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Advanced Multi Location IoT Enabled Smart Car Parking System with Intelligent Face Recognition

Sumit Das[1*], R. Kayalvihzi[2]
[1]Masters Student, School of Computing, SRM Institute of Science and Technology, Chennai, India
[2]Assistant Professor, Department of Networks and Communication, SRM Institute of Science and Technology, Chennai, India

***Abstract*: Smart city applications are increasingly being used in many countries because of the positive effects they have on citizens' quality of life and the environment through more efficient use of resources. Parking garages in smart cities typically have better access management and space distribution to cut down on congestion and wait times in high-density commercial zones. The human face is crucial in communication because it reveals a person's individuality. Biometric facial recognition technology, which uses a person's appearance as a means of identification, has gained a lot of popularity. In recent years, face recognition technology has become increasingly common because the user does not need to make any kind of physical touch with the device. The authentication process involves scanning the user's face and cross-referencing it with a database for verification. Additionally, it is easy to set up and doesn't necessitate any costly hardware. The usage of facial recognition technology is widespread across many different types of security systems, such as those used to manage physical access or computer user accounts. It is essential to monitor and manage the access of automobiles to parking places in order to improve the safety and security measures that are in place around the world. This article presents a study of face recognition-based access control system for vehicles entering the park, which can be conveniently deployed at the parking lot entrance.**

***Keywords*: smart city, face recognition, smart car parking.**

1. Introduction

Recently, the development of intelligent industry has been aided by the merging of industrial Internet of Things (IoT) and Artificial Intelligence (AI). The IoT technology used in the application like smart traffic and smart parking environments. The IoT receiver side provides users with four distinct features. Its primary function is to help the user find a vacant parking spot that meets their needs in terms of proximity to their destination and the quality of the available parking options. Second, it recommends a route to get there from where the user currently is, based on criteria such as travel time or traffic. Third, it facilitates real-time prediction of parking zone availability, which is comprised of clusters of parking places. In a privacy-conscious workplace, it provides an implementation that is in line with the General Data Protection Regulation [1]. One of the most exciting uses of IoT in the automotive sector is the Internet of Vehicles (IoV), which allows vehicles in motion to communicate with one another and with fixed objects such as infrastructure by the side of the road, distant servers, traffic control centres, and so on and so forth. Intelligent transportation systems will rely heavily on IoV because of the variety of vehicle services it is expected to enable. These services include navigation, entertainment, safety, and parking [2]. As a result of the significant analytic capabilities of big data, deep learning (DL), has been utilised rather frequently to model on data collected in industrial IoT. Traditional data-gathering centralised learning, on the other hand, is not suited to industrial circumstances that are sensitive to training sets, such as facial recognition and medical systems, because of privacy concerns [3]. Convolutional neural networks, more commonly referred to as CNNs, have emerged as an important technology in recent years because of their ability to help face tracking systems accomplish both the detection and recognition of faces. Traditional CNNs, however, typically have non-trivial computational time and considerable energy consumption, rendering them unsuitable for deployment in the large-scale time-sensitive face tracking system [4]. A first attempt was made to tackle the tough task of recognising emotions portrayed on a person's face by employing deep metric learning and facial picture synthesis. This was the first attempt of its kind. To supplement the training data, a StarGAN is technically implemented to generate synthetic facial images reflecting unique yet comprehensive basic emotions for each identity. Finally, a network based on deep convolutional neural networks is used for the purpose of automatically extracting hidden information from both real and synthetic face images [5]. Incorporating technological advancements, smart cities to improve the living conditions of their citizens. Among the most crucial features of intelligent metropolises is convenient public transportation. There is an increase in traffic congestion in urban areas as the number of cars in these areas rises. IoT devices and an ensemble-based predictive model for estimating parking spot availability [6]. In most cases, methods for parking lot vehicle detection require the use of energy-intensive and/or battery-operated sensor equipment. The use of a solar-powered energy harvester and an electronic wake-up signal as a prototype for a Bluetooth low-energy radio is explored. Together, these technologies are exploited to create a low-cost, autonomous node that can detect cars in the parking lot and report on their location [7]. In the context of the IoT, a dual lens

