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RESEARCH ARTICLE

Intelligent Face Recognition Based Multi-Location Linked IoT Based Car Parking System

VANKADHARA RAJYALAKSHMI AND KURUVA LAKSHMANNA
SITE, Vellore Institute of Technology, Vellore 632014, India

Corresponding author: Kuruva Lakshmanna (lakshman.kuruva@vit.ac.in)

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ABSTRACT Many nations are adopting smart city applications, which boost residents' satisfaction with their living conditions and reduce pollution by better-using people's time and resources. Multi-Location parking garages are standard in smart cities because they allow for better access control and space allocation to avoid traffic and delay in complex business areas. The Internet of Things (IoT) has the potential to link billions of devices and services worldwide, at any time, and for a wide range of uses. Smart parking is currently one of the most talked-about subjects in IoT research. More than a million cars are on the roadways of a contemporary major city, but more parking spots are needed to accommodate them. The main idea of the research is to link multiple parking stations as a single unit using IoT and to design a shared parking system to avoid delays in parking. An intelligent parking system is proposed in this research to help users overcome the challenge of locating parking and reduce the time spent searching for the closest accessible parking spot. In order to ensure the safety of highly restricted places such as residential areas, military bases, and government buildings, the system has developed to serve as the centralized automatic vehicle identifier for owner identification.When a vehicle enters the parking station, the slot number will display with the vehicle number and capture the Driver's image to maintain vehicle security. If the slots are unavailable, the model displays the corresponding parking station slot number to avoid delay. The image processing technique is applied to recognize the driver/owner of a vehicle while leaving the parking station to avoid the theft of vehicles and to enhance vehicle security. Suppose a driver is allowed or denied access to a particular parking station. In that case, they can see this information clearly on the user interface installed at the exit gate. The proposed algorithm is an Intelligent Face Recognition based Multi-Location Linked IoT-based Car Parking System (IFRbMLL-IoT-CPS) for secure car parking that reduces parking delay with better efficiency levels. The proposed system also reduces traffic congestion, saves drivers valuable time and money, innovative natural resource usage, lowers pollution, wastage of fuel, and improves vehicle security. The proposed model exhibits better performance when contrasted with traditional models.

INDEX TERMS Smart city, car parking, multi-location linked parking, image processing, face recognition, Internet of Things, vehicle security.

I. INTRODUCTION

In recent years, smart cities have become a highly discussed topic. The concept of a smart city is starting to seem realistic due to advancements in the Internet of Things (IoT). Consistent research and development in the field of IoT are being conducted to improve urban infrastructure's efficiency and dependability [1]. IoT solutions are being implemented for issues like traffic congestion, inadequate parking, and unsafe driving conditions. The world's car population is projected to grow from 1389 million in 2021 to more than 2.3 billion in 2035. Public facilities like stadiums, market areas, hospitals, retail malls, and airports all have parking lot shortages, so governments are working on upgrading their

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transportation networks [2]. However, the issue has become much more widespread due to the delayed development of city planning. Locating vacant parking places in most contemporary cities might take time, especially during busy periods like festival seasons.

The issue is most prevalent in today's metropolitan areas, where a large influx of automobiles competes for a limited supply of available parking spots and threatens the safety of parked vehicles [3]. Moreover, most of the time is spent at indoor parking lots looking for an empty spot, which adds to the congestion [4]. The situation deteriorates rapidly when every parking lane has a surplus of available spots [5]. Outside or underground, cars idling in parking lots contribute to air pollution. In addition, most people use their automobiles for transportation, increasing city traffic and making it more difficult for other motorists to locate a vacant parking spot [6]. Cost-effectively transmitting such data, conserving energy, and making timely information readily available are all pressing concerns that must be addressed. There is a growing interest in intelligent parking systems in several nations due to the growing difficulty locating parking spaces [7]. The IoT equips us to face such difficulties since it may be configured to collect sensor data for monitoring smart city hotspots [8].

Connecting various devices began with the concept of things or identities. Control and monitoring of these gadgets can be performed remotely via the Internet from a computer. The two most powerful words in IoT are Internet and Things [9], and the Internet is a massive network that links servers to devices. The Internet allows for the transfer of data and the establishment of two-way communication between various devices. Congestion and pollution in the air directly result from the parking issue [10]. These days, finding parking in the middle of the city is difficult. That is why installing a smart parking system is crucial for reducing fuel waste and pollution [11]. Smart parking could reduce the time and effort spent looking for a parking spot and the money spent on fuel. The process begins with collecting sensor data from multiple parking slots, which is then analyzed and processed to provide the final result [12].

Currently, the average number of cars owned by a single household is more than the number of people living in that home. As a result, the number of cars on the road has increased across the country, creating a parking situation that needs to meet the needs of its citizens. This makes it more challenging to find parking, which increases the time required and the gasoline the car uses [13]. As a result, parking is a significant issue for businesses and offices in urban locations, especially during the week. Even middle-class families can purchase a car in today's market, and low-income households can join the car-owning club [14]. Parking spaces are also at a premium in these overcrowded cities because of the rise in cars. Parking is a significant problem everywhere, from retail centers and malls to train and airline terminals. People waste much time looking for parking spots [15]. Searching causes traffic jams, making it difficult for drivers to locate a suitable parking spot. In urban areas, car congestion is the primary cause of traffic, and as a result, drivers have to waste time driving around aimlessly, looking for parking spaces [16]. Moreover, pollution is a global problem caused by the rise in vehicle numbers. Figure 1 shows the general parking slot allocation.

FIGURE 1. **Parking slot allocation.**

An intelligent central car parking system for integration into a smart-city IoT architecture is proposed in this research. An IoT management center administrates the smart city via an IoT-integrated services portal. At the bottom, several business services explore a standard interface to the communication layer [17]. These include a car parking locator, supervision, information services, and a driver face recognition model for enhancing the security of the vehicles also. Different sensing technologies could be utilized at the sensor layer for embedded parking solutions, such as Radio Frequency Identification (RFID) [18] for car parking access control; laser, passive infrared, microwave radar, ultrasonic, passive acoustic array sensors, or Closed-Circuit Television (CCTV) with video image processing for detecting the status of the car parking lots; license plates with installed 3G/4G communication module for cars' tracking and tracing, etc.

