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Optimizing Pick Sequences Using Discrete-Event Simulation: A Warehouse Efficiency Case Study

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Abstract

In the fast-paced world of logistics and warehouse management, the optimization of pick sequences stands as a pivotal factor in enhancing operational efficiency. This study addresses this crucial aspect by critically analyzing traditional and proposed picking processes. The study challenges the conventional snake-like picking pattern, highlighting its inefficiencies, such as prolonged travel times, congestion, employee fatigue, and a heightened risk of collisions.

Central to this paper is the introduction of an innovative zig-zag picking sequence, meticulously designed to significantly curtail travel distances, optimize congestion management, and reduce operator interactions. The foundation of this proposal is a robust modeling and simulation framework, Flexsim. This tool was instrumental in creating a highly detailed and accurate model of the warehouse environment, allowing for a comprehensive comparison between the traditional snake-like sequence and the proposed zig-zag pattern.

Simulations conducted using Flexsim revealed improvement in efficiency, with the new picking method projecting an increase in operational efficacy for certain methods. The proposed implementation strategy is comprehensive, encompassing an initial assessment phase, systemic modifications, a phased implementation approach, and continuous performance evaluations.

The expected outcomes of adopting this innovative picking sequence are multifaceted, including significantly enhanced efficiency, reduced picking times, a safer work environment, and augmented customer satisfaction. This presentation not only offers a blueprint for optimizing warehouse operations but also exemplifies the power of advanced simulation technologies like Flexsim in transforming supply chain and inventory management practices for the future.

Keywords

Modeling and Simulation, Continuous Process Improvement, Flexsim, Facilities Design, Warehouse Efficiency

1. Introduction

In the dynamic realm of logistics and supply chain management, the quest for operational efficiency within warehouse operations is unending. The art and science of optimizing pick sequences are paramount in this quest, offering a pathway to reducing operational costs and enhancing service delivery. Traditional picking strategies, while foundational, often fall short in addressing the nuanced demands of contemporary commerce, characterized by a need for speed, accuracy, and flexibility. This gap between traditional practices and modern requirements underscores the need for innovative approaches in managing pick sequences.

Upon analysis of the complex ecosystem of warehouse operations, order picking stands out notably as the most labor-intensive and costly endeavor, accounting for a substantial portion of operational expenses. Research by de Koster et al. [1] and supported by Rushton et al. [2] highlights the critical nature of this activity, which entails the retrieval of items from storage to fulfill customer orders. A detailed breakdown of the order-picking process reveals that a significant portion of time, approximately 50%, is dedicated to navigating through storage locations, with additional segments of time allocated to item search, actual item retrieval, and other preparatory tasks, as outlined by Tompkins et al. [3]. Furthermore, the financial impact of order picking is profound, representing 60-70% of warehousing costs, a statistic highlighted by Chen et al. [4].

The pursuit of efficiency within warehouse operations, despite their technical simplicity, presents a myriad of complex decision-making challenges. As de Koster et al. [1] articulate, warehouse managers are tasked with making critical operational and tactical decisions, ranging from warehouse layout design and storage assignment policies to picking and routing policies. These decisions are pivotal in optimizing the travel distance/time and minimizing order throughput times, essential for enhancing operational efficiency, as emphasized by Grosse et al. [5].

This paper aims to delve into the intricacies of optimizing pick sequences within such a context, leveraging discrete-event simulation to propose an innovative approach that addresses these fundamental challenges. By focusing on the methodology of the simulation, our study contributes to the ongoing discourse on warehouse management efficiency.

2. Problem Statement

In a high-stakes environment where efficiency directly impacts healthcare delivery, a distribution center in the southern United States confronts the challenge of optimizing its order picking processes. The crux of the issue lies in the traditional picking methods that dominate the warehouse floor—methods that are increasingly inadequate in the face of growing demand and the diverse inventory of medical supplies. These methods lead to excessive travel times and operational inefficiencies, and excessive overtime hours to meet workplace goals, hampering the center's ability to meet the stringent requirements of accuracy and timeliness.

