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PRODUCT POSITIONING OPTIMIZATION IN INTELLIGENT WAREHOUSE

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Abstract. To obtain competitive advantages in the global market scenario, companies have aimed at reducing logistic costs as well as streamlining the order fulfillment. The use of tools to efficiently manage the warehouse, ensuring a best allocation of the products has been growing. The method of the ABC Curve, based on the Principle of Pareto qualifies the portfolio of a company so that products can be separated into classes. The items of Class A deserve special attention since they represent 80% of the financial transactions of a company. On the other hand, the AHP multi-criteria tool enables the analysis of several criteria (demand, financial transaction, seasonality, among others) to determine the best alternative to achieve the main goal. In this context, this paper presents a tool/technique to ensure the correct positioning of the products optimized by either the allocation based on the ABC classification or the allocation by prioritizing the products established by the AHP. The tool/technique was implemented in language C and 1,620 loading and unloading tasks were simulated for random allocation, ABC and AHP to assure the flow of inputs and outputs from the storage. The results show that the system proposed is viable and efficient, as it shortens the distances traveled and streamlines the order fulfillment time, reducing the logistic costs. The reductions achieved with the allocations based on the ABC method ensure 8.42% for the traveled distances and 8.43% for the time spent to unload the trunks. The multi-criteria tool allowed reductions of 12.81% and 13.47% in the traveled distances and time spent, respectively, to allocate the items into the storage. The research is of great relevance for the area, as it ensures an optimum flow of the storage, reducing the unnecessary movements.
Keywords: Optimization, products positioning, AHP, ABC Curve.

1. INTRODUCTION

According to world stage of competitiveness and different degrees of market globalized economy, the enterprises as an alternative to stay active, search joint improvement to mitigate the differences in the market. The management of storage, adopted as a factor of high importance in the business context, is considered an element of strategic superiority and if done efficiently, searching to reduce costs, of movement time and agility in the service request and adopting tools able to support the logistics decision, is able to bring countless benefits to the enterprise (Oliveira, *et al.*, 2011).

According to the Council of Logistic Management - CLM (1996), the concept of logistics can be definite as the "process of planning, implementing and controlling the efficiency flow and storage of goods, services and related information from the point of origin to the point of consumption to conform to costumers requirements" (Tinelli, *et al.*, 2011).

Logistics is an important factor to obtain strategic advantage for the enterprise Bowersox, *et al.*, (2007) state that logistics represents a source of competitive advantage if managed in an integrated manner.

In this context, the logistics optimization is achieved by the correct positioning of the item inside the warehouse in order to reduce the distances traveled during all the process of movement. The availability of an adequate infrastructure enhances gains of efficiency for the productive system, as increase the value while reducing the costs per unit of input. The effects of infrastructure on the general considerations of efficiency of the economy are quite evident (CSCMP, 2010).

Are common papers that investigate the best route collection to meet the demands requests, considering only the fixed position of the items into the warehouse (Klimm, *et al.*, 2007; Olmi, *et al.*, 2008; Ravizza, 2009; Vivaldini, 2010) showing the need for comprehensive research and continues in this area. Recent researches showed that the optimization of operations in warehouse relative to resources represent a great improvement in the logistics process of the enterprise (Baker and Canessa, 2009; Gu, *et al.*, 2007; Mountz, 2010; Tinelli, *et al.*, 2011; Zhanga and Laib, 2010).

In this context, the automation of warehouse aims to reduce both the logistics costs and stock levels, as to obtain higher agility to customer service, create a competitive and a better monitoring of warehouse productivity.

Recent researches show that the optimization of operations in warehouse represents a great improvement in the logistics process of the enterprise (Queiroz and Cavalheiro, 2003). A relevant number of researches support the optimization as a competitive factor (Grossmann, 2005; Varma, *et al.*, 2007; Sarker and Diponegoro, 2009; Sousa, *et al.*, 2008; You and Grossmann, 2008).

The Mobile Robotics Laboratory - LabRoM Group of Mechatronics Engineering School of Sao Carlos - EESC / USP engaged in developing tools for intelligent warehouse management, the group has published several papers in the

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area. This paper presents the continuation of studies on optimizing the positioning of finished products (Vilvadini, *et al.*, 2009; 2010; Tinelli, *et al.*, 2011; 2013)

This paper presents two methods to assure a correct positioning of the stocked products, guaranteeing a great material handling based on the financial transactions and, consequently, reducing logistics costs.

