Chapter 14
Metaheuristic-Guided Deep Learning for Smart Warehouse Anomaly Detection

Usharani Bhimavarapu
https://orcid.org/0000-0002-0246-1420
Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

ABSTRACT

This study presents an intelligent approach to enhancing warehouse operations through smart warehousing detection using a Bi-Stacked Long Short-Term Memory (Bi-Stacked LSTM) model. Data were collected from a case study company's internal database, including sales records, inventory data, product categories, and pricing information over the past two years. After rigorous preprocessing involving data cleaning, integration, and transformation, relevant features were selected using the Ant Colony Optimization (ACO) algorithm to reduce dimensionality and improve model performance. The Bi-Stacked LSTM model was trained on the selected features to detect operational anomalies and performance patterns across time-series data. The bidirectional and stacked architecture of the LSTM allowed the model to learn both past and future contextual dependencies effectively.

INTRODUCTION

Intelligent warehousing solutions are the new buzzword of the day to make deliveries for quick and seamless logistically optimized operations in the current

DOI: 10.4018/979-8-3373-3176-8.ch014

e-commerce environment. Same-day or one-day delivery orders by customers made traditional vintage-look warehouses a new phenomenon. Smart solutions eliminate lengthy and laborious manual interventions, thereby reducing lead times and human errors as well. Smart solutions permit improved real-time tracking of the stock, and it is urgently necessary to do that when trying to ship orders without running out of inventory. With the use of top-of-the-line sensors and RFID, the warehouse is now precise to stock. Predicting the trend of demand with order forecasting utilizing predictive analytics enhances inventory planning. It makes supply chain responsiveness improved and prevents unnecessary stock. It also increases space usage even more with even more fully-stocked stock. There is also intelligent warehousing with logistics efficiency, responsiveness, and customer satisfaction.

There should also be inclusion of intelligent technology in efforts to address protection needs and minimize labor reliance for warehouses. Warehouses are normally dangerous environments with risks of forklift, heavy load, and repetitive strain injury injury. Robot arms, conveyor belts, and autonomous mobile robots (AMRs) minimize the employees. Vision systems and artificial intelligence surveillance maximize monitoring and accident prevention. Robot assistance minimizes the workers during peak season. Wearable technology is also monitoring the health condition of the workers and alerting them in the form of risk factors. The goal is a healthy and safe work environment and increased productivity. Smart systems also support obeying safety regulations. It is cheap insurance and greater worker resilience. Smart technology thus allows a green and safe place to work. Real-time decision-making is another completely critical ability of smart warehousing. Legacy systems are batch-upgraded and contain written memos typewritten within them, which allows data to spoil. Internet of Things-capable devices are allowing flashing weather, equipment condition, and inventory levels to be easy. Cloud WMS provides remote monitoring and centralized monitoring. Real-time visibility allows the managers to take decisions beforehand and reduce downtime. Machine learning capability identifies data pattern to recommend simplification of the workflow. For example, heatmaps can identify bottlenecks in the warehouse. Dashboards and reports give them recommendations to the managers. Data translucency also enables them to communicate with distributors' warehouses and suppliers. In particular, smart technology enables translucency of warehousing, responsibility, and planning. Smart warehousing technology must also maximize cost of operation and ROI.

Material handling and man power are large warehousing cost drivers. AGVs and drones minimize man power transport requirement and inventory inspection. Smart HVAC and lighting minimize energy use based on occupancy and weather. Sensor equipment maintenance minimizes equipment failure and repair cost. Lean inventory practice and demand planning minimize the cost of carrying inventory. Artificial intelligence-based order picking minimizes rework and return, and maximizes pick