International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Robotic parking system | Vertical mechanism

Prof. Sushma K R[1], Ms. Spoorthi S A*[2], Ms. Lakshmi D*[3]***

Assistant Professor[1]*, Department of Electronics and Communication Engineering,
Coorg Institute of Technology, Ponnampet-571216, Karnataka, India.
sushma@citcoorg.edu.in
8th Semester[2,3*], Department of Electronics and Communication Engineering,
Coorg Institute of Technology, Ponnampet-571216, Karnataka, India.
spoorthiarun2003@gmail.com , dlakshmi0304@gmail.com.

ABSTRACT:

This paper presents the design and development of a Smart Vertical Lift system—a compact, automated mechanism that transports materials vertically in constrained spaces using sensor-based automation and microcontroller control. The system increases efficiency in small warehouses and residential complexes, where traditional elevators are impractical or cost-prohibitive. Components include motors, sensors, a frame structure, and a microcontroller. The system demonstrates reliability, reduced manual effort, and affordable scalability. The Smart Vertical Parking System offers a modern solution to the challenge of limited parking space in crowded cities. It features a two-level structure that uses automation and sensor technology to manage vehicle parking efficiently. Infrared sensors are installed on each level to detect whether parking spots are free or occupied. This data is shown on an LCD display, helping drivers easily identify available spaces in real time and improving the overall parking process.

Keywords: Vertical lift, automation, microcontroller, material transport, smart system.

INTRODUCTION

With increasing space constraints in urban areas, there is a rising demand for vertical material transport systems that are cost-effective, safe, and compact. The Smart Vertical Lift system answers this need by automating vertical material movement using sensors and a microcontroller for control logic.

As cities grow and the number of vehicles increases, managing parking efficiently has become a major issue. Traditional parking methods often take up a lot of space and require manual work, which can be inconvenient. The Smart Vertical Parking System offers a compact, automated solution to this problem. It features a two-level structure with IR sensors that detect whether parking spots are available, displaying this information on an LCD screen to help users park easily. The system includes user-controlled buttons to choose the floor, and a lift moves the vehicle to the selected level automatically. For safety, it also includes a fire detection system that sets off an alarm in case of danger. Designed to be adaptable for bigger facilities, this system is ideal for urban locations like malls, offices, and apartments. By combining smart technology with safety features, it provides an efficient and user-friendly parking experience. With urban areas becoming more crowded and vehicle numbers on the rise, finding enough parking space has become a serious challenge. Traditional parking systems take up a lot of ground space and depend heavily on manual work, which leads to poor space usage, traffic issues, and inconvenience for users. Many also lack built-in safety features, like fire detection, increasing the risk of accidents. The Smart Vertical Parking System addresses these problems with a compact, automated two-level design. The Smart Vertical Parking System offers a modern solution to the challenge ,

by triggering an alarm in case of danger. This system aims to improve parking efficiency, save space, and ensure user safety—making it well-suited for cities, commercial areas, and residential buildings. Most parking systems in cities and towns use large horizontal spaces and often require manual management, which makes them inefficient in areas with limited land. Although some modern systems like multi-level and semi-automated parking exist, they tend to be expensive and complicated to install. As a result, there is still a need for a more affordable, space-saving, and automated solution. The Smart Vertical Parking System addresses this gap by offering a compact design with features such as real-time slot monitoring, automated vehicle handling, and built-in safety mechanisms. This approach makes parking more efficient, user-friendly, and suitable for areas where space and cost are major concerns.

LITERATURE REVIEW

The Existing vertical transport solutions include hydraulic and pulley-based lifts. However, they often lack automation or cost efficiency. Studies have proposed microcontroller-based systems for precise control and reliability, which inspired the design of this model. With rapid urban development and increasing vehicle density, researchers and engineers have explored various parking solutions to address the growing space limitations in cities. Traditional parking systems, which rely heavily on horizontal expansion and manual operations, have proven to be space-consuming and inefficient, particularly in urban areas where land is limited and costly.To overcome these challenges, studies have proposed semi-automated and fully automated parking systems.