*Corresponding author: sd0459@srmist.edu.in

milli metre wave radar antenna is required for a smart parking system. To offset the loss of gain caused by penetration in MMW, a flat dielectric punch lens is employed to enhance the transmitting antenna's performance. To compensate for lost received energy because of scattering from the car chassis, a dielectric rod lens is used, which allows for the beam's direction to be altered while still maintaining a large beamwidth [8]. To alleviate this issue, a cutting-edge DL and cloud-based mobile smart parking app has been created. A parking space prediction service that is powered by DL and long short-term memory (LSTM) has been incorporated into the app. Here, the user's mobile device is given real-time access to the pre-existing the mobile device, an LSTM-based model is used, and the presentation of the park occupancy rates at the desired location is carried out by providing the necessary parameters [9]. Caps Field is a deep solution for facial expression and face recognition that employs a CNNs and a second capsule network that makes use of dynamic routing to discover the hierarchical connections between capsules. After producing face photos as a set of 2D sub-aperture images from each light field image, Caps Field learns the angular part-whole relations between these images using the information contained within the images [10].

2. Literature Survey

The utilization of face recognition has emerged as a significant method for verifying identity in various IoT applications, including infrastructure and communities of smart cities, smart buildings, and smart buildings. Numerous methodologies have been devised to address the various challenges associated with face recognition effectively. In real-world IoT applications, where data on human faces is limited, especially when captured by IoT devices with similar intrasubject variation, creating a model or representation becomes extremely challenging. In many cases, building a deep neural network model becomes impractical. This is particularly true when dealing with IoT applications and data captured by IoT devices with comparable intersubject variation [11]. The detection of facial action units involves the identification of facial expressions through the analysis of information related to the activity of specific individual muscles in the localized face region. When performed in edge devices, where specialised and unique algorithms are utilised to analyse the raw visual data from each camera, it is simpler to transmit the identified emotions to the end-user. Because of the huge network overhead required in delivering the facial action unit feature data, installing a real-time facial expression recognition system in a distributed manner while it is operational in a production environment can pose challenges. This is due to the fact that transmitting the data involves sending the facial action unit features [12]. AIoT systems that are equipped with artificial intelligence capabilities. Hence, the development of resilient deep learning models suitable for deployment on devices with limited resources has emerged as a significant area of investigation within the realm of 6G-enabled AIoT. In addition, a multi-objective gradient optimisation approach that, when combined with adversarial training and model delay limits, enables autonomous searching of network architectures [13]. Using the user's voice and facial expressions, can calculate an emotion index that can be used to track the user's emotional well-being over time. Using federated learning, users can safely train the model on their own local machines. Instead of sending actual data to the central server, the suggested technique merely communicates model weights, which are then integrated at the server to produce a superior global model and transmitted back to the users [14]. Two types of health checks can be performed in real time using a face mask health screener: The user's health data, including non-contact body temperature and blood oxygen saturation, is sent to the cloud for processing and visualization via an IoT node that performs detection of intelligent face masks in real time with the use of a multi-level, high-speed augmented CNN [15]. A CNN model can be used to determine an individual's emotional state. After being trained on the cloud overnight, the model is transferred to a local device, known as an edge server. During this part of the test, an end device such as a smartphone will capture a picture of a participant's face and processes it in several ways, such as detecting their features, cropping just their faces, increasing the contrast, and resizing the image. Once the image has been pre-processed, it is delivered to the edge server. Emotional inference is performed via a CNN model on the edge server [16]. Face expressions are one of the most prevalent methods by which humans convey their feelings to one another. To analyze human perceptual and emotional states, it is useful to recognize the many groups of face expressions. The field of facial expression analysis has garnered significant attention over the past few decades. Some facial expressions are hybrids of different fundamental expressions, rather than pure examples of any one of the designated affective states [17]. In particular, it constructs a featured dictionary with the help of employing both training and test images in the process. To this end, we can minimize the variation between samples of each class by using a shared feature that is learnt using a Gaussian mixture model was applied in a semi-supervised manner to both the training image and the test image. The estimated label serves as the seed for the test data's latent indicator in the optimization [18]. This system, comprising modules for face/fiducial detection, face association, and face recognition, achieves highly accurate unconstrained video-based face identification with swift processing speed. Intially begin by effectively locating faces in videos using multi-scale single-shot face detectors. Next, the identified faces are sorted into categories using face association techniques developed specifically for films with multiple camera angles. The face matcher is based on an unsupervised subspace learning technique as well as a subspace-to-subspace similarity metric. This face matcher is then used to identify the faces [19]. By treating each edge device as a node in a blockchain network, the blockchain-based decentralized authentication modelling scheme (called BlockAuth) can give a novel solution that is more secure, reliable, and fault-tolerant in an edge and IoT [20]. Face video retrieval requires searching a database for clips that feature a certain face, with either a picture or a video of that face serving as the query for the search. Face films include considerable intra-class differences due to different angle, illumination, and facial expression, making it difficult to extract discriminative characteristics with minimal storage capacity [21]. A multi-task cascading deep learning system for facial recognition. We tested our ability to identify faces using a variety of benchmark datasets, such as FDDB and WIDER FACE, and compared them to the most advanced algorithms currently available. In addition, we have conducted a number of experiments on three-layer and cloud-computing architectures in order to quantify the delay as well as the load that is brought on by face recognition [22]. The inpainting module converts textures captured in the near infrared wavelength range into the visible spectrum. When an near infrared image is combined with a visible image, the correction component converts any orientation to a frontal orientation. To combine the two into one cohesive deep network, a warping process is designed. Both a fine-grained discriminator and a discriminator based on wavelets aim to enhance image quality [23]. Intelligent parking solutions are quickly becoming a necessity to address these issues. There have been multiple attempts made by academics to use cutting-edge technology to entirely automate the process of assigning parking spots. The Research were made in Wireless Sensor Networks, Cloud Computing, Fog Computing, and the Internet of Things has greatly contributed to the advancement of intelligent parking services [24]. Many people are worried about the safety of their IoT devices. It has recently come to light that face detection under arbitrary occlusion is a major issue in the field of social security. In order to identify certain criminal activities, this study creates a novel face occlusion recognition system inside the IOT security domain [25].