The challenge at hand, therefore, revolves around optimizing the order picking process—a task that is both labor-intensive and costly, yet fundamental to the facility's operational success. This case study explores the potential of discrete-event simulation to enhance picking strategies, aiming to reduce the operational bottlenecks that currently hamper efficiency. By introducing an innovative picking sequence and leveraging state-of-the-art simulation software, the study seeks to offer a solution that not only improves the operational metrics of the warehouse but also supports the company's overarching goal of advancing healthcare delivery.

3. Background

The backdrop of this case study is set within a sprawling 25,000 square foot manufacturing facility that plays a crucial role in the healthcare supply chain. Employing over 300 dedicated workers, the facility is a microcosm of the company's vast operations, which span across 125+ countries with a global workforce of 30,000 employees. This healthcare giant, a manufacturer, distributor, and solutions provider, is at the forefront of enhancing healthcare operations. It partners with an extensive network of healthcare systems and facilities, offering both clinical and supply chain resources essential for sustaining high-quality care while ensuring long-term financial viability.

Central to the company's mission is its focus on the production and distribution of surgical procedure trays, indispensable in a wide array of medical procedures ranging from hip replacements to open-heart surgeries. These trays, critical for the seamless execution of surgeries, underscore the facility's significance in the national healthcare system. The logistical demands of supplying these vital components to healthcare systems nationwide necessitate a highly efficient and responsive warehouse operation.

To manage the intricate logistics of distributing these surgical trays, the facility relies on a team of 8 warehouse pickers, each operating a forklift, to navigate through the vast array of inventory. This operation's complexity is not just in the physical scale of the warehouse, or the volume of products handled, but also in the critical nature of the items being distributed. The efficiency, accuracy, and speed of the picking process directly influence the facility's ability to meet urgent healthcare needs.

4. Approach

An essential part of our approach involved a thorough analysis of the current picking process, captured in the flowchart shown as Figure 1. This visual representation meticulously details the sequence of actions undertaken by warehouse operators, from the initial receipt of pick tickets all the way through to the delivery of items. The flowchart is pivotal in several respects. It provides a clear and detailed overview of the operational flow, serving as a comprehensive process map. This mapping is crucial for identifying key stages in the picking process that present opportunities for optimization.

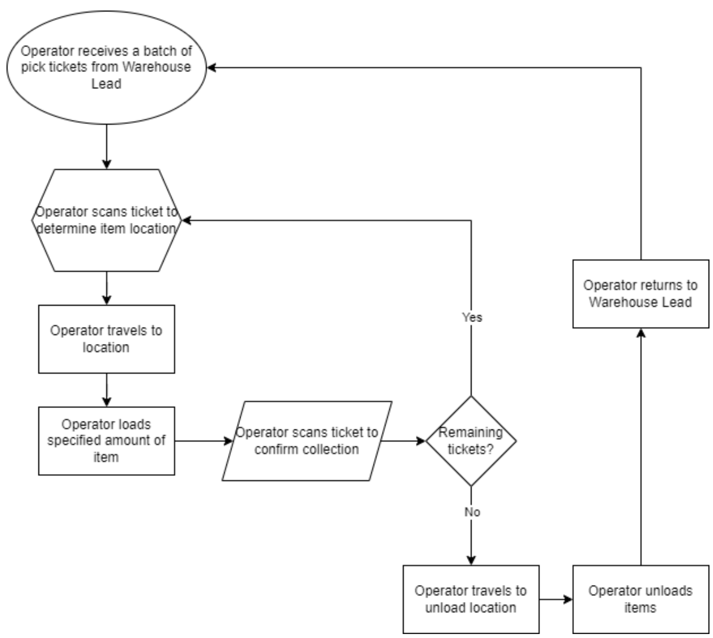

Figure 1: Flowchart demonstrating the general process that is followed by each operator throughout the shift.