To enable the car parking system to work as an operational platform in a smart city, different car parking areas must be distinguished in providing the 'best' car parking lots by executing different business roles and applications [18]. The car parking areas could be divided into categories based on their properties. A transportation hub area, a residential/community area, a ground/street area, and a shopping mall/hotel/restaurant area are classified. The cars can get a parking slot from a central parking allocation center [19]. The relevant management and control entities, including a highway center, emergency center, traffic control center, and police, can access the information managed by the car parking information center with high authority [20]. The sensors deployed in the car parking area periodically send updated information regarding occupancy of the car parking lots to the car parking central stations, pushing this data to the information center [21]. Vehicle ownership is now far more accessible than it was a decade ago. Attempting to locate a parking space has become routine for many people

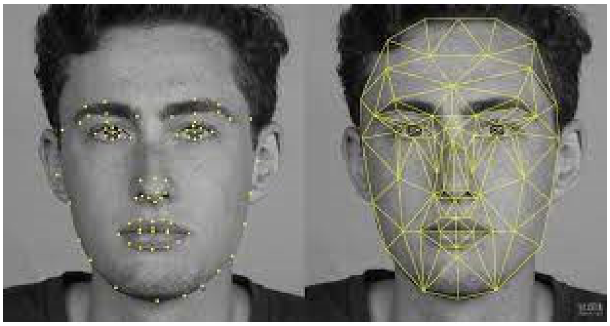

FIGURE 2. Face recognition pixel sets [25].

worldwide. It might happen in the workplace, the mall, or the university [22]. This activity uses up a significant portion of the world's oil supply daily. If these issues are resolved, they will get better. Consequently, a smart parking system that integrates facial recognition and optical character recognition with an IoT device is proposed to reduce the waste of parking space and maximize security for the vehicles also [23]. To determine who is driving, facial recognition technology is introduced. The face of the driver is captured, and the entry-level and the exact vehicle will be verified at the exit level to avoid vehicle theft [24] by verifying the driver with the registered phase. IoT would be connected with the entrance of the parking spot, and RFID sensors would determine whether or not the spot is occupied, ensuring that vehicles would only be let out if their driver and vehicle matched those in the database.

The primary of face recognition is to recognize a person's face. Face recognition provides several benefits compared to other bio-metric methods, like fingerprinting or iris scanning. Distance is not an issue in facial recognition [26]; hence, personal interaction is not necessary for identity verification [27]. Therefore, bio-metric verification is the most practical choice since it dramatically reduces the time needed for the verification process. Facial recognition algorithms come in many flavors. Figure 2 the face recognition process. The Convolutional Neural Network algorithm is used for facial pixel set detection, and the Canny edge detection method is used for facial edges/boundaries identification.

In order to begin the process, the entered vehicles and the driver images are stored in the database. During exit levels [28], the vehicle and driver faces are recaptured and verified with the database for authentication [29]. This process allows only authenticated users to leave the parking and maintain high security for the vehicles. An Intelligent Face Recognition-based Multi-Location Linked IoT-based Car Parking System is proposed to perform specified operations for secured car parking that reduces delay with better efficiency.

II. LITERATURE SURVEY

The automotive industry is fast growing to fulfill the rising demand for cars as a means of transportation. As the number of automobiles on the road has expanded, parking has become increasingly complex, resulting in congestion, time, air pollution, and fuel wastage. However, the number of parking spaces in cities is growing slower than the number of cars. In order to solve these issues, smart parking solutions are becoming essential. Multiple specialists have attempted to utilize advanced computational capacity to allocate parking spots automatically via programming. Experts in domains such as Wireless Sensor Networking (WSN), Cloud Technology (CT), Fog Computing (FC), and the Internet of Things (IoT) have worked hard to improve parking services that employ these technologies. Until recently, only a few groups of academics had formulated plans for intelligent parking lots to use cloud computing infrastructure. However, intelligent transportation and parking systems have a higher stake in resolving this latency problem than other cloud-based services. Fog computing, which pushes cloud computing resources to the network's edge, eliminates latency while addressing scalability, portability, and security concerns. The proposed solution by authors in [3] uses fog computing to lessen the smart parking system's dependence on the network and its accompanying delay. Through iFogSim simulations, users can see that the proposed solution successfully decreases delay and network utilization compared to cloud-based deployments of the smart parking system. The authors in [3] described a cloud-based setup in the iFogSim simulator. Multiple cameras and LEDs are connected to the cloud server via a router for performance evaluation in a cloud-based scenario. Cameras send images of parking spaces to a cloud server. The cloud server processes the images of parking slots, and the information about the parking slots is displayed on the LED linked to the cloud server. The number of cameras was gradually increased to investigate the importance of latency and network usage. Compared to the cloud-based implementation, the experimental results show that the fog-based implementation results in lower latency and network usage. Fog Computing helps in the quick processing of data.

In highly populated areas, searching for parking adds to congestion and pollution. IoT-based smart parking system [30] improvements have been shown to reduce gridlock by alerting motorists to available spots. Most parking lot vehicle recognition technologies are either extremely power-hungry or run on portable, battery-powered sensors. Solic et al. [4] detailed a hardware-based approach to develop a self-sufficient sensing node capable of detecting the presence of a vehicle in its immediate vicinity. Currently, researchers are testing the feasibility of using a solar-powered energy capture system and wake-up trigger prototype with a Bluetooth low-energy (BLE) device for detection purposes. The integration of these technologies enables the development of a cheap, self-sufficient node that can monitor the parking lot for the presence of vehicles and report on their condition. The intended trigger system uses a mere 150 nA of electricity. The light level difference of only 6.5 W/m^2 between the two panels is sufficient to set off the trigger since solar radiation measured under the vehicle significantly differs from diffuse horizontal irradiance.

In recent years, an ever-increasing number of vehicles on the road has stressed urban parking facilities. In this regard, Cai et al. [5] designed a dual-lens millimeter wave (MMW) radar antennae for use in an IoT-based smart parking system. Using a flat visco-elastic punch lens, authors can increase the transmitter's strength to compensate for the loss of penetration inherent to MMW. A dielectric rod lens alters the beam's direction while maintaining the beamwidth, compensating for the loss of received energy caused by the scattering of the car chassis. The combination dual-lens antenna improves the accuracy and dependability of MMW radar if it works at 24 GHz. It was found that the transmitting antenna had a gain of 15.8 dBi, the receiving antenna had a gain of 7.9 dBi, and the 3-dB beam-width was roughly 65 degrees. The measurements show that the proposed antenna performs well in the lab and is a good fit for the MMW radar in the intelligent parking system.

