

ABSTRACT

This research implements an integrated logistics system to automate warehouse operations, addressing the challenges of inefficiency, high manual error rates, and limited inventory traceability in conventional processes. The primary goal is to enhance operational efficiency and picking accuracy, as well as to optimize robot navigation within the warehouse environment. The research scope is limited to the application of a Pick-to-Light system in warehouses with medium to high operational volumes and small to medium-sized items.

The designed system integrates Pick-to-Light (PTL) technology with Automated Guided Vehicles (AGVs) and a cloud-based Internet of Things (IoT) Charging Station. The PTL module provides visual guidance to operators, while real-time two-way communication between the operator's web interface, a cloud database (Google Sheets with Apps Script and Vercel proxy), and microcontrollers (ESP32/ESP8266) on the robots and PTL devices ensures seamless coordination. The methodology involves system design, implementation, and comprehensive testing in a simulated warehouse scenario.

Testing results demonstrate a significant improvement in operational efficiency with the PTL system, achieving a 28.99% increase in work time efficiency. The error rate was successfully reduced from an average of ~6% in conventional methods to <1% with the integrated logistics system, surpassing the target reduction below 5%. While wireless link characterization analysis confirmed signal stability, end-to-end communication latency and throughput showed potential bottlenecks for high-bandwidth applications (0.417 kbps downlink, 0.062 kbps uplink). This study validates the effectiveness of the integrated system in improving warehouse productivity and accuracy while highlighting key areas for future development to support more advanced functionalities.

Keywords: Pick-to-Light, AGV, Integrated Logistics, Cloud Computing, IoT, Warehouse Efficiency, Latency, Throughput