Delving into the process allowed us to allocate time to each discrete step, including the journey to item locations, the loading of items, and the confirmation of item collection. These time allocations became integral components of our simulation model, informing the parameters that would drive our analysis.

Furthermore, the flowchart facilitated the identification of potential bottlenecks—such as the scanning and confirmation of items—which could introduce delays into the process. Recognizing these bottlenecks was instrumental in pinpointing where improvements could have the most significant impact.

In the simulation, we scrutinized each step for time efficiency and error rates, with a particular focus on the travel times to and from item locations. Given that these movements constitute a considerable portion of the picking process, optimizing these paths was a primary goal. The simulation was designed to streamline these routes, thereby reducing the overall time spent and increasing the efficiency of picks.

By weaving the flowchart into the fabric of our methodology, we grounded the simulation model in the actual workflow of the warehouse. This strategic inclusion allowed us to undertake a targeted and practical approach to process improvement, one that was not only theoretical but also immediately applicable to real-world operations.

4.2 Simulation Parameters

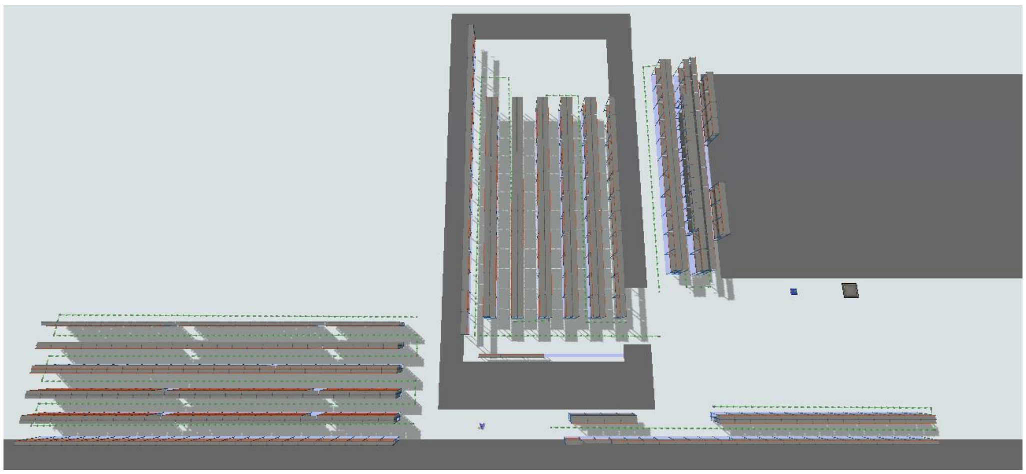

Figure 2: An aerial view of the simulation model created in Flexsim. This model is a 1:1 representation of the warehouse layout.

The simulation model pictured in Figure 2 was meticulously crafted to be a faithful representation of the warehouse's layout, with precise measurements ensuring that the distances within the simulation mirrored the actual conditions of the facility. Every variable pertinent to the picking process, including loading and unloading times, pick ticket scans, and the number of picks per batch, were captured and quantified. These time metrics were derived from an extensive eight-week study where pickers were shadowed to gather data, which was then analyzed using EasyFit 3.0 to establish the statistical distribution of the observed times.

Complementing this, an exhaustive analysis of the historical picking data, spanning three years, was undertaken. This analysis established a realistic baseline that allowed for an accurate comparison between the current operations and the optimized picking sequences proposed by the simulation. Forklift dynamics were not overlooked; the simulation incorporated the forklifts' operational speed of 12 mph, as well as the time efficiency of unloading picks, which are crucial factors in the overall picking process.

The entirety of the simulation's design was a data-driven endeavor. A comprehensive array of empirical data informed every variable and parameter, cementing the model's foundation in the tangible realities of the distribution center's operations. This approach was key to ensuring the model's precision and applicability.