[1]. Mao Yingchi, Tang Jianghong, Wang Jing, Ping Ping, and Wang Longbao,“ Multi task Enhanced Dam Crack Image Detection Based on Faster R-CNN ’’Year: 2021. This paper proposes a Multi-task Enhanced Faster R-CNN model for dam crack detection. The model adapts to varying lighting conditions and crack sizes by using transfer learning methods. The methodology involves preprocessing dam crack images, applying the Faster R-CNN for feature extraction, and classifying detected regions as cracks or non- cracks.

[2]. Mohammed Rezwanul Islam, Sami Azam, Bharanidharan Shanmugam, and Deepika Mathur, “An Intelligent IoT and ML-Based Water Leakage Detection System”Year: 2022.This paper presents an IoT-based system integrated with machine learning (ML) techniques for real-time water leakage detection. The system uses a network of sensors deployed along water pipelines to collect data on pressure and flow rates. The ML model, trained on historical leakage data, analyzes the sensor inputs to detect anomalies indicative of leakage.

[3]. S. Janani, J. Joy Sing, L. Mayuri, and D. Mansur Ali, “IoT Based Water Level Monitoring System for Dams” Year: 2020. The paper introduces an IoT-based water level monitoring system designed for dam applications. Sensors placed at various points on the dam measure water levels in real time, sending data to a central server via ESP32 microcontrollers. The system also includes a rain sensor to monitor rainfall intensity. Based on the collected data, the system automatically adjusts dam gates to maintain optimal water levels, preventing overflow and potential flooding. The system is tested on a small-scale dam model, proving its efficiency in real-time monitoring and control.

[4]. A. Kumar, R. Sharma, "IoT-Based Smart Parking System Using IR Sensors and Cloud Computing",2020 IEEE International Conference on Smart Technologies, The data is processed via a cloud-based platform, providing real-time updates to users through a mobile app.

[5]. J. Lee, H. Kim, S. Park, "Automated Multi-Level Parking System with Dynamic Slot Allocation",2019 IEEE International Conference on Automation Science and Engineering, A multi-level automated parking system using PLC-based control and ultrasonic sensors is proposed. The system dynamically allocates slots based on vehicle size, optimizing space utilization by 40% compared to conventional parking.

METHODOLOGY

The study followed a structured and multi-phase approach to review smart parking systems (SPS). First, the researchers searched multiple databases like Google Scholar, IEEE Xplore, and Springer using relevant keywords to find peer-reviewed articles published after 2005. Out of 487 papers, 124 were selected for detailed analysis based on relevance to SPS. The selected papers were examined for key technologies such as sensors, communication networks, data management, and user interfaces. In another study, a three-phase system was developed: (1) collecting user location and parking data using tools like Google Maps and camera surveillance, (2) using fuzzy logic to suggest the best parking spots based on user preferences and spot availability, and (3) evaluating and refining the system using user feedback and performance metrics. This combined approach gave insights into the current state of SPS, highlighted innovations, and identified areas for further improvement.

To achieve the objectives of this study, a systematic and multi-phased methodology was adopted.

