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Modeling and Analysis of Smart Warehousing through Simulation Study

Amal Viswam[1], Vineetha S. Das[2]
[1]*Student, Department of Mechanical Engineering, College of Engineering, Trivandrum, India*
[2]*Assistant Professor, Department of Mechanical Engineering, College of Engineering, Trivandrum, India*

***Abstract*: A warehouse is a commercial building which is a planned space for the efficient storage and handling of goods. Warehousing has become an important part of the supply chain of any business. With a rise in global business there is increasing pressure to modernize and improve the critical components of warehouse. This paper describes a model for automation of warehousing by using swarm robots. The warehouse management system and optimized robot control were implemented using Python3.6. Algorithm reduces the distance traveled by robot. The model brings reduction in retrieval time compared to manual labor retrieval system. Implementation of this automated pickup can cause the fast delivery of items. Cost benefit analysis conducted to check the feasibility of the proposed scheme and it proves its advantage in terms of performance.**

***Keywords*: Logistics, Python, Simulation, Smart warehousing, Swarm Robotics.**

1. Introduction

A warehouse is a space for storing materials associated with an industry. Goods stored include raw materials, finished goods, tools and other implements associated with production and packaging. In manual warehouses worker collect items from the pickup location and delivers it to the point of requirement. The system may not be completely manual. Depending upon the complexity and size of materials, various materials handling equipment may also be used.

A traditional warehouse includes specific areas for receiving storing, assembling, loading, unloading, and dispatching goods. The traditional warehouse layout has some disadvantages in terms of allocating the storage space available and the effectiveness of material handling. The major issues identified are over-handling, inefficient operations and workflow bottlenecks, negligence and damaged materials, inefficient space management, inefficient materials handling equipment etc. A warehouses serves to store goods to meet requirements for seasonal production, seasonal demand, large-scale production, quick supply, continuous production, and price stabilization.

Smart warehousing is a combination of inter connected technologies working towards a common goal, trying to optimize their operation at all its intermediate stages. This helps in overcoming the pit falls of the traditional system. The concept of warehousing is revitalized using emerging technologies such as cloud computing, Internet of things (IoT), robotic systems, RFID, ERP, and sensing system. These are suitably incorporated to promote a process of smart business operations. In recent years, many companies have been on the forefront of smart warehouses using robots. The internet connected robots have replaced human labor to move around the warehouse and pick customer-ordered items [1].

The demand for increased productivity and throughput to meet global competition is a challenge for both online and conventional retailers. The improved layouts, mobile material handling equipment etc. are employed in an effort to achieve competitive advantage [2]. But the number of warehouses mechanized is only about 5% and even these won't use robotic systems. The key functions are still handled by men and the automation is in terms of highly mechanized environment.

Coordinated work of a large number of simple robots interacting with each other as well as environment forms the base for swarm robotic system [3]. Large number of co-operating members can handle multiple tasks in a distributed environment saving time. Local interaction between members helps them to join or quit the activity at any instant without disturbing the system. The members adapt to changes in the task allocations without external intervention. Even when a part of the swarm quits, the system effectively works towards objective. In this due to the shortage of robots in the swarm the performance may get degraded. This feature makes the system suitable to work in dangerous environments.

The importance of warehousing lies in the fact that with the limited space available, an industry / firm should optimally allocate space for all its operations. Along with effective space utilization a good warehouse should minimize the material handling cost without affecting the quality of the product. A good warehouse should be flexible with regard to the placing of products, accessing the stored products should be easy and at the same time it should be as fast as possible. Swarm robotics is a budding area of research inspired from swarm intelligence and robotics. Though there is much research in to this area, remarkable advances are yet to be made. When swarm robotics is introduced to warehousing, we can change a traditional warehouse into smart warehouse and achieve a lot of advantages in terms of cost effective performance.

This paper proposes automation of warehouse using swarm

robots. The key features, infrastructural changes to be incorporated, algorithm for warehouse operation, comparison of the proposed warehouse with its conventional counterpart etc. are also dealt with.

2. Need for the new system

The availability of labor poses a big challenge for the logistics industry all over the world. There is a great gap in the demand and supply of top quality workforce that can be employed in logistics. Apart from this management of warehouse such as space utilization, retrieval time, storage design, efficiency of warehouse etc. causes various issues. Smart warehousing system can tackle these challenges very effectively.