In the era of the IoT and sustainable urban ecosystems, Canli et al. [8] argued that innovative smart parking systems are crucial to developing greener metropolitan areas. As the city's car population grows, parking becomes increasingly challenging and time-consuming. The existing options are inadequate for users' needs. Driving around searching for a parking spot causes wasted time, fuel, pollution, and stress. To address this issue, this research developed a novel mobile smart parking application using cloud-based deep learning. The software features a parking spot prediction service backed by deep learning and Long short-term memory (LSTM). In this case, the user's mobile device can instantly access the LSTM-based model established earlier. The process of displaying the park occupancy rates at the desired location is completed on the mobile phone by giving the relevant parameters. There have been efficiencies made in both energy use and maintenance time. Using real-time data gathered from Istanbul, Turkey, parking lots, the authors demonstrated the reliability of the findings. The proposed novel model was tested against other popular methods, such as Random Forest, Support Vector Machines, and ARIMA, to prove its worth.

Light field (LF) cameras have recently emerged as a possible solution for improving human-machine systems such as biometrics and practical computing due to the rich temporal pictorial representations they provide by observing the visual scene from various perspectives. While the LF representation has proven helpful in analyzing specific facial images, it has never been applied to actual faces or facial expressions. To address this issue, Sepas-Moghaddam et al. [9] presented CapsField, a novel deep face and face recognition solution based on a convolutional neural system and an additional capsule network that uses routing updates to learn relationships between capsules. By analyzing facial photographs and extracting pertinent spatial information, CapsField can understand the angular part-whole correlations for a limited set of 2D sub-aperture images formed from each LF image. The author collected and made available the first LF face dataset and a new supplementary constrained face dataset from the same participants recorded in the original study, all to evaluate the performance of the proposed approach in real-world settings. Photographs of people in the outdoors have been annotated for use in research on facial emotion recognition. When comparing and matching photos collected in various wavelength ranges of light, heterogeneous facial recognition software can identify faces, also known as NIR-VIS or near infrared-visible. VIS face recognition algorithms are being brought into the NIR range using VIS image synthesis from NIR photographs. However, when comparing the NIR and VIS images of a face, the former will always lack some visible brightness due to self-occlusion and the latter due to a sensing gap. High-resolution heterogeneity face synthesis is modeled in this research by He et al. [31] as the result of a mutually reinforcing interaction between two separate but related procedures: texture inpainting and position correction. The inpainting module uses the NIR texture data to generate a new texture data set that may be applied to the VIS images. Each NIR picture position is converted to a frontal VIS image pose via the correction component, resulting in consistent textures throughout both wavelength ranges. A warping procedure is developed to fuse the two deep networks into a more robust system. Improving image quality is an aim shared by the fine-grained classification model and the wavelet-based discriminator. A novel 3D-based pose correcting loss, two adversarial losses, and a pixel loss are imposed to ensure successful synthesis outcomes. The author demonstrated that the spectral and postural discrepancies during heterogeneous recognition are reduced, and the complexity of heterogeneous face synthesis is decreased, by switching from one-to-many uncommitted image translating to one-to-one matched image translations, as a result of incorporating the correction component. As the model is with the parking station. Light or visibility issues will not occur as sufficient light is provided in the image capturing section.

A smart city's widespread IoT sensors might make collecting massive amounts of publicly available data challenging. In this research, Li et al. [10] proposed a novel urban vehicle network, which refers to as the LUV (location-based urban vehicular network), to complete the smart city's non-real-time information gathering duty. The author analyzed trace data from 8900 privately owned vehicles in Changsha, China, and based on the findings. The author focused less on moving vehicles and urban streets and more on parked vehicles and parking lots. Wireless connections are more reliable and predictable using a location-based strategy, and the system's topology is significantly reduced. It ensures that a vehicle network deployed in a dense metropolitan area can collect the most data possible.

The authors in [12] developed a novel framework for extracting highly condensed and segmented facial video for retrieval applications using deep convolutional neural networks (CNN). Face video retrieval is searching a database for videos containing a given face, using either an image or a video of the face as a query. Extracting discriminant information from face recordings is complicated due to large intraclass fluctuations caused by camera angle, illumination, and facial expression variances. Using CNNs and binary hashing, researchers have achieved significant advancements in the image and video retrieval in recent years. However, storage limitations and inevitable data loss constrain the present CNN-based digital hashing and metrics learning. The proposed framework proposes a two-pronged fix for these problems. First, a novel loss function is introduced that uses a radial basis functions kernel (RBF Loss) to train a neural net to produce compressed and discriminatory high-level features; second, an optimized representation using a sigmoid function is suggested to transform a true attribute to a 1-byte integer value with the relatively limited level information loss. Through trials with face information extraction on a challenging TV program data set, it is proven that the proposed framework outperforms state-of-the-art approaches for feature extraction.

Large data systems in the IoT, such as those found in smart cities, smart healthcare systems, and industrial IoT systems, can be converted into networked sensor nodes in recent years. When used to the IoT, edge computing has the potential to enhance algorithm efficiency, customer experience, operational efficiency, economic viability, and environmental protection, all while encouraging more sustainable corporate practices. Facial expression unit detection analyses signal produced from the action of atomic muscles in the immediate facial region to recognize emotions sent by the face. The computed face emotion values from the subject's facial feature points can then be employed in classification algorithms to assess the subject's emotional state. When the essential visual information from each camera is processed in edge devices using optimized and proprietary algorithms, sending the identified emotions to the end user is much easier. An extensive network overhead caused by transmitting the facial expression unit features data makes it challenging to implement a distributed real-time face recognition system in an operational situation. Due to this, Yang et al. [13] developed a lighter-edge technology distributed network based on Raspberry Pi and expedited data transit and component deployment. In order to reduce latency and facilitate the execution of complex calculations and the provision of a highly reliable, scalable providing framework, local separation of front- and back-end processor modes is essential. They can be modified into wireless, networked sensor systems for IoT and smart city applications.