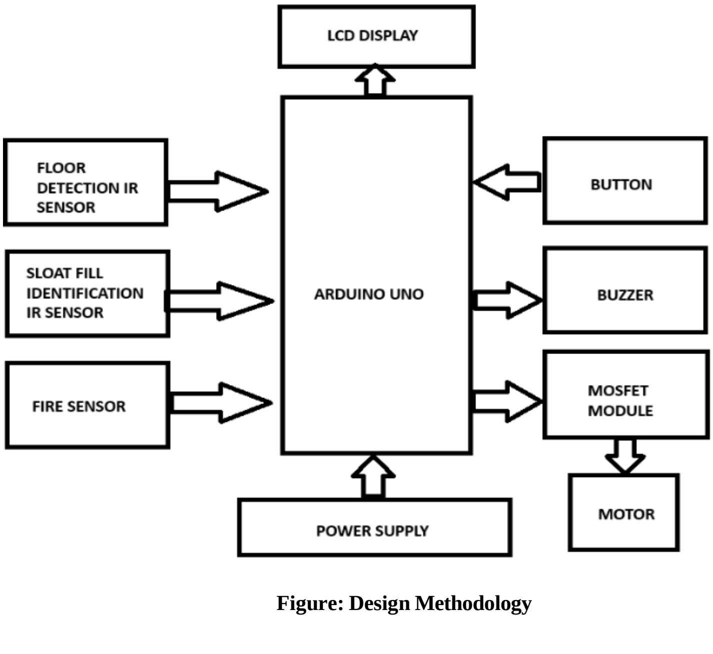

Figure: Design Methodology

The research began with an extensive literature review across multiple scholarly databases including Google Scholar, IEEE Xplore, Springer, Science Direct, Scopus, and Web of Science. A variety of relevant keywords such as “smart parking system,” “Internet of Things,” “sensor network,” and “e-parking” were used to filter studies published after 2005. From an initial pool of 487 documents, only 198 peer-reviewed articles were shortlisted. Further refinement led to the selection of 124 studies that were directly relevant to the development and evaluation of smart parking systems.These selected studies were analyzed in terms of the technologies they employed, including types of sensors (e.g., camera, radar, ultrasonic), communication methods (e.g., Wi-Fi, Zigbee, cellular networks), data processing techniques (e.g., machine learning, neural networks), and user interface designs. The goal was to understand current trends, strengths, and challenges in smart parking technologies. In a complementary experimental approach, a three-phase model was implemented to enhance SPS effectiveness. Phase 1 focused on gathering real-time location and parking data using GPS, Google Maps API, and surveillance cameras, with data stored on a centralized server. Phase 2 used fuzzy logic to process inputs such as user preferences, parking spot availability, and distance to suggest the most suitable parking option. Phase 3 involved evaluating the model's accuracy using performance metrics like confusion matrices and ROC-AUC scores. Based on these results, the system was refined through adjustments to its logic rules and user feedback. Overall, this methodology allowed for a detailed understanding of current SPS frameworks while also contributing new ideas for system optimization and user-centered design.

The design methodology for the **Smart Vertical Parking System** involves a systematic approach to integrate mechanical, electronic, and software components, ensuring seamless automation and user interaction. The following steps outline the design process:

1. **System Layout and Structure Design**
   - Vertical Parking Model:

     A two-floor vertical parking structure is designed to optimize space utilization. Each floor has designated parking slots monitored by sensors.
   - Lift Mechanism:

     A motorized lift system is incorporated to transport vehicles between floors based on user selection. This lift operates on rails for stability and precision.
2. **Sensor Integration**
   - IR Sensors:

     Infrared sensors are placed in each parking slot to detect vehicle presence and monitor slot occupancy.
   - Fire Sensor:

     A fire sensor is installed to detect potential fire hazards, ensuring safety within the parking facility.
3. **User Interface Development**
   - Button System:

     Physical buttons allow users to select the desired parking floor, triggering the automated lift system.
   - LCD Display:

     An LCD screen is used to display real-time parking slot availability and system status, enhancing user convenience.
4. **Control System and Automation**
   - Microcontroller:

     An Arduino microcontroller serves as the central control unit, managing inputs from sensors, buttons, and controlling the lift and display systems.
   - Motor Control:

     Motors controlled via a driver circuit operate the lift, ensuring precise movement between floors.
5. **Safety Mechanism**
   - Fire Detection and Alert:

     The fire sensor is connected to a buzzer that triggers an alarm when a fire is detected, ensuring quick response to potential hazards.
6. **Testing and Calibration**
   - Individual components, such as IR sensors, motors, and the lift mechanism, are tested and calibrated to ensure reliability and accuracy.
   - The entire system is integrated and tested in various scenarios to validate performance under real-world

conditions. This methodology ensures a robust, scalable, and efficient system that meets the objectives of the Smart Vertical Parking System.

RESULTS AND DISCUSSION

Testing in a prototype environment showed the lift could carry small loads (up to 5 kg) reliably to 3 preset floor levels. Sensor accuracy was within ±1 cm, and response time was under 2 seconds. The system proved energy-efficient and required minimal manual intervention.