The article is organized as follows: Section 1 introduces the subject; Section 2 shortly contextualizes about storage management; Section 3, describes the product position optimization; Section 4 presents a methodology; Section 5 shows the layout adopted; Section 6 describes the evaluation of criteria; The Section 7 presents the results and simulation; Finally Section 8, presents the conclusions and the main contributions.

2. STORAGE MANAGEMENT

A great relevance area for the sector of operations management is internal logistics, covering, among other things, storage area, displacement of consumer goods, as well as management information. The same is likely to improve, already that ensure an optimum flow of materials in the environment and get reduction of logistic costs. Ballou (1993) states that the internal logistics planning match a large gap in competitiveness between companies, since this schedule is directly linked to costs. So, the storage and handling of materials become essential components to the set of logistical activities.

The storage management aims to control all the tasks referring to the flow of materials, as information about the storage. *Gu, et al.*, (2005) presents that the main activities developed during the storage process are: receive the product, do the storage, retrieves and dispatches them.

An efficient management of storage stock can ensure greater competitive edge and profitability. The type of stock that will addressed in this paper is the storage of finished products. Thus, for managing with effectiveness and agility the storage management becomes crucial the application of Information Systems, since it will ensure agility and reliability during the information process.

In the business environment, several industries store their finished products is in distribution centers or in the manufacturing building. The storage can occur in three forms, being the first one the same simplistic based on the operator´s memory. The second way is based on fixed positions for each product, featuring easy to locate the item in the warehouse (Ballou 1995). Both not use information systems, because of this, only one or some logistics operators know to search for a particular product into the warehouse and do not lend themselves to variations of demand (Moura 1997). The third way is random positioning, that available all the positions of storage for all the products, thus, requires integration of information systems to manage the location of finished products (Moura 1997; Arnold 1999; Dias 1993).

A new way to manage the positioning of finished products into warehouses is most suited to the current business scenario; it ensures agility and reliability, because it occurs by integrating tools to properly position the items into the warehouse and the WMS (Warehouse Management System). This will ensure a good flow while handling the materials and reduce the distances and time service request.

2.1 Materials handling

The handling of materials referents to the internal logistics occurs inside the warehouse, realizing a flow of input, storage and output of the products. The movement and handling of materials needs time, manpower and money. So, it is necessary to minimize, to do not execute unnecessary movement, and reduces the request time, as, wear of materials handling equipment.

According Moura (2005), the movement of materials represents between 15% to 20% of the total cost of a finished product, being a passive point to reduce of costs.

2.2 Decrease distances of movement

The definition of the location of the manufactured product into the warehouse will determinate the traveled distances during the path made to ensure that the same come to the dispatch area. Similarly, when positioning the heavier products, or the most fragile, nearest places on the expedition seeks to reduce the effort of moving, as, premature wear of handling equipment. So, when allocating products that have the flow of movement/demand into the warehouse in places near the areas of expedition, reduces the total movement (Oliveira, *et al.*, 2010).

Gu, *et al.*, (2007) presenting the Storage Location Assignment Problem – SLAP how to search by designation of the physical place where each item should be stored, aiming reduce the costs of handling of materials and improve the use of space.

The objective of SLAP is determinate in which area/shelf store items of received products, so that the total operational costs is minimized, reducing the movement of materials and according Carlo and Giraldo (2012), the SLAP can be classified according with the information provided about the arrival and departure of the stored products into the warehouses, being classified in three types, based on:

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- Information of the item (SLAP /II): in this case the information about arrival and departure of the item for the warehouse, are provided, not considering the specifics characteristics about the item, as code, or type of the item;
- Information of the product (SLAP /PI): for this classification, it is known product data, as code, batch, unit value, among other items. Thus, held the attribution of classes for the product. The products will be storage, according, with pre-established areas for a given class;
- No data (SLAP /NI): do not exist relationship of storage with item/product, since no information about the classification above is considered. In this case, the storage occurs randomly obeying the closest position.

The information and necessary criteria for the application of SLAP for definition of physical arrangement are related to several factors as floor plan of the warehouse, area/capacity of storage, relationship of total positions of shelving, as data about the products to be stocked and order processing time.

Onüt, *et al.* (2008) to reduce the distances of movement into the warehouses, realized a heuristic propose based on criterions to classification the items in classes, possibility a high application of the paper when exists qualitative factors in the decision process.

