Comprehensive Analysis of Research for Warehouse Pick Path Problem

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Abstract - Improving the overall performance of warehouse operation is the goal of every operator be it in the manufacturing or in a distribution business setting. To do this, an efficient optimization of order picking process is needed to reduce the time for an orders to ship out, which in turn, will improve the overall effectiveness of its workers. Several approaches had been applied including the improvement of warehouse layout, routing methods, item storage set-up and batching. This paper focused on the routing method to improve the order picking process and selected different studies from 2013 to 2018 for analysis and evaluation. The selection of different studies was based on the method they applied such as the used of unmodified algorithm, enhancement or modification of existing algorithm, combining several algorithm, and other framework or model to improve the routing methods. Results shown that the unmodified algorithm had limited features and capability. Modification greatly improve the efficiency and effectiveness in its application and combining 2 or more algorithm resulted better results and efficiency and effectiveness. Lastly, the application of other frameworks were also useful to improve order picking time but the consistency in its application requires constant analysis, and evaluation to measure OP time performance.

Keywords - Aisle Setup, Efficient Optimization, Frameworks, Models, Order Picker, Pick Path Algorithm, and Routing method.

I. INTRODUCTION

The common goal of businesses including warehouse related businesses is to increase the overall profit margin through efficient optimization of order picking to reduce the time it takes orders to ship out, as well as, improving the overall effectiveness of its workers [1]. This setup is commonly seen in business establishments such as groceries and warehouses where aisle is used to arrange their products according to its classification. This strategy guides and directs the management and staff so with the clients to easily locate the items they needed.

Warehouse, as defined by Meller and Gue (2009), is a unit-load setup where racks are arranged in a parallel picking aisle that sometimes in an orthogonal cross aisles that minimize travel distances of an OPs [4]. A layout is conventionally designed in parallel pick aisles and straight middle aisles like in figure 1 while a recent proposal for layout trends improvements is flying-V, fishbone [5], Chevron, Leaf design, and Butterfly [4] designs for single and dual command operations.

Order pickers (OP) is the one responsible for retrieving the items in the storage locations (warehouse). A large number of orders will require hiring many OPs at the same time to process each order within a short amount of time [6]. Picking an item/s may be easy, however, prioritizing which item should be picked first may be a problem when items are scattered in a different aisle in a warehouse. Relying on the OPs alone may not be effective and may cause a delay in the delivery of the items to the customers. Statistics show that picking the ordered items accounts to 55%, the highest warehouse expenses in terms of collections which can be attributed to OPs [7], resulting in increased in warehouse management operation cost [8].

Routing method (RM) is one way of the several approaches on how to improve the operational efficiency of picking an item [2]. RM uses an algorithm to lessen the total travel distance in collecting the list of ordered items. It applies mathematics formulation using pick path optimization algorithm to determine the shortest path between items to another item stored in the different aisle [3]. Studies show that 55% of the total Labor Cost were spent on OP, thus to reduce the cost of warehouse operation, optimizing Picking operations becomes essential. If we analyze the Picking tasks in detail in figure 1, usually for an optimized environment, the combined searching and travelling accounted to 70% of the total time spent by OP [8].
This research focused on the routing method to improve the order picking process. Although there were many research conducted from 2013 to 2018, this research selected only 15 studies and evaluated their methods and solutions. The selection of different studies was based on the method they applied such as the used of unmodified algorithm, enhancement or modification of existing algorithm, combining several algorithm, and other framework or model to improve the routing methods.

This research was arranged as follows: Section 2 provided the literature related to the study; Section 3 identified the methodologies used; Section 4 listed the different researches to be evaluated; Section 5 presented the results evaluation in relation to the method applied; Section 6 concluded the evaluations, and lastly, provided the Future Trends and Research Opportunities.

