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PARK-EZE: An IoT based Smart Parking System using DLSTM Prediction

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***Abstract*— In response to escalating urbanization and vehicular congestion, our project PARKEZE a Smart Parking System introduces an innovative solution integrating IoT and DLSTM (Deep Long Short Term Memory) technologies. By employing IoT sensors for realtime data collection and DLSTM for predictive analysis, the system PARK-EZE aims to revolutionize parking management. This exploration delves into PARK-EZE's design, implementation, and transformative potential, elucidating its role in creating smarter, more sustainable urban spaces. Through comprehensive data analytics, PARKEZE seeks to alleviate congestion and inefficient parking allocation, fostering efficient urban mobility patterns. PARK-EZE represents a paradigm shift towards efficiency, accessibility, and environmental stewardship in urban environments.**

***Index Terms*—PARK-EZE, Prediction, Real-time parking data**

I. Introduction

Efficient parking management is crucial for urban traffic flow and livability. However, traditional systems often struggle to meet dynamic city demands, resulting in inefficiencies. Integrating advanced technologies offers promising opportunities for improvement. This project proposes a comprehensive approach, combining Radio Frequency Identification (RFID) systems, Ultra Sonic sensors, and Long Short-Term Memory (LSTM) predictive modeling. By seamlessly integrating these technologies into parking infrastructure, the system enables real-time monitoring, efficient entry/exit processes, and accurate occupancy forecasting. A centralized server infrastructure facilitates seamless data flow between RFID scanners, Ultra Sonic sensors, user accounts, and the web application interface. RFID technology streamlines entry/exit with users accessing real-time availability via RFID-enabled cards. Scanners update the web interface, reducing congestion, while Ultra Sonic sensors provide precise slot availability information. Furthermore, RFID technology accurately tracks session durations, enhancing transparency. LSTM predictive modeling analyzes historical data to forecast availability, aiding resource optimization. Rigorous evaluation ensures model reliability. In summary, this system advances parking facility operation and utilization. Integrating RFID technology, Ultra Sonic sensors, and LSTM modeling optimizes processes, improves user experiences, and enhances overall efficiency. This innovative approach has the potential to transform urban parking management, fostering sustainable, accessible, and livable cities.

II. LITERATURE REVIEW

Various researchers have proposed frameworks to enhance parking management by integrating IoT, Machine Learning, Deep Learning, and Image Segmentation [1-4].

Aditya et al. [1] introduce an IoT-assisted Intelligent Parking System (IPS) for smart cities, addressing the challenge of finding parking spaces in high-density areas. Their system utilizes IoT to gather real-time data and recommend suitable parking spaces via a mobile app. However, reliance on multiple hardware components (Raspberry Pi, NodeMCU, RFID, IR sensors) may increase deployment costs and complexity, while accuracy could be affected by IoT sensor reliability.

Ghulam Ali et al. [2] present a system predicting parking space availability using a Deep Long Short-Term Memory (DLSTM) network integrated with IoT and cloud technology. They emphasize ethical surveillance practices and outperform state-oftheart prediction models using the Birmingham parking sensors dataset. However, deep learning models like DLSTM demand substantial computational resources, potentially resulting in latency issues for real-time parking space availability predictions. Additionally, integrating cloud technology may raise concerns about data privacy and security.

Tekouabou et al. [3] propose a framework integrating IoT and predictive modeling to optimize parking space predictions in smart cities, achieving improved accuracy while reducing system complexity. However, while achieving improved accuracy, integrating IoT with predictive modeling may introduce complexities in data preprocessing, model training, and deployment, potentially hindering scalability.

Ajchariyavanich et al. [4] develop Park King, an IoTbased smart parking system for college campuses, focusing on quality assurance and prototype development. However, the campus-specific approach may limit its applicability to other urban environments, and the emphasis on quality assurance and prototype development may neglect scalability and longterm maintenance needs.

Our system overcomes these drawbacks by offering a streamlined solution that minimizes hardware complexity, optimizes computational resources, ensures data privacy and security through edge computing, simplifies integration and scalability, and provides a customizable and scalable framework adaptable to diverse urban settings while prioritizing ongoing maintenance and support.