The improved processing capabilities of resource-constrained devices, such as smartphones, are essential to the success of many IoT applications. Recovering photos from a smartphone in an IoT environment is challenging due to computational and storage concerns. In order to retrieve images from the vast amounts of data generated by the Internet of Things, Mehmood et al. [14] proposed a lightweight deep learning-based solution for devices with limited resources. At first, a face and nonface classifier and the Viola-Jones method are used to identify and extract the face areas from a picture. Additionally, a low-cost pretrained Classification algorithm employing predefined features represents the faces. After then, the features of the large data repository are indexed to facilitate a faster matching process and near-instantaneous retrieval. Finally, the author used the Euclidean distance to evaluate how well the images match those already in the collection. A database of local facial pictures is collected for the experimental evaluation, individually and in groups. This dataset can benchmark the performance of several real-time facial picture retrieval methods.

III. PROPOSED METHOD

Sustainable development, economic progress, and enhanced quality of life are all made possible by the smart city idea, which involves the integration of Information and Communication Technology (ICT). Intelligent transportation and effective traffic management solutions are being developed to help drivers better plan their routes and reduce traffic congestion. Currently, cars must find a parking spot by scouring the lot until they locate a vacant one. This results in the loss of productive time, which can slow down the economy. Moreover, automobiles waste fuel waiting in traffic, contributing to high greenhouse gas emissions. A smart parking system, which allows drivers to locate and book parking spots before they even get to their desired parking slot, can help alleviate these problems. Any big city in the globe would benefit significantly from such a system, but it would benefit festivals and other special events. Congestion would be alleviated, pollution would decrease, and the adverse effects on the city's environment and aesthetics would become lesser.

The proposed driver face edge detection technique uses for accurate edge detection of the face. Maximum pooling layers includes in the model's four-stage down-sampling process. There are four leftover blocks between stages. A depth-wise convolutional layer, a ReLU layer, and a point-wise convolutional layer comprise each block's residual path. We additionally employ the side structure to build an edge map at each stage, based on which a side loss is calculated with the ground truth map to offer deep supervision, allowing us to learn rich recursive edge representations. Then, the feature volume is further reduced to a single channel map by an 11 convolutional layer, which is then interpolated back to the original size and subjected to a Sigmoid function to generate the edge map. After combining the feature maps from the four individual channels, the resulting edge map is ready for testing using a concatenation, a convolutional layer, and a Sigmoid function. 1×1 size filter window applies for the parking slot confirmation that deeply analyzes each parking location slot. The proposed model's accuracy levels in detecting the real slot are higher than the traditional models. As a security measure, the driver's facial features and multiple persons' images consider providing flexibility to drivers at the exit level.

The proposed model initially performs the multi-parking slot linking using the min-max scalar function, and then the central parking station maintains all the parking slots. The proposed model considers multiple linked slots, whereas no existing model considers multi-parking slots. The slot confirmation stage uses the ReLU. The captured facial data is processed using Pixel Difference Network (PiDiNet), which accurately detects the facial edges and the facial features extracted from the captured faces at parking slots. The parking slot confirmation performs using adam optimizer in the ReLU unit, and facial features are processed and trained with the Stochastic Gradient Descent (SGD) optimizer. The face detection rate of the proposed model is high as a feature-wise similarity check is performed. Adam uses the average of the secondary and primary data of the gradient to modify learning rates rather than the average of the first moments, as is done in Root Mean Square Propagation. It can function with sparse gradients, does not necessitate a stationary target, and accomplishes a type of step-size annealing without any additional effort on the user's part. The optimization approach known as Stochastic Gradient Descent uses to educate models of neural networks. In order to derive updated values for the model variables, the Stochastic Gradient Descent algorithm has to compute gradients for each variable.

The rising rate of automobile ownership and the resulting traffic congestion are contributing to the shortage of parking spaces, which is a byproduct of the growing population and rapid urbanization in major cities. Drivers must be able to locate a vacant parking spot in a busy neighborhood, particularly during rush hour. Parking is a big concern for consumers visiting commercial areas. Factors like increased fuel consumption, air pollution, anxious drivers, an inability to precisely forecast trip time, and a lack of space increase the likelihood of crashes. The proposed model concentrates on maintaining a central authority that links multiple parking locations as a single unit where it can provide users with different parking slots based on their convenience. The proposed model also considers the Driver's face and the vehicle details at the entry levels, and then during exit, the Driver's face is also verified for authentication. The proposed model and a smart parking system concentrate on vehicle security. Figure 3 shows the proposed model framework. The dataset was collected from public providers. The default computer generated filters can be applied to the dataset to remove image noise.

Recognizing people's faces is a challenge in optical pattern recognition. In that environment, a 2-D representation of a face is to investigate how it responds to different lighting conditions, facial expressions, and other variables in the third dimension. Localization and normalization are the key handling processes that occur before face recognition, and a face recognition system typically consists of four modules: detection, alignment, feature extraction, and matching. Canny edge detection is used in this research to efficiently reduce the data required for processing by extracting relevant structure information from various face objects. A variety of computer-based vision systems have made extensive use of it. According to Canny's research, the requirements for using edge detection on various vision systems are comparable in face detection.

Separating the face from its environment is the first step in face recognition. The faces must be tracked using a face-tracking component in the video. Since the goals of face placement include more precise confinement and normalization of the person's features, face detection yields an approximate estimate of the location and scale of each identified face. After the eyes, nose, mouth, and facial border are marked with their respective locations, the input face shot is morphed and transformed geometrically to standardize its geometrical properties, such as its stance and size. The face is typically more standardized regarding photometric details like lighting and grayscale. After a face has been geometrically and photometrically normalized, characteristic extraction offers valuable information for distinguishing between the faces of various persons. It is consistent with the variations mentioned earlier.

In order to confirm parking slots, the suggested model uses the ReLU network model. A special kind of scaler called a MinMaxscaler makes the minimum and maximum values equal zero and one for multi-location parking slot linking. However, the StandardScaler will scale all values between the minimum and maximum to fit within that range. The research uses the Rectified Linear Activation Unit (ReLU) function and its derivative, which are monotonic. If the input is negative, the function will return 0, but it will return the input value if it is positive. It thereby provides a result that can be anywhere from zero to infinity. This results in a sparse network because it is highly likely that any given unit will not activate since ReLU gives output zero for all negative inputs. Let us compare the ReLu activation function to other well-known ones, including the sigmoid and the tanh, and see why the former is superior. Before ReLU, it was common to practice utilizing activation functions like the sigmoid or tanh activation function, which inevitably reached saturation, which means that for the tanh and the sigmoid, values that are too large snap to 1.0. At the same time, those too-small snap to -1 or 0. Furthermore, the functions are most sensitive to changes at their midpoint of input, such as 0.5 for sigmoid and 0.0 for tanh. Because of this, they ran into the vanishing gradient problem. In our context, we only consider a driver's exit and entry face match to enhance vehicle security. More images can be considered based on the number of persons in the car. Face equating works by comparing the extracted features of a face to those of previously stored faces. If a match discovers with sufficient confidence, the identity of the face is confirmed; otherwise, it depicts the unknown face. While face localization and normalization serve as the foundation for extracting valuable features, the success of a face recognition system is mainly dependent on the