II. RELATED LITERATURE

Warehouse layout is designed to provide an effective and efficient flow of products from the aisle to the dropping area. In the study of Žunić et al. (2018), stated that in warehouse design and layout, a large number of interrelated decisions must be considered. They also described that layouts are designed in such a way aisle whether for picking or cross-aisles must be straight. Picking aisles were designed to parallel format and in pairs while the cross-aisles serves as the path to go between picking aisles. Products may be stored in a pallet located on the shelves [9].

There are existing strategies that can be used to assist in providing the shortest route in the warehouse to minimize the path to collect all items of an order. This strategy helps reduce the order picking costs to a minimum of the warehouse [10]. In a real situation, the warehouse routing problem is mainly solved by heuristics using a routing approach such as an Aisle-by-aisle approach, S-Shape, and Largest Gap. All this approach can also be combined to make the collection more efficient but that may be on a case to case basis.

Several studies were conducted that applies algorithms and model to provide solutions to the warehouse pick path problem. A study conducted by Davarzani and Norrman [11] provides a comprehensive review of the existing literature conducted from the year 2000 to 2012. The research aim identifies how they provided solutions both methodology and algorithms applied, and the gaps, and limitation in each study.

A similar study by Cano, Correa-Espinal and Gómez-Montoya [12] which discussed different warehouse picking operations such as order batching, picker routing problems, sequencing in the actual conditions and identifies solutions and methods to order picking operations, function objectives, problem settings in different literature conducted.

Another study also summarizes algorithms and model but specifically focused on the warehouse picking problem shown in Table 1 was conducted by Prodhon and Prins [13]. It included the location of depots, and analyzing what routes will it takes to get the customers’ order which called Location Routing Problems (LRP).

<table>
<thead>
<tr>
<th>Kind of location-routing problem</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRP with uncapacitated vehicles</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>LRP with uncapacitated depots</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Capacitated LRP (CLRP)</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Two-echelon LRP</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Truck and trailer routing problem (TTRP)</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>LRP with special or multiple objectives</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Additional attributes on nodes and vehicles</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Multi-period LRP</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Inventory LRP</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>LRP with uncertain data</td>
<td>0</td>
<td>0</td>
<td></td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>72</td>
</tr>
</tbody>
</table>
III. METHODOLOGY

Four steps were involved in our methodology as shown in figure 2.

Figure 2: Literature Review Analysis

A. Collection of Related Studies.

In this phase, the researcher collected several literature from year 2013-2018 that provided a solution regarding the pick path problems.

B. Analysis.

In the analysis phase, four (4) criteria were set and will be collected including the aisle set-up, algorithm or framework used, approached and techniques applied, and the results and conclusion of the literatures.

C. Evaluation.

This phase determined the effectiveness of tools and techniques they applied in their study. This includes the used of unmodified algorithm which defined as a way to solve or complete a process such as a route finding problem that can be used in a warehouse or any other conditions without extra information needed [20]. This type of method was applied in the pick path optimization without any modification of its features. Such as Dynamic programming [9, 7, 20], Dijkstra’s algorithm [20], and Heuristic approach call merge and reach [14], which despite no modification or enhancement in their original structure, were able to provide good solution to the warehouse pick path problems [20, 7, 14]. Another is the enhancement of the algorithm in order to meet future needs and applications [27]. This has been evident in many types of research in warehouse pick path optimization such as Truncated Branch-and-Bound Algorithm [6] with heuristic evaluation method from the Branch-and-Bound Algorithm, and the Dijkstra’s algorithm that was enhanced [19] to improve its searching capability.

The same with enhancing or improving the algorithm, combining or merging 2 or more algorithms also proved effective in solving warehouse routing problem. It gave each algorithm to use its specialty in doing thing the right way. Such as some of the algorithms used in different studies showed in table 2 like the combination of Adaptive large Neighborhood Metaheuristic, branch and cut algorithm in evaluation that solved the order picking method [15], Ant-colony optimization and the Floyd-Warshall procedure [18], Mixed Integer Linear programming (MILP) using a sparse and dynamic programming [7], and the Simple algorithm based on the combinations of Hamiltonian cycle (HCP) and Hamiltonian path (HPP) problems [22].

