a global perspective, reviewing existing work to understand the steps involved in a common video surveillance system, how to detect and analyze behaviour and intentions as well as approach challenges.

In this paper, a progressive approach to vehicle Re-Id based on deep learning uses deep CNN to extract appearance attributes as coarse filters and verifies license plates based on neural network Siamese scriptures when an exact search is suggested. Furthermore, the spatio-temporal relationships of vehicles in real-world urban surveillance are studied and incorporated into the proposed method. To facilitate the research, one of the largest vehicle re-identification datasets from urban surveillance video with various vehicle attributes, full license plate and spatial information- The exact time has been created. The experimental results verified that the proposed vehicle detection and tracking method for road surveillance video footage has good performance and feasibility. Compared with traditional hardware-based automotive traffic monitoring methods, the method in this article is low-cost, very stable, and does not require large-scale construction or installation on existing monitoring devices. Have. According to the research reported in this article, surveillance cameras can be further calibrated to obtain internal and external parameters of the camera. Therefore, the position information of the vehicle trajectory is converted from the image coordinate system to the world coordinate system. Vehicle speed can be calculated based on camera calibration results. Combined with the presented vehicle detection and tracking methods, unusual parking events and traffic congestion events can be detected to obtain richer traffic information. The method and results of the vehicle detection and counting system provided in this analysis will become an important reference for transport studies in Europe.

The article evaluates the placement of public surveillance cameras in and around Gaborone and applies situational crime prevention theory. Research shows many cameras are not located in grey areas, lack warning labels in the Setswana language and privacy concerns can be used as an excuse by violators. However, the light around the cameras is enough to enhance their effectiveness. The document calls for further research to evaluate the effectiveness of CCTV cameras and establish surveillance systems for public safety. Research shows that CCTV cameras are effective in preventing traffic violations, property crimes and crimes against people. Live inspection machines and 3D software can improve their accuracy. The optical correlation system presented in this paper is capable of guiding the vehicle along a pre-programmed route and automatically identifying and tracking targets in real-time. Up to 1,000 holograms are stored in one location using 100mm thick DuPont photopolymer and up to 10,000 holograms are stored in photorefractor crystals. This capability could enable mapping of an entire building or campus for automated vehicle navigation, storing several targets from every possible angle, scale and elevation for identification and tracking. automatic targeting, while using smarter correlation peaks, improved control algorithms, and optimized correlation models can further increase system capacity. This study presents a vehicle flow detection method to detect traffic anomalies, using optical flow estimation and nearest neighbour machine learning techniques. Test results on public highways show that it can detect vehicles traveling against the flow of traffic, but requires a dedicated camera for each lane. Future research topics include detection through a single camera, detection of different types of anomalies, and passerby detection. CMMR is an important topic for developing intelligent transportation systems but is difficult to recognize in limited light conditions due to a lack of features. This article proposes a method to recognize CMM at night using outstanding features of car rearview mirrors. The proposed method is robust and can handle many missing features, with an average recognition accuracy of 93.8%. Future work will involve finding more robust features of individual features to improve classification accuracy.

The title “Vehicle Surveillance and Identification Technologies” reflects the focus on research and development of technologies related to vehicle surveillance, identification and analysis in a variety of contexts. This field covers a wide 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.