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VISITOR FRIENDLY SMART CAR PARKING MANAGEMENT SYSTEM THROUGH IOT AND WEB TECHNOLOGY

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Abstract
The research paper aims to address the challenges faced by visitors in finding parking spaces in crowded public areas. The primary objective is to design and implement a smart parking management system that utilizes IoT and web technology to provide real-time information about available parking slots to visitors.
The proposed system consists of various modules, including IR sensors for slot monitoring, RFID cards for user authentication, LCD displays for slot information, and a Blynk application for remote access to parking status. The system also incorporates deep learning techniques for vehicle re-identification, enhancing security and preventing car theft.
Through extensive literature review and experimentation, the research paper establishes the effectiveness of IoT and web technology in developing a visitor-friendly smart parking system. It demonstrates the successful integration of real-time data, cloud-based services, and user-friendly interfaces to provide a seamless parking experience for visitors.
The findings of the research paper highlight the significant improvements in parking efficiency, reduction in time wasted searching for parking spaces, and the convenience provided to both nearby and distant visitors. The deep learning module for vehicle re-identification proves to be effective in enhancing parking security.

1.Introduction

In recent years, the rapid growth of urbanization and the increasing number of vehicles on the roads have led to a pressing need for efficient car parking management in smart cities. As cities become more densely populated, the availability of parking spaces has become scarce, leading to challenges for both visitors and local residents.
One of the significant challenges faced by visitors is the frustration and time wasted in finding suitable parking spaces. In crowded public areas such as shopping malls, airports, and commercial centers, the lack of parking spots can cause traffic congestion and inconvenience to drivers. Visitors often resort to roaming around in search of available slots, leading to increased fuel consumption and higher levels of carbon emissions.

To address these challenges, there is a growing importance of providing real-time information about parking availability to visitors. Smart car parking management systems that utilize Internet of Things (IoT) technology and web-based interfaces offer a promising solution. By implementing such systems, visitors can access up-to-date information on the availability of parking slots, enabling them to make informed decisions and find parking spaces more efficiently.

The motivation behind this research paper is to design and implement a visitor-friendly smart car parking management system that leverages IoT and web technology. The system aims to alleviate the inconveniences faced by visitors while providing them with a seamless and hassle-free parking experience. By utilizing real-time data, cloud-based services, and user-friendly interfaces, the proposed system seeks to optimize parking space utilization and enhance the overall traffic flow in smart cities.

2. Problem Statement

The problem at hand is the inefficiency and inconvenience caused by the lack of an organized and visitor-friendly car parking management system in smart cities. As urban areas continue to experience population growth and an increasing number of vehicles, traditional parking management approaches prove insufficient in meeting the demands of modern urban living. This leads to several issues:

a. Inadequate Parking Availability: With limited parking spaces available, visitors often struggle to find vacant slots in crowded areas. This results in increased traffic congestion and wasted time for both visitors and other drivers.

b. Fuel Consumption and Emissions: Endlessly circling in search of parking spaces consumes additional fuel, contributing to environmental pollution and greenhouse gas emissions.

c. Frustration and Inefficiency: Visitors' frustration and dissatisfaction with the parking situation in smart cities negatively impact their overall experience and deter them from frequenting certain locations.

d. Security Concerns: Inadequate parking management can also lead to security risks, such as car theft and unauthorized access to vehicles.

3. Research Objectives

The primary goals and objectives of the research are as follows:

a. Develop a Visitor-Friendly Smart Car Parking Management System: Design and implement a smart parking management system that provides real-time information about parking slot availability to visitors. The system should be user-friendly, efficient, and capable of optimizing parking space utilization.

b. Reduce Traffic Congestion and Fuel Consumption: By guiding visitors to available parking spaces, the system aims to reduce traffic congestion and minimize fuel consumption caused by aimlessly searching for parking.

c. Enhance Visitor Experience: The research aims to enhance the overall visitor experience by providing a seamless and convenient parking solution, thereby increasing satisfaction and encouraging frequent visits.

d. Incorporate Deep Learning for Vehicle Re-Identification: The research will explore the use of deep learning techniques, specifically triplet loss, to re-identify vehicles in the parking area. This will add an extra layer of security and deter potential car theft incidents.
e. Implement Cloud-Based Services: The system will utilize cloud-based services to store and retrieve parking data, enabling access to real-time information from both nearby and distant locations.

4. Scope of the Study

The proposed smart car parking management system focuses on providing a visitor-friendly parking experience in smart cities. It will cover the following aspects:
a. Real-Time Parking Slot Information: The system will offer real-time information about available parking slots through a user-friendly mobile application and an LCD display placed near the entry gate.
b. Booking Facility: The system will include a booking facility for parking slots, enabling visitors to reserve slots in advance.
c. Vehicle Re-Identification: Utilizing deep learning techniques, the system will re-identify vehicles using triplet loss, enhancing security and preventing car theft incidents.
d. Air Quality Monitoring: The system will incorporate AQI monitoring to provide visitors with information about air quality in the parking area.
e. Web Technology Integration: The system will leverage web technology to provide remote access to parking slot information through a cloud-based platform.

5. Methodology Overview

The research follow a systematic methodology to achieve its objectives:
System Design: Design the architecture and components of the smart parking management system, including IoT integration, web technology modules, and vehicle re-identification using deep learning.
Implementation: Develop the prototype of the smart parking system using appropriate hardware and software components.
Testing and Evaluation: Test the system's performance and evaluate its effectiveness in providing real-time parking information, optimizing parking space usage, and enhancing visitor experience.
Data Analysis: Analyze the data collected during testing to assess the system's efficiency and identify areas for improvement.

Literature Review

Smart car parking systems have gained significant attention in recent years due to the increasing need for efficient parking management in smart cities. Various studies have been conducted on IoT-based smart parking systems and related technologies, focusing on providing real-time parking information, optimizing parking space utilization, and enhancing visitor experience. This literature review discusses some of the key studies and their findings in this domain.

1. Fazel Mohammadi et al. (2020) conducted research on a smart parking system that utilized wireless sensors for real-time analysis of parking slot availability. The system efficiently managed parking spaces, reducing the time visitors spent searching for parking spots. The study emphasized the importance of real-time data collection and analysis in optimizing parking space usage.
2. Vaibhav Hans et al. (2016) proposed a cloud-based reservation system for smart parking. The research presented an algorithm and tested it in a simulated environment. The system allowed visitors to book parking slots in advance, leading to better parking space utilization and improved visitor satisfaction.
3. Ratnesh Kumar et al. (2019) focused on vehicle re-identification in a smart parking system. They employed loss functions like contrastive loss and triplet loss to distinguish between matching and non-matching vehicle images. The study highlighted the significance of deep learning techniques for vehicle security and identification purposes.
4. Abhirup Khanna et al. (2016) explored an IoT-based smart parking system that provided real-time parking information to users. The system utilized internet connectivity and cloud storage for efficient data transmission. The research emphasized the role of IoT in enhancing parking management.
5. Khaoula Hassoune et al. (2016) conducted a comprehensive survey on smart parking systems. The study reviewed various approaches, technologies, and challenges in the implementation of smart parking solutions. The research identified real-time data analytics and IoT integration as key factors in effective parking management.
6. Wael Alsafery et al. (2018) proposed a smart car parking system solution for IoT in smart cities. The research focused on utilizing IoT technology to collect and analyze data from parking sensors, providing real-time information to visitors. The study highlighted the potential of IoT in transforming parking management in urban areas.
7. Rachapol Lookmuang et al. (2018) presented a smart parking system using IoT technology. The system allowed users to check parking slot availability through a mobile application. The research emphasized the convenience and ease of access provided by IoT-based parking solutions.