The reduction of the distances is also a powerful tool to improve the movements. According Freire (2008), frequently papers of layout and positioning of the production line and storage, are looking for reduce the distances of necessary movement to the flow of finished products.

Change in technologies of internal movement and packing in the reduction of movement of equipment with the use of the gravity between line and stock and reduction of the weight total of non-products transported, tend to reduce the passive logistical movement, improving the productivity of the activities. Investments in these technologies, that privilege the active movement, has proven highly advantageous the medium and long term. Beyond to reduce costs in repetitive operations, these technologies also bring a positive environmental impact, reducing the use of energies, as fuels and electricity, beyond the corresponding reduction of emissions and pollutants (Freire, 2008).

3. PRODUCT POSITIONING OPTIMIZATION

Defining the location of the product within the warehouse determines the distance to your recovery and directly impacts on storage costs. The model designation position seek to reduce the distances between the shelves and the expedition.

Slack, *et al.* (1999) state that any stock where there are more than one item type, some are more important than others. Thus, when discriminating the different items stocked so that you can treat each one specifically according to their priority, minimizes the complexity of the problem and facilitates the management of the stock.

A relatively simple tool but powerful and widely used is the ABC classification, which is based on the Pareto Principle (Slack, *et al.*, 1999) where 20% of stocked items represent 80% of total company financial transactions. The Pareto Principle ensures that all companies will occur in the ratio 80/20. The method consists of classifying the products stocked in three groups A, B and C, which is the order of decreasing priority. Thus, the logistics manager may treat each group differently, focusing their efforts on the class A, which represents the largest portion of the value of the stock at the expense of other classes, especially C, which is lower significance in business, and it does not require much care. Tinelli, *et al.*, (2011) present and validate the use of the ABC classification.

The method of the curve ABC is used to qualify the items that have a high movement of higher financial movement, the tool is used in several areas of the literature (Jing-Wen and Tie-Jun, 2009; Lourenço and Castilho, 2006; Ramanathan, 2004; Tinelli, *et al.*, 2010, 2011; Tuji, Jr., *et al.*, 2004 and Atamanczuk 2009) propose the application of the Curve ABC to qualify the products that shows a better participation on the flow of movement, so better demand to the enterprise.

Tuji Jr., *et al.*, (2004) applied the method of the Curve ABC to ensure improvements in inventory management in a micro enterprise of food and highlights that this tool provided improvements in the operational activities of the enterprise.

A paper that determinate the localization of products into a warehouse from the established classes according with the index of movement of products was proposed by Petersen, *et al.*, (2004). The products that have higher rates of movement will be allocated next of the terminals of load and unload (expedition). The classification by demand inside the perspective ABC, for the supermarket sector, ends up generating limitations in relation to adequate storage of the products, once, products of supermarket have different physical characteristics.

To Huiskonen, *et al.*, (2003) can be used other aspects beyond the demand to improve the efficiency of the inventory management. The authors employed the utilization of qualitative aspects.

Martins and Alt (2001) claim that the Curve ABC can be used to manage efficiently the values applied in stock when defined their classification by values, as, provides improved operational results in the monitoring of activities of movement when their classification occur based on the amount busy. The application of the tool occurs via demand survey of the items and planning of the same in decreasing. The items that possess greater movement, form the class A, the items of regular movement, form the class B and the other constitute the class C.

Gouvinhas, *et al.*, (2005) define the two fundamental principles should be followed: the first one is related with the planning of the activities of the item directed to the shipping dock; the second is related to find nearby activities to achieve reduce the distances of movement between the operations. These authors developed a paper in an enterprise of food storage that used the technique ABC to determinate the best allocation of products in the plant of the warehouse privileging activity of movement.

According Van den Berg (1999), the enterprise may get reduction of operational costs without losing quality of the product of service provided, by applying the Curve ABC to analysis the stock, thus highlighting, the item that deserve more attention in the administration.

Another tool used is the multi-criteria analysis, Analytic Hierarchy Process (AHP), establishing which criteria (demand, fragility, weight, financial transactions, and seasonality) should be prioritized. The technique differs from the ABC curve, as can perform a joint analysis of several criteria, thus to carry out their hierarchy. Several studies in the literature perform different applications to prioritize items, ideas and decisions.

Magalhães (2011) proposes that using the multi-criteria tool AHP to prioritize the portfolio of the enterprise producer of appliance white line to establish which items should have more attention in the implementation of reserve logistics.