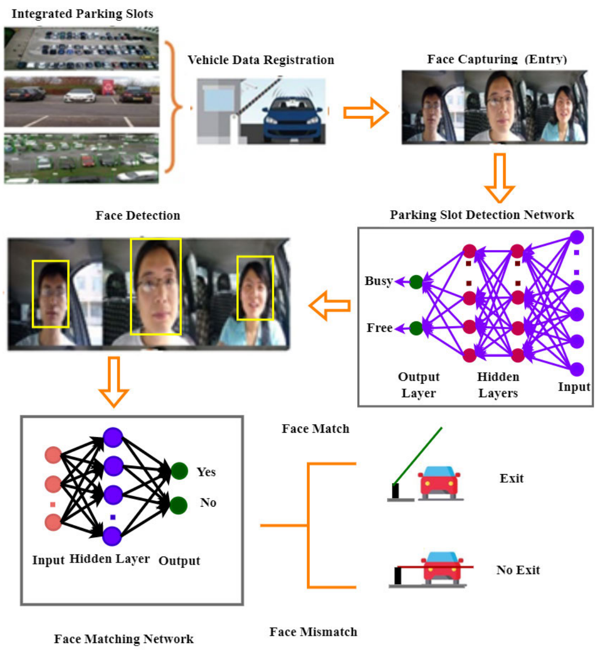

FIGURE 3. Proposed model framework.

characteristics that extract to recognize the face pattern and the classification methods used to differentiate between faces. Suppose the vehicle has multiple persons during parking. In that case, all possible faces capture at the entry level, where those faces will compare at the exit level to maintain security.

An Intelligent Face Recognition based Multi-Location Linked IoT-based Car Parking System is proposed for secure car parking that reduces delay with better efficiency to perform specified operations. As with the proposed strategy's working model, a vehicle is initially registered with the central parking management center when it arrives in a city. It can choose a nearby parking slot based on its requirements. If they directly reach the location, there is a chance for a delay in identifying a parking slot. The delays will reduce as the proposed model suggests suitable parking slots in traffic areas. If the requested slot is unavailable, the model allows an alternative parking slot to the user from this multi-location linking parking system, which reduces parking delays with better efficiency levels.

A. STEPS FOR INTELLIGENT FACE RECOGNITION BASED MULTILOCATION LINKING CAR PARKING SYSTEM (IFRbMLL-IoT-CPS)

Algorithm steps for IFRbMLL-IoT-CPS

Input: Parking Slot Information Datasets [PSIset]

Output: Parking Slot Information and Exit Status

Step-1: Initially, the multiple parking slots will register to the central parking station for monitoring and allocating available slots in all the parking areas. The multiple parking slots registration is performed as

$$PslotReg[M] = \sum_{p=1}^{M} getloc(\lambda) + vehcapacity(\lambda) + getdata(\lambda) + Th \begin{cases} 1 & if\ slot(\lambda) == veh(p) \\ 0 & Otherwise \end{cases} \tag{1}$$

In the above equation (1), M is the total number of real slots registered with the central parking station, getloc refers to the current location of the vehicle, getdata signifies the slots availability in the central parking system, vehcapacity indicates the information related to the size of the car, either small or big, and Th indicates the threshold value (1- parked slot, 0 - empty slot). λ is the current parking slot considered among the registered slots and p is the multiple parking locations, here p is from 1 to 4.

Step 2: Vehicles that require parking slots will reach the central parking station to get a parking slot. The central parking station will identify a slot in the selected area by the vehicle owner, and the parking slot detection process is performed as

$$Ploc(\lambda) = \sum_{p=1}^{M} getTimeslot(Val) \begin{cases} Val = 0 & if\ Val(Timeslot) == 0 \\ Val = 1 & Otherwise \end{cases} \tag{2}$$

$$PSD(\lambda) = \sum_{p=1}^{M} getloc(getVal(Ploc(p))) \begin{cases} 0 & if\ (Timeslot(\lambda)) == 0 \\ 1 & if\ (Timeslot(\lambda))! = 0\ and\ p++ \end{cases} \tag{3}$$

Here in the above equations (2) and (3) getTimeslot represents the time slot of the entry out of 24 slots, getVal is used to retrieve the parking slot occupancy, and getloc is used to know the parking area location.

Step 3: The Driver's face will be captured, and the facial features will be extracted from the Driver's image. Then, features are stored in the central database and further used for verification at the exit level. The facial feature extraction is performed as

$$PixsVal[IMG]_M = \sum_{p=1}^{M} 255 + \left(\frac{\lfloor getIntensity_p(p) - getPixelVal_p(p+1) \rfloor}{(sizeof(IMG(p)))} \right) + Th \tag{4}$$

$$FeatExtr(PixsVal(M)) = \frac{\max Intensity(p)}{M} * \sum_{p=1}^{M} \lambda * \left(Maxpix(\lambda) - \frac{Minpix(\lambda)}{Th} \right)^2 \tag{5}$$

The above equations (4) and (5) are for converting image into number format and for facial feature extraction process.

In the equations (4) and (5), PixsVal denotes the pixel values of the complete image, maxIntensity refers maximum intensity of the image, p, p+1 are the current, next slot times, getPixelVal(M)_p refers the pixel value of the current position of the image, sizeof(IMG) denotes the size of the image, minpix, maxpix indicates minimum, maximum image pixels respectively. Th is the thresh hold value (1 - parked slot, 0 - empty slot).

Step-4: If the parking slot is unavailable in the selected parking area, an alternative slot is selected from the remaining slots, the driver image is captured, and facial features are extracted. The process is performed as

$$PixsVal[IMG]_M = \sum_{p=1}^{M} 255 + \left(\frac{\lfloor getIntensity_p(p) - getPixelVal_p(p+1) \rfloor}{(sizeof(IMG(p)))} \right) + Th \tag{6}$$

$$FeatExtr(PixsVal(M)) = \frac{\max Intensity(p)}{M} * \sum_{p=1}^{M} \lambda + 1 * \left(Maxpix(\lambda+1) - \frac{Minpix(\lambda+1)}{Th} \right)^2 \tag{7}$$

Step-5: At the exit level, the Driver's face is again captured, and the facial features are extracted to verify with the database. The facial verification is performed, and the exit status is displayed. If the facial features are similar, the vehicle can be allowed to exit. The vehicle will be allowed to exit if the status is 0 and not allowed if the exit status is 1. The process of face matching and the vehicle exit status is performed as the equation can be derived, as shown at the bottom of next page.