Increased online opportunities along with need for effective logistics to fulfill the retail customers, the need for effective supply chain is on an increase. To have efficient and responsive supply chain changes should start from the warehouse itself. The warehouse automation can help in achieving these goals. The modification of warehouse using swarm robots can reduce the time of retrieval of the objects and optimize the navigation path within the warehouse thus enhancing the performance.

3. Methodology

The proposed system is an attempt to overcome the pitfalls of traditional warehousing system by automating it using swarm robots. Typical problems of the existing warehousing system include issues relating to space and retrieval time allocation, power consumption, efficiency and accuracy. To design new system using swarm robots the data pertaining to the warehouse is required. Simulation study also require data pertaining to the operation of warehouse. As the concept of using swarm robotic system in warehouses is in the budding stage, no library data of the same is available. Hence to effect the simulation fictitious data set as in Table 1 is created. Proving the effectiveness of the proposed system is possible only by comparing it with the prevailing system. Additional data required for the purpose is speed of workers. This is obtained by conducting suitable measurements at M/s Slovak Technologies, the firm where case study is conducted. The data is presented in Table 2.

Based on the data set created flowchart of the proposed

Table 1
Sample data set

S. No.	Product Code	Location X	Location Y	Item Name	Stock Level	Delivery Point
1	ABCXYZ	1	1	XYZ tab Pro 10.5	2	3
2	ABCXXZ	1	2	XYZ tab Pro 12.9 (2015)	1	3
3	ABCXWZ	2	1	XYZ tab Pro 12.9 (2017)	5	1
4	ABCXVZ	3	1	XYZ tab Pro 9.7	8	3
5	ABCXUZ	3	2	XYZ tab Wi-Fi	5	2
6	ABCXTZ	4	1	XYZ tab Wi-Fi + 3G	6	2
7	ABCXSZ	4	2	XYZ iPhone	8	3
8	ABCXRZ	4	3	XYZ cell3G	10	3
9	ABCXQZ	5	1	XYZ cell3GS	6	2
10	ABCXPZ	5	2	XYZ cell4	3	2

Table 2
Speed of human worker inside warehouse

Trial No.	Distance covered (m)	Time (seconds)						Speed	
		t1	t2	t3	t4	t5	Mean	m/s	kmph
1	155.31	86	87	87.1	86.1	86.6	86.56	1.794	6.459
2	58.00	120	13	13	12	12	34	1.706	6.141
3	73.43	140	14	15	13	14	39.2	1.873	6.743
4	98.92	170	22	21	21.5	23	51.5	1.921	6.915
5	199.96	112	111	111	112	111	111.4	1.796	6.464
6	272.99	150	151	150	151	150	150.2	1.817	6.542
7	271.44	143	144	141	144	143	143	1.899	6.835
8	186.24	99	99	98.9	98.3	98.8	98.8	1.885	6.786
9	202.66	121	122	122	122	121	121.6	1.667	6.001
10	156.14	80	83	84	85	82	82.8	1.886	6.789
11	175.24	100	99	99.8	101	100	99.94	1.753	6.312
12	123.44	69	70	71	69.6	69.3	69.78	1.769	6.368
13	175.94	98	98	98.3	98.9	99	98.44	1.787	6.434
14	219.08	130	131	131	130	129	130.2	1.682	6.057
15	175.94	95	96.3	96.6	95.5	96	95.88	1.835	6.606
Average speed									**6.497**

algorithm for managing the activities of the warehouse is shown in figure 1. The activities starts with the receipt of order. Once a request for an item is received the availability of the item is checked and if it is available its location is identified. Then the algorithm identifies the robot in swarm to pick and deliver the item optimizing the performance measures and assigns the job to it. The robot then moves to the product location picks the product and delivers to the required point.

The flowchart of the proposed algorithm for the control of the robot is given in figure 1. Once an assignment is made, the respective robot is triggered and then it checks its adequacy to be selected for the task. If the robot thus identified is operational it goes to the product location, picks the item and delivers it to the point of need. Once the action is complete the robot is void of any activity and updates its location and waits for the next assignment. When an identified robot as per consideration is not operational, another robot with the next best payoff is selected and the first one is assigned for maintenance work.