Chiyoshi, *et al.*, (2000) apply the integrated hypercube model to metaheuristic, as simulated annealing and search taboo, to solve problems of localization probabilistic related to randomness the availability of servers.

Atamanczuk (2009) addresses the classification of stock to designation of positioning of products in a physical arrangement of a warehouse in the supermarket sector. The conditions for the positioning used by Atamanczuk (2009) follow the Standards of Sanitary Surveillance, separating the products in groups, for example: drinks, solid foods, frozen, cleaning, and others. According with the family of the products, areas were determinate in the physical arrangement of the warehouse to designate them.

In this context, Santos and Rodrigues (2006), relied in the classification of the products in family, respecting the similarities of the items.

Tools like ABC and AHP are fundamental to classify and prioritize finished product. Based on this information together with the applications of techniques of detection of demand, we obtain data to position optimally the products into the warehouse.

4. METHODOLOGY

In this context, this research aims implement a system for optimization in the heading of items taking into the financial transactions of the products aiming the reduction of the distances to be traveled during the process of handling of materials. This system provide improvements in agility of all the operational process, enabling efficient operation of warehouse jobs by supplying correct of finished products, where the items with larger spin/financial movement or higher density become more next of the dispatch area reducing costs with unnecessary travel.

In this section will be presented methods adopted in this research. First, will be shown the AHP multi criteria tool and their formulation to find which tool/method reach higher efficiency to optimize the positioning of finished products, after this, the methodology of application of the AHP to allocate finished products into the warehouse will be presented, based on the criteria listed as high-priority on application of the AHP tool. This paper proposes the application of these methods (ABC Method and AHP multi criteria tool) in Language C and will make tests of simulation and run time of tasks into the warehouse.

In this context, the problem of Designation of Storage Location (SLAP) based on product information (PI) will be studied in this thesis to propose a solution to optimally allocate finished goods in the warehouse, obtaining also reduce costs of unnecessary travel material handling equipment and maintenance. In this regard, we have seen that a tool is required to rank and prioritize product. Thus, the next chapter will be presented the literature review covering a brief introduction to demand forecasting, seasonality and techniques for the optimization of product positioning.

First of all, this section describes the model of the warehouse adopted for both methods. After this research propose the applications of the AHP multi criteria tool, to obtain a theoretical result relative at which method/tool, respectively ABC/AHP, ensure further optimization for the positioning of finished products into the warehouse. So, adopts the ABC Curve, based on the Pareto´s Principle to designate areas in the warehouse to store each class obtained. The AHP multi criteria tool, after applied, will give us which criteria should prioritize in relation to other, thus to propose a designated area for each hierarchy established in all the tests based on the AHP.

The methods were created in Language C and by integrating of the Proposed System with the Supervisor System developed in LabRoM, the algorithm was validated by tests of simulation.

4.1 MULTI-CRITERIA AHP TOOL TO ESTABLISH THE CRITERIA FOR ALLOCATION

The Analytic Hierarchy Process (AHP) is a decision-making technique developed by Thomas Saaty in 1977, being a method of multi-criteria decision aid in complex environments where many variables or criteria are considered in the prioritization and selection of alternatives.

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According to ODPM (2004), with the AHP, the analyst conducts trials simple pairwise comparison of product characteristics, which are then used to develop priorities ranking of the alternatives. The weights and scores are achieved primarily through pairwise comparisons among all criteria.

The AHP can be used to build the problem of decision making, being a simple hierarchy consisting of three levels: overall goal of the decision, the criteria by which the alternatives will be evaluated and the alternatives available. Thus, analysts can systematically evaluate alternatives, making pairwise comparisons for each of the criteria chosen. This comparison can use concrete data from alternative or human trials as a way to input information underlying (Vargas, 2010; Saaty, 2008a).

4.2 AHP

Saaty (1987), defines the structure for the application of AHP multi-criteria tool. Tinelli, *et al.* (2013) conducted the application of the tool, In order to find what criteria (demand, financial transactions and seasonality) should prioritize areas for well designated the warehouse to allocate the product hierarchy, as follows:

High: includes few items, which are representing the largest share on criteria established as a priority in the application of AHP multi-criteria tool, along with items that have higher density (representing approximately 80% of the criterion with respect to the sum of this criterion);

Average: Products that have significance for the average criterion established as a priority, but have low weight (this category comprises 15% stake in the criteria);

Low: items that have little involvement in the priority criterion of application of AHP multi-criteria tool (only 5% interest on criteria established).