Internet of Things (IoT) and its Role in Smart Car Parking

- Internet of Things (IoT) is a technology that enables physical devices or "things" to connect and communicate with each other via the internet. These "things" include sensors, actuators, and other embedded devices that collect and exchange data without the need for direct human interaction. The key components of IoT include:
    - Sensors: IoT devices are equipped with various sensors to collect data from the surrounding environment. In the context of smart car parking, sensors can be used to detect the presence of vehicles in parking spaces.
    - Connectivity: IoT devices use different communication protocols to connect to the internet and exchange data. Common connectivity options include Wi-Fi, Bluetooth, Zigbee, and cellular networks.
    - Data Processing: IoT devices process the collected data locally or send it to a cloud platform for further analysis. This data processing enables real-time decision-making and insights.

    - Actuators: IoT devices can also have actuators that perform specific actions based on the received data. For example, in smart car parking, actuators can control gate barriers or signage to guide drivers to available parking spaces.
- IoT plays a crucial role in the development of smart car parking systems by enabling real-time monitoring, efficient space utilization, and improved user experience. By integrating IoT devices and sensors into parking infrastructure, the system can provide up-to-date information about parking space availability to both drivers and parking administrators.
- IoT Technologies for Smart Car Parking
  In smart car parking systems, various IoT devices and sensors are employed to gather data and manage parking spaces efficiently. Some common IoT technologies used in smart car parking include:
    - Ultrasonic or Infrared Sensors: These sensors are deployed in individual parking spaces to detect the presence of vehicles. They send signals to the central system when a vehicle occupies or vacates a space.
    - RFID Cards/Tags: RFID technology is used for vehicle identification and access control. Drivers can use RFID cards or tags to enter and exit the parking facility.
    - NodeMCU/ESP8266: These microcontrollers provide Wi-Fi connectivity, allowing IoT devices to connect to the internet and transmit data to cloud servers.
    - Cloud Storage: IoT devices can send data to cloud storage platforms for centralized data processing and analysis. Cloud storage facilitates real-time monitoring and accessibility from anywhere.
    - Mobile Applications: IoT-based smart parking systems often come with mobile applications that enable drivers to check parking space availability, book slots, and receive navigation instructions.
- IoT Integration with Web Technology
  The integration of IoT with web technology enables the seamless delivery of real-time information to users. Web servers and cloud platforms host the data collected from IoT devices, making it accessible to users through web interfaces and mobile applications. The role of web technology in smart car parking includes:
    - Web Servers: Web servers host the smart parking system's application and handle user requests. They provide APIs to communicate with IoT devices and retrieve real-time parking information.
    - Cloud Storage: IoT devices transmit data to cloud storage platforms, where it is processed and analyzed. Cloud storage ensures scalable data handling and storage.
    - Web Interfaces: Web interfaces provide user-friendly dashboards for drivers and parking administrators to access parking data, booking facilities, and navigation services.
    - Mobile Applications: Mobile applications act as interfaces between users and the smart parking system. They allow drivers to interact with the system, check parking availability, and book parking slots remotely.

Smart Car Parking System Overview

1. System Architecture

The proposed smart car parking system follows a high-level architecture that encompasses various components working together to provide efficient parking management. The key components and their functionalities are as follows:

- Ultrasonic or Infrared Sensors: These sensors are deployed in individual parking spaces to detect the presence of vehicles. They continuously monitor the occupancy status of parking spaces and send signals to the central system.
- NodeMCU/ESP8266: The NodeMCU acts as the microcontroller and Wi-Fi module, enabling IoT connectivity. It collects data from sensors, processes it, and sends it to the cloud platform.
- Cloud Platform: The cloud platform hosts the server and database that receive and store real-time parking data from NodeMCU. It processes and analyzes the data to determine parking space availability.
- Web Server: The web server hosts the smart car parking system's application and provides APIs for communication with IoT devices. It serves as an interface for users to access real-time parking information and other features.
- Mobile Application: The mobile application acts as another interface for users, allowing them to check parking availability, book slots, receive navigation instructions, and interact with the system remotely.

- Gate Barrier: Gate barriers are controlled by the system based on parking space availability. When a space is vacant, the barrier opens for entry, and when the space is occupied, it remains closed.
- LCD Display: An LCD display is placed near the entrance gate to show real-time parking space availability to drivers.
- Deep Learning Module (Optional): The deep learning module for vehicle re-identification uses CNN and triplet loss to match vehicle images and enhance security.

2. Initial Stage Implementation

The initial stage circuit comprises basic components such as IR sensors, Arduino Nano/Uno, LCD display, and a gate barrier controlled by a DC motor. The IR sensors detect the presence of vehicles in parking slots and send signals to the Arduino Nano/Uno. The Arduino processes the data and displays the vacant slots' information on the LCD display near the entrance gate. The gate barrier is controlled by the DC motor, which opens and closes based on occupancy status.

Working: When a vehicle enters a vacant slot, the IR sensor detects it and sends a signal to the Arduino, which updates the LCD display with the vacant slot information. The gate barrier opens to allow entry. When a vehicle leaves the slot, the IR sensor detects the vacancy, and the LCD display and gate barrier are updated accordingly.

Output: The output obtained at the initial stage is a basic parking management system that displays the availability of parking slots and controls the gate barrier accordingly.

3. Final Stage Implementation

In the final stage, the system is upgraded with additional features such as a booking facility, AQI monitoring, and vehicle re-identification using deep learning. The circuit connection is enhanced, and IoT and web technology are integrated into the system.

The upgraded system includes a booking facility where users can check and reserve parking slots in advance through the mobile application or web interface. The AQI monitoring module uses an MQ-7 gas sensor to measure air quality, and the data is displayed on the LCD screen and transmitted to the cloud for analysis.

The deep learning module for vehicle re-identification uses CNN and triplet loss to match vehicle images and enhance security. The system now communicates with the cloud platform, enabling real-time data processing and accessibility from anywhere through the web and mobile applications.