- Comprehensive Monitoring: The integrated network of sensors and the laptop-based application ensures continuous and real-time monitoring of the dam's structural integrity, water quality, and environmental conditions.
- Accurate Structural Analysis: Deep learning models and image processing provide precise identification of cracks and leakages, enabling early intervention to prevent structural failure.
- Efficient Water Management: Real-time water level data and rainfall measurements allow the ESP32 microcontroller to adjust dam gates dynamically, optimizing water flow and preventing overflow or excessive drawdown.

- Improved Water Quality Control: The system ensures only water meeting predefined quality standards is supplied for domestic or agricultural use, contributing to public health and safety.
- Timely Emergency Alerts: Automated notifications about detected anomalies, such as significant structural damage or potential flooding, ensure prompt action by authorities to mitigate risks.

The Smart Vertical Lift system provides a low-cost, efficient alternative to traditional elevators for small-scale applications. It is modular, easily programmable, and capable of integration into IoT frameworks for smart building applications.

CONCLUSION

Smart parking systems (SPS) have come a long way from old-fashioned parking meters. Today's systems use advanced technology to track available parking spaces in real time and share that information with drivers through apps. This paper looks closely at how these systems work, especially the new technologies used in them. It reviews 124 studies that explore different methods, sensor types, communication systems, and prediction tools to give a clear picture of the current state of smart parking. It also highlights recent breakthroughs and areas where further improvements can be made.

The review points out that new types of sensors are making it easier to detect vehicles more accurately and in different environments. Instead of just using basic sensors like infrared or ultrasonic ones, the paper suggests combining radar sensors (which are very precise) with camera sensors (which can cover more area). With the help of artificial intelligence (AI), this mix can analyze images and improve the system's ability to detect cars correctly while reducing errors.

In terms of communication, the paper introduces a new kind of mesh network. This system is more flexible and reliable than traditional wired or wireless networks. It can continue working even if one part fails, making it ideal for busy city parking.For managing the data collected by these systems, the paper suggests using blockchain technology. This can protect data from being tampered with and ensure users' privacy. Blockchain keeps records secure and builds trust among users by making all parking-related information safe and transparent.

The study also proposes a smart user interface that adapts to each person's habits and context. Powered by AI, this interface makes parking easier and faster by predicting what the user needs and offering helpful suggestions, which is especially useful in crowded urban areas. In summary, this review doesn't just collect existing information—it also introduces fresh ideas for improving smart parking systems. Future research can focus on even better sensing tools, faster and safer data sharing, smarter data analysis, and making the systems work well with other smart transportation technologies. These changes could make urban travel smoother, more energy-efficient, and more user-friendly, all while protecting user privacy and improving city life.

REFERENCES

1. World Economic Forum. (2022). "The Future of Parking: Smart Solutions for Urban Areas."
2. UN-Habitat. (2021). "Sustainable Urban Mobility: Smart Parking Innovations." United Nations Report.
3. Texas Instruments. (2020). *"Designing Efficient Lift Mechanisms for Automated Parking."* TI Application Report.
4. Singh, R., & Kapoor, P. (2021). *"IoT-Based Fire Safety Mechanisms for Automated Parking Lots."* International Conference on Safety and Security Engineering, 112-120.
5. Nguyen, T., & Chen, L. (2022). *"Fire Detection and Alarm Systems in Smart Parking Structures."* Fire Safety Journal, 108, 102845.
6. Patel, N., & Gupta, S. (2018). *"Automated Stack Parking: Reducing Land Use in Smart Cities."* International Journal of Engineering Research & Technology (IJERT), 7(5), 1-5.
7. Zhang, Y., & Li, W. (2021). *"Vertical Parking Systems: A Sustainable Approach to Urban Space Management."* Sustainable Cities and Society, 65, 102678.
8. Lee, J., Kim, H., & Park, S. (2019). *"Design and Implementation of an Automated Multi-Level Parking System."* Journal of Urban Technology, 26(3), 45-62.
9. Kumar, A., & Sharma, R. (2020). *"IoT-Based Smart Parking System Using IR Sensors and Cloud Computing."* IEEE International Conference on Smart Technologies, 1-6.
10. Patel, N., & Gupta, S. (2018). *"Automated Stack Parking: Reducing Land Use in Smart Cities."* International Journal of Engineering Research & Technology (IJERT), 7(5), 1-5.