Conference Article

The Use of Collaborative Robots as an Internal Logistics Solution and the Effect of These Robots on Increased Operational Efficiency

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Abstract

It is noteworthy that operational transactions demonstrated a corresponding increase with the burgeoning e-commerce activity during the COVID19 pandemic period. The unanticipated nature of the pandemic event has revealed the limitations of many companies in coping with the surging online demands. These limitations manifest as delays in order fulfillment, inaccuracies and discrepancies in delivered orders, resulting in substantial reductions in both customer and personnel satisfaction, internal disruptions within the organizations, and an inadequacy in the workforce. To mitigate these challenges, several companies have embarked on the utilization of Collaborative Robots.

The present study aims to set out the specific parameters and the extent to which operational efficiency within the organization is enhanced through the adoption of Collaborative Robots.

1. Introduction

During the sudden onset of the pandemic period, many firms engaged in e-commerce encountered a variety of problems in order to meet the increasing demand. The common denominator among these problems was internal logistics issues. The problems encountered in the process of collecting online orders from warehouses and preparing them for shipment included: (a) delays in order picking, (b) incorrect, excessive, and missing product picking, (c) the necessity of assigning personnel for each order, (d) inadequacy of the current personnel count relative to the increasing number of orders, (e) personnel dissatisfaction due to the need for more labor-intensive work, (f) the negative impact of personnel dissatisfaction on productivity, and (g) decreases in customer satisfaction due to incorrect, excessive, and missing product deliveries.

To cope with these challenges, some firms started using Collaborative Robots that have the potential to increase efficiency and resolve internal logistics issues. This study examines and shares results on how firms utilizing Collaborative Robots have overcome these problems and the areas in which they have increased efficiency.

2. Materials and Method

Materials and methods related to the system used by companies during the pandemic period and aimed at overcoming the problems that emerged are outlined below.

2.1. Collaborative Mobile Robot

Collaborative Robots, which have been adopted by retail and logistics companies, were developed to each hold 3 baskets, allowing for the simultaneous picking of up to 3 orders. In cases where the total volume of products in any online order does not fit into one basket, the Collaborative Robot can allocate 2 or 3 baskets for that order.

Thanks to these Collaborative Robots that can carry the assigned personnel on them, the need for the personnel to walk throughout the day for order picking is eliminated.

Figure 1: An Illustration of Collaborative Robot

2.2. Indoor Localization System

In areas where Collaborative Robots are used, it is crucial for the System Software to have real-time knowledge of the exact position of each robot. Therefore, the Location Tracking System working on the robots instantaneously determines the robot's indoor location and communicates it to the Server Software. This system, developed using Ultra Wide Band (UWB) technology, has a positioning accuracy margin of ±10cm.

2.3. Autonomous Navigation

Each Collaborative Robot has the capability to complete the designated route within the warehouse without any human intervention. This is made possible by loading the digital map of the warehouse into the Collaborative Robot and allowing each robot to determine its own real-time location. As a result, each robot can complete its assigned route, including pick locations.
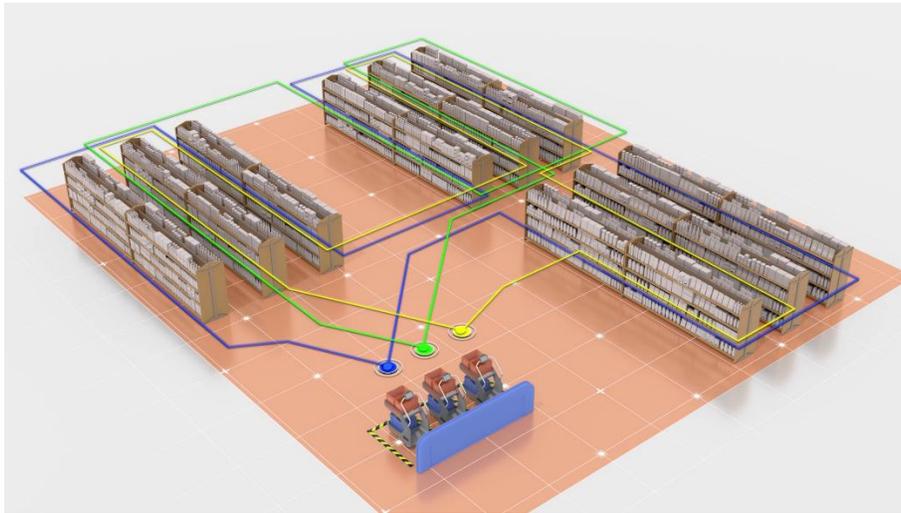
Figure 2: Collaborative Robots path planning and traffic management