There are other means to solve the warehouse routing problem beside the application of an algorithm had proven to be effective as well. The used of a model also plays a vital role in shortening the path to collect the list of order by the picker. Included in this type of framework is the application of Beisteiner-1, Beisteiner-2 and Egbelu Estimation Model [16] to calculate all inter-related variables in the warehouse in any given time. Other methods include Pyramid structure model which cut off the components of the graph representing parts of the warehouse [23]. Simulated annealing based sampling [26] also proven its worthiness in reducing traffic congestion and enhance the collection of orders in the warehouse. Lastly, the empirical data using qualitative methods of observation, interview, and collection of orders [25] to develop a way of providing a solution to the warehouse routing problem.

D. Knowledge.

This phase had established the advantages and disadvantages of using the tools and techniques applied in different studies thus, the best approach in solving the pick path problems will be concluded.

IV. ADAPTATION OF ALGORITHM AND FRAMEWORK

An overwhelming volume of studies were conducted to find the best pick path procedure in the warehouse. However, the researchers listed only 15 and presented in a tabular format as shown in table 2. The selected studies were taken from 2013 to 2018 which was based on the method applied such as the used of unmodified algorithm, enhancement or modification of existing algorithm, combining several algorithm, and other framework or model to improve the routing methods.
<table>
<thead>
<tr>
<th>Aisle Set-up</th>
<th>Algorithm and Framework</th>
<th>Approach/ Technique</th>
<th>Results/ Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple cross aisle</td>
<td>Heuristic approach called merge and reach algorithm (TMMBA) [21]</td>
<td>Two approaches were made, (1) the merge and reach applied a loop to the 2-OPP solutions then (2) using a heuristic approach, the solution is evaluated if applicable, thus the best solution can be found and updated.</td>
<td>Although the improved heuristic techniques had shown improvements in determining the shortest path, this method was also applicable to other warehouse layouts despite the improvement in performance and robustness to other heuristic methods.</td>
</tr>
<tr>
<td>Narrow and Parallel format</td>
<td>Adaptive large neighborhood search algorithm (ALNSA) [15]</td>
<td>Applied three different algorithms for solving the order picking problem, namely Adaptive large Neighborhood Metaheuristic, and cut algorithm in the evaluation.</td>
<td>The combined approaches heuristics and algorithms method minimized the total distance traveled in picking all ordered items, this approach only identified the algorithm to be used if it encountered a certain set of aisle layout.</td>
</tr>
<tr>
<td>Parallel format</td>
<td>Mixed Integer Linear programming (MILP) using sparse and dynamic programming [7]</td>
<td>Application of sparse formulation in MILP including determining the valid inequalities and preprocessing adequately and integrating an algorithm (dynamic programming) [7] to test in a parallel aisle set up.</td>
<td>Using the combined approach, the experiment resulted in a 6 cross-aisles generated the shortest path within the average time of 0.27 seconds.</td>
</tr>
<tr>
<td>Non-standard warehouse layout</td>
<td>Dynamic programming (DPA) [17]</td>
<td>The non-standard layout must be deal differently because does not follow the standard format. Thus, the approached was to divide the layout of the warehouse into a smaller group of units before calculating the two pallet distance using dynamic programming algorithm to generate the shortest pick path for order picking.</td>
<td>The results have shown that the algorithm had generated a significant improvement in picking an ordered process in the warehouse. However, it was not able to divide the layout into a basic unit because there are a lot of constraints like finding the entrance and exit common in the basic layout units.</td>
</tr>
<tr>
<td>Narrow and Multiple cross aisle</td>
<td>Fracuted Branch-and-Bound Algorithm (TBB) with heuristic evaluation method [6]</td>
<td>Used TBB algorithms to deal with the OP's determination that provided waiting instructions memory issues and computing time. In this algorithm, evaluation methods were applied using heuristic pruning of branches approach to reduce the computational effort.</td>