III. PROPOSED SYSTEM

The proposed system utilizes a variety of technologies to manage parking efficiently, offering essential services such as searching for parking slots and features like monitoring parking availability. It incorporates RFID scanners, RFID cards, sensors, a mobile webapp, real-time availability tracking, duration monitoring, and parking prediction. A user-friendly mobile webapp has been developed, allowing users to easily create accounts or log in using email and other necessary credentials. Users can also link their RFID cards to their accounts for seamless access to parking facilities. A central server has been set up to manage RFID card information, sensor data, and user accounts. Sensors are connected to the central server to provide real-time data on parking space availability, which is displayed on the mobile webapp interface as either available or occupied. When scanning the RFID card using the RFID scanner, available slots are shown on the app, and users can park their vehicles accordingly. The system confirms the parking duration based on the exit time. Figure 3 depicted below demonstrates the system process flow our smart parking solution. Regarding the parking space prediction, the proposed LSTM model operates as follows:

1. Historical parking space occupancy data is represented as sequences.
2. The input sequences are provided to the LSTM cell, which consists of cell state, input, output, and forget gates.
3. The input is combined with the previous cell state to compute the new cell state and output for the current time step.
4. During training, the LSTM learns to adjust the weights associated with the input, forget, and output gates to capture relevant patterns in the data
5. The LSTM cell learns to remember or forget information based on the patterns in the input sequences.
6. The output of the LSTM cell at each time step can be used to make predictions about the future occupancy of parking spaces.
7. The performance of the LSTM model is evaluated on a separate validation or test dataset using appropriate metrics

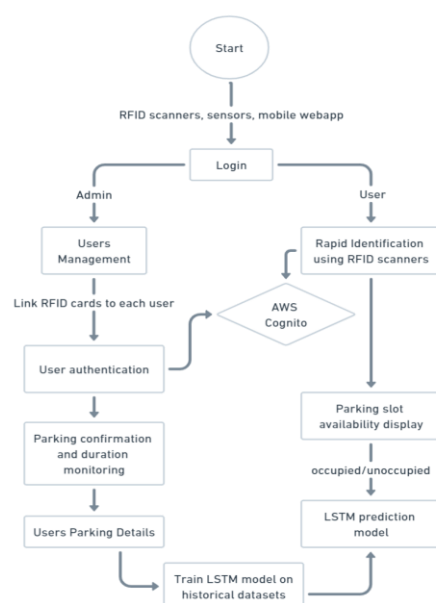

Fig 3.1 System Process Flow

A. Hardware requirements

1) *JSN SR04T Ultrasonic Sensor:* It is a compact and versatile device commonly used for distance measurement. Some key features are its simplicity of use, waterproof design and non-contact measurement capability. It typically operates on a low voltage, making it suitable for integration with microcontrollers like Arduino or Raspberry Pi.

2) *RFID RC522 Module:* It is a compact device designed for RFID applications. It enables communication between RFID tags/cards and micro-controllers, such as Arduino or Raspberry Pi.

3) *RFID Card:* An RFID (Radio-Frequency Identification) card is a small, flat electronic device that contains a unique identifier and an embedded RFID chip. This chip communicates wirelessly with an RFID reader when it's within close proximity. RFID cards come in various shapes like cards, key fobs, and adhesive tags.

4) *ESP32:* It is an effective and flexible microcontroller created by Espress iFrameworks. It is known for its capability to connect to Wi-Fi and Bluetooth systems. It provides high performance processing and consumes less power.

B. Software Requirements

1) *Arduino IDE:* It simplifies coding and uploading for the Arduino UNO, a popular microcontroller platform, with its user-friendly interface. It enables control of sensors, actuators, and displays through the Arduino Uno board.

2) *AWS IoT Core:* It securely connects and manages IoT devices in systems like smart parking. It ensures data security through encryption and authentication. Each device has unique credentials to prevent unauthorized access. AWS IoT Core also offers device management features for remote configuration and monitoring, enhancing system efficiency

3) *AWS Dynamo DB:* It is a fully managed NoSQL database by AWS, offers serverless, high-performance storage. It scales seamlessly, ensuring low latencies and high availability with SSDs and replication across AWS Availability Zones. *4) AWS Lambda:* It is an Amazon Web Services (AWS) service, enables serverless computing, scaling code execution as needed, and billing based on usage. It supports multiple programming languages and handles tasks like database interaction efficiently.