In equation (III-A), simm indicates the similarity index between the entry level (λ) and exit level $\lambda + 1$ images, p, P+1 are current, next slots. Fmatch(FeatExtr(M)) refers to the feature extraction of face matching of the total image.

$$ExitS[V] = \sum_{p=1}^{M} getStatus(PSD(p)) \begin{cases} p = 0 & if\ simm(\lambda, \lambda+1) < Th \\ p = 1 & Otherwise \end{cases} \tag{8}$$

The equation (8) shows the final exit permission status Exits[V] of the vehicle after the face verification matching process, whether the car can exit or not. In the equation (8) getStatus(PSD(p)) refers the parking slot detection status of the current parking slot. If the similarity index between the entry and exit images is less than the thresh hold value, the p-value becomes zero; otherwise, it equals one. By considering both the parking slot detection status and face matching status, the vehicle can permit to exit or not.

TABLE 1. Vehicle registration time levels.

Number of Vehicles Maintained	Vehicle Registration Time Levels in Milliseconds	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	13	25
200	14	27
300	16	28
400	17	30
500	17.5	31
600	18	32

IV. RESULTS AND DISCUSSION

A smart parking system present that can significantly improve user experience by speeding up the process of finding a parking spot and decreasing the cost of getting there. Multiple parking slots integrate as a single unit maintained by a central authority for providing the parking slots based on user convenience. The most notable discovery from this research is our proposed smart parking system, ensuring less data carry over the network and less energy usage at the central layer. The proposed research aims to save the user's time, reduce the time spent in traffic, increase the number of available parking spots, and decrease the amount of petrol drivers use. Additionally, Driver's facial recognition also performs in this research that verifies the driver images during entry and exit levels for vehicle security. The proposed model is executed and tested in Python and executed in Google Colab. Four data sets, P1, P2, P3, and P4, are considered from parking slots in a 24-hour slots per day format in which each parking slot can accommodate 50 vehicles. As four slots consider, 200 vehicles can accommodate to reduce traffic levels. The empty slot represents 0, and the occupied slot represents 1. An Intelligent Face Recognition based Multi-Location Linked IoT-based Car Parking System (IFRbMLL-IoT-CPS) is proposed for secure car parking that reduces delay with better efficiency levels to perform specified operations. The proposed model compares with the traditional IoTRec: The IoT Recommender for Smart Parking System and An Automatic System for Unconstrained Video-Based Face Recognition (IoTRec-UVbFR) Model. The proposed novel model compares with the traditional models, and the results represent the proposed model's high performance.

The vehicles entered into the central parking center will be registered with the time of entry and the vehicle details. The Driver's face also captures for exit-level verification to maintain vehicle security. During registration, the central unit stores the vehicle information for further detection. The vehicle registered, and its Driver's face must match at the time of parking exit. The vehicle registration time levels of the proposed model are less than the traditional models. Table 1 and Figure 4 show the comparisons for vehicle registration time levels of the existing and proposed models. Figure 4 quickly identifies that the vehicle registration time levels are much lower than the existing method with increasing the number of vehicles.

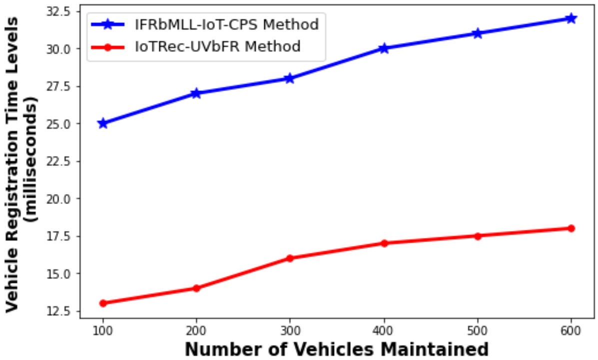

FIGURE 4. Vehicle registration time levels.

TABLE 2. Parking slot detection accuracy levels.

Number of Vehicles Maintained	Parking Slot Detection Accuracy Levels in %	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	92	85
200	93	87
300	95	89
400	96	91
500	97	92
600	98	93

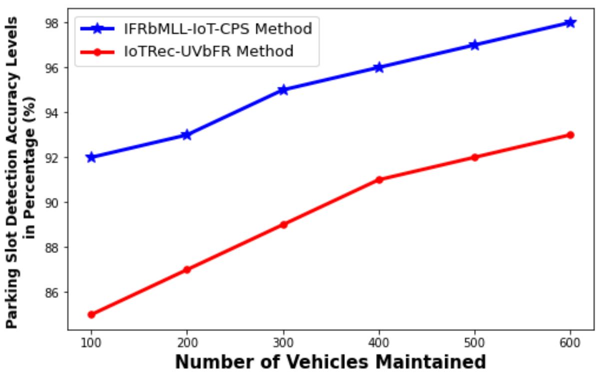

FIGURE 5. Parking slot detection accuracy levels.

The multiple parking slots integrate, and a central parking center maintains it. When a vehicle enters the parking center, the parking slot will be allocated based on entry time. If not available in one location, the parking slot will allocate with a new slot in another. Table 2 and Figure 5 show the proposed and traditional models' parking slot detection accuracy levels. Table 3, Figure 6 show the parking slot detection time levels.

Figure 5 and Table 2 show that the parking slot detection accuracy of the proposed model is higher than the existing model, with an increase in the number of vehicles. Figure 6 and Table 3 show that the proposed models' parking slot detection time levels are low, nearly half the time lesser of the existing model concerning the number of vehicles.

TABLE 3. Parking slot detection time levels.