<td>Results of the numerical experiments shown, TBB had demonstrated to provide excellent results by decreasing the waiting time by up to 96%. It also shown that it can reduce by as much as 62% by giving more importance on selecting which OP that needed to wait in some situation. However, instead reducing the waiting time, it would be more appropriate if the other OP will use other path or collect other orders to provide a continuous process of picking collections.</td>
</tr>
<tr>
<td>Multiple cross aisles</td>
<td>Adapted ant-colony optimization and the Floyd-Warshall procedure (FW-ACO) [18]</td>
<td>Conducted two analysis; (1) determined the ACO algorithm’s best effective setting by evaluating its performance through application of ACO metaheuristic’s common parameters function. (2) Compare, evaluate, and to what extent its performance can outperform with other routing algorithms.</td>
<td>With FW-ACO algorithm’s minimum computational time, it generated a very good outcome in terms of results because it runs once to generate the shortest path. The results also shown the algorithm could be adapted in a situation and condition wherein the constraints exist on picking operations which were not giving importance in other literature that dealt with shortening the picking distances.</td>
</tr>
<tr>
<td>Dijkstra’s algorithm adjustment (DAA) [19]</td>
<td>The algorithm was enhanced (adjusted) and applied in the simulation of the picking process in the warehouse for 20 days.</td>
<td>Results of the simulation shown that the algorithm optimization model had increased by up to 15% and could even reach to 41% in its maximum which means that it can reduce the generation of picking path effectively.</td>
<td></td>
</tr>
<tr>
<td>Dynamic Programming (DPA) and Dijkstra’s algorithm (DA) [20]</td>
<td>Compare the two algorithms to determine which of them could provide the shortest path for the OP in a warehouse</td>
<td>Results shown that Dijkstra’s algorithm was not flexible enough to select a path in real situation as compared with the Dynamic programming that considers all possible path to generate a shortest path in the warehouse. However, the test only applies random order and does includes turning the aisle penalty.</td>
<td></td>
</tr>
<tr>
<td>Parallel format</td>
<td>Travel time minimization with Biobjective turn algorithm (TMMBA) [21]</td>
<td>Applied 3 experiments: (1) time requirements in generating the Pareto front in various sizes were measured, (2) compare it with other algorithms in term of total time and turn while traveling, and (3) Quantify the exact approach value of the problem for biobjective in contrast to using time intimidation approaches.</td>
<td>Results had shown that by using the studied algorithm, it generated the corresponding Pareto front within a short time period, outperforming other heuristic approaches used in practice in the process.</td>
</tr>
<tr>
<td>A simple algorithm based on the combinations of the Hamiltonian cycle (HCP) and Hamiltonian path (HPP) problems (HCP-HPP) [22]</td>
<td>Combined two simple algorithms to deal with the partnered company warehouse's specific configuration and determine the shortest path that will optimize the measure of performance of items collected in multiple batches set up by the OP.</td>
<td>Results shown from experiments revealed the effectiveness and potential of the approach, thus it was able to lessen the monthly total distance traveled by the OP by more than one fourth.</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE II. ALGORITHM APPLIED TO SOLVE PICKING PROBLEM AND THEIR FINDINGS**

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Aisle Set-up | Algorithm and Framework | Approach/ Technique | Results/ Recommendations
--- | --- | --- | ---
Narrow and Multiple cross aisle | Pyramid structure to cut off the components of the graph representing parts of the warehouse. | Extending the Single-Picker Routing Problem (SPRP) formulation to be used and considered in different scenarios such as in minimizing model size (number of location's independence in term of size in a layout with single-block to be visited) but also can be extended to multiple blocks. | By means of numerical experiments, it demonstrated that the formulation had the capacity to decrease by up to 60% in generating the shortest path, with 99.5% reduction of computing time regardless of the number of blocks used.

