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A DEEP LEARNING-POWERED SMART PARKING SYSTEM BASED ON FACIAL RECOGNITION AND LICENSE PLATE ANALYSIS

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ABSTRACT

Parking congestion has become a major problem in today's metropolitan environments, resulting in lost time, higher emissions, and irritated drivers. There is a significant lack of parking spots in large cities as a result of the expanding number of vehicles and the ever-increasing metropolitan population. In addition to making it difficult and time-consuming to find a parking space, this shortage has made pollution and traffic congestion worse. Conventional parking management methods are becoming less and less effective in addressing these issues because they usually depend on physical barriers or manual ticketing. Innovative approaches that combine automation and technology are getting more and more popular as a way to solve this problem. Conventional parking management systems often rely on human interaction and physical infrastructure, which leads to restricted scalability and inefficiency. On the other hand, adding deep learning methods and cutting-edge computer vision technologies to parking management opens up new possibilities for a smarter, more effective, and more user-friendly experience. This system makes use of two essential elements: automatically recognizing license plate numbers for vehicle identification and facial recognition technology for person identification. By seamlessly integrating these technologies, the system not only facilitates effortless parking but also enhances security and optimizes parking space utilization. In this survey, we will explore the fundamental components, benefits, and potential impact of the Face and Number Plate-Based Smart Parking System. Experimental results shows that improved efficiency in smart parking system using face and number plate verification system.

Keywords: Smart Parking System, Face Recognition, License Plate-Based Verification, Features Extraction, Character Recognition

1. INTRODUCTION

Effective parking space management is becoming essential to everyday life and urban development in our increasingly urbanized environment. Parking is crucial for environmental sustainability, traffic control, and generating income for businesses and communities, in addition to being a convenience for drivers. Advanced parking systems have been developed to solve the problems associated with parking in crowded urban areas and to simplify the parking process. These systems leverage technology, data, and automation to optimize parking space utilization, improve user convenience, and enhance overall parking facility management.An overview of parking systems is given in this introduction, with emphasis on their significance, elements, and advantages for drivers and parking operators. Parking systems play an increasingly important role in building more sustainable and efficient cities as metropolitan areas continue to grow. When designing parking systems, security is crucial since it guarantees the safety of users, cars, and the facility as a whole. Here are key aspects of security in a parking system:

- Access Control: Put strong access control measures in place to stop illegal access. Turnstiles, obstacles, gates, RFID card readers, license plate recognition software, and mobile app-based access are a few examples of this.

- Surveillance Cameras: Put security cameras in key places to keep an eye on the whole parking lot. In the event of an incident, high-resolution cameras can provide as important evidence and serve to discourage criminal activity.
- Lighting: Sufficient lighting is essential for improving visibility and discouraging illegal activity. Parking lots with good lighting make the region safer for both cars and pedestrians.
- Data Security: Protect user and payment information among the data the system collects by using encryption and adhering to data protection laws.
- Environmental Monitoring: Some systems monitor environmental factors, such carbon monoxide levels and fire alarms, in addition to security to guard against potential threats.

In addition to safeguarding automobiles, security in parking systems aims to make the environment friendly and safe for users. Parking facility owners can reduce hazards and give customers and their cars a sense of safety by implementing strong security measures and keeping up with the most recent security technologies. Fig 1 shows the smart parking system using IOT technology

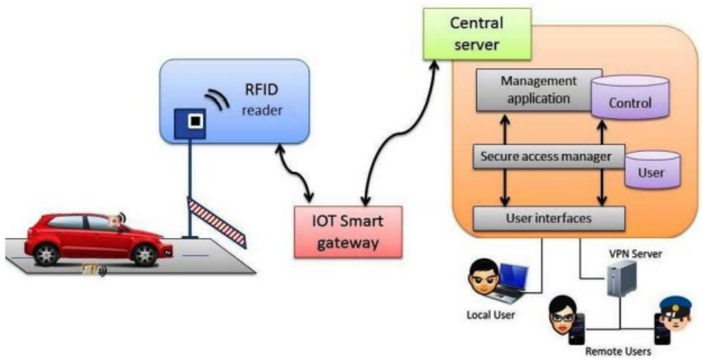


Figure 1: IOT BASED SMART PARKING SYSTEM

2. RELATED WORK

Yasir Saleem et al. [1] introduced IoTRec, an IoT Recommender system for smart parking, aiming to enhance vehicle mobility in urban areas. IoTRec provides real-time parking occupancy based on historical IoT data and GDPR-compliant recommendations for parking spots and routes. Residents of Santander, Spain, evaluated the prototype called Rich Parking.