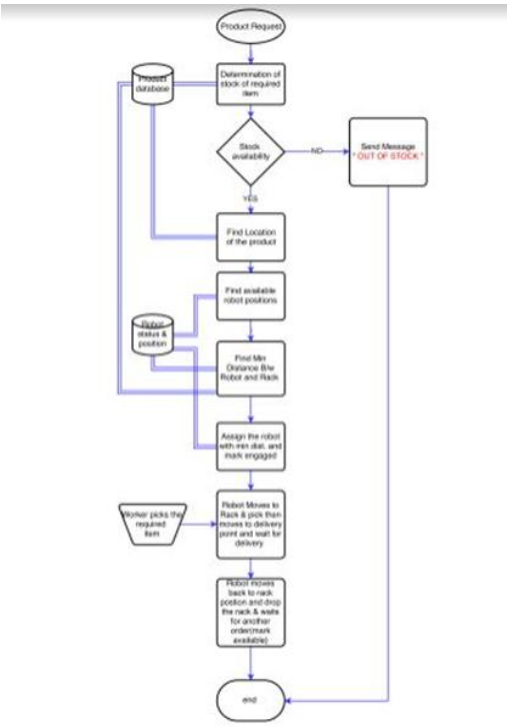

Fig. 1. Flowchart1

Performance analysis of new system is assessed by analyzing the system currently in use at M/s Slovak Technologies, Kollam, engaged in the production and distribution of car shampoo and body wash. The changes needed to make the system for automation is considered and the effect of automation is assessed through simulation.

Currently M/s Slovak Technologies uses a purely manual warehousing system. Once an order is received a worker is assigned the job. He identifies the packet, prepare it for packaging and the properly packaged product is supplied to the point of delivery. The finished product is stacked un-scientifically in a raised platform of the warehouse in boxes. The workers engaged in production activities itself are engaged for warehousing activities also.

To compare the proposed system with the available system the main parameter required is the time an average worker will take in identifying and supplying the product to the dispatch location once an order is received. This time includes the time elapsed in searching for a particular box. 15 hypothetical situations are identified and the time taken by each of five workers engaged in the activity is measured. From this average speed of a manual labor is calculated as 6.497 Kmph. The industrial robots can move inside warehouse in speed up to 15kmph and usually operates at a speed of 10kmph. The time for search and identification is negligible in case of robot. The increased speed at which the robots can be made to move and the extra searching time required by the human workforce gives the proposed system an advantage with regard to performance.

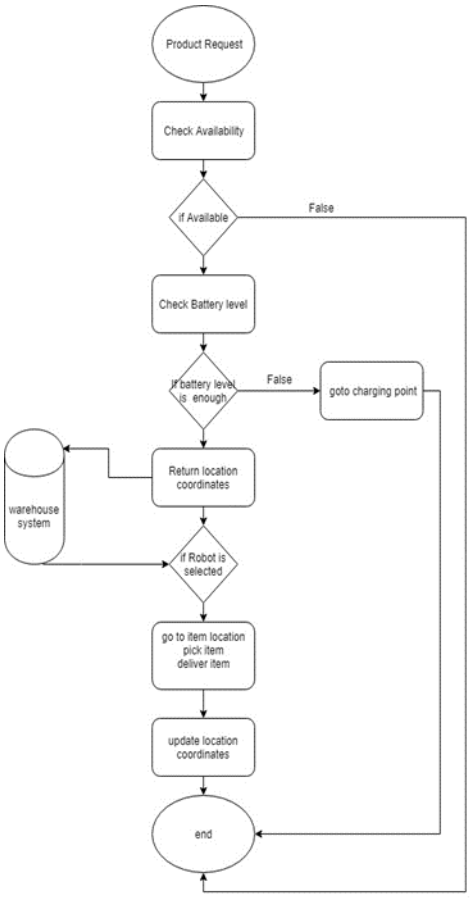

Fig. 2. Flowchart 2

Before incorporating any change or starting a new project the worth of the action is to be considered. Cost-benefit analysis helps to evaluate all the potential costs and revenues a company may generate on implementing the change. The outcome of the analysis will determine whether the project is financially feasible or not. In the case of M/s Slovak Technologies, the present warehousing system should be revamped before they

could employ the swarm robotic system. This requires a considerable expenditure as the initial cost of the system and for the functional changes that are to be brought about in the warehouse. On the benefits side, the adoption of the new system can save manual labor and increase the supply chain efficiency and responsiveness. This intern will bring intangible benefits in the form of customer satisfaction and goodwill. For the analysis purpose the data regarding employee wages are collected from M/s Slovak Technologies. The main cost associated with Warehouse automation is the cost of installation of robots and its maintenance cost. The cost associated with warehouse modification is also to be considered. Maintenance cost and layout modification cost are arrived at consultation with experts.

