International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Design and Implementation of QR Code Generation and Verification System Using Raspberry Pi for Smart Parking and Billing

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Abstract-This paper presents the development and implementation of an automated QR Code Generation and Verification System using Raspberry Pi for smart parking management applications. The proposed system is designed to automate parking operations, enhance security, and ensure efficient management of vehicle entry and exit processes. At the time of vehicle entry, the system generates a unique Quick Response (QR) code acting as a digital ticket, which is printed via a thermal printer for the user. Concurrently, an image of the user is captured using a USB camera and securely stored in local storage as a backup measure. During vehicle exit, the system scans and decodes the QR code. Upon successful verification against the stored database, the system automatically computes the total parking duration and calculates the corresponding fee. The results demonstrate a reliable, secure, and efficient solution that minimizes manual intervention, reduces operational errors, and ensures accurate billing.

***Key Words*:** Smart Parking, Raspberry Pi, QR Code, Automated Billing, Python, Embedded Systems, Image Capture.

1. INTRODUCTION

The rapid growth of smart technologies and embedded systems has opened new possibilities for improving traditional parking management. With the increasing number of vehicles in urban areas, there is a growing need for efficient, secure, and automated solutions. Conventional parking systems often rely on manual paper-ticketing processes, which can lead to inefficiencies, errors, ticket loss, and security concerns.

While modern iterations utilize QR codes, they heavily depend on continuous internet connectivity, third-party online tools, and smartphones for generation and verification. This disjointed approach limits scalability and automation. By integrating QR code technology with a compact, cost-effective embedded platform like the Raspberry Pi, it is possible to develop an intelligent, self-contained system. This paper focuses on creating a unified platform that automates vehicle entry, image-based backup verification, and automated billing, improving overall system efficiency and user convenience.

2. LITERATURE SURVEY

Several research works have explored smart parking systems and automated billing using QR codes, embedded systems, and IoT. Previous studies highlight the importance of automation in mitigating revenue losses and inefficient space utilization caused by manual monitoring.

For instance, existing literature on "QR Code Based Smart Parking Systems" demonstrates how dedicated mobile applications can enable quick vehicle identification. However, these often require the user to have a smartphone and internet access. Other systems utilize sensors (like IoT-based space detection) to monitor parking availability in real-time but fail to fully address secure vehicle identification and automated billing. RFID-based automated systems offer faster processing but require specialized hardware and tags for every single vehicle, drastically increasing implementation costs. These gaps create the need for a cost-effective, fully automated, and locally processed system using Raspberry Pi.

3. EXISTING SYSTEM

Existing parking management systems typically rely on manual ticketing methods where users are issued paper-based tickets at entry, which are later manually verified for fee calculation at exit. This method is highly susceptible to human error, ticket damage, or duplication.

More advanced automated systems utilize RFID or smartphone-based QR scanning. However, RFID demands high infrastructure and per-vehicle tag costs. Existing QR-based systems usually generate codes via online tools and verify them through mobile apps, creating a heavy reliance on internet connectivity and multi-device coordination. They often lack centralized local control, real-time data processing, and integrated hardware like thermal printers and image-capture backups.

4. PROPOSED SYSTEM

The proposed system integrates embedded processing, image capture, display interfaces, local storage, and automated billing to manage parking operations seamlessly. The Raspberry Pi serves as the central processing unit, coordinating all hardware and software modules via Python-based execution.

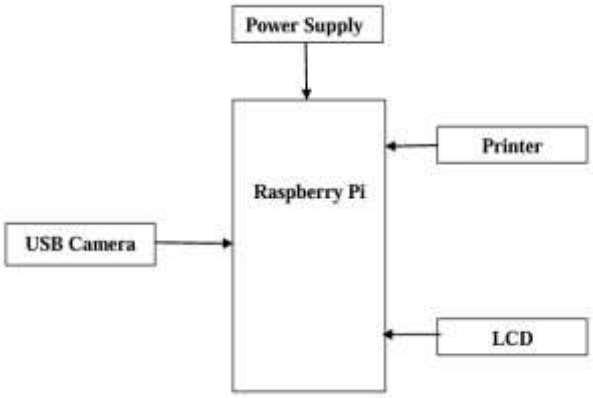

Fig.4.1: Block Diagram of the proposed system

The block diagram illustrates the proposed hardware architecture for an integrated image processing and output system, centered around a Raspberry Pi as the main processing unit. In this setup, the Raspberry Pi acts as the brain of the operation, coordinating the flow of data between various peripherals and executing the necessary software algorithms. To begin the workflow, a USB camera is connected directly to the processor, serving as the primary input device to capture real-time images or video frames from the surrounding environment. This visual data is then sent to the Raspberry Pi to be analyzed, which could involve tasks like reading text, recognizing faces, or scanning codes, depending on the specific application of the paper.