4.3 AHP for products allocation

The AHP Method differs from the ABC, this one considers only one criteria per analysis (for example: financial transactions or spin), already the AHP Method can be based on several criteria. Thus, a propose to designate item from the warehouse based on the AHP will be based on items that presents the largest financial transactions along with the variable of the items that present the largest mass, already the items heavy generate increase wear of equipment of handling, allocating the same near of the dispatch areas we were able to reduce this costs.

Designation of positions into the warehouse for each level of hierarchy was proposed based on similar to the layout with areas for each class ABC. As shown in the Figure 2 (b).

High priority: 20 positions, representing approximately 20% of the positions available;

Medium priority: 67 positions, being 40% of the total of positions into the warehouse;

Low priority: 81 positions, in other words, 48% of the 168 positions available for storage of finished products.

4.4 ABC for products allocation

The ABC Method is usually employed to investment management in stock, but, also can be used to management of operational activities. Thus, it is concluded that the proper adjustment of space to storage and analysis of financial transactions or seasonal demand of the portfolio ensure the optimization of the storage system.

In this context, to demarcate the areas that belongs of each class, A, B and C, into the warehouse. The shelving that are closest to the shipping area will be designated as class A, the Pareto´s Principle propose that his class behold 20% of the effectives positions into the warehouse, since this product belong 80% of the profitability of the enterprise. Continuing the determination of the number of shelving for each class B and C, behold 30% and 50% respectively.

In the warehouse that we have adopted, a total of 168 positions (Figure 2(a)), being:

A – 34 positions, representing 20% of the positions available into the warehouse;

B – 50 positions, being 30% of the positions;

C – 84 positions, in other words, 50% of the positions of storage into the warehouse.

The Curve ABC is based on data related to demand of finished products, their respective unit values and the code of the product. To obtain a classification of the items, was multiplied the demand by the unit value of the products, to find what products representing largest share of financial transactions of the enterprise. These products should be organized in decreasing.

The determination of classes was obtained by the percentage accumulated of each item relative to the total financial transactions. Establishing this script, based on the limitations of each class proposed by Martins and Laugeni (2002).

Integrating the information of the classification of the products with the designated areas into the warehouse for each class, the algorithmic developed allocates the items of optimized way compared to random classification.

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5. LAYOUT

To validate the application of the techniques adopted is necessary a layout to simulate the tasks of loading and unloading of the truck, in other words, simulate the flow of input and output of the warehouse of finished products. So, we can verify the costs, in other words, the distances traveled and the run time of each task, be it from the dock to the shelf (unloading) of from the shelf to the dock (loading).

The layout of the warehouse used (Figure 1) have nine aisles, three platforms of loading and unloading, designated docks and six depots, because the warehouse operates with six AGVs (Automated Guided Vehicle). The AGVs receive tasks to be executed, may be of loading or unloading, after conclude the task the system is informed about how long it took each task and the distances traveled.