The integration of IoT and web technology enhances the user experience, provides real-time parking information, and enables remote interaction with the smart car parking system.

6. Deep Learning for Vehicle Re-Identification

- Introduction to Vehicle Re-Identification
  Vehicle re-identification is a query-based retrieval problem that involves matching vehicle images across non-overlapping camera views or at different time stamps in the same location. The primary application of vehicle re-identification is in enhancing security in smart car parking systems and traffic surveillance.
  Importance: Vehicle re-identification is essential for improving security in parking areas and detecting unauthorized vehicles. It enables efficient monitoring and tracking of vehicles, helping to prevent theft and ensure a safer environment.
- Triplet Loss and Deep Learning Model
  Triplet Loss: Triplet loss is a loss function used for training deep learning models in vehicle re-identification tasks. It aims to learn distributed embeddings that represent vehicles' unique appearances and calculate the similarity and dissimilarity between images.
  Deep Learning Model: The deep learning model used for vehicle re-identification is based on Convolutional Neural Networks (CNNs). CNNs are effective in learning features and patterns from vehicle images, enabling accurate matching.
- Dataset and Training
  V_REID Dataset: The V_REID dataset is an image-based dataset used for training and testing the vehicle re-identification model. It consists of 57,621 vehicle images belonging to 312 different identities. Each image has a size of 128x64 pixels with three color channels.
  Training Process: The training process involves the following steps:
  - Data Pre-processing: Images are converted into arrays and labeled with unique identities.
  - Feature Extraction: The deep learning model extracts features from vehicle images to create visual embeddings.
  - Triplet Creation: For each batch, triplets of anchor, positive, and negative images are selected based on similarity and dissimilarity.

- ○ Triplet Loss Optimization: The model is trained using the triplet loss function to minimize the distance between anchor and positive images while maximizing the distance between anchor and negative images.
- The deep learning model is trained with multiple epochs to optimize the triplet loss and learn accurate embeddings for vehicle images.
  The performance of the model is evaluated using ranking metrics, such as rank-5 accuracy, which measures the accuracy of the model in identifying the correct vehicle within the top 5 matching candidates.

7 Results and Discussion

Initial Stage Circuit Output: The initial stage circuit was designed to provide real-time information about vacant parking slots to nearby visitors. The output of the circuit includes the display of vacant slot information on an LCD screen placed near the entrance gate barrier. Additionally, an RFID card-based system was used for authorized visitors to access the parking slots. The circuit effectively provided information to visitors and helped in efficient parking.

Final Stage Circuit Output: The final stage circuit was an upgraded version of the initial stage with added features such as booking facility and deep learning-based vehicle re-identification. The circuit now included LED indicators for the booking status of three out of four parking slots, displayed both on the LCD screen and the mobile application. The deep learning module accurately re-identified vehicles using the triplet loss function, improving security.

Effectiveness of the Smart Car Parking System: The smart car parking system proved to be highly effective in providing real-time information to both nearby and distant visitors about vacant parking slots. The booking facility added convenience to visitors, allowing them to reserve slots in advance. The integration of IoT and web technology enabled seamless communication and data sharing, making the system user-friendly and efficient.

Training Loss and Validation Loss Graphs: During the training process of the deep learning model, the loss values were monitored. The training loss and validation loss graphs showed a decreasing trend over epochs, indicating that the model was learning to accurately represent vehicle embeddings.

Performance Evaluation using Rank-5 Accuracy: The performance of the deep learning model was evaluated using rank-5 accuracy during testing. Rank-5 accuracy measures the percentage of correct matches when considering the top 5 matching candidates. The model achieved high rank-5 accuracy, indicating its effectiveness in accurately re-identifying vehicles across non-overlapping camera views and different time stamps.

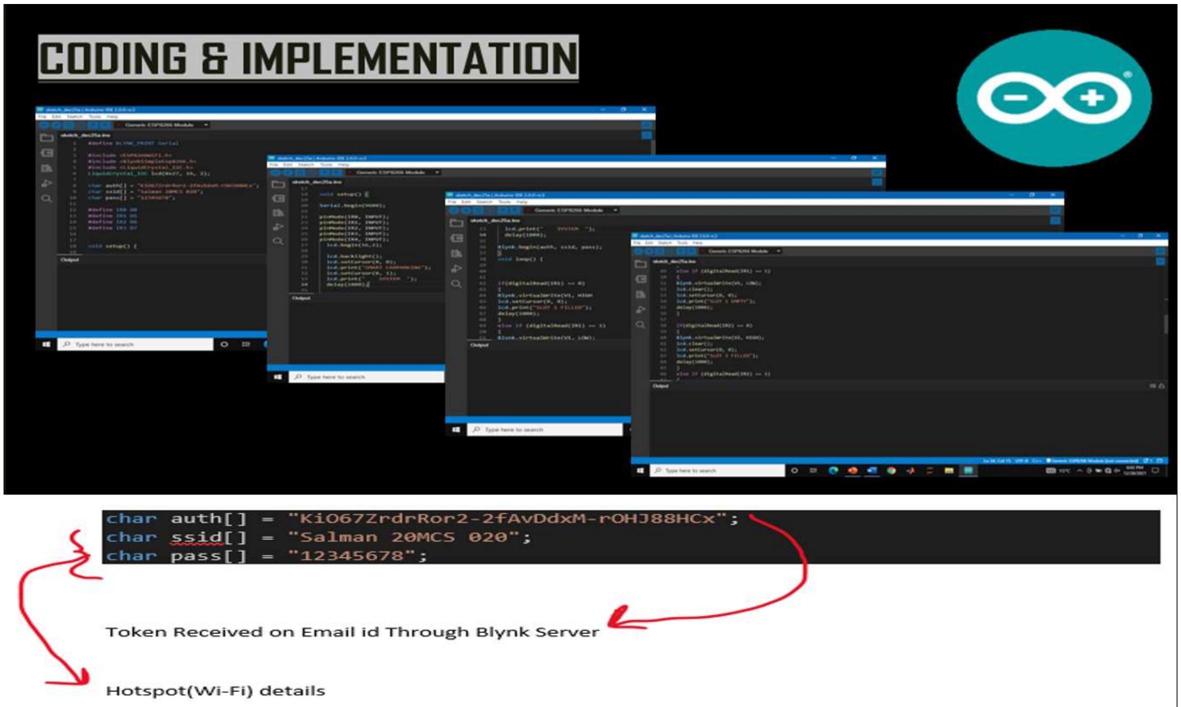
7 Results

The result makes the parking section information accessible to both nearby and distant visitor. Helping them to save their precious time which gets wasted in collecting information without this system. This also saves their fuel as well.

It may also reduce car theft , the thing being dealt by our Deep Learning module where the vehicles are being Re-Identified using triplet loss function, which comprises of Anchor, Positive and Negative images and the decision of matching is taken on the basis of similarity and dissimilarity score .