To ensure the system operates reliably, a dedicated power supply is connected to the central unit, providing the stable voltage required to keep both the processor and its attached accessories running without interruption. On the output side, the system utilizes two distinct components to interact with the user and deliver results. An LCD screen is wired to the Raspberry Pi to function as a visual interface, displaying real-time status updates, instructions for the user, or the immediate results of the camera's image processing. Simultaneously, a printer is integrated into the architecture to provide tangible hard copies of the processed information, such as printed tickets, logs, or receipts. Together, these components form a complete, self-contained kiosk or monitoring station capable of taking in visual data and producing both digital and physical outputs.

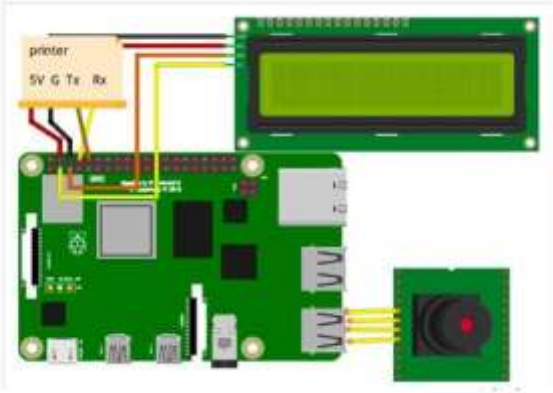

Fig.4.2: Schematic diagram of the proposed system

Hardware Architecture:

- **Raspberry Pi:** The core controller managing all logic, database entries, and peripheral communications.
- **USB Web Camera:** Captures user/vehicle images at entry for security and scans the printed QR code at exit.
- **Thermal Printer (RS203):** Interfaces via serial communication to instantly print the generated QR code ticket for the user.
- **LCD Display (16x2):** Provides real-time visual feedback (e.g., "Entry Successful," "Scan QR," and billing amounts).

Fig.4.3: Hardware Setup of the proposed system

Operational Flow:

1. **Entry Phase:** The system registers the incoming vehicle. The USB camera captures a security image, and the system logs the entry timestamp. A unique QR code (encoding vehicle ID and time) is generated, displayed on the interface, and printed via the thermal printer. Data is stored in a local database.
2. **Exit Phase:** The USB camera scans the user's printed QR code. The system decodes it, verifies the data against the local database, and calculates the total parking duration. The automated billing logic then computes the fee based on predefined parameters.

This modular architecture ensures that all operations are processed locally, ensuring high reliability even in environments without internet access.

5. RESULTS AND DISCUSSIONS

To evaluate performance, the hardware setup was successfully synthesized and tested under real-time conditions. The Raspberry Pi was programmed using Python, utilizing the OpenCV library for camera interfacing and Pyzbar for QR decoding.

Entry Validation: During testing, the system successfully captured user images and instantly generated customized QR codes. The thermal printer reliably dispensed the digital tickets containing the vehicle ID, timestamp, and the QR code itself. The 16x2 LCD provided immediate feedback, displaying "Entry Success" to the user.

Fig.5.1: QR Code Generation and Printing

Exit and Billing Validation: At the exit node, the USB camera accurately detected and decoded the printed QR codes under varying lighting conditions. The system's Python backend seamlessly queried the local database, verified the timestamps, and calculated the precise parking duration. The LCD successfully displayed the final billing amount (e.g., "Amount: 130.0").

Fig.5.2: QR Code Verification and Billing

Performance Analysis: The system demonstrated negligible latency between scanning the QR code and generating the final bill. By keeping the database local and eliminating the need for cloud-based verification delays, the system showcased a significant reduction in vehicle processing time compared to manual or mobile-dependent methods. Furthermore, the image-capture backup proved effective in simulating scenarios where a printed ticket might be lost.