To guarantee the model's reliability and relevance, a phased testing and validation strategy was in place. This iterative process allowed for the fine-tuning of the model, based on the outcomes of the simulation and necessary parameter adjustments. Such a meticulous strategy assured that the simulation would not only represent warehouse operations accurately but that its findings and recommendations would be robust and actionable in real-world scenarios.

5. Solution

We delved into the efficacy of two distinct order picking patterns within the warehouse environment, utilizing discrete-event simulation to drive our analysis. The initial phase of the simulation aimed to replicate the traditional snake-like pattern—a method characterized by operators traversing one side of the aisle before looping back around to complete the other. This simulation ran on a monthly cycle to mirror the typical operational tempo of the warehouse.

Upon calibrating the simulation to reflect the conventional snake-like pattern, the resulting data provided a baseline that was comparable, albeit with some margin of error, to the empirical data accumulated over the past three years. With this validation, the simulation platform proved to be a reliable tool for assessing the potential improvements offered by alternative picking patterns.

We then initiated a second phase of the simulation, implementing a zig-zag sequence. This approach allowed operators to traverse each aisle only once, eliminating the need for the loop-back inherent in the snake-like pattern. The simulation's findings were clear: when running year-long simulations to compare the two methods, the zig-zag sequence consistently outperformed the traditional snake-like sequence in terms of completed picks.

Table 1: Average Picks Per Month of Simulated Sequences

	January	February	March	April	May	June	July	August	September	October	November	December
Current	39639	40304	48889	42752	44146	46801	40912	47421	42450	44439	42497	34797
Zig Zag	41589	45397	53058	43227	46421	50207	47732	53001	45749	50209	44654	43713

The average data produced from the simulation—spanning 10 simulated years as shown in Table 1—reveals a tangible increase in the number of completed picks using the zig-zag pattern, affirming the efficiency of this method. The simulation results not only demonstrate the superior performance of the zig-zag pattern but also underscored the value of adopting such a sequence in practice. This innovative solution presents a compelling case for re-evaluating and re-engineering order picking strategies to achieve substantial gains in operational efficiency within the warehouse.

In interpreting the data, it is evident that the reduction in travel distance and time is a significant factor in the enhanced performance of the zig-zag sequence. This improvement translates directly into increased productivity and, by extension, can lead to reduced operational costs, safer workplace practices and enhanced service levels. The evidence gathered through this rigorous simulation process showcases the value of the zig-zag picking sequence as a strategic solution to a prevalent logistical challenge.

6. Conclusions and Final Thoughts

This case study has presented a comprehensive examination of order picking strategies within a warehouse environment, leveraging the capabilities of discrete-event simulation to explore and validate potential efficiencies. The major findings indicate that the traditional snake-like picking pattern, while entrenched in warehouse operations, is not the most effective strategy in terms of pick completion rates and overall efficiency. The introduction of the zig-zag picking sequence offers a promising alternative, showcasing a marked improvement in operational performance.

The simulation's month-long comparative analysis revealed that the zig-zag pattern consistently resulted in a higher number of completed picks compared to the snake-like pattern. This improvement can be attributed to the reduction in travel time and distance, ultimately contributing to a leaner, more agile picking process.

For practitioners and managers in the field of logistics and supply chain management, these findings underscore the importance of re-evaluating traditional processes in light of new data and technologies. The discrete-event simulation serves as a powerful tool for such evaluations, offering empirical insights that can inform strategic decision-making.

The recommendations resulting from this study advocate for the implementation of the zig-zag picking pattern, considering its demonstrated efficiency gains. By adopting this strategy, the facility under study has the potential to significantly improve its order picking operations, which can lead to reduced costs, faster order fulfillment, and increased customer satisfaction. Moreover, the iterative approach employed in the simulation provides a model for continuous improvement, allowing managers to refine operations further as new data and patterns emerge.

In conclusion, the case study emphasizes the potential for innovative approaches to transform warehouse operations. The impact of applying such findings can extend beyond the immediate operational context, contributing to broader strategic goals and competitive advantage in the healthcare supply chain industry.

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