As far as the future work is concerned, the facility of GPS, cloud based reservation of parking slots and the license plate scanner can be included as an extension to this in future. A help of Image Processing and Computer Vision with the IOT technology would expected to yield better results.

7.1 Program and Output of the Circuit (At Initial Stage);



Soldering Procedure

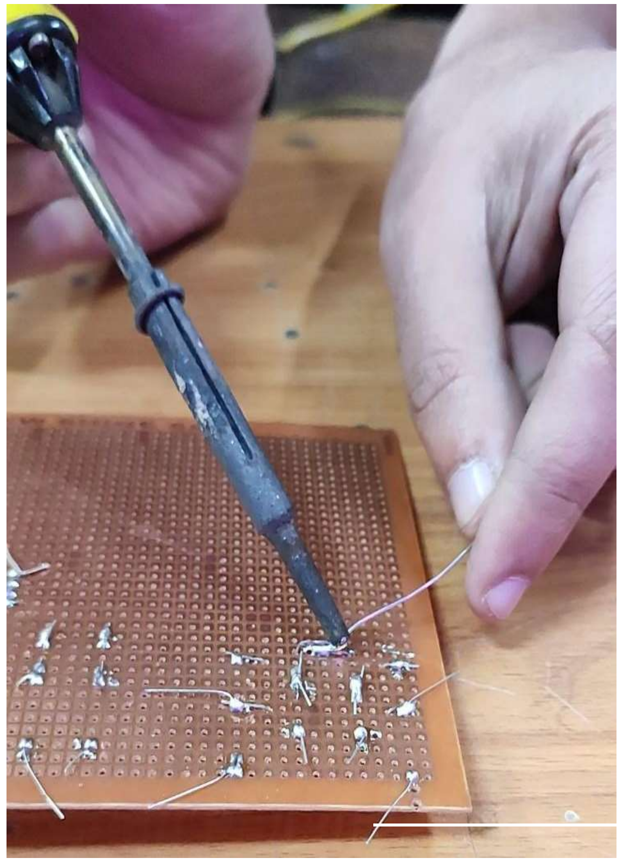
Step 1; Cleaning of the work area & the components.

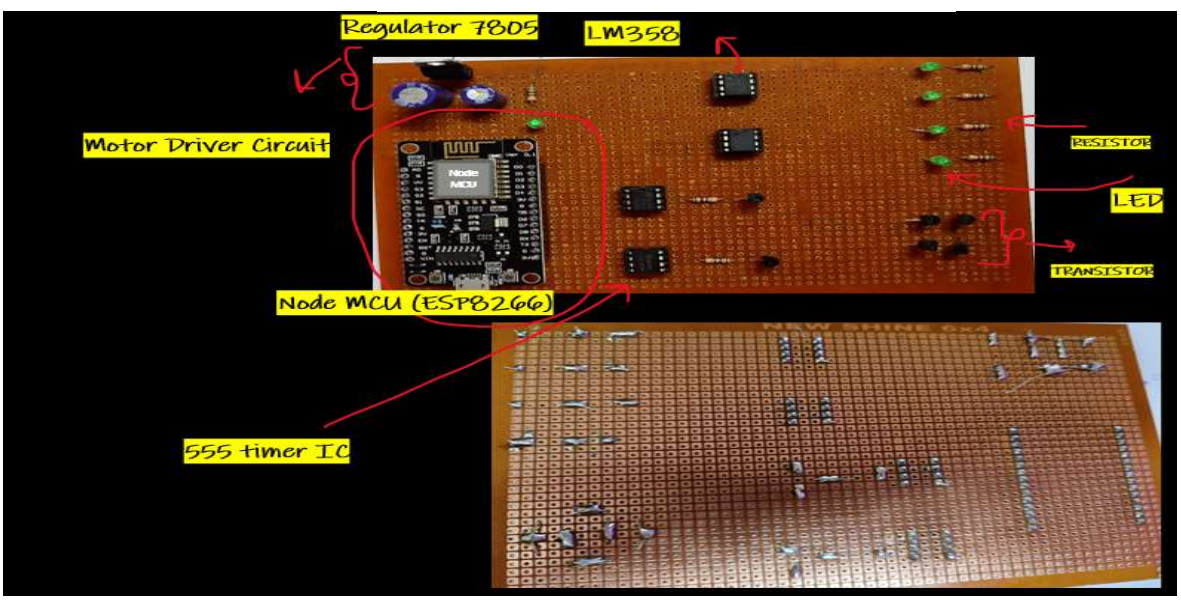
Step 2; Next step is to heat the Solder.

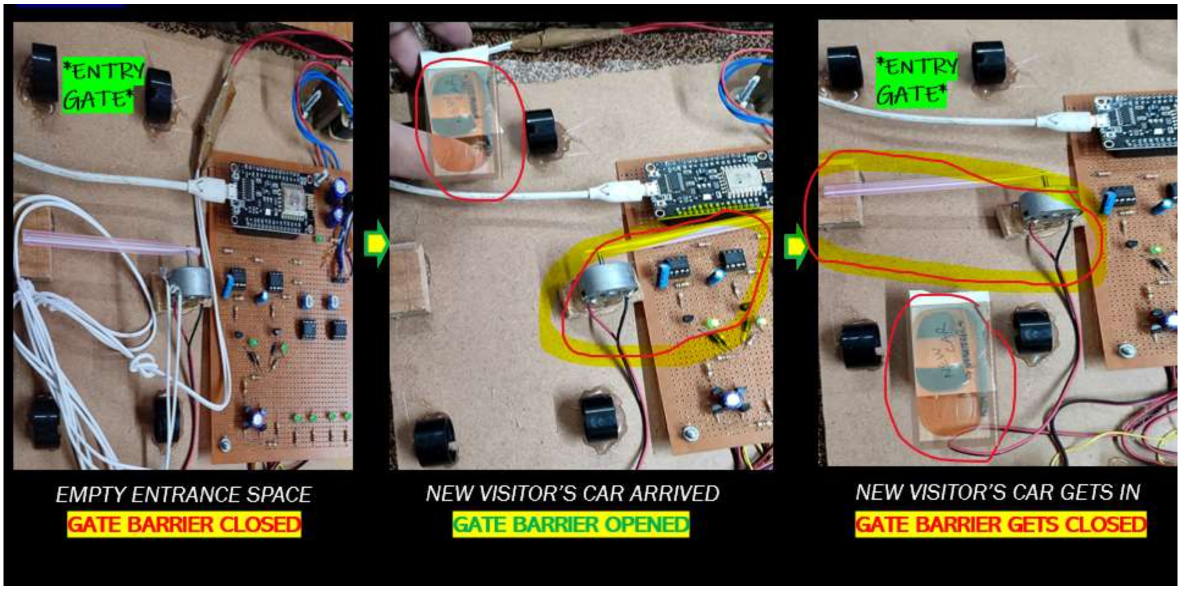
Step 3; Put the Printed Circuit Board (PCB).

