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PRPS: AI-based Parking Receipt Possession System using OpenCV

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***Abstract*— With rapid urbanization and increasing vehicle numbers, efficient parking management systems are crucial, especially in developing countries like India. Traditional methods of manually issuing parking receipts at establishments like shopping malls and apartments often lead to congestion and inefficiencies. This research proposes an innovative AI-based Parking Receipt Possession System (PRPS) using OpenCV (Open-Source Computer Vision Library) to automate parking ticket handling and enhance overall parking facility management. The PRPS aims to revolutionize the conventional ticket issuance and possession process at establishments like malls and apartment complexes. By leveraging OpenCV, the system automates vehicle information capture at entry points. Upon arrival, users interact with an AI-Integrated virtual keyboard to input their details effortlessly. The system then generates a digital parking receipt based on the provided information, eliminating manual data entry and physical ticket issuance.**

***Index Terms*— AI-based Virtual Keyboard, Automated Parking Systems (APS), OpenCV, Parking Management.**

I. INTRODUCTION

With the proliferation of urbanization and increment in vehicular population, efficient parking management has become a critical challenge, especially in developing nations like India. Traditional methods involving manual ticket issuance and possession at entry points of establishments such as shopping malls and apartment complexes often result in congestion, inefficiencies, and poor user experiences. Addressing these issues requires innovative technological solutions that can streamline parking operations, enhance user convenience, and optimize overall facility management.

This research proposes an AI-based Parking Receipt Possession System (PRPS) that utilizes OpenCV (Open-Source Computer Vision Library) to modernize parking ticket handling processes. By leveraging computer vision technology, the PRPS aims to automate the capture, processing, and possession of parking receipts, revolutionizing conventional methods prevalent in urban parking environments.

The primary goal of this study is to introduce and evaluate the effectiveness of the PRPS in overcoming the limitations of traditional parking management systems. By harnessing AI and computer vision, the PRPS seeks to eliminate manual data entry and physical ticket issuance, reducing congestion at entry points and improving operational efficiency. Additionally, the integration of a timestamp mechanism enables accurate tracking of parking durations, facilitating seamless payment transactions and minimizing human intervention.

This introduction sets the foundation for subsequent sections of the research paper, which will explore the methodology, experiments conducted, potential applications, and conclusions of the PRPS. Through a comprehensive examination of the system's functionality, usability, and performance in diverse parking scenarios, this study aims to demonstrate the potential of AI-driven solutions in transforming parking facility management practices.

In summary, the development and adoption of AI-based technologies like the PRPS can significantly enhance parking management operations, improve user experiences, and alleviate traffic congestion in densely populated urban areas. By embracing innovation and leveraging advanced technologies, stakeholders in the parking industry can pave the way for a more sustainable and efficient future in urban mobility.

II. PREVIOUS WORK DONE

Automated Parking Systems (APS) have gained traction as a solution to address parking challenges posed by increasing vehicle ownership and limited land availability. The concept of APS dates back to the early 20th century, with pioneering implementations like the Rue de Pont Neuf system in Paris in 1905 and the Ferris wheel-like APS designs in the 1920s [1]. However, these early systems faced mechanical constraints and prolonged wait times, hindering their widespread adoption. A resurgence of interest in APS occurred in the 1990s, particularly in the United States and Japan, where several major projects were initiated [2], [3].

APS offers numerous advantages, including optimizing parking capacity, mitigating congestion, enhancing user convenience, and promoting sustainability [4]. The evolution of APS has been facilitated by advancements in technologies such as computer vision, sensor systems, and robotics, enabling more efficient and reliable operations [5]. In recent years, APS has been recognized as an integral component of smart city initiatives, contributing to the development of intelligent transportation systems and sustainable urban

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planning [6].

While traditional parking management systems exist, there is a pressing need for innovation to overcome inherent limitations such as manual processes, congestion, and inefficiencies [7]. The proposed AI-based Parking Receipt Possession System (PRPS) in this research aims to address various challenges, such as monitoring parking space availability, providing guidance to drivers, ensuring safe parking through ultrasonic sensors, and automating record-keeping using RFID technology. Additionally, features like green communication for energy conservation, entry-exit logbooks, printed receipts, and automated payment systems are integrated into the proposed design.

Despite the advantages, APS faces challenges such as high initial investment costs, maintenance requirements, and potential system failures [8]. Future research directions may include exploring cost-effective solutions, enhancing system reliability, incorporating advanced technologies like machine learning and artificial intelligence for predictive analytics and adaptive control systems [9], and assessing the environmental and social impact of APS implementation [10].