Jingxiao Zheng et al. [2] proposed an automated face recognition system for unrestricted video-based face identification tasks. The system consists of modules for face detection, alignment, representation, association, tracking, subspace learning, and similarity-based matching. Experimental results on four video datasets demonstrated high performance despite challenges like motion blur, low quality, occlusion, and scene changes.

Li Mao et al. [3] developed a real-time obscured face detection method with higher accuracy and lower computing cost than existing algorithms. Their IoT surveillance-based framework includes stages for face detection, tracking, and verification, utilizing novel techniques like deep CNN-based tracking and dictionary learning for verification.

H. Canli et al. [4] presented a deep learning-based architecture for parking occupancy detection in IoT-based smart cities. Their LSTM-based approach outperformed SVM, RF, and ARIMA models using multivariate and multi-time series parking data. They emphasized the importance of large datasets for improving model effectiveness.

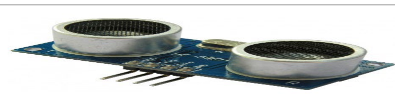
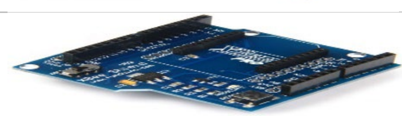
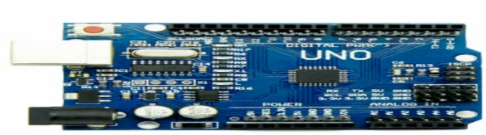
Awais Abdul Khaliq et al. [5] proposed a secure parking recommender system based on elliptic curve cryptography, local differential privacy, and IOTA DLT. Their protocol ensures privacy and integrity of parking data through ECC, HMAC, LDP, and IOTA DLT, addressing concerns of unauthorized access and data misuse while preserving anonymity and scalability.

3. SENSOR BASED SMART PARKING SYSTEM

An inventive way to maximize parking management and enhance the parking experience for customers and operators alike is to implement a sensor-based smart parking system. These systems continuously monitor parking lot occupancy using a network of sensors, including infrared, magnetic, ultrasonic, and video-based sensors. After being gathered, the data is sent to a cloud-based platform or central server for real-time processing, enabling users to receive the most recent information on parking spots that are available. This real-time information is made available to drivers through websites, mobile apps, electronic displays, and on-site signage. It reduces the time it takes to find an open spot and helps drivers identify parking spaces more quickly. For a pleasant parking experience, several systems even include alternatives for reservations and pre-booking. Traffic congestion is decreased by additional process streamlining provided by navigation and guidance services. Payment processing is made easier via integration, and safety is improved by security features like surveillance cameras.Parking operators can make data-driven decisions with the use of data analytics, and certain systems encourage environmental sustainability by providing EV charging stations. Because of these systems' scalability, which enables them to accommodate varying parking facility sizes, contemporary urban parking difficulties can be effectively and conveniently solved.

- Ultrasonic Sensors: Sound waves are used by ultrasonic sensors to identify the presence of automobiles. They measure the time taken for ultrasonic pulses to return after being emitted. The sensor recognizes the reflected sound waves when a vehicle moves into a given area and records the region as occupied.
- Magnetic Sensors: Magnetic sensors rely on variations in the Earth's magnetic field brought about by an automobile. The sensor recognizes the disturbance caused by a car parking over a magnetic field and labels the space as occupied. Usually, these sensors are set into the pavement.
- Infrared Sensors: Infrared light is used by infrared sensors to identify automobiles. When a car passes in front of their infrared beam, which they emit, the sensor detects that the area is occupied. Automated barrier systems often use infrared sensors.
- Ground-Loop Sensors: Electromagnetic sensors that form a loop in the pavement are called ground-loop sensors. The electromagnetic field is disrupted when a car passes over the loop, indicating that the area is occupied.
- Acoustic Sensors: Acoustic sensors identify the presence of vehicles using sound-based technology. To ascertain whether an area is occupied, they listen for noises produced by moving cars and engines.
- Wireless Sensors: Wireless sensors are lightweight and simple to set up. Through wireless communication, they exchange real-time parking space occupancy data with a central system. These sensors frequently communicate using Wi-Fi, LoRa, or Bluetooth.
- Laser-Based Sensors: Parking places are monitored by laser sensors that emit laser beams. The sensor detects that the area is occupied when a car passes in front of the laser beam.
- RFID Sensors: Vehicle RFID tags are used by radio-frequency identification (RFID) sensors to detect and monitor parking space occupancy. RFID readers are needed at entry and exit points for these sensors.
- Ultraviolet Sensors: UV sensors detect the presence of vehicles using UV light. They work especially well for indoor parking lots.

The type of sensor utilized depends on a number of parameters, including the type of parking facility, the needed level of precision and cost concerns. These different sensor technologies can be used separately or in combination to monitor parking spot occupancy. Sensor-based parking systems are essential for streamlining parking operations, lessening traffic, and enhancing users' parking experiences in general. Fig 2 shows the components for smart parking system.