5) *AWS API Gateway:* It is a service by Amazon Web Services (AWS), enables the creation and management of RESTful APIs, exposing various AWS services. It supports interaction through REST API requests, console, CLI, or SDKs, and facilitates access to backend features via standard HTTP protocols or platform-specific SDKs.

6) *AWS Cognito:* It is an authentication service that verifies user credentials and manages user registration, password recovery, and multi-factor authentication for secure access to applications and interfaces.

7) *Blynk IoT API:* It is a user-friendly IoT platform for connecting devices to the cloud, enabling custom application development and remote device control. With support for Android and iOS, Blynk offers intuitive mobile access and customizable dashboards for sensor data visualization.

8) *HTML/CSS/ES6 - Web Dashboard:* It is a tool for creating dynamic web dashboards. It uses HTML for structure, CSS for styling, and ES6 for scripting, enabling developers to craft interactive interfaces with charts, graphs, and widgets. This platform simplifies the creation of powerful web-based dashboards for data visualization and analytics.

IV. Methodology

Our system unveils a smart parking solution integrating AWS Cognito for user authentication and seamless cloud integration. It provides secure access to real-time updates, enhanced by an LSTM prediction model for insightful forecasts. Integration via Streamlit and CORS management ensures ease of use, representing a significant advancement in parking management and predictive analytics. The working of these methods are given below.

A. User Authentication and cloud Interface

The hardware setup comprises an ESP32 microcontroller equipped with an RC522 RFID module, enabling the recognition of pre-programmed RFID tags and their communication with Wi-Fi networks. Subsequently, the ESP32 works by identifying users and transmitting their entry/exit status to the AWS IoT Core platform, facilitating seamless integration with cloud services. Within the AWS ecosystem, data is routed to DynamoDB through AWS IoT Core and the Rules Engine, enabling reliable storage and management of parking-related information. On the user side, AWS Cognito handles secure authentication, allowing authorized users to access the web dashboard. This dashboard, developed using HTML/CSS/ES6, presents real-time parking status information retrieved from DynamoDB, enhancing user experience and facilitating informed decision-making. Additionally, integration with the Blynk app enables mobile users to monitor parking availability and receive updates in real-time, further optimizing the management of parking spaces. Ultrasonic sensors play a crucial role in detecting obstacles and dynamically updating parking occupancy status, ensuring accurate and up-to-date information is reflected in both the dashboard and Blynk app. Overall, this methodology encompasses hardware setup, cloud integration, user authentication, and interface development to create a comprehensive smart parking solution. The architecture of our mobile web application is illustrated in figure 4.1.

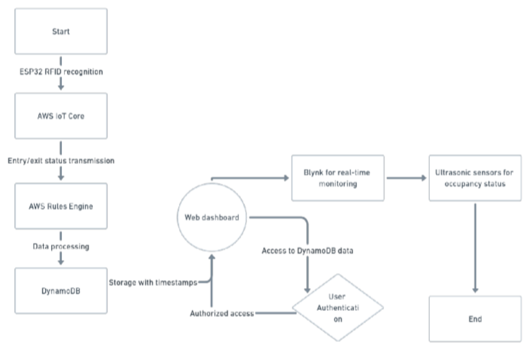

Fig 4.1 User Authentication

B. LSTM Prediction Model

The LSTM prediction model operates by first training on relevant historical datasets to learn patterns and relationships for accurate predictions. Once trained, the model is deployed on a cloud server using a Python application, enabling remote accessibility. Concurrently, a user-friendly interface is crafted using the Streamlit module in Python, providing intuitive interaction with the model. This interface is hosted locally on a specific port, typically port 8501, for easy access. To integrate the Streamlit dashboard with an existing website, it is linked or embedded using hyperlinks or iframes, allowing users to seamlessly interact with the model through the website interface. Cross-Origin Resource Sharing (CORS) is managed to ensure proper communication between different ports, facilitating smooth operation of the integrated system. Overall, this approach enables users to access and interact with the LSTM prediction model through a web interface, enhancing usability and effectiveness. The parking slot availability prediction using DLSTM model is demonstrated in figure 4.2.