III. PROPOSED SOLUTION

To streamline parking operations and address the inefficiencies of traditional management systems, we propose an AI-Powered Parking Receipt Possession System (PRPS). This innovative solution harnesses computer vision and artificial intelligence to automate the capture, processing, and possession of parking receipts.

At the core of the PRPS is an OpenCV Virtual AI Keyboard, serving as the primary user interface for data input. This AI-driven keyboard eliminates manual ticket issuance and human intervention, reducing congestion at entry points and enhancing operational efficiency. The PRPS operates as follows:

1. Vehicle Entry and Recognition:

a) OpenCV-enabled Access Point Systems (APS) with number plate recognition capabilities are utilized.
b) As vehicles approach, the APS scans number plates and cross-checks against resident, guest, or customer databases based on the parking scenario (apartment complex or shopping mall).
c) Authorized vehicles are granted access without further intervention.

2. AI Keyboard Activation and Data Input:

a) For unrecognized vehicles, the OpenCV Virtual AI Keyboard is activated.
b) In apartment parking, users (residents or guests) input their name, mobile number, and additional details via the AI Keyboard.
c) In shopping mall parking, users (customers or associates) input their mobile number and estimated parking duration in hours.

3. E-Receipt Generation and Database Integration:

a) Upon successful data input, the system generates an electronic receipt (e-receipt) for the user.
b) The e-receipt is sent to the user's mobile number, eliminating physical ticket possession.
c) Entry details and parking duration information are securely stored in respective guest or customer databases for accurate tracking and billing.

The PRPS leverages cutting-edge technologies like computer vision, AI, and database integration to revolutionize parking management practices. By automating the receipt possession process and eliminating manual interventions, the PRPS offers:

1. Improved operational efficiency and reduced entry point congestion.
2. Enhanced user convenience through seamless, contactless parking experiences.
3. Accurate tracking of parking durations for efficient billing and payment processes.
4. Integration with existing parking management systems and databases for seamless data exchange.
5. Scalability and adaptability to various parking scenarios, including apartment complexes, shopping malls, and other urban facilities.

The proposed PRPS represents a significant step forward in leveraging AI and computer vision to address parking management challenges in urban environments. By providing a robust, efficient, and user-friendly system, the PRPS aims to transform the parking experience for both facility operators and users, paving the way for a more sustainable and optimized future in urban mobility.

IV. METHODOLOGY

1. Research Design: This investigation employs a mixed-methods research design, synergizing quantitative and qualitative approaches to evaluate the efficacy and user satisfaction of the AI-based Parking Receipt Possession System (PRPS).

2. Data Acquisition: a) Quantitative Data: Parking facility data, encompassing entry/exit timestamps, parking durations, and transaction records, will be captured through sensors integrated with the PRPS. This data will undergo rigorous analysis to assess system performance and efficiency metrics.

b) Qualitative Data: Semi-structured interviews and surveys will be conducted with parking facility users to garner insights into their experiences with the PRPS. Participants will be selected through purposive sampling to ensure diverse representation.

3. PRPS Implementation: a) The PRPS will be implemented leveraging OpenCV for computer vision tasks and AI-driven functionalities. Strategically positioned cameras, equipped with OpenCV, will be deployed at entry

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and exit points to capture vehicle data and facilitate automated ticket issuance.

b) RFID technology will be integrated to enable seamless access control and payment processing. RFID readers will interface with the PRPS to track vehicle movements and manage billing processes.

4. Data Analysis: a) Quantitative Analysis: Parking occupancy data, entry/exit timestamps, and transaction records will be rigorously analyzed using statistical methods to evaluate system performance and efficiency. Key metrics, such as parking turnover rate, average occupancy duration, and revenue generation, will be calculated.

b) Qualitative Analysis: Interview transcripts and survey responses will undergo thematic analysis to identify user perceptions, satisfaction levels, and suggestions for improvement regarding the PRPS. Qualitative data will be coded and categorized to uncover emerging themes.

5. Validation and Evaluation: The PRPS will undergo rigorous validation and evaluation through field testing in a real-world parking environment. System performance metrics and user feedback will be collected and analyzed to validate the effectiveness of the PRPS in addressing parking management challenges and enhancing user experiences.

6. Ethical Considerations: Ethical approval will be obtained from the relevant institutional review board before data collection commences. Informed consent will be acquired from all participants, and stringent measures will be implemented to ensure the confidentiality and anonymity of participant data.