COMPONENT NAME	**IMAGE**	**DESCRIPTION**
ULTRASONIC SENSORS		An ultrasonic sensor gauges object distance using ultrasonic sound waves.
ZIGBEE		*ZigBee Modules facilitate radio signal transmission and reception.*
ARDUINO UNO		Arduino UNO, based on the ATmega328P microcontroller, features 14 digital I/O pins (6 usable as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, USB connectivity, a power jack, an ICSP header, and a reset button.

LED DISPLAY		An LED display is a flat panel screen employing an array of light-emitting diodes (LEDs) as pixels to create video displays.

Fig 2: Components for smart parking system using Sensor

4. PROPOSED METHODOLOGIES

In the context of smart parking, a suggested face and number plate recognition system would consist of a number of integrated technologies intended to improve security, expedite access control, and offer a seamless user experience. The core component of this system would be strategically placed high-resolution cameras with dual functionality—license plate recognition (LPR) and facial recognition—at the parking facility's entrance and exit points. These cameras would function as the first points of contact, gathering vital information from cars and drivers alike. As cars and passengers approach these sites, a deep learning system would be used to record and authenticate their identities using advanced facial recognition software. Then use optical character recognition with OTP verification to identify the license plate with the matching faces. Fig 3 shows the proposed framework in parking system.

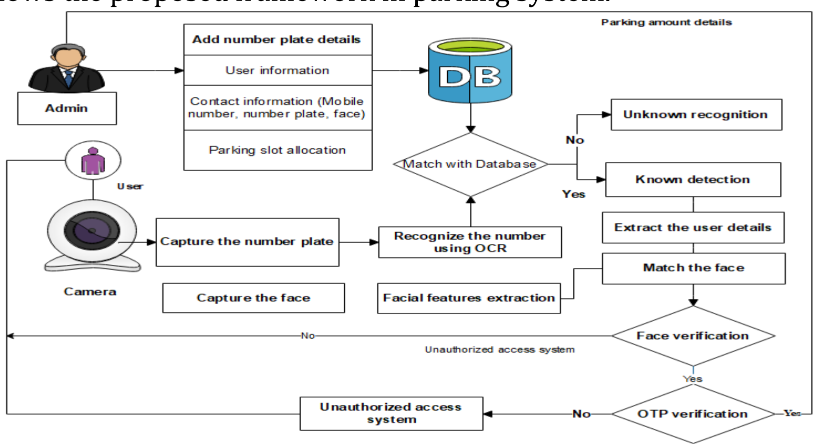


Fig 3: Proposed architecture

GRASSMAN ALGORITHM

To begin, facial regions are detected and extracted from each frame within a video sequence. Subsequently, these extracted face images are categorized into K distinct groups. Drawing inspiration from video face matching techniques, we employ a Grassman algorithm to partition the facial images. Central to our proposed methodology is the sampling and characterization of a registration manifold. We introduce a novel perspective on frame selection, leveraging feature richness as a key criterion. Our assertion is that evaluating the feature richness of an image facilitates the identification of frames likely to contain distinguishing features. Prior to feature richness computation, the input image (detected face) must undergo preprocessing to achieve a standardized size and grayscale format. By prioritizing face recognition and focusing exclusively on facial regions, we mitigate potential interference from non-facial elements in the frame. Geometric normalization is performed by computing a set of affine parameters based on pairs of facial coordinates. This affine transformation maps the (x, y) coordinates of the source image to the (u, v) coordinates of a normalized image.

ALGORITHM STEPS

Input: A set of P points on the manifold $\{X_i\}_{i=1}^{P} \in G(d,D)$
Output: Karcher mean μK
Initialize the Karcher mean $\mu_K = X_i$ randomly chosen from $\{X_i\}_{i=1}^{P}$
Compute the average tangent vector $A = 1/P \sum_{i=1}^{P} \log_{\mu K}(X_i)$
If $\|A\| < \varepsilon$, return μK and stop; otherwise, proceed to Step 4
Update μK in the direction of the average tangent $\mu K = \exp_{\mu K}(\alpha A)$, where $\alpha > 0$ is the step size parameter. Go to Step 2 until termination conditions are met (e.g., maximum iterations reached or convergence achieved).
The resultant trajectory, connecting various points on the Grassmann manifold, is utilized to modify the video content. Decomposition of the projection onto the Grassmann manifold proves indispensable, offering reversible transformations without information loss. The identification of specific skeletal sequences is then accomplished by assessing the similarity between trajectories of human skeletal joints..