The analysis shows that the cumulative cost of implementing the new system is far more than proceeding with current system for the first five years. Just after the beginning of the 6th year the change brings positive effect as the cumulative cost of the existing system exceeds the cumulative cost of the new system. The plot of cumulative cost Vs time (in year) is plotted (figure 3) also reveals this fact.

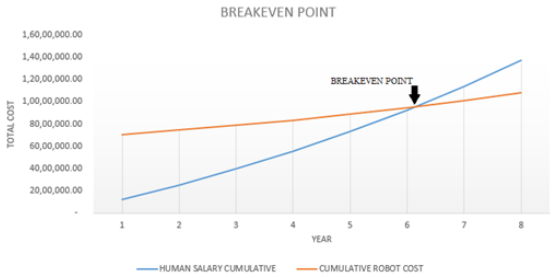

Fig. 3. Graph obtained after cost benefit analysis shows the breakeven point

4. Results and discussion

A model for automation of warehousing with its simulation is developed using Python 3.6 with the help of Spyder. The model helps in improving the space utilization, reducing retrieval time and power consumption, thus improving the overall efficiency of the system. It consists of a number of robots collaborating with one another for the accomplishment of a preset goal. For simplicity the number of robots for the simulation study is taken as four as they are sufficient for the current warehouse layout. All four robots are similar in geometry and operation. The aim of the simulation was to allocate robots to the requirement centers to accomplish the task such that the total distance traveled will be minimum. The results of the simulation are tabulated in Table 3.

The tabulation includes the time required by the human worker to complete the same set of jobs also. The results shows that the robotic system can accomplish the work much better faster than their human counterparts. The distance covered is a function of the position of the item and the selected robot. So items with same product code when retrieved by the same or different robots, the distance traversed may be different. The optimization happens before assigning a particular robot for the job only the robot which has to travel the minimum distance is assigned the job and the contrary happens only when that particular entity is out of order.

Table 3
Simulation Results

Sl No.	Product Code	Robot Engaged	Distance Covered	Time Taken by robot	Time taken by human worker
1	G	Robot1	28	10.07	15.51
2	S	Robot1	26	9.35	14.40
3	P	Robot2	25	8.99	13.85
4	B	Robot1	28	10.07	15.51
5	N	Robot1	27	9.71	14.95
6	W	Robot1	23	8.27	12.74
7	T	Robot1	32	11.51	17.72
8	F	Robot1	28	10.07	15.51
9	V	Robot2	21	7.55	11.63

5. Conclusion

This paper introduces smart warehouse using swarm robots. Algorithms were developed for warehouse management and operation of swarm robots. With the parameters identified from M/s Slovak Technologies dataset for implementing simulation is created and the simulation study proved the effectiveness of the proposed scheme. The case study conducted at M/s Slovak Technologies also provided significant insights into the implementation of proposed scheme.

From the study it can be concluded that:

- Smart warehouse with swarm robots considerably reduces the operation time.
- It is an effective way for improving the performance of logistic systems.
- The implementation calls for infrastructural changes which are very costly and takes years for getting a visible positive result.

The present study is based some assumptions regarding the warehouse operation which are far from the actuals. To overcome this, associated hardware programming for robot along with intelligent warehousing algorithm may be attempted. 3-D simulation may be used for more reliability. Costs which were not considered in the present study may be considered and the benefits of the system may be identified in a more realistic framework.

References

[1] Kamali, D. A.," Smart warehouse vs. traditional warehouse-review", *CiiT International Journal of Automation and Autonomous System* 11(1), 9–16, 2019.

[2] Rauf, H., "Trends in china's e-commerce market. Technical report", *China Briefing-Business Intelligence from Dezan Shira & Associates*, 2014.

[3] Tan, Y., "Advances in Swarm Intelligence", *Springer International Publishing*, 2014.

[4] Tan, Y., "Handbook of Research on Design, Control, and Modelling of Swarm Robotics (1st ed.)", *Hershey, PA, USA: IGI Global*, 2015.

[5] M. Dorigo, E. S., "Swarm robotics - special issue". *Autonomous Robots* 17, 111–113, 2004.

[6] Wu, S., "Forrester research online retail forecast, 2015 to 2020 (us). Technical report", *E-business & Channel Strategy Professionals*, 2015.