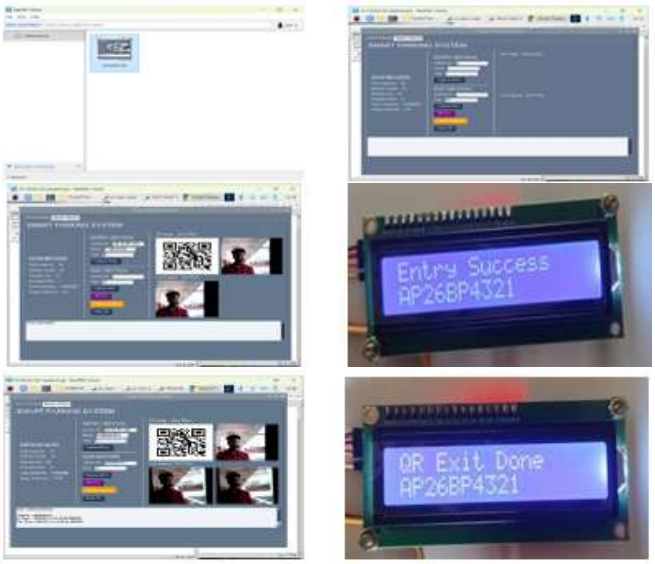

Fig.5.2: LCD Display Results

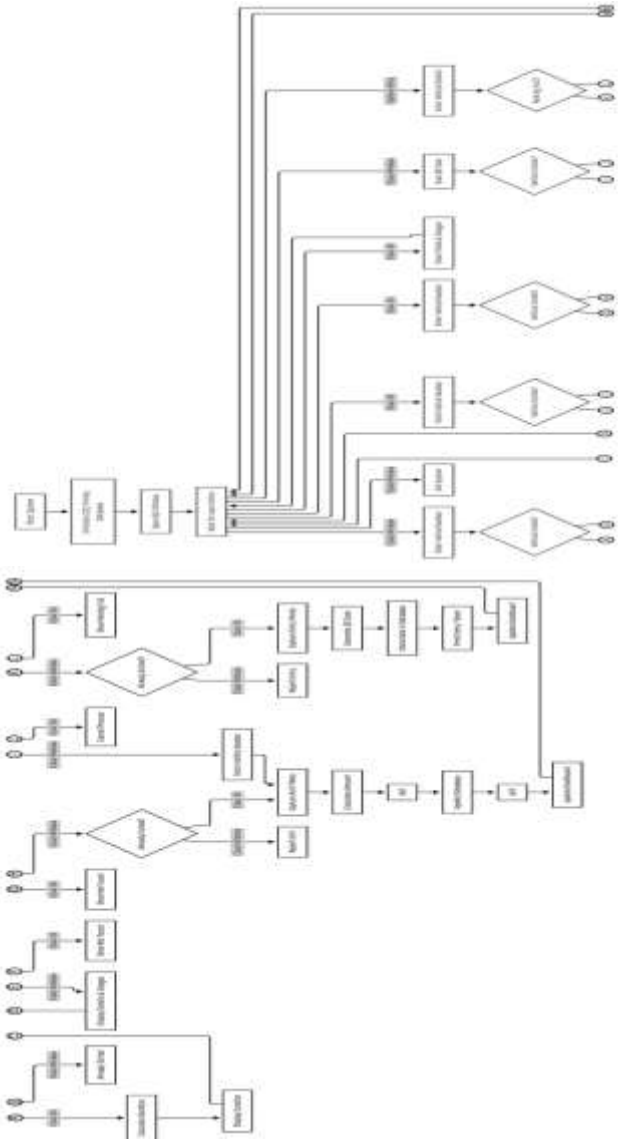

Fig.5.3: Smart Parking System Flowchart

CONCLUSION AND FUTURESCOPE

CONCLUSION

This paper presented the successful design and implementation of a QR Code Generation and Verification System using Raspberry Pi. The system provides a secure, fully automated approach to modern parking management. By consolidating QR generation, thermal printing, image capture, and automated billing into a single embedded platform, the system effectively eliminates the inefficiencies and errors of manual ticketing. The localized processing ensures accurate, high-speed operation without internet dependency, making it a highly practical solution for commercial complexes and institutional parking.

FUTURE SCOPE

The architecture can be further expanded into a broader smart-city infrastructure. Future enhancements could include integrating the system with a dedicated mobile application for advance slot booking and cashless digital payments. Furthermore, integrating Artificial Intelligence for Automatic Number Plate Recognition (ANPR) and IoT sensors for real-time parking slot monitoring would elevate the system's intelligence, optimize space utilization and further reducing urban traffic congestion.

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