OPTICAL CHARACTER RECOGNITION

A technique for turning scanned or photographed text documents into machine-readable text is called optical character recognition, or OCR. To recognize characters and words, OCR systems often employ a variety of image processing, pattern recognition, and machine learning approaches. Below are some key details on the components and processes involved in OCR algorithms:

IMAGE PREPROCESSING

Noise Reduction: The technique starts by eliminating background interference, dust, scratches, and other undesired artifacts from the image, along with any noise. Typical methods consist of edge detection, Gaussian smoothing, and median filtering.
Image Enhancement: To boost contrast, brightness, and sharpness, the image may be upgraded. Common techniques include contrast stretching and histogram equalization.

TEXT DETECTION

Localization: OCR algorithms use methods like edge detection, contour analysis, and connected component analysis to identify regions in the image that might contain text.
Text Region Segmentation: The algorithm divides possible text regions into individual lines or words after it has identified them. Character recognition depends on this.

CHARACTER RECOGNITION

Feature Extraction: Features such as the size, shape, and relative positions of different components (strokes, loops, dots, etc.) are extracted for each character or symbol inside a segmented text region.
Pattern Matching: OCR algorithms match the features that are extracted to models or templates of characters that are predefined in a reference database.
Machine Learning: Neural networks and other machine learning techniques are used by many modern OCR systems to increase the accuracy of character recognition. Convolutional Neural Networks (CNNs), a category of deep learning models, have demonstrated exceptional efficacy in Optical Character Recognition (OCR).

POST-PROCESSING

Contextual Analysis: Some OCR algorithms use contextual analysis, which takes into account the characters around the target character to enhance character recognition. For example, contextual correction can be applied to recognize "i" next to "j" or "u" next to "v".
Dictionary Look-Up: When a word or phrase is identified, the OCR system may go to a dictionary to ensure that the text recognition is accurate.

OUTPUT FORMATTING

• The identified text is organized and arranged to provide the desired results, which can include structured data, searchable PDFs, or plain text.

According to the definitions given above, a face can be identified using its features and its number plate, after which it will automatically convert to text format. Lastly, OTP-based verification can be used to increase parking lot security.

5. EXPERIMENTAL RESULTS

In this chapter, real-time datasets were utilized. The framework incorporates face recognition and detection algorithms. Subsequently, performance assessment is conducted using accuracy measurements. The accuracy metric is defined as:

$$Accuracy=(TP+TN)/(TP+TN+FP+FN) *100$$

The proposed algorithm demonstrates a superior accuracy rate compared to conventional machine learning algorithms.

Accuracy table shown in table 1.

Algorithm	Accuracy (%)
Adaboost classifier	50
Viola jones classifier	70
Grassmann algorithm	90

Table (1) Accuracy table

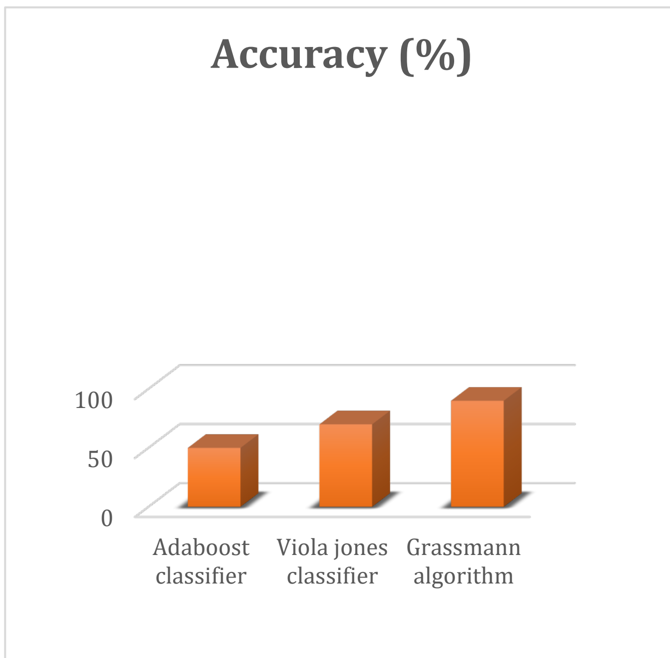


Fig 4: Performance report

From the performance chart in fig 4, comparing the accuracy of the Grassmann method to other machine learning algorithms, it is greater. There are fewer false positives using the suggested system.

6. CONCLUSION

In conclusion, integrating technology for number plate and face recognition into smart parking systems offers a promising solution for urban parking management challenges. These systems, powered by deep learning algorithms, efficiently monitor and oversee parking facilities, improving the experience for operators and users alike. Facial recognition ensures authorized access, simplifying security while enhancing protection. Number plate recognition enables seamless entry and exit without physical tokens or access cards. With robust data processing and management, valuable insights on parking trends and real-time space availability are gleaned, optimizing space usage and alleviating traffic congestion.

CONFLICT OF INTERESTS

None.

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