Number of Vehicles Maintained	Parking Slot Detection Time Levels in milliseconds	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	9	24
200	11	25
300	12	27
400	14	28
500	15	30
600	16	31

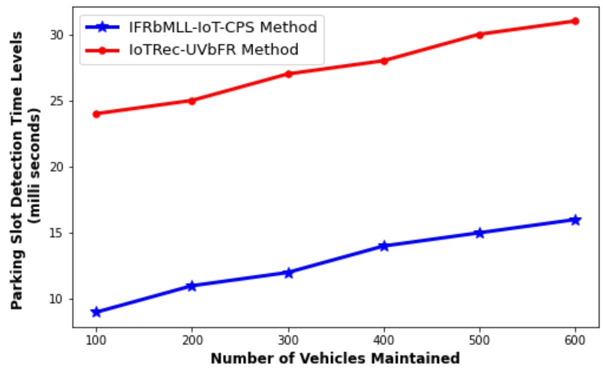

FIGURE 6. Parking slot detection time levels.

TABLE 4. Alternative parking slot detection time levels.

Number of Vehicles Maintained	Alternative Parking Slot Detection Time Levels in ms	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	8	22
200	9	25
300	9	26
400	11	27
500	12	29
600	14	32

The parking slot is also unavailable in multiple locations, so the system will search for a parking slot and allocate it to the vehicle. The alternative parking slot helps drivers to search for a new parking location that increases traffic. Table 4 and Figure 7 show the proposed and existing models' alternative parking slot detection time levels. Figure 7 indicates that the alternative parking slot detection time level is lower than the existing model, which helps decrease traffic congestion. It saves the drivers valuable time and environmental pollution.

When a vehicle enters a parking slot, the vehicle details will record, the Driver's face will be captured, and the features of the face will be extracted and then stored in the database. The Driver's face features are helpful at the exit level for verification. Table 5 and Figure 8 show the Driver's face feature extraction accuracy levels.

$$Fmatch(FeatExtr(M)) = \frac{\sum_{p=1}^{M} simm(FeatExtr(p), FeatExtr(p+1)) - \min(FeatExtr(p+1))/\lambda}{size(FeatExtr(p))}$$

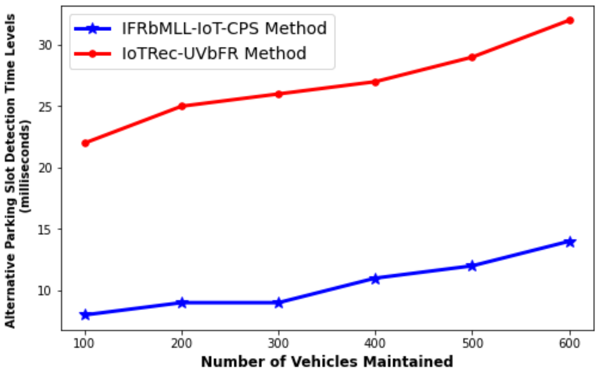

FIGURE 7. Alternative parking slot detection time levels.

TABLE 5. Drivers' face feature extraction accuracy levels.

Number of Vehicles Maintained	Drivers' Face Feature Extraction Accuracy Levels (%)	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	92	84
200	93	86
300	94	89
400	95	90
500	96	91
600	97	92

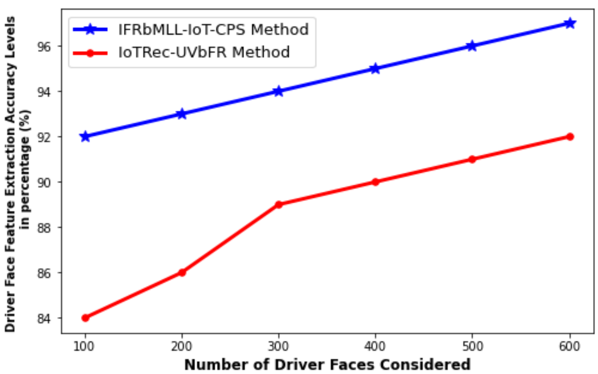

FIGURE 8. Drivers' face feature extraction accuracy levels.

The process of determining whether or not two faces are a match is known as face verification. It is a straightforward case of matching one individual to another. Thus it is best to verify their authenticity. Deep learning (CNN) Convolutional Neural Network is the familiar machine learning algorithm for facial recognition. Among the many applications of artificial neural networks, CNNs excel at the classification of images. At the exit level, the Driver's face will capture again to maintain vehicle security. The newly captured face features are extracted and compared with the facial features in the database. If a match is found and it matches with the vehicle data, then the vehicle will be exited. Table 6 and Figure 9 show the Driver's face verification time levels at the exit level. Table 7, Figure 10 show the face verification accuracy levels; with little time, the proposed model gives higher face verification accuracy than the existing model.

A computer-generated filter is used in facial recognition to convert pictures of faces into numbers that can then compare

TABLE 6. Driver face verification time levels.

Number of Vehicles Maintained	Driver Face Verification Time Levels(ms)	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	10	24
200	11	26
300	12	28
400	13	29
500	14	30
600	15	31

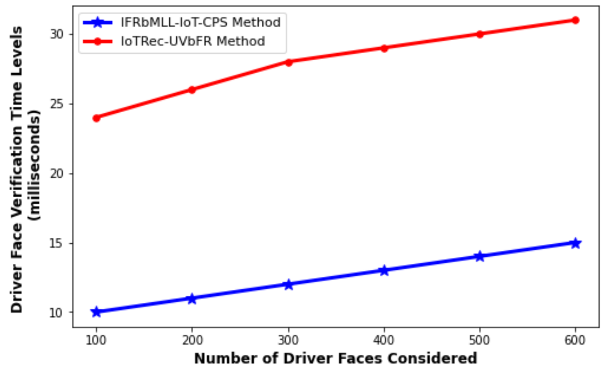

FIGURE 9. Driver face verification time levels.

TABLE 7. Driver face verification accuracy levels.

Number of Vehicles Maintained	Driver Face Verification Accuracy Levels (%)	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	91	86
200	92	87
300	94	88
400	95	89
500	96	92
600	98	93

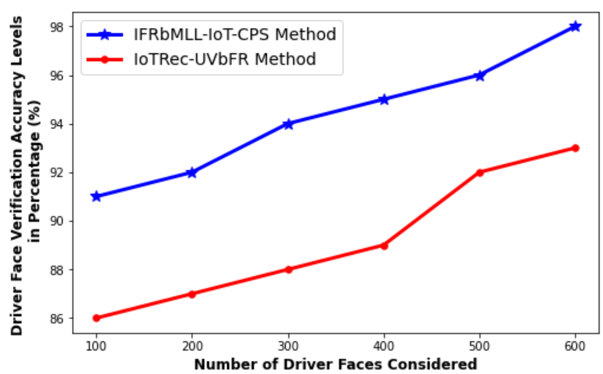

FIGURE 10. Driver face verification accuracy levels.

to determine how similar they are. Deep learning, which uses ANNs to process data, is typically used to produce such filters.