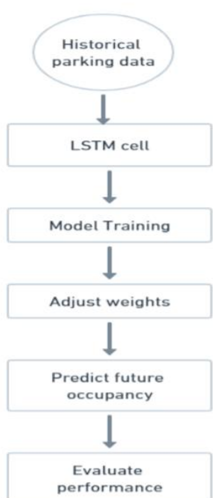

Fig 4.2 Prediction Model

V. RESULT

This session incorporates a range of solutions for smart parking management. It enables real-time monitoring of parking status through a web dashboard and supports mobile access for parking availability updates via the Blynk app. The LSTM prediction model offers accurate predictions for parking slot availability. Users can seamlessly interact with the model through a user-friendly web interface. Additionally, ultrasonic sensors ensure dynamic updates on parking occupancy status, enhancing the overall efficiency and effectiveness of the smart parking system.

Figure 5.1 displays the sign in page of the proposed web application where you can either sign up as admin or the user.

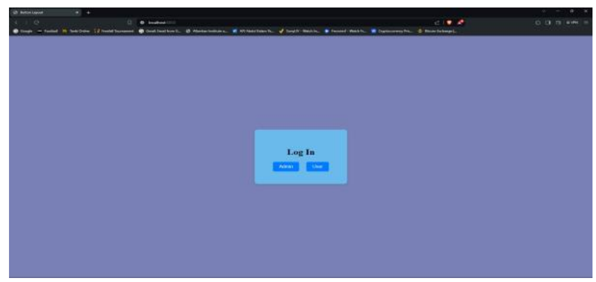

Fig. 5.1 Sign In page

Figure 5.2 is the admin page which points out the user details. For example the user name, parking date, entry and exit time and status of each individual.

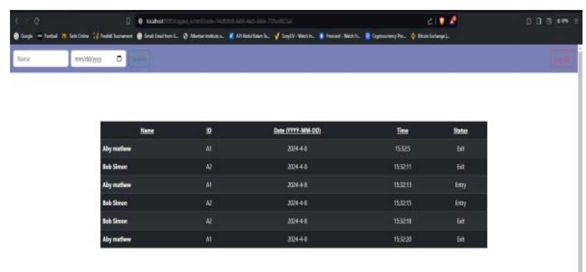

Fig. 5.2 Admin page

Figure 5.3 visualizes the total hours used for parking by each user as a graph.

Fig 5.3 User Graph

Figure5.4 utilizes the model on our complete dataset to generate the pie chart.

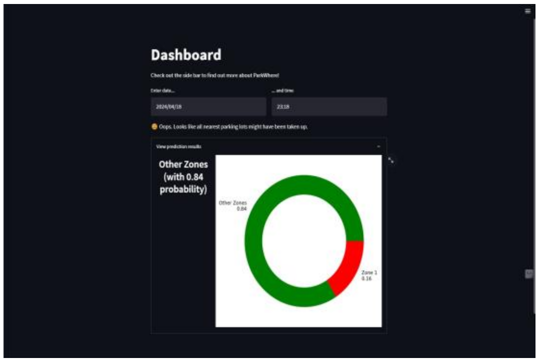

Fig 5.4 Prediction Model

Figure 5.5 is the user page which indicates the parking slots availability as well as their status.

Fig 5.5 Slot Availability

VI. Conclusion and Future Scope

In conclusion, the integration of IoT, cloud computing, and LSTM predictive modeling has led to the development of an advanced smart parking system. Utilizing an ESP32 microcontroller, AWS services, and Stream lit for user interface, the system efficiently manages parking, enhances user experience, and optimizes operations. Real-time monitoring of parking availability, secure authentication, and remote access to predictive models are facilitated through seamless hardware and software integration. With AWS services ensuring data security and scalability, this system represents a significant advancement in addressing urban parking challenges, offering improved efficiency and user satisfaction. Future enhancements could include advanced analytics for utilization trends, dynamic pricing based on demand, interoperability with smart city infrastructure, and ongoing refinement of predictive models for improved accuracy and responsiveness.

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