Parallel format | Interventionist routing algorithm. (IRA) [24] | Integrating the algorithm in the order picking process to allow to rearrangement the orders even if it has started a picking cycle. Such that in the middle of picking process, new orders can be added (intervened) to the existing orders currently in the list of order of the picker anywhere inside the warehouse. | Results of the interventionist optimization algorithm outperformed other heuristics such used in the simulation including travel distance and the time spent by the OP in the warehouse. The reduction of order completion time using this algorithm was achieved and resulted in an increase in traveling distance for the OP.

Multiple cross aisle | Empirical data using qualitative methods of observation, interview, and collection of orders [25] | Empirical data using qualitative methods of observation, interview, and collection of orders and recommend changes and repositions of location in the warehouse for some of the products. | Results of the study shown that to efficiently optimize the order picking processes, the company must define and analyze the data and information used in the company’s Warehouse Management System (WMS), conduct a warehouse storage location reorganization to improve order picking time, and Order picking process must be constantly observed, analyzed, and evaluated to measure OP time performance.

Different sizes and layouts of warehouses | Simulated annealing based sampling [26] | To reduce traffic congestion and enhance the collection of orders in the warehouse, it will apply sampling using simulated annealing and each item will be assigned to their specific location in the storage which will then be used to generate a shortest piking path to be used by the picker. | The results revealed that it can be applied in different applications in the warehouse that include assigning of items in the storage efficiently, evaluate warehouse trustworthiness, and be able to estimate traffic congestion including the number of aisles both parallel and cross, and the point placement for I/O. However, the estimation of the reliability of coupling base on the demand value that will overcome the problem is unknown, the same with the analyzation of the impact in warehouse performance in terms of collective multiple orders in a single picking process.

**TABLE III. SUMMARY OF RESEARCH BY ALGORITHM, MODEL AND/OR FRAMEWORK.**

<table>
<thead>
<tr>
<th>Algorithm used</th>
<th>Multiple</th>
<th>Non-Standard</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhance Algorithm</td>
<td>Wide</td>
<td>Narrow</td>
<td>3</td>
</tr>
<tr>
<td>Combination of 2 or more Algorithm</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>No modification of Algorithm</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Other Framework or Model</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4</td>
<td>15</td>
</tr>
</tbody>
</table>

V. RESULTS ND DISCUSSION

The findings on the literature offer an interesting view, there's no single solution but it opens doors to explore a new approach. The study offers awareness into different techniques and procedure implemented into warehouse operations. Table 2 shows the different algorithms and other methods had been applied in different studies. It includes the aisle set-up wherein majority are in cross aisle settings, each finding which provides improved solutions to the piking problems. All studies conducted had applied computer simulation to evaluate the efficiency and effectiveness of the algorithms, frameworks and/or models in the given layout which incidentally did not fail to provide good results in generating the shortest path.

In this paper, we analyzed different papers available in the literature that optimize warehouse pick path and categorized their methods used as follows:

A. No Modification of the Algorithm.

The application of unmodified algorithm had been proven to be effective in determining the shortest path in the warehouse using MRA which had shown its effectiveness not only in a multiple cross aisle layout but also in other layout as well. Same observation with the DPA when applied to the same layout but was not as effective when applied in a Non-standard warehouse layout.

B. Enhanced Algorithm.

The reason why an algorithms were needed to enhanced or modified was to provide solutions to the needs of the warehouse picking problem. The selected algorithms had a different objectives but were similar to one goal, to improve the process of OP in the warehouse. While the DA enhancement focused on the improvement of the optimization in the generation of picking path, TBB and IRA had focus their attention on the problems that delay the process of picking orders. Results on the DA enhancements,
the optimization of picking path had improved by efficiently reducing the pick path generation by up to 41% in the multiple cross aisle setting. On the other hand, the TBB saw the delay in the process of picking orders through the incident of picker blocking which were successfully solved and resulted in the reduced the waiting time of OP by up to 96% and provided capability to select which OP were needed to wait in some situation. Lastly, IRA saw the delay in the process of picking orders because of waiting for the picker to collect the order. Through intervention or IRA, it was not only minimized the travel distance and the time spent by the OP, but also reduced the order completion time.