V. EXPERIMENT DONE

This experiment aimed to develop and evaluate the functionality of an AI virtual keyboard for intuitive user interaction within the proposed AI-based Parking Receipt Possession System (PRPS). The implementation leveraged computer vision techniques and hand tracking to detect user gestures and simulate keyboard inputs in real-time.

1. System Setup: a) A standard webcam (resolution: 1280x720) was employed for real-time image acquisition.

b) OpenCV (Open-Source Computer Vision Library) and the cvzone library were utilized for image processing, hand tracking, and gesture recognition.

2. AI Virtual Keyboard Design: a) The AI virtual keyboard comprised a grid layout of interactive buttons, each representing a specific alphanumeric character or function key.

b) The cvzone library was utilized to create interactive button objects with defined positions, sizes, and corresponding text labels. (refer to Fig. (a))

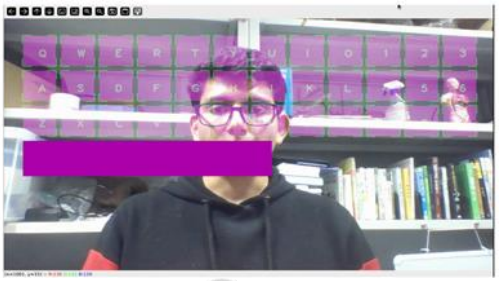

Fig. (a)

3. Hand Tracking and Gesture Recognition: a) Hand detection and tracking were facilitated by the HandDetector class from the cvzone library.

b) The HandDetector class employed a pre-trained model to detect hand landmarks and estimate hand gestures, enabling precise interaction with the virtual keyboard. (refer to Fig. (b))

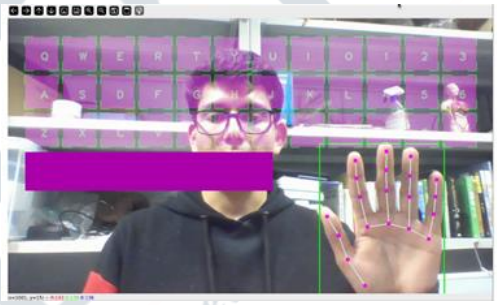

Fig. (b)

4. User Interaction: a) Users interacted with the AI virtual keyboard by positioning their hands within the camera frame and performing gestures to select desired characters.

b) Hand gestures, specifically the distance between specific landmarks (e.g., thumb tip and index fingertip), were used to simulate mouse clicks and trigger keyboard inputs. (refer to Fig. (b))

5. Functionality Testing: a) The functionality of the AI virtual keyboard was tested in real-time scenarios to evaluate its responsiveness, accuracy, and usability.

b) Users performed tasks such as typing alphanumeric text, entering numeric inputs, and triggering special function keys (e.g., Enter, Backspace). (refer to Fig. (c))

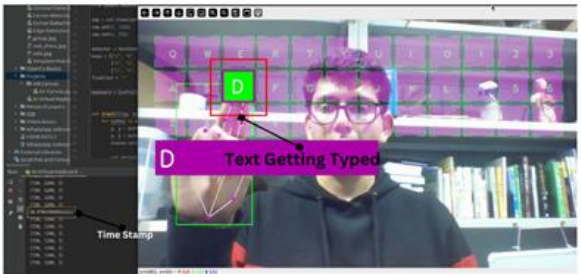

Fig. (c)

6. Performance Evaluation: a) The performance of the AI virtual keyboard was assessed based on the accuracy of gesture recognition, the latency of keyboard inputs, and the

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overall user experience.

b) Quantitative metrics, such as gesture recognition accuracy and response time, were measured to objectively evaluate system performance.

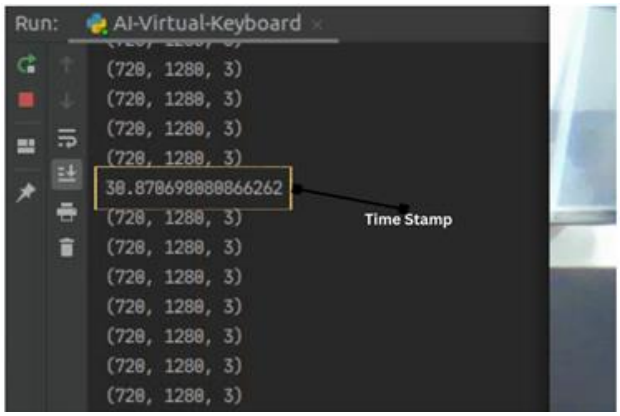

Fig. (d)

7. Results and Observations: a) The AI virtual keyboard demonstrated robust performance in accurately interpreting user gestures and generating corresponding keyboard inputs.

b) Users reported a seamless and intuitive typing experience, with minimal latency between gesture execution and keyboard response.

c) The system exhibited reliable functionality across various lighting conditions and hand orientations, ensuring consistent performance in practical applications.