3. Methodology

Traditional location-based attributes, including geographical, temporal, and capacity factors, are augmented with vehicle entry and exit events to enhance quality assurance. These parking events (PEs) are leveraged to generate dynamic features, enabling the system to adapt to temporary fluctuations in on-street parking availability. In addition, an OSPI add-on model called parking behaviour change detection is created to initiate prospective parking map modifications [26]. In particular, this study's original addition is the availability model's predominant usage of characteristics based on parking occurrences, dynamic features that keep or boost a model's performance.

A market-competitive model was sought, notwithstanding the biassed nature of the PE dataset. The PE dataset is skewed because it only includes data on available parking spaces and not on those already in use. Moreover, additional aggregate qualities can be derived from fundamental characteristics like parking capacity explained in figure 1.

Undoubtedly a major challenge in many poor countries is keeping track of traffic in this kind of setting. An innovative method of vehicle recognition and classification for the purpose of intelligent traffic monitoring. When processing aerial data, a CNN is utilized for the segmentation process. The images are divided, and then novel customised pyramid pooling is used to detect the automobiles. The vehicles that have been detected are then sorted into a number of different groups. Finally, Kalman filter (KF) and kernelized filter-based approaches are used to keep tabs on these vehicles, allowing for the management of large traffic flows with minimal human interaction [27]. After the frames have been reclaimed from the traffic video, they are subjected to an in-depth analysis of three unique types of noise, after which they are de-noised via a variety of filtering techniques. The optimal filter for each type of noise is applied only when necessary, and this includes the defogging of aerial photos in real time. Figure 2 shows the architecture system of traffic monitoring system.