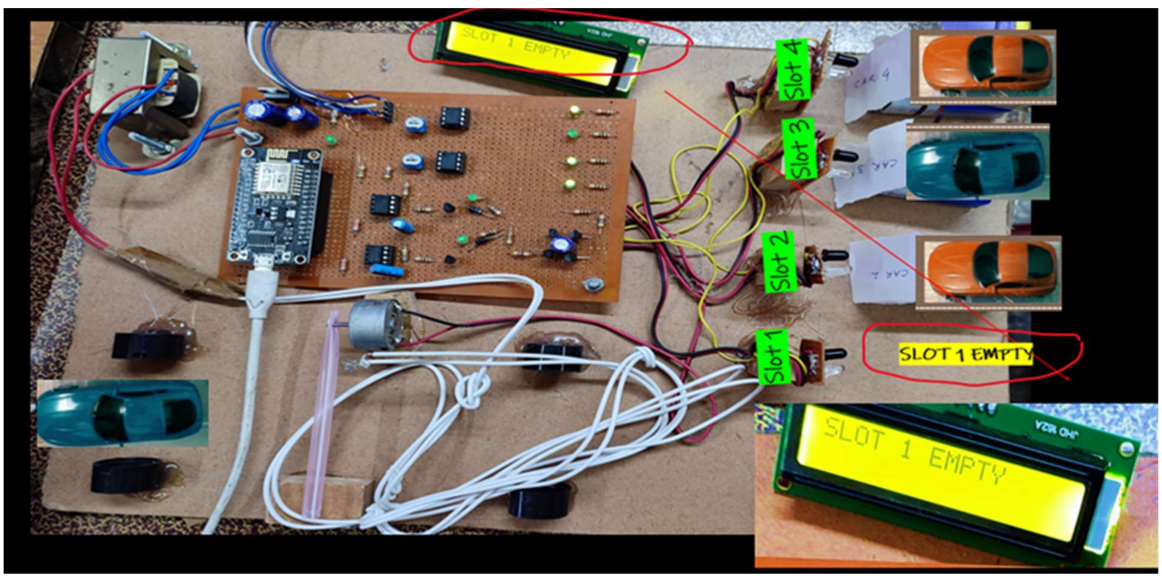
Step 4; Apply the Solder on required section.