8. Conclusion: a) The successful implementation and evaluation of the AI virtual keyboard validate its suitability for integration into the AI-based Parking Receipt Possession System (PRPS).

b) The AI virtual keyboard enhances user interaction and convenience in the PRPS, offering a modern and intuitive alternative to traditional input methods.

VI. ADVANTAGES OF HAVING SUCH AI-ENABLED SYSTEM

1. Operational Efficiency Amplification: The PRPS automates parking ticket handling processes, eliminating the need for manual data entry and physical ticket issuance. This streamlines the entry process, mitigates congestion at entry points, and enhances overall operational efficiency.

2. Elevated User Experience: By leveraging computer vision technology, the PRPS offers a seamless and user-friendly parking experience. Users can interact with the system effortlessly through an AI virtual keyboard, eliminating the hassle of manual ticket filling and possession.

3. Precise Parking Duration Tracking: With the integration of a timestamp mechanism, the PRPS accurately tracks the duration of parking for each vehicle. This ensures fair and precise billing based on actual parking duration, eliminating disputes and improving transparency.

4. Contactless and Secure Transaction Facilitation: The PRPS facilitates contactless payment transactions, reducing physical interactions and enhancing safety, especially in hygiene-conscious environments. Additionally, the system ensures secure data handling and transaction processing, safeguarding user information.

5. Scalability and Adaptability Prowess: The modular design of the PRPS allows for easy scalability and adaptability to various parking scenarios and environments. Whether deployed in shopping malls, apartment complexes, or office buildings, the system can be customized to meet specific requirements and accommodate fluctuating demand.

6. Seamless Integration with Existing Infrastructure: The PRPS seamlessly integrates with existing parking management systems and infrastructure, minimizing implementation barriers and maximizing interoperability. This ensures a smooth transition to automated parking solutions without disrupting established operations.

7. Environmental Sustainability Contribution: By reducing manual processes and optimizing parking operations, the PRPS contributes to environmental sustainability efforts. The system helps minimize vehicle idling and traffic congestion, leading to reduced carbon emissions and environmental impact.

8. Data-driven Insights and Analytics Generation: The PRPS generates valuable data insights and analytics on parking utilization patterns, user behavior, and facility performance. These insights can inform strategic decision-making, optimize resource allocation, and improve overall parking facility management.

9. Future-Proof Technology Adoption: Leveraging advanced technologies like computer vision and artificial intelligence, the PRPS represents a future-proof solution for evolving parking management needs. Its adaptability to emerging technologies ensures long-term relevance and effectiveness in addressing dynamic urban mobility challenges.

VII. APPLICATIONS

The proposed AI-Powered Parking Receipt Possession System (PRPS) aims to revolutionize parking management practices by leveraging advanced computer vision and artificial intelligence technologies. The system is designed to be implemented in two primary scenarios: apartment complexes and shopping malls. In the apartment parking system, OpenCV-enabled Access Point Systems (APS) capture and identify vehicle number plates, cross-referencing them against a resident and guest database to grant seamless access to authorized vehicles. For unrecognized vehicles, an OpenCV Virtual AI Keyboard interface is activated, allowing users to input their name, mobile number, and additional identifiers to generate an electronic receipt (e-receipt) and store entry details securely. Similarly, in the shopping mall parking system, the APS grants access to authorized customer and associate vehicles while deploying the AI Keyboard for unrecognized vehicles to capture mobile numbers and estimated parking durations, generating

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e-receipts accordingly. The PRPS offers numerous advantages, including enhanced operational efficiency, elevated user convenience, precise parking duration tracking, contactless and secure transactions, scalability and adaptability to varying demands, and the generation of valuable data insights for optimized facility management. By integrating cutting-edge technologies, the proposed system presents a robust and future-proof solution for addressing parking management challenges in urban environments, paving the way for a more sustainable and optimized urban mobility paradigm.

VIII. POTENTIAL AREAS OF FURTHER EXAMINATION

While the innovative Parking Receipt Possession System (PRPS) powered by artificial intelligence presents an encouraging solution to streamline parking protocols, multiple facets merit thorough scrutiny and meticulous academic inquiry to bolster its effectiveness and tackle emerging obstacles. The ensuing areas outline prospective pathways for supplementary scholarly pursuits:

1. Refining Data Organization and System Capabilities: Delving into strategies for enhancing database indexing, query optimization algorithms, and distributed frameworks to propel data storage, retrieval, and processing prowess, ensuring unwavering performance during peak utilization periods and enabling system growth.