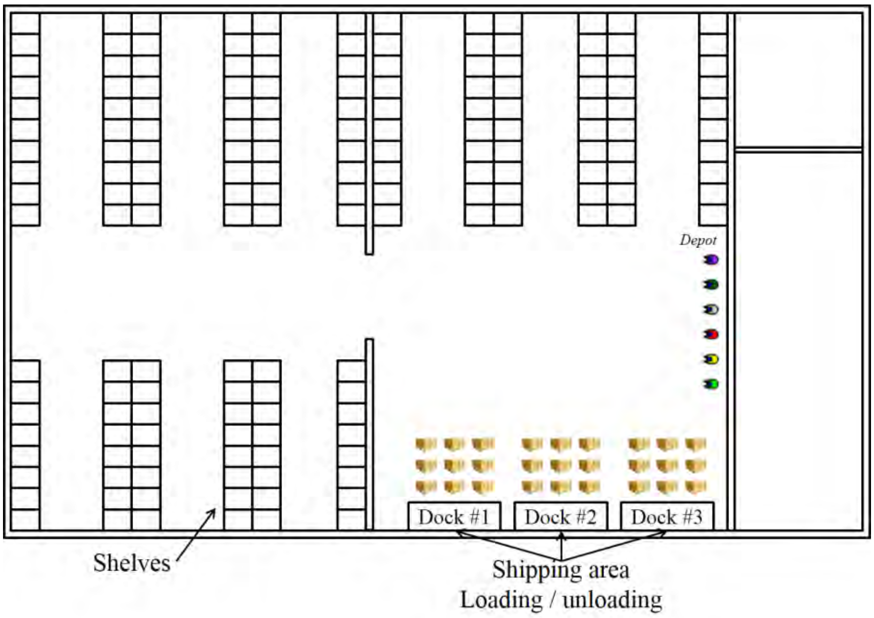
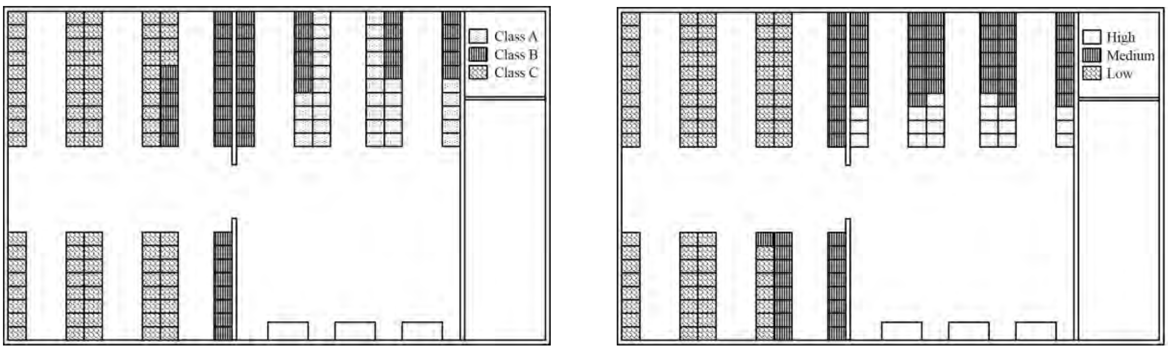


Figure 1. Layout adopted

The tasks are received by the WMS, where each task has a source (*xi*, *yi*) and destiny (*xf*, *yf*). The set of tasks representing the treatment for each request, as loading or unloading from each cart. Adopted that each request contains a set of tasks of unloading from one truck, in other words, transport pallets from the dock to the shelf, and for each request a set of 27 tasks (27 pallets).

Based on this conditions the Method ABC was applied and the AHP multi criteria tools to allocate 27 pallets into the warehouse, it is noteworthy for this initial test the warehouse shows all the positions available (Figure 2).



(a) (b)

Figure 2. Areas designated in warehouse for (a) ABC class and (b) level of the hierarchy

6. EVALUATION OF CRITERIA

Following the steps proposed by Saaty and analyzing the multi criteria tool to determinate which one technique of allocation must obtain the best results, we obtain the prioritization of the items that submit the greater participation scale

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in the question financial transaction, together with the allocation based on AHP multi criteria tool, presented 69.8% relative to the allocation based on the Curve ABC that presented 30.2%.

The application AHP have priority relative to the Method ABC, thus the AHP should present further optimization of positioning of finished products in warehouses during the simulations.

7. RESULTS AND SIMULATION

The result of the project was the implementation of a system for optimizing the positioning of finished goods stored in warehouses smart to reduce logistics costs and ensure optimal flow of materials, as well as streamline the service request

To validate the Proposed System, simulations were performed both techniques implemented (ABC and AHP) and random storage, in order to compare the running time and distance traveled in each category.

The simulations were based on loading and unloading tasks for a period of a day, comprising 20 to 1,620 tasks performed simulation tests for the random storage, based on the ABC method and AHP using the criterion.

The AHP allows to evaluate variables in a decision-making process generating the result that this research objective. This tool was adopted because enables the analysis of several criteria for classification, diverging the ABC Method. With respect to the number of items analyzed the ABC obtain a better performance, since it has no limit to generate the classification, in order to assign one hierarchy for lots of items with the AHP, we need to use families of products or classify the items according with the criteria established as high-priority by the AHP.

The programs were developed in C language, to validate the progress of the tasks assigned the Proposed System Optimization System developed interacts with the Supervisor of assigning tasks to the AGVs developed in LabRoM (Mobile Robotics Lab - EESC / USP) by Kelen C. T. Vivaldini. The tests were performed by means of computer simulations using six AGVs in an intelligent warehouse.

The tools used were programmed in C language and integrated with the System Supervisor assigning tasks to the AGVs, and the System Supervisor receives the tasks to be executed and passes them to the AGVs.