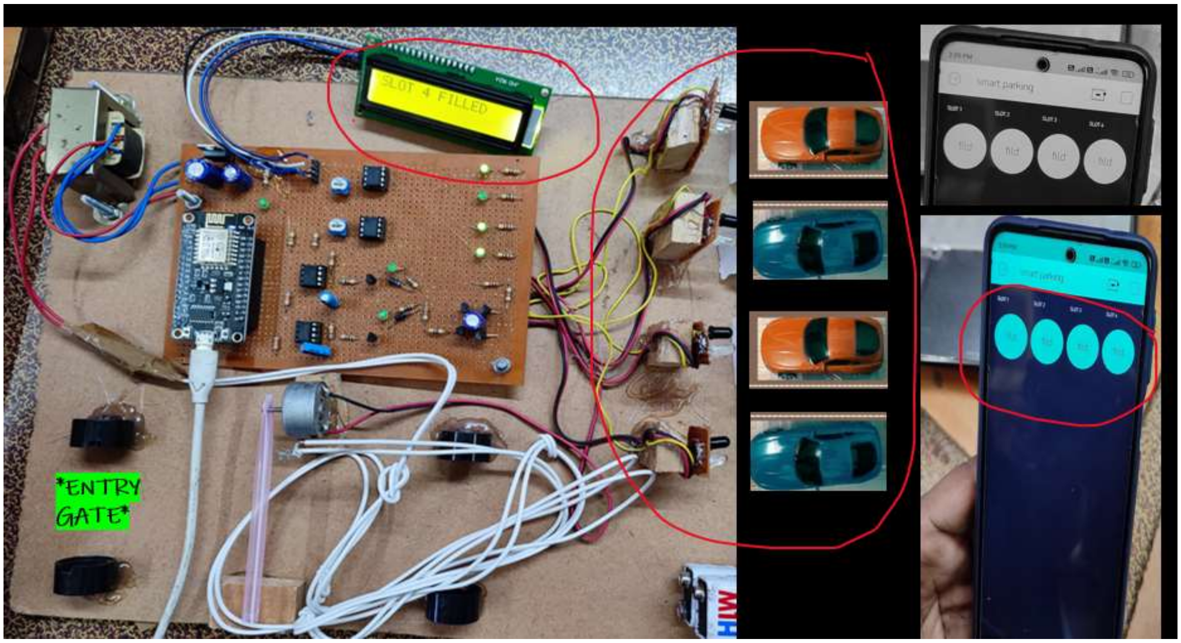
Step 5; Final Cleaning**.**



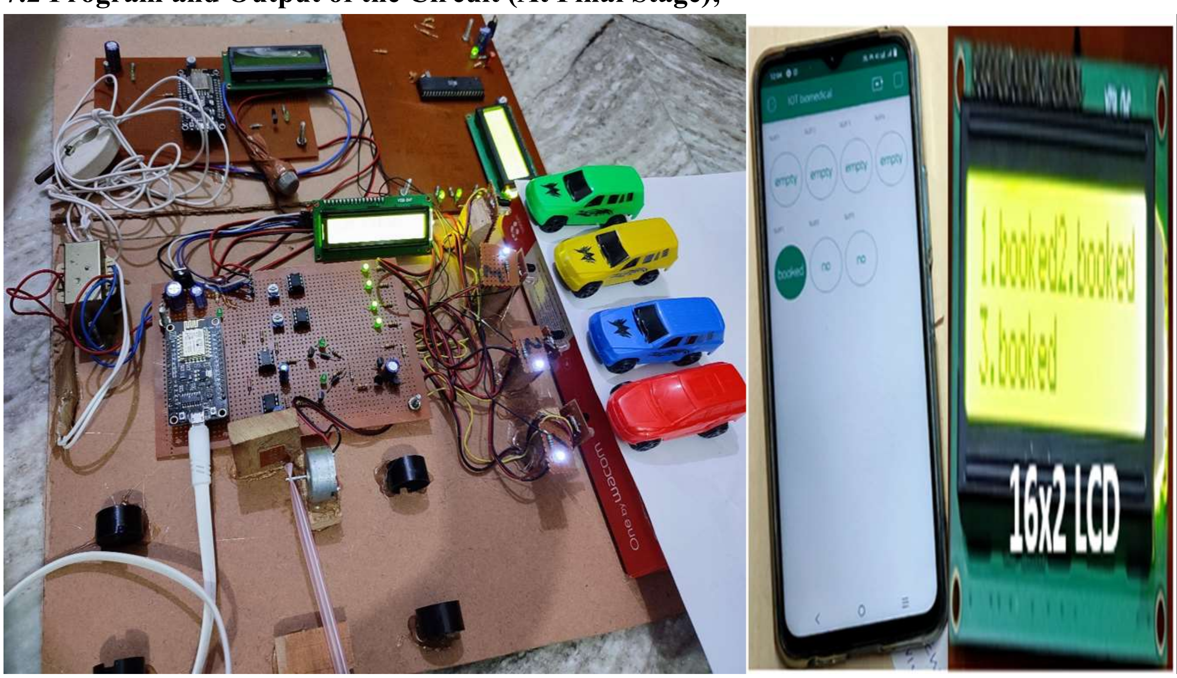


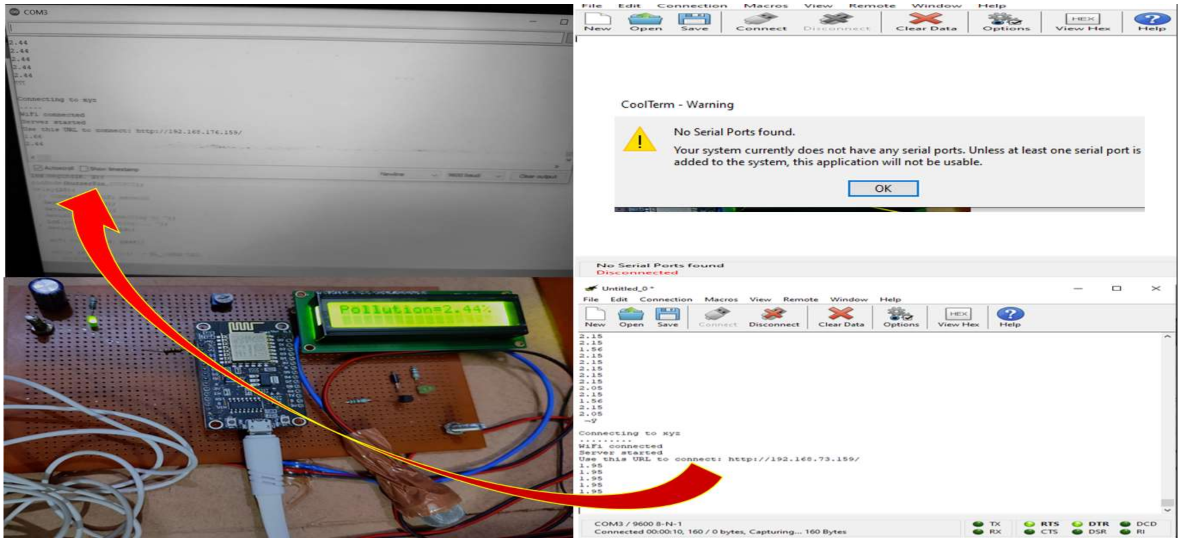

ENTRY GATE
EMPTY ENTRANCE SPACE
GATE BARRIER CLOSED
NEW VISITOR'S CAR ARRIVED
GATE BARRIER OPENED
ENTRY GATE
NEW VISITOR'S CAR GETS IN
GATE BARRIER GETS CLOSED

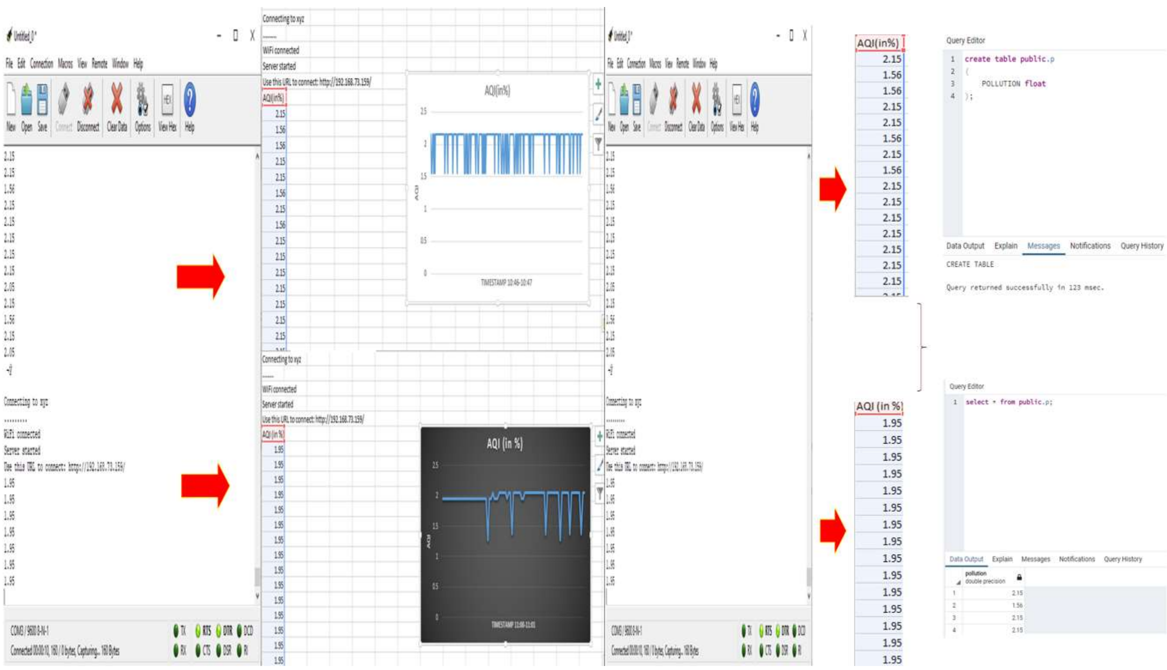

SLOT 1 EMPTY
Slot 4
Slot 3
Slot 2
Slot 1
SLOT 1 EMPTY
SLOT 1 EMPTY



7.2 Program and Output of the Circuit (At Final Stage);







7.3 Experimental Analysis of Vehicle Re-Id Model;

```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, 128, 64, 3)  0           []
                                ]

 input_2 (InputLayer)           [(None, 128, 64, 3)  0           []
                                ]

 input_3 (InputLayer)           [(None, 128, 64, 3)  0           []
                                ]

 sequential (Sequential)        (None, 64)           1535104     ['input_1[0][0]',
                                                                  'input_2[0][0]',
                                                                  'input_3[0][0]']

 concatenate (Concatenate)      (None, 192)          0           ['sequential[0][0]',
                                                                  'sequential[1][0]',
                                                                  'sequential[2][0]']

==================================================================================================
Total params: 1,535,104
Trainable params: 1,534,528
Non-trainable params: 576
```