2. Fortifying Data Integrity and User Privacy: Implementing robust encryption protocols, access control mechanisms, and audit trails to shield sensitive user data, thwart unauthorized access, and uphold adherence to data protection mandates, thereby nurturing user trust and confidence.

3. Buttressing System Resilience and Contingency Protocols: Devising robust data redundancy, replication, and recovery tactics to mitigate the risk of data loss or system disruption due to hardware failures, natural calamities, or other unforeseen events, ensuring uninterrupted operation and data integrity.

4. Safeguarding Communication and Data Transmission: Deploying secure communication protocols, encryption standards, and secure socket layers to protect data transmission between PRPS components, external payment gateways, and user interfaces, preventing eavesdropping, tampering, or interception of sensitive information.

5. Refining User Verification and Access Control: Implementing multi-factor authentication, biometric authentication, and role-based access control (RBAC) mechanisms to validate user identities, enforce granular access permissions, and prevent unauthorized access to sensitive system functionalities and data resources.

6. Optimizing Data Lifecycle Management: Developing comprehensive policies and procedures for data collection, storage, retention, archival, and secure deletion, ensuring compliance with regulatory requirements, minimizing storage costs, and mitigating data-related risks.

7. Continuous Monitoring and Compliance Assurance: Implementing auditing and compliance monitoring mechanisms, including audit log generation, regular security audits, and intrusion detection systems, to track user activities, system events, and data access patterns, ensuring accountability and timely response to potential security incidents.

8. Pioneering Advanced Security and Privacy Techniques: Exploring cutting-edge security and privacy techniques, such as homomorphic encryption, differential privacy, and advanced biometric authentication methods, to further augment data protection and user privacy within the PRPS.

9. Optimizing Artificial Intelligence and Machine Learning Capabilities: Refining computer vision models, parking duration prediction algorithms, and resource allocation techniques utilizing advanced AI and machine learning methodologies to enhance the overall performance and efficiency of the PRPS.

10. Improving User-Centric Design and Inclusive Accessibility: Conducting user-centric design research and implementing adaptive user interfaces, voice-controlled interactions, and intuitive feedback mechanisms to ensure an inclusive, seamless, and accessible parking experience for users with diverse needs and abilities.

By meticulously addressing these domains through rigorous research and development endeavors, the PRPS can attain heightened echelons of security, reliability, and usability, positioning it as a robust and trusted paradigm for optimized parking management in contemporary urban landscapes.

IX. CONCLUSION

In this study, we proposed an innovative solution, the AI-based Parking Receipt Possession System (PRPS), leveraging OpenCV technology, to address the pressing challenges faced by traditional parking management systems in urban environments. Through a comprehensive exploration of the current landscape of parking management, previous research on automated parking systems, and the proposed PRPS solution, several key findings have emerged.

The PRPS represents a significant advancement in parking management technology, offering a transformative approach to streamline parking operations, enhance user experiences, and optimize overall facility management. By automating the capture, processing, and possession of parking receipts, the PRPS eliminates manual interventions, reduces congestion at entry points, and improves operational efficiency. Furthermore, the integration of timestamp mechanisms enables accurate tracking of parking durations, facilitating seamless payment transactions and minimizing human intervention.

The advantages of the PRPS-enabled system extend beyond operational efficiency to include improved user

convenience, enhanced security, and potential environmental benefits. The system's contactless, AI-driven interface ensures a seamless parking experience for users while safeguarding sensitive data through robust security measures. Additionally, the PRPS has the potential to contribute to sustainability efforts by optimizing parking space utilization.

While the PRPS demonstrates promising capabilities, there are several areas for further research and development. Future studies may explore enhancements in database management, security, scalability, and interoperability to strengthen the system's functionality and address emerging challenges. Additionally, ongoing evaluation and refinement of the PRPS in real-world parking scenarios will be crucial to validating its effectiveness and ensuring user satisfaction.

In conclusion, the AI-based Parking Receipt Possession System (PRPS) represents a significant step forward in modernizing parking management practices and shaping the future of urban mobility. By embracing innovation and leveraging advanced technologies, stakeholders in the parking industry can create more efficient, sustainable, and user-centric parking solutions, ultimately contributing to the development of smarter, more livable cities.

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