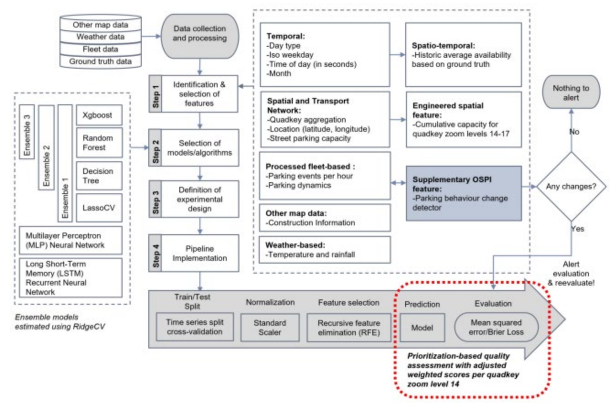

Fig. 1. Block diagram of data-driven on-street parking information system

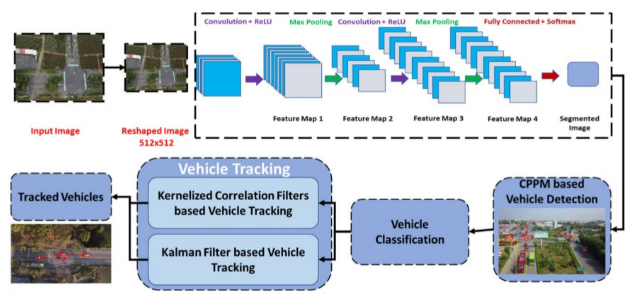

Fig. 2. Architecture system of traffic monitoring system

The design focuses on pre-processing, segmentation, and character recognition, three phases of image processing, to achieve high accuracy in licence plate identification. The number plate and car edges are located using a cunning edge detection method that employs a number of thresholds, contour detection, and masking techniques [28]. The first step in building an accurate model is called "pre-processing," and it entails adjusting the raw licence plate image so that it may be used by later stages.

Segmentation is the process of separating the changed image into smaller images of classifiable items (letters, numerals, etc.) so that the OCR can read the licence plate. OCR: Using optical character recognition to decipher the sub-images obtained from segmentation in order to determine the specific licence plate in system architecture shown in figure 3.

In the motion planning section, we take advantage of a recurrent network topology to expand upon a recently presented approach of using deep neural networks, often known as DNNs, are used to approximate the best parking trajectory. The primary objective is to make optimal use of the training procedure's intrinsic correlations between various states of the vehicle. As a means of achieving greater accuracy in manoeuvre trajectory tracking, an adaptive learning tracking control mechanism has been devised and implemented as part of the motion controller [29]. The RDNN motion planner has the capability of being modified to accommodate a variety of AGVs through the use of two different transfer learning algorithms. To maintain the desired AGV linear and angular velocities, an ALNN-based (adaptive learning neural network) control system is developed. Figure 4 explains the block diagram of the ALNN motion controller.

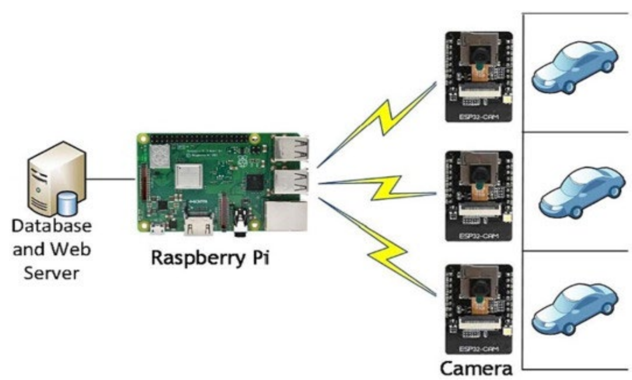

Fig. 3. system architecture of smart parking system

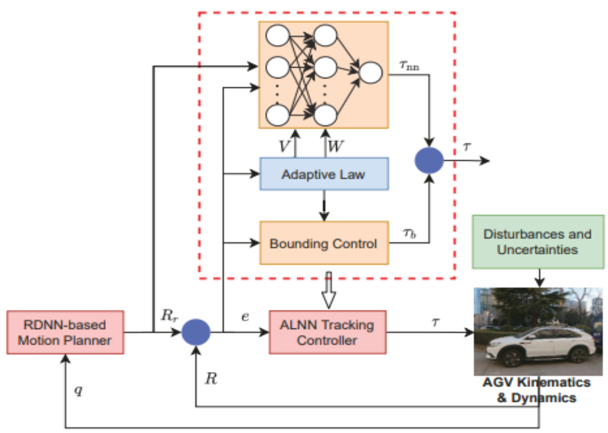

Fig. 4. Block diagram of ALNN based parking system

Using as minimal resources (such as time and space) as feasible, "Smart Parking" aims to find quicker and easier parking locations for automobiles through a combination of technological and human innovation. Users of a smart parking system will receive recommendations for available parking spots based on their preferences and the history of their use of the system. However, users' privacy may be compromised if their data is shared without their knowledge or consent with a third-party recommendation system. As the history of their pairings allows us to infer their behaviour and the mobility of their nodes [30]. Existing systems contain a number of flaws that leave users vulnerable in terms of their privacy and security. These flaws include worries about the revelation of one's identity and location, as well as availability and authenticity. Another problem with the methods that are currently used is that most distributed systems demand the involvement of a third party in the process of anonymizing user data shown in figure 5.