The request is received by the WMS, so the proposed system remakes the positions where the pallets will be loaded and unloaded. So, the proposed system invite to the Supervisor the requests, and then the Supervisor checks the service time for the request, the quantity of AVGs are necessary to execute the task and then make the attribution of the tasks for the AVGs. After the execution of each loading and unloading of one pallet, the AVG invite a message to the Supervisor, and the Proposed System (Figure 3) is updated, also updating the data of the WMS about the order fulfillment. So, after the order fulfillment is finalized the Proposed System has the data relative the cost (distances traveled) and service time.

It was used the simulated environment Player/Stage (Gerkey, 2003) to execute the order fulfillment by emulating the execution of the routes by the AGVs.

Test II was carried out 20 tests, and 540 for each type of task allocation random ABC and AHP, totaling 1,620 tasks. Each test run consisted with the execution of 27 tasks, 10 tests for loading, in other words remove the pallet from the shelf and take it to dock and 10 tests for truck unloading, or transporting pallets from the dock to the shelf.

As can see in the Table 1, for the activities of loading and unloading from truck, were obtained considerable reductions both in the distances traveled, as for the run time of the tasks. The tool that obtained further optimization related with the positioning based on the random allocation was the AHP.

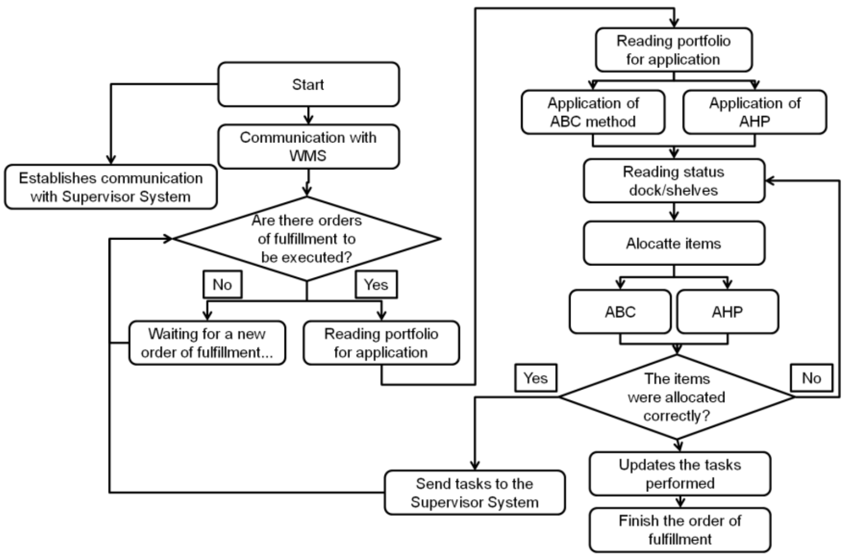

Figure 3. Proposed System

Table 1. Comparison among random, ABC and AHP allocations for cost (distance traveled) and time spent.

		Reduction (Random - ABC)	Reduction (Random - AHP)	Reduction (ABC - AHP)
Total distance traveled (m)	Unloading	8.42 %	12.81 %	4.39 %
	Loading	1.96 %	3.06 %	1.10 %
Total time of execution (ms)	Unloading	8.43 %	13.47 %	5.04 %
	Loading	0.18 %	4.42 %	4.24 %

The optimization can be seen in the Figures 4 - 7, where is shown the data of tests to loading and unloading tasks.

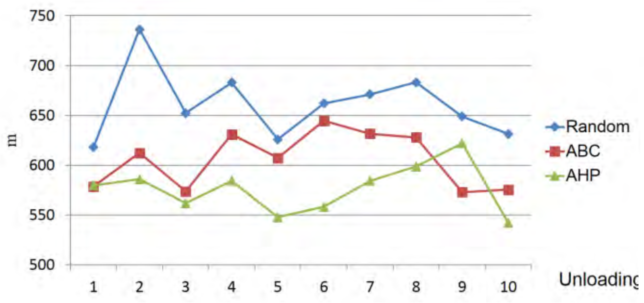

Figure 4. Comparison among random, ABC and AHP allocations for cost (distance traveled) and time spent.

Figure 5. Comparison among random, ABC and AHP allocations for cost (distance traveled) and time spent.