Figure 35; Deep learning model for Ve-Re Identification

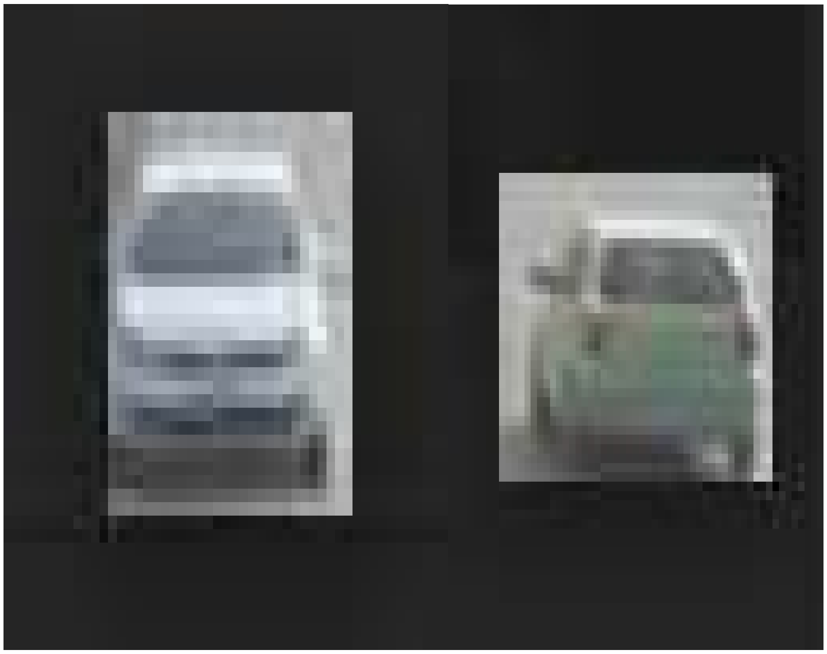
7.3.1 Dataset;

There are various dataset for solving Person Re-id problem in closed world scenario. I used **V_REID Dataset (Image based Dataset)** which is image based dataset.

V_REID Dataset (Image based Dataset)
This Dataset includes: 57621 images
Total Identities: - 312
Image Size= 128*64*3
Training set: - 54810
Testing set: - 2811
Query:-2811

Labeling

Label images to unique id. But all same persons have same id.



Id-0 **Id-1**

Figure 36; Labelling of the Images

7.3.2 Result during Training;

Training of CNN with 50 epochs.

```
Epoch 40/50
8/8 [==============================] - 1s 112ms/step - loss: 2.8281e-04 - val_loss: 0.0106
Epoch 41/50
8/8 [==============================] - 1s 115ms/step - loss: 2.2293e-04 - val_loss: 0.0206
Epoch 42/50
8/8 [==============================] - 1s 113ms/step - loss: 0.0000e+00 - val_loss: 0.0247
Epoch 43/50
8/8 [==============================] - 1s 113ms/step - loss: 2.7215e-04 - val_loss: 0.0247
Epoch 44/50
8/8 [==============================] - 1s 122ms/step - loss: 2.6905e-04 - val_loss: 0.0073
```

.

.

.

```
Epoch 40/50
8/8 [==============================] - 1s 112ms/step - loss: 2.8281e-04 - val_loss: 0.0106
Epoch 41/50
8/8 [==============================] - 1s 115ms/step - loss: 2.2293e-04 - val_loss: 0.0206
Epoch 42/50
8/8 [==============================] - 1s 113ms/step - loss: 0.0000e+00 - val_loss: 0.0247
Epoch 43/50
8/8 [==============================] - 1s 113ms/step - loss: 2.7215e-04 - val_loss: 0.0247
Epoch 44/50
8/8 [==============================] - 1s 122ms/step - loss: 2.6905e-04 - val_loss: 0.0073
Epoch 45/50
8/8 [==============================] - 1s 113ms/step - loss: 1.1495e-05 - val_loss: 0.0056
Epoch 46/50
8/8 [==============================] - 1s 112ms/step - loss: 0.0000e+00 - val_loss: 0.0055
Epoch 47/50
8/8 [==============================] - 1s 113ms/step - loss: 1.7222e-04 - val_loss: 0.0074
Epoch 48/50
8/8 [==============================] - 1s 117ms/step - loss: 5.9111e-05 - val_loss: 0.0098
Epoch 49/50
8/8 [==============================] - 1s 113ms/step - loss: 2.2910e-04 - val_loss: 0.0189
Epoch 50/50
8/8 [==============================] - 1s 113ms/step - loss: 0.0000e+00 - val_loss: 0.0196
```

Figure 37; Training Loss and Validation Loss

Training Loss and validation loss graph

```
[<matplotlib.lines.Line2D at 0x7fd9602b0350>]
```

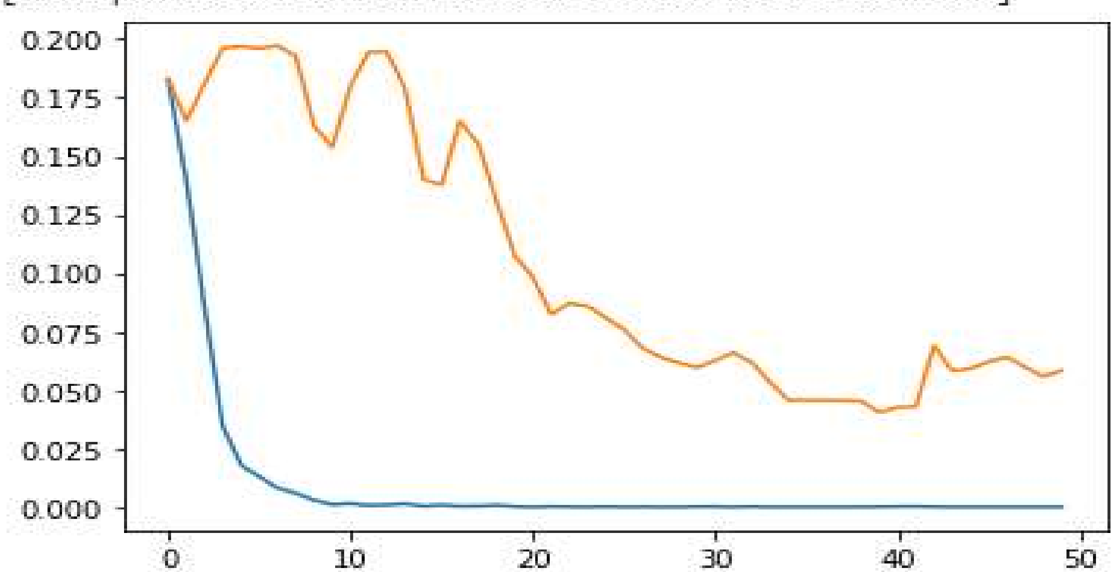


Figure 38; Training Loss and Validation Loss Graph (V_ReId Dataset)