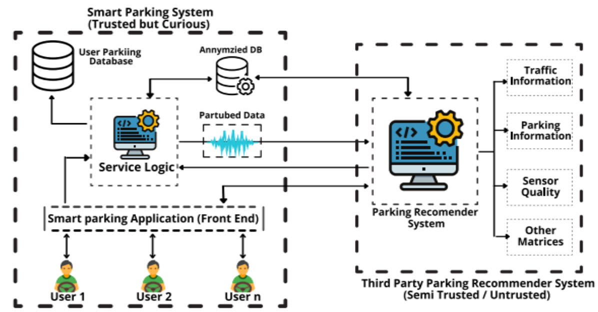

Fig. 5. Smart parking system using third party parking recommender

Parking spots that drivers will find useful in making a decision on where to park their cars are predicted by artificial neural networks. In the long run, this method helps drivers become more accustomed to the roadways, which improves their safety and happiness. The use of Deep Extreme Learning Machine (DELM) allows for increased trustworthiness at a low enough mistake rate that scepticism can be mitigated [31]. A DNNs size is directly proportional to the number of neurons that are present in its hidden layers. These neurons are essential to the functioning of the network. The key benefit of our approach is the drastically shorter training time and lower memory requirements for the network. Given these characteristics, it's likely that the following technique for improving network performance can be performed with limited resources. Figure 6 explains the block diagram of car parking space prediction.

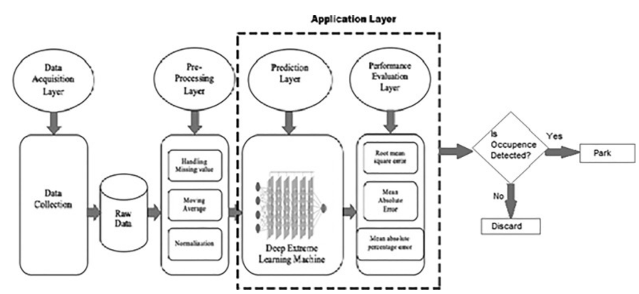

Fig. 6. Block diagram of car parking space prediction

Vehicles in Internet of Vehicles (IoV) situations have access to computing resources that allow them to run IoV apps with a focus on the vehicle itself. In the meantime, Multi-access Edge Computing (MEC) scenarios offer the opportunity to make use of these computing capabilities in order to reduce the workload placed on edge servers and enhance the rate at which devices complete activities. In the context of Mobile Edge Computing (MEC), a method for jointly offloading tasks and allocating resources is essential. This scenario encompasses various devices, stationary cars, and mobile vehicles all served by a Base Station (BS) equipped with an edge server, as illustrated in Figure 7. Devices can unload their duties to the base station

(BS), which in turn can delegate them to the vehicles. Our system model accounts for the amount of time an on-the-move vehicle can offload tasks before leaving the range of the BS's signal [32].

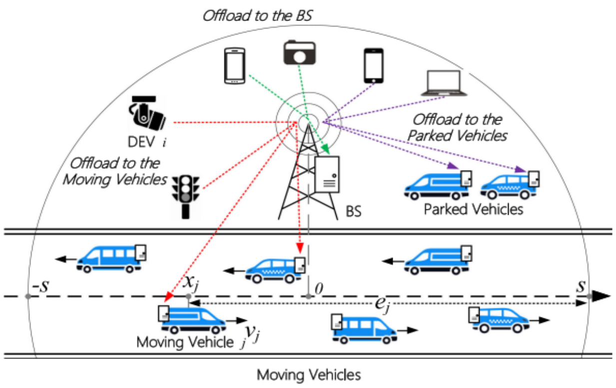

Fig. 7. Network topology of Mobile Edge Computing (MEC) facilitated by mobile vehicles

In [33], process also includes the planning and commissioning of a smart transport system. The development of smart cities is primarily reliant on technology advancements made in the fields of information and communication networks and the IoT. In order to boost the level of service provided by the local government and encourage increased engagement between the populace and the administration. To keep an eye on cities for many reasons, it streamlines communication between authorities and the general public and municipal infrastructure. With the support of IoT, city services are expected to improve in both quality and interactivity. Registering vehicle information using a roadside sensor is the initial stage in the traffic management concept. It also specifies where the vehicle needs to go once it arrives. In order to collect traffic data, the roadside sensor in one area is linked to its counterpart in another area. The traffic conditions along a potential first route for a vehicle are examined. If the first option is doable, it is presented; if not, the second option is explored, and so on. Congestion in metropolitan areas can thus be reduced by directing vehicles along the most efficient route. Figure 8 shows the System Architecture of IoT-based smart transportation system for smart cities.

