Research Trends in Warehousing Order Picking Systems

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Abstract

Efficient logistics operations depend upon the effectiveness of warehousing and other nodes in a distribution network. Logistics costs constitute the key component in supply chains. In entire warehousing operations, order picking is the most time-consuming activity and implies huge costs. This accounts for approximately 55 percent of the cost and 50 percent of the total order picking time and therefore, being the most critical activity, it attracts attention of the researchers and practitioners in warehousing operations. In recent years, companies made significant cost cutting efforts in their logistics operations which can be attributed to the increased competition, personalized deliveries and globally distributed operations utilizing the local resources for cost advantage. The warehousing industry uses either manual or machine operated order fulfilment system. Majority of the warehouses around the globe are suited to operate manually. Despite the technological advancements such as automated storage and retrieval systems, automated guided vehicles; picking robots; scan verification devices; light assisted systems; their pace of absorption is slow in the warehouses. The typical challenges in warehousing are in dealing with the small order size; tight delivery schedules; dynamic order and route updation; congestion problems and real time performance monitoring of the warehousing operations. In a nutshell, extensive research involving decision support models; improved algorithms and solving the warehousing problems in an integrated manner will be helpful in advancing the theory and practice in this evolving field.

Keywords: Warehousing; order picking; decision support; manual systems; automated systems
Dynamic Human-Robot Collaborative Picking Strategies

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Abstract

With growth in online sales and more customers demanding fast home delivery, warehouses are facing tremendous pressure to improve order pick productivity and responsiveness. Robotic mobile fulfillment systems are gradually finding their way in many e-commerce warehouses which used to be operated mainly manually. While robots can carry items over large distances in expansive warehouses efficiently, they lack the dexterity, the skill, to grab a variety of item shapes and sizes. This lack of dexterity also makes the role of humans in the warehouses invincible. Hence, robots can collaborate with human pickers to carry out the order fulfillment jobs more efficiently and ergonomically. In a human-robot collaborative pick environment, robots work alongside pickers to improve the picking efficiency by reducing the pickers' unproductive walking time. However, the optimal picker deployment strategy, pooling pickers across all zones (parallel) or dedicating pickers to a warehouse zone (sequential), is not clear. In this research, we compare two picking strategies. First, we develop queueing network models to obtain load-dependent pick throughput rates with a fixed number of resources and deployment strategy. Then, we develop a Markov decision model to investigate how higher pick performance can be achieved with fixed picker and robot resources and a dynamic pick strategy.

Keywords: Warehousing, Collaborative Robots, Order Picking, Queuing Network, MDP
Dynamic Correlated Storage Assignment in Semi-automated Warehouses

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Abstract

Continuous improvement induced by tight competition in e-commerce, has compelled companies to design cost and time efficient operations. The aim of this paper is to minimize the total inbound and outbound storage and retrieval effort in warehouse operations using the available customer demand data. In a semi-automated order picking system products are stored on mobile storage pods driven by robotic vehicles, each containing multiple storage levels accessible for a manual picker. We cluster correlated products on the pods, and assign the pods to storage zones. At the same time, we aim to disperse each product over multiple pods to decrease the proximity to the pick stations. The aim of the model is to minimize the expected travel time of storing and retrieving products. Additionally, we dynamically assign replenishment and newly introduced products on a rolling horizon, such that correlation and dispersion is maintained during warehouse operations. We use a greedy construction and improvement heuristic and solver to solve the model, which is NP-hard, and use a simulation to evaluate the performance. Preliminary results show this model reduces the total replenishment and order picking time compared to conventional storage assignment policies.

Keywords: Logistics, storage policy, cluster-based storage, correlated storage, product affinity
Experience-based Territory Planning and Vehicle Dispatching with Variable Demand and Driver Present Condition

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Abstract

In the parcel delivery industry, the territory-based delivery system is widely used by large corporations like USPS. The advantage of such a system is that the drivers can improve their delivery efficiency with the increased familiarity of the territories they are assigned to. On the other hand, the territory-based system is believed to be lack of flexibility, because it tends to fix the "core areas". As the experience on the cells changes continuously, the current territory plan strategy may not fit the familiarity of the drivers. Thus it makes the current territory plan outdated. In this paper, we introduce a Markov Decision Process based territory planning model for the territory plan problem. To solve the problem, we introduce a two-stage territory assignment approach. In the first stage, we assign some of the cells to the core areas with a Rolling Horizon method based on predicted demands. The remaining cells are assigned to the drivers in the second stage based on their present condition and experience level. Our numerical study suggests the territory plan varies when drivers' capacity changes and a nonconsecutive territory plan can be optimal when the learning effect impacts the delivery time very much.

Keywords: Territory planning; Vehicle dispatching; Rolling planning