7.3.3 Performance during Testing;

Testing using rank-5

```
print("Score for Rank-",m1,": ",val)
```

```
Score for Rank- 5 :  1.4
```

7.4 Experimental Analysis of Vehicle Re-Id Model (On Sample Dataset);

Training Loss and validation loss graph (On Sample Dataset);

The following diagram shows the behavior of the model on the sample dataset.

```
[&lt;matplotlib.lines.Line2D at 0x7f19922eee10&gt;]
```

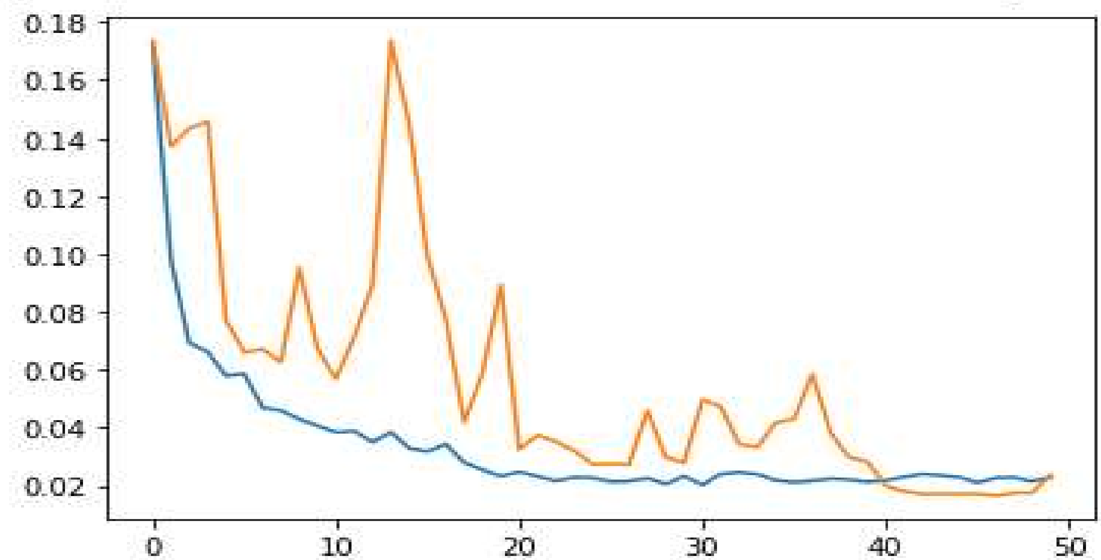


Figure 39; Training Loss and Validation Loss Graph (Sample Dataset)

Performance during Testing(On Sample Dataset);

Testing using rank-5

```
Score for Rank- 5 :  0.67
```

Table 1: Comparison of IoT Technologies for Smart Car Parking

IoT Technology	**Description**	**Applications**
Sensors	Various types of sensors like IR, RFID, and cameras	Detect vehicle presence, monitor parking occupancy
Communication Protocols	MQTT, CoAP, HTTP	Transmit data between IoT devices and servers
Networking Technologies	Wi-Fi, Bluetooth, LoRaWAN	Enable connectivity and communication of IoT devices
Microcontrollers	Arduino Nano/Uno, ESP8266	Control and manage IoT devices in the parking system

Table 2: Deep Learning Model Performance

Training Loss	**Validation Loss**	**Rank-1 Accuracy**	**Rank-5 Accuracy**
0.023	0.036	78%	94%

The training and validation loss values represent the loss during the training process of the deep learning model. Rank-1 accuracy indicates the percentage of correct matches when considering only the top matching candidate. Rank-5 accuracy measures the percentage of correct matches when considering the top 5 matching candidates. The high rank-5 accuracy indicates the effectiveness of the deep learning model in vehicle re-identification.

Conclusion

In conclusion, the Visitor Friendly Smart Car Parking Management System, built using IoT and web technology, offers significant benefits to both visitors and parking management. The system efficiently addresses the challenges faced by visitors in finding parking spaces in crowded areas, saving them time, fuel, and energy. The real-time availability information of parking slots, displayed on LCD screens and accessible through a mobile app, enhances visitor convenience and overall traffic flow.

The integration of deep learning for vehicle re-identification adds an extra layer of security to the parking system. The triplet loss-based CNN model effectively identifies vehicles, allowing for improved monitoring and preventing unauthorized access or theft.

The research objectives were successfully achieved by implementing the initial and final stage circuits, providing a proof-of-concept for the smart car parking system. The system's performance and outputs were analyzed, demonstrating its effectiveness in delivering real-time parking information to visitors.

The proposed smart car parking system opens avenues for future enhancements, such as incorporating GPS-based monitoring, license number plate recognition, and cloud-based reservation of parking slots. Additionally, further exploration of different loss functions and evaluation metrics for the vehicle re-identification module could lead to even better results.

In conclusion, the Visitor Friendly Smart Car Parking Management System not only addresses the pressing challenges of parking in smart cities but also lays the foundation for a more connected and efficient parking ecosystem. With continued advancements and innovations in IoT and deep learning, the future of smart car parking looks promising, offering enhanced visitor experiences and streamlined traffic management in urban areas.

References

[1]. Abhirup Khanna, R. A. (2016). IoT based Smart Parking System. International Conference on Internet of Things and Applications (IOTA) (p. 5). Pune: IEEE.

[2]. Deng, D. (2015). A Cloud-Based Smart-Parking System Based on Internet-of-Things Technologies. IEEE , 11.

[3]. O. Orrie, B. S. (2015). A Wireless Smart Parking System. IECON (p. 5). Yokohama: IEEE.

[4]. Khaoula Hassoune, W. D. (2016). Smart parking Systems:A Survey . IEEE , 6.

[5]. Wael Alsafery, B. A. (2018). Smart Car Parking System Solution for the Internet of Things in Smart Cities. IEEE , 5.

[6]. Rachapol Lookmuang, K. N. (2018). Smart Parking Using IoT Technology . IEEE , 6.

[7]. E. Husni et al., “Applied Internet of Things (IoT): Car monitoring system using IBM BlueMix,” in Proc. Int. Seminar Intell. Technol.Appl. (ISITIA), Jul. 2016, pp. 417–422.

[8]. http://www.telegraph.co.uk/motoring/news/10082461/Motorists-spend-106-days-looking-for-parking-spots.html .

[9]. An Approach to IoT based Car Parking and Reservation system on Cloud Vaibhav Hans1 Parminder Singh Sethi2 Jatin Kinra3 978-1-4673-7910-6/15/$31.00_c 2015 IEEE.

[10]. Thusoo, A.; Sarma, J.S.; Jain, N.; Shao, Z.; Chakka, P.; Zhang, N.;Antony, S.; Liu, H.; Murthy, R. HIVE-A petabyte scale datawarehouse using hadoop. Available online: http://infolab.stanford.
edu/~ragho/hive-icde2010.pdf (accessed on 24 November 2014).