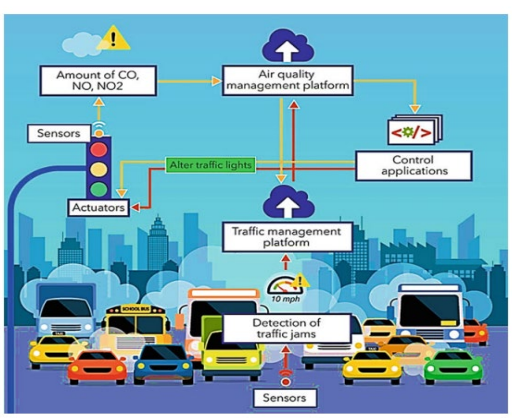

Fig. 8. System architecture of IoT-based smart transportation system for smart cities

Parking management through the use of federated learning, as well as the presentation of FedParking, a system in which Parking Lot Operators (PLOs) collaborate with one another to train a LSTM model for parking spot prediction without sharing the raw data. We also look into FedParking's administration of PVEC (Pooled Vehicle Assisted Edge Computing). The incentive structure for PVEC is established on the foundation of compute demand and parking capacity constraints derived from FedParking. Various PLOs actively engage in PVEC by offering incentives to PVs, encouraging them to act as edge computing nodes for service offloading. This incentive structure is based on the compute demand and parking capacity limitations that are determined from FedParking [34]. FedParking is an application of federated learning for the estimation of parking space that enables several PLOs to maintain ownership of their raw data while cooperatively training a global model. This is accomplished by merely exchanging the updated model parameters with a parameter server. Figure 9 shows the system design of fed parking.

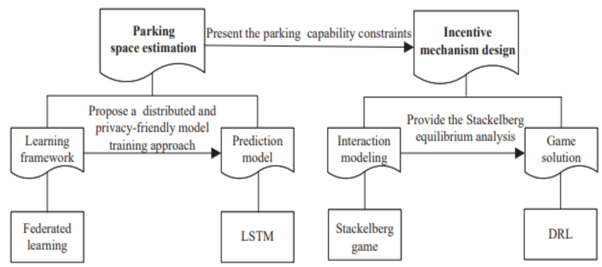

Fig. 9. System design of feding parking

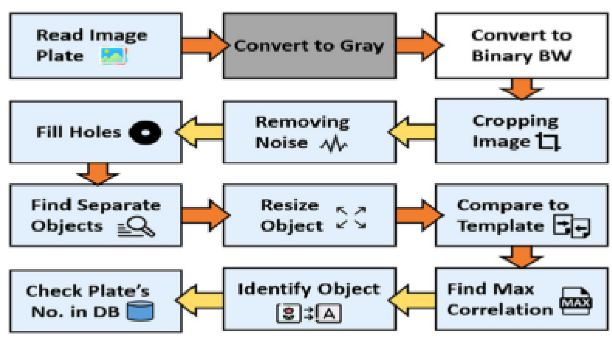

Fig. 10. Block diagram of web-based smart parking system

While millions of smart services and applications have significantly improved various aspects of our lives, including transportation, health, education, business, and more, smart cities still hold great potential for the residents who inhabit them. One of the prevalent challenges that smart cities strive to address is the congestion in public transport system by introducing IoT technologies and AI algorithms for the development of infrastructure. Findings from this study illustrate the contribution of parking in some streets and key locations to urban traffic congestion [35]. It also suggests a web app that is based on an OCR algorithm to automatically book empty seats for users before they arrive at the venue, and then it fine-tunes the process based on the results of that app's identification of the composite plate. This app will be able to automatically reserve seats for users based on the information that they provide into the website the system architecture shown in figure 10.

4. Conclusion

Facial recognition possesses a wide range of applications and are anticipated to be seamlessly incorporated into diverse systems in the forthcoming years. They are considered to be one of the most highly favoured varieties within the field of biometrics. The camera utilises facial scanning technology to compare the user's face with a pre-existing database in order to authenticate their identity. Additionally, the installation process is straightforward and does not necessitate the use of costly gear. Facial recognition technology is extensively employed in diverse security systems, including physical access control and online user accounts. It is important to create comprehensive surveillance and regulating protocols for vehicular access within parking facilities in order to strengthen the global security measures that are in place.

