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O.R. Applications

A clustering algorithm for item assignment in a synchronized zone order picking system

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Abstract

In a synchronized zone order picking system, all the zones process the same order simultaneously. There may be some idle time when the zone pickers wait until all the pickers complete the current order. This paper develops a heuristic algorithm to balance the workload among all pickers so that the utilization of the order picking system is improved and to reduce the time needed for fulfilling each requested order. A similarity measurement, using customer orders, of any two items is first presented for measuring the co-appearance of both items in the same order. With this similarity measurement, a natural cluster model, which is a relaxation of the well-studied NP-hard homogeneous cluster model, is constructed. The heuristic algorithm is then proposed to solve the model for locating all the items into distinct zones. Finally, empirical data and simulation experiments verify that the objectives of the item cluster model are achieved.

Keywords: Warehousing; Item cluster; Synchronized zoning; Utilization improvement; Heuristic

1. Introduction

Order picking is defined as the process by which appropriate amounts of products are retrieved from specified storage locations to fulfill customer orders. The total pick area may be divided into picking zones so that each picker is dedicated to picking the items only in his/her zone. Depending on the process sequence, zoning is further classified into progressive zoning and synchronized zoning. Under progressive zoning, each order is processed by one zone picker at a time. Under synchronized zoning, all the zones are processing the same order at the same time.

In general, the order picking process is one of the most laborious processes of all warehouse operations. Coyle et al. (1996) estimate that on average 65% of the total operating costs of a common warehouse are spent on order picking activities. According to Delaney's (2000) annual studies of transportation and logistics cost, in 1999 the overall logistics cost is estimated to be 10.9% of

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the Gross National Product, and 8% of this logistics cost is used for warehousing. In a survey conducted by the Warehousing Education and Research Council (1986), order picking activity has been identified as the number one area for improvement in warehousing. In today's competitive environment, the increasing emphasis on better delivery time and accuracy standards cause the order picking system to play an increasingly important role in a distribution center.

To improve the order picking process, most of the researches focus on travel time reduction as well as storage location assignment in a general warehouse. Amirhosseini and Sharp (1996) present a generalized correlation measure that examines the degree to which two or more products together fill warehouse or customer orders to reduce the overall distance during order picking. Petersen (1997) evaluates various routing policies in a random storage environment, and the impact of warehouse shape and pick-up/drop-off location. On the basis of the ratio of the required space to order frequency, Caron et al. (1998) evaluate the expected travel distance for traversal policy and return policy in low-level picker-to-part systems in which items are assigned to storage locations. In simultaneous analysis of products and orders in storage assignment, Hall (1993) evaluates and compares strategies for routing a manual picker through a simple warehouse. Several rules of thumb are derived for selection of order pick strategies and optimization of warehouse shape. Chew and Tang (1999) present a travel time model in a rectangular warehouse, give the exact probability mass functions that characterize the tour of an order picker, and derive the first and second moments associated with the tour. Guenov and Raeside (1992) investigate the effect of zone shape in a class-based storage on the optimal picking tour of the S/R machine. As to person-on-board AS/RS systems, in which recurrent orders are to be retrieved, Oudheusden and Zhu (1992) solve the storage layout problem by making use of the traveling salesman problem in order to minimize the routing distance. To save the travel distance of the picker in a general warehouse, the homogeneous cluster (HC) model for locating items is proposed by Rosenwein (1994). In the HC model, items are grouped into a specified number of p clusters by means of selecting p items as the medians such that the sum of distance from all items to their respective median is minimized. One famous storage location rule is the cube-per-order index rule proposed by Heskett (1963). This index is defined as the ratio of the space requirement (cube) of an item to its turnover rate. The rule ranks the items in an ascending order of the index, and then assigns them in that order to the locations nearest to the I/O point.

Brynzer and Johansson (1996) propose a storage location assignment strategy using product structure, which results in a reduction in picking information. For environments where items may be stored in multiple locations, a model for determining simultaneously the assignment and sequencing decisions is formulated and is compared with previous models for order picking (Daniels et al., 1998). The so-called pattern graph proposed by Suzuki (1988) enables planners to identify the relationships between orders, items and retrieved quantities. For manual pickers, a computer-aided system can be used for order picking to simplify the tasks of human pickers (Frazelle, 1989), and a light-directed pick system with automated data entry can reduce human errors by 95% as well as increase productivity by 10% (Tolliver, 1989). The analytical design algorithm by Bozer and White (1996) which uses an approximate analytical model is presented to estimate the expected picker utilization for general system configurations with two or more pick positions per aisle and/or two or more aisles per picker. All the above studies focus on general warehouses. However, zone picking systems are rarely discussed. For a progressive zone picking system, heuristic algorithms proposed by Jane (2000) are to balance the workloads among the pickers and to adjust the zone size for order volume fluctuation.

This paper deals with the synchronized zone manual order picking system, in which all the zone pickers are working on the same order simultaneously. To improve the utilization of the order picking system and to reduce the time needed for fulfilling each order, this paper first proposes a similarity measurement for any two items, and