C. Combination of 2 or more Algorithm.

The combination of 2 or more algorithm can be more effective in solving a problem such as in the warehouse pick path optimization. Such problems included were the “turn” effect (U-turn, left or right, and return), and narrow aisle setup. Several studies had been conducted using this strategy to fill the limitation of a certain algorithm. Such as the application of ALNSA, FW-ACO, TMMBA, HCP-HPP, and MILP which combined several algorithm to optimized the picking path generation. The results of experiment using HCP-HPP, MILP, TMMBA, and ALNSA shown that each of the combined approached heuristics and algorithms method minimized the total distance traveled in picking all ordered items, however ALNSA may be more effective since this approach has the capability to identify the algorithm to be used if it encountered a certain set of aisle layout. FW-ACO was the same with ALNSA that provided a good results in terms of optimization, however, it only run once to generate the shortest path and can also be adapted in a situation and condition wherein the constraints exist on picking operations which were not giving importance in other literature that dealt with shortening the picking distances.

D. Other Framework.

Other ways to minimize the OP process in a given warehouse is the application of qualitative methods of observation, interview, and collection of orders, and graph representation. In the qualitative approach, the company must define and analyze the data and information and conduct a warehouse storage location reorganization to improve order picking time. However, order picking process must be constantly observed, analyzed, and evaluated to measure OP time performance. Graph representation can demonstrate that it had the capacity to decrease by up to 60% in generating the shortest path, with 99.5% reduction of computing time regardless of the number of blocks used.

Analytical method can also be applied because it was faster and easy to use as compared with the simulation method (consumed a lot of time to estimate), the latter proved much reliable due to its ability to handle different dispatching rules, blockings, and congestions. Simulated annealing based sampling also proved useful because it can be applied in different applications in the warehouse that include assigning of items in the storage efficiently, evaluate warehouse trustworthiness, and be able to estimate traffic congestion regardless on the number of aisles both parallel and cross, and the point placement for I/O. However, the estimation of the reliability of coupling base on the demand value that will overcome the problem is unknown, the same with the analysis of the impact in warehouse performance in terms of collective multiple orders in a single picking process.

VI. CONCLUSION AMD FUTURE WORK

Based on the results of the researches on warehouse picking optimization, the following conclusion are drawn:

- The unmodified algorithm had shown its usefulness however its performance were focused only on its limited features and capability.
- Modification or enhancement of the algorithm greatly improve the efficiency and effectiveness in its application.
- The combination of 2 or more algorithm proved to be more effective than the other methods, and through its enhancement or combination with other algorithm resulted better results and efficiency and effectiveness.
- The application of qualitative methods of observation, interview, and collection of orders to define and analyze the data and information and conduct a warehouse storage location reorganization were also useful to improve order picking time. However, the consistency in its application requires constant analysis, and evaluation to measure OP time performance.
- Therefore, the combination of 2 or more algorithms proved to be more effective than the other methods given which had shown better results in terms of efficiency and effectiveness.

Future Trends and Research Opportunities

In anticipation of the outgrowth of the study, consider the following research opportunities:

- Combination of 2 or more enhanced or modified algorithm leading to growth and success of performance for better efficiency and effectiveness.
- Out of the modified and combined algorithm, the integration of data mining can also be considered for forecasting purposes among warehouse operators.
- Side by side, it will set the starting point of leading the development of a smart picker that will employ machine learning and much improved routing pathing.
REFERENCES