References

[1] Saleem Y, Sotres P, Fricker S, de La Torre CL, Crespi N, Lee GM, Minerva R, Sanchez L. IoTRec: The IoT recommender for smart parking system. IEEE Transactions on Emerging Topics in Computing. 2020 Aug 6;10(1):280-96.

[2] Yang T, Zhang N, Xu M, Dianati M, Yu FR. Guest Editorial Special Issue on Space–Air–Ground-Integrated Networks for Internet of Vehicles. IEEE Internet of Things Journal. 2022 Apr 6;9(8):5666-9.

[3] Fu A, Zhang X, Xiong N, Gao Y, Wang H, Zhang J. VFL: A verifiable federated learning with privacy-preserving for big data in industrial IoT. IEEE Transactions on Industrial Informatics. 2020 Nov 6;18(5):3316-26.

[4] Liu X, Yang J, Zou C, Chen Q, Yan X, Chen Y, Cai C. Collaborative edge computing with FPGA-based CNN accelerators for energy-efficient and time-aware face tracking system. IEEE Transactions on Computational Social Systems. 2021 Feb 25;9(1):252-66.

[5] Huang W, Zhang S, Zhang P, Zha Y, Fang Y, Zhang Y. Identity-aware facial expression recognition via deep metric learning based on synthesized images. IEEE Transactions on Multimedia. 2021 Jul 9;24:3327-39.

[6] Tekouabou SC, Cherif W, Silkan H. Improving parking availability prediction in smart cities with IoT and ensemble-based model. Journal of King Saud University-Computer and Information Sciences. 2022 Mar 1;34(3):687-97.

[7] Šolić P, Leoni A, Colella R, Perković T, Catarinucci L, Stornelli V. IoT-ready energy-autonomous parking sensor device. IEEE Internet of Things Journal. 2020 Oct 14;8(6):4830-40.

[8] Cai Z, Zhou Y, Qi Y, Zhuang W, Deng L. A millimeter wave dual-lens antenna for IoT-based smart parking radar system. IEEE Internet of Things Journal. 2020 Jun 23;8(1):418-27.

[9] Canli H, Toklu S. Deep learning-based mobile application design for smart parking. IEEE Access. 2021 Apr 22;9:61171-83.

[10] Sepas-Moghaddam A, Etemad A, Pereira F, Correia PL. Capsfield: Light field-based face and expression recognition in the wild using capsule routing. IEEE Transactions on Image Processing. 2021 Feb 1;30:2627-42.

[11] Yang S, Wen Y, He L, Zhou M, Abusorrah A. Sparse individual low-rank component representation for face recognition in the IoT-based system. IEEE Internet of Things Journal. 2021 May 13;8(24):17320-32.

[12] Yang J, Qian T, Zhang F, Khan SU. Real-time facial expression recognition based on edge computing. IEEE Access. 2021 May 21;9:76178-90.

[13] Wang K, Xu P, Chen CM, Kumari S, Shojafar M, Alazab M. Neural architecture search for robust networks in 6G-enabled massive IoT domain. IEEE internet of things journal. 2020 Nov 24;8(7):5332-9.

[14] Chhikara P, Singh P, Tekchandani R, Kumar N, Guizani M. Federated learning meets human emotions: A decentralized framework for human–computer interaction for IoT applications. IEEE Internet of Things Journal. 2020 Nov 10;8(8):6949-62.

[15] Deepa T, Hariprasad S, Bharathiraja N, Chokkalingam A. A Real Time Face Mask Detection and Health Status Monitoring using Deep Learning after Pandemic. In2022 International Conference on Augmented Intelligence and Sustainable Systems (ICAISS) 2022 Nov 24 (pp. 430-435).

[16] Muhammad G, Hossain MS. Emotion recognition for cognitive edge computing using deep learning. IEEE Internet of Things Journal. 2021 Feb 10;8(23):16894-901.

[17] Li W, Luo M, Zhang P, Huang W. A novel multi-feature joint learning ensemble framework for multi-label facial expression recognition. IEEE Access. 2021 Aug 30;9:119766-77.