A model's error rate is the percentage of times its predictions are off compared to the gold standard. The frequent usage of phrase error rate in the framework of

TABLE 8. Error rate.

Number of Vehicles Maintained	Error Rate in percentage	
	Proposed IFRbMLL-IoT-CPS Model	Existing IoTRec-UVbFR Model
100	2.5	12.3
200	2.7	15.0
300	5.0	15.4
400	7.2	17.5
500	7.5	18.3
600	8.3	21.8

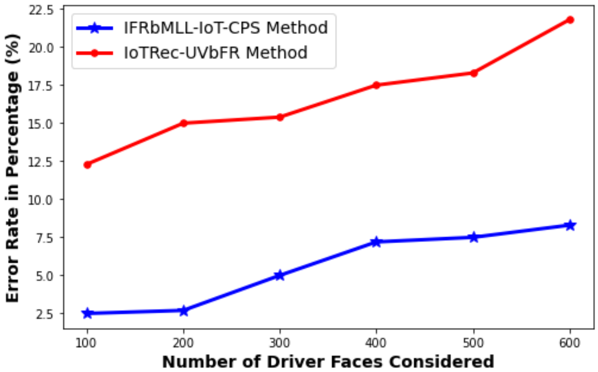

FIGURE 11. Error rate.

classification models whereas, in this setting, the error rate is defined as the probability density function P((X)Y), where XY is a joint allocation and is a classification model for X and Y. Error rate represents by the false detection of vehicles and Driver faces. The error rate will result in the theft of vehicles. The proposed model error rate is very minimal than the existing models. Table 8 and Figure 11 show the error rate of the existing and proposed models.

Figure 11 shows that the error rate for the proposed model is less than the existing model, and very slight variations obtain with an increase in the number of faces.

The proposed model's training and testing loss levels represent the performance levels. The less the loss level, the highest the performance. Figure 12 the training and testing loss rate of the proposed model. It shows that the loss rate decreases concerning the number of epochs in the training and testing phases. Figure 12 indicates a minute loss variation between the training and testing phases.

The existing state-of-art models contain either security or searching for parking slots. The proposed centralized multi-location linking parking system integrates the parking slots available in smart cities at multiple or distant locations. The system uses the allotment of alternative parking slots in another location when the parking slot is unavailable based on the user's choice without wasting their valuable time. This research provides multi-location linking, alternative parking slot allotment, more innovative natural resource utilization, lessening the time spent searching for parking spots, reducing pollution, enhancing vehicle security using intelligent face recognition based on a similarity index strategy, and

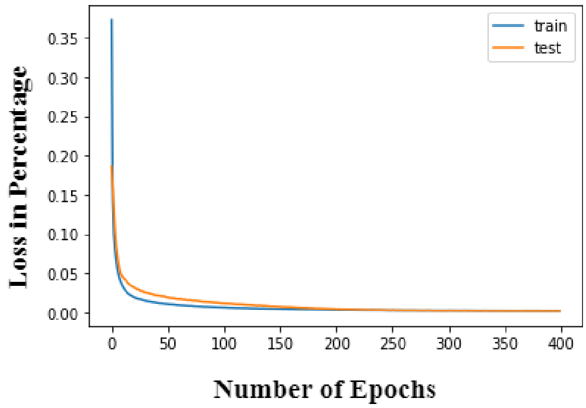

FIGURE 12. Training and testing loss.

high-efficiency levels. The facial images of all the persons in a car can capture at the time of vehicle entry and exit based on the user's wish, which provides high-end security for the vehicle. Most existing models consider only the driver image, and the system fails to identify the driver change at the entry and exit levels. In some scenarios, the same person may not be a driver while entering and exiting the parking location. The proposed research considers the images of all the persons in a car, including the Driver, even though it took some additional time to identify the driver change at the entry and exit levels. This research improves the orderly and disciplined arrangement of vehicles parking in smart cities, which leads to more innovative utilization of natural resources like the place, air, and environment.

V. CONCLUSION

IoT has wholly transformed every aspect of modern life by leveraging these massive technological advancements, including parking systems. Motivated by these opportunities, a smart parking system was developed to automate the advice of free parking spots using an integrated multiple-slot model to the drivers seeking them, cutting down on the time drivers spend searching for parking and the money spent on staffing parking lots. Smart cities aim to improve residents' quality of life, providing better transportation and more convenient travel options. Here, smart parking technology assists drivers in both finding parking slots and securing vehicles. This research suggests a smart parking system based on a multi-slot integrated model to remedy the current state of the parking industry. The vital goal of our research is to identify efficient strategies for decreasing the time and energy needed to park a vehicle. An innovative parking system that relies on a network of sensors connected to the IoT to monitor parking availability in multiple parking slots. The proposed approach reduces motorist effort and time spent searching for parking by providing them a parking slot in their required parking area. To perform specified operations, an Intelligent Face Recognition based Multi-Location Linked IoT-based Car Parking System gives secure car parking that reduces delay with better efficiency. To improve the flexibility of the proposed model by allowing the Driver's registered id to send text messages and alerts regarding the slot information. Sensors help to prevent future illegal parking and identify when a car is in a restricted zone.

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VANKADHARA RAJYALAKSHMI received the M.Sc. degree in electronics from ANU, India, the M.C.A. degree from IGNOU, India, and the M.Tech. degree in computer science and engineering from JNTUH, Hyderabad, India. She joined as a Research Scholar with VIT, India. Her research interests include the Internet of Things, machine learning, deep learning, big data, security, and data science.

KURUVA LAKSHMANNA received the B.Tech. degree in computer science and engineering from the Sri Venkateswara University College of Engineering, Tirupati, India, in 2006, the M.Tech. degree in computer science and engineering (information security) from the National Institute of Technology Calicut, Kerala, India, in 2009, and the Ph.D. degree from VIT, India, in 2017. He was a Visiting Professor with the Guangdong University of Technology, China, in 2018. He is currently an Associate Professor with VIT. He has published research papers in IEEE, Elsevier, and Springer, most of which are indexed in the SCOPUS database. His research interests include machine learning, data mining in DNA sequences, the IoT, data science, and security.