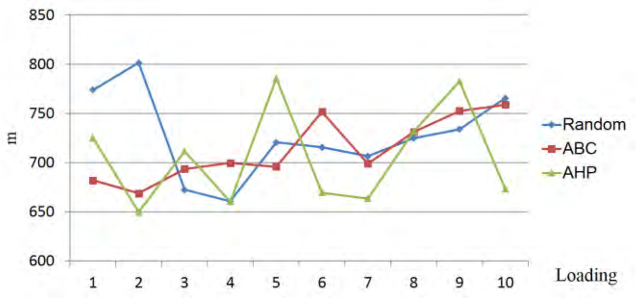

Figure 6. Comparison among random, ABC and AHP allocations for cost (distance traveled) and time spent.

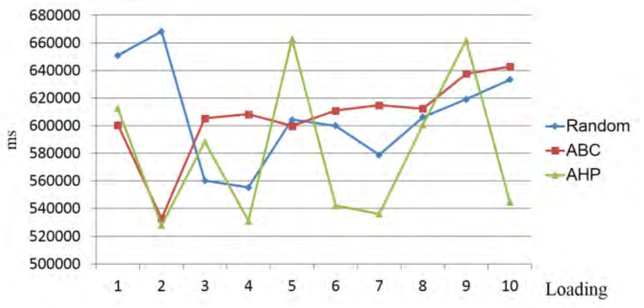

Figure 7. Comparison among random, ABC and AHP allocations for cost (distance traveled) and time spent.

As can be seen the reduction of distances occurs because the items are allocated according to their representation in the financial transactions of the company. Application of the Proposed System will result in a better flow in the warehouse, ensuring no unnecessary movements of cargo and material handling equipment.

This section presents the tests were performed by means of simulations in C language Both tests obtained optimization for placement of finished goods in warehouses intelligent, both for loading and for unloading, some tasks showed increased distance, but at the end of each test, and overall optimization was achieved.

The optimization for positioning was achieved, as through simulations yielded significant reductions in the execution time of the task and the distances traveled, so the costs of material handling equipment will be reduced, since through the System proposed activities will be performed with greater speed and efficiency. It is worth mentioning that the reduction in execution time of tasks may result in fewer labor or AGVs needed.

Thus, the aim of this paper was achieved, i.e., the proposal was feasible, applicable and secured an optimization of the positioning of finished goods in warehouses intelligent, since the proposed application of the ABC method and AHP reduced the distances and the service time of the application, but the application of AHP reached further optimization compared to ABC.

8. CONCLUSIONS

The contribution of this project in researches developing in the LabRoM (Mobile Robotic Laboratory) was to provide theoretical basis to application of optimization of positioning products in stock focusing the minimization of costs operating in storage environment using AGVs.

Present as a relevant factor the high cost of manpower involved in the activities of handling, therefore the optimization of this activity of handling provide relevant reductions in the operational costs. To determinate this reduction one solution presented is related about the activities of movement of the finished products into warehouses. With the reduction of times and distances traveled the enterprises can perform their activities with less need for human resources and with more agility.

The topic is of great relevance in the improvement of storage conditions, since it is an approach with low development and national dissemination. This research raised some theoretical aspects related to the management of storage, so as to propose a system to classify / categorize the company's portfolio. For this approach the Proposed System was based on techniques from the literature, is following analysis, we adopted the methods ABC and AHP.

In this study, we sought to show the main calculations performed for the AHP during the analysis, in order to provide a proper understanding of the technique. For the mathematical calculations used an algorithm integrated into the Proposed System. The AHP was used in two ways, being first applied in pure form, or to categorize the portfolio by the characteristic (criterion) prioritized and the second application consists in proposing an arrangement of positions for each hierarchy at layout. The curve ABC method was applied to the same ideal, namely, first to establish the products in each class and then propose an arrangement of areas designated for each class.

The steps of the project were: the classification of the finished products with greater representation in the financial transactions of the company according to the ABC method, the prioritization of certain items in relation to the other, with the application of AHP multi-criteria tool to select which feature prioritize such as financial transactions, demand and seasonality.

Finally, we performed a comparative analysis of classification of products, random allocation, based on ABC and AHP, where the Proposed System was tried and efficient computational tool has been validated. With analysis of the results is found to optimize the positioning of the products in the warehouse, since both the distances traveled, and the time to service request were reduced.

As future works we can mention the application of the Proposed System in a company as well as the integration of the same techniques to determine improvements in the layout according to the needs of an intelligent warehouse.

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