[18] Yang S, Wen Y, He L, Zhou M. Sparse common feature representation for undersampled face recognition. IEEE Internet of Things Journal. 2020 Oct 15;8(7):5607-18.

[19] Zheng J, Ranjan R, Chen CH, Chen JC, Castillo CD, Chellappa R. An automatic system for unconstrained video-based face recognition. IEEE Transactions on Biometrics, Behavior, and Identity Science. 2020 Feb 14;2(3):194-209.

[20] Zhaofeng M, Jialin M, Jihui W, Zhiguang S. Blockchain-based decentralized authentication modeling scheme in edge and IoT environment. IEEE Internet of Things Journal. 2020 Nov 12;8(4):2116-23.

[21] Choi YR, Kil RM. Face video retrieval based on the deep CNN with RBF loss. IEEE Transactions on Image Processing. 2020 Dec 4;30:1015-29.

[22] Kolhar M, Al-Turjman F, Alameen A, Abualhaj MM. A three layered decentralized IoT biometric architecture for city lockdown during COVID-19 outbreak. Ieee Access. 2020 Sep 4;8:163608-17.

[23] He R, Cao J, Song L, Sun Z, Tan T. Adversarial cross-spectral face completion for NIR-VIS face recognition. IEEE transactions on pattern analysis and machine intelligence. 2019 Dec 24;42(5):1025-37.

[24] Awaisi KS, Abbas A, Zareei M, Khattak HA, Khan MU, Ali M, Din IU, Shah S. Towards a fog enabled efficient car parking architecture. IEEE Access. 2019 Nov 1;7:159100-11.

[25] Mao L, Sheng F, Zhang T. Face occlusion recognition with deep learning in security framework for the IoT. IEEE Access. 2019 Dec 2;7:174531-40.

[26] Gomari S, Domakuntla R, Knoth C, Antoniou C. Development of a data-driven on-street parking information system using enhanced parking features. IEEE Open Journal of Intelligent Transportation Systems. 2023 Jan 10;4:30-47.

[27] Rafique AA, Al-Rasheed A, Ksibi A, Ayadi M, Jalal A, Alnowaiser K, Meshref H, Shorfuzzaman M, Gochoo M, Park J. Smart Traffic Monitoring Through Pyramid Pooling Vehicle Detection and Filter-Based Tracking on Aerial Images. IEEE Access. 2023 Jan 5;11:2993-3007.

[28] Abdellatif MM, Elshabasy NH, Elashmawy AE, AbdelRaheem M. A low cost IoT-based Arabic license plate recognition model for smart parking systems. Ain Shams Engineering Journal. 2023 Jun 1;14(6):102178.

[29] Chai R, Liu D, Liu T, Tsourdos A, Xia Y, Chai S. Deep learning-based trajectory planning and control for autonomous ground vehicle parking maneuver. IEEE Transactions on Automation Science and Engineering. 2022 Jun 23.

[30] Khaliq AA, Anjum A, Ajmal AB, Webber JL, Mehbodniya A, Khan S. A secure and privacy preserved parking recommender system using elliptic curve cryptography and local differential privacy. IEEE Access. 2022 May 17;10:56410-26.

[31] Siddiqui SY, Khan MA, Abbas S, Khan F. Smart occupancy detection for road traffic parking using deep extreme learning machine. Journal of King Saud University-Computer and Information Sciences. 2022 Mar 1;34(3):727-33.

[32] Fan W, Liu J, Hua M, Wu F, Liu YA. Joint task offloading and resource allocation for multi-access edge computing assisted by parked and moving vehicles. IEEE Transactions on Vehicular Technology. 2022 Feb 9;71(5):5314-30.

[33] Fantin Irudaya Raj E, Appadurai M. Internet of things-based smart transportation system for smart cities. In Intelligent Systems for Social Good: Theory and Practice 2022 Jun 11 (pp. 39-50). Singapore: Springer Nature Singapore.

[34] Huang X, Li P, Yu R, Wu Y, Xie K, Xie S. FedParking: A federated learning based parking space estimation with parked vehicle assisted edge computing. IEEE Transactions on Vehicular Technology. 2021 Jul 20;70(9):9355-68.

[35] Alharbi A, Halikias G, Yamin M, Abi Sen AA. Web-based framework for smart parking system. International Journal of Information Technology. 2021 Aug;13(4):1495-502.