Figure 3: Collaborative robots navigating autonomously through aisles and turns

2.4. Artificial Intelligence (AI)

Artificial Intelligence technology has been employed on the robots to determine whether the products picked from the shelves during online order fulfillment are the correct items. A combination of Deep Learning (DL), Machine Learning (ML), and Image Processing (IP) techniques, along with storing actual product images in the System Software's database, enables the system to identify the nature of the product placed into or removed from the basket.
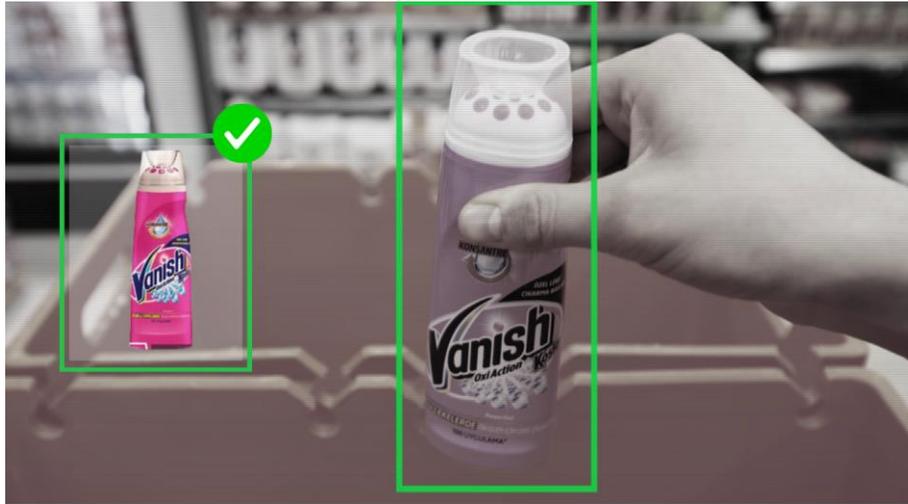
Figure 4: Product recognition and verification using Artificial Intelligence

2.5. P2L (Pick-To-Light) System

To expedite the process of picking products from the shelves for online orders, a Pick-To-Light (P2L) system, different from the existing systems, has been implemented. In this system, as a collector approaches the shelf module where a product is located and travels on the Collaborative Robot, an LED array just below the product is illuminated and flashed to make it visible to the collector. Unlike similar products in the market, this system aims to accommodate items of all sizes with software-defined bins. The picking personnel can configure each item's bin size therefore the LED array only lights up that specific portion in order to prevent picking the wrong item. This way, the collector can easily see where the next product is located within the relevant aisle, on which shelf module, and on which shelf. This system also eliminates the time wasted searching for the product in the aisle, improving efficiency for the picking personnel.

Figure 5: Pick-To-Light (P2L) System illustration

Figure 6: Pick-To-Light (P2L) live system working stage

2.6. System Management Software

A cloud-based central software has been developed and utilized to control the entire system in a warehouse, manage the Collaborative Robots, monitor the system in real-time, facilitate communication with the company's online Order Management Software, perform various analysis tasks, and generate reports.

2.7. Performance Analysis

Performance measurement of the system has been accomplished by using reports generated by the System Software, along with information obtained from 12 store managers responsible for 12 different stores and a total of 52 picker personnel working in these stores. The performance evaluation has been completed, and results have been obtained for this study based on the collected information.

3. Results

Within the scope of this study, the efficiency improvements brought about by the use of Collaborative Robots during the collection of online orders from warehouses on a store-by-store basis have been determined. Information obtained regarding this system, which results in cost reduction, increased speed, accuracy, and efficiency, as well as improved customer and personnel satisfaction, is summarized in the table below.

Table 1: Results before and after use of Collaborative Robots

Store #	Daily Distance Traveled by Picker Personnel to Pick Items (mt.)		Average Picking Timei (sn.)		Unit Per Hour (UPH)		Correct Picking Rate of Items (%)		Time Spent to Find an Item (sec.)		Employee Satisfaction (%)	
	Before CoBot	After CoBot	Before CoBot	After CoBot	Before CoBot	After CoBot	Before CoBot	After CoBot	Before CoBot	After CoBot	Before CoBot	After CoBot
1	8.000	460	745	173	66	313	84	99,5	16	0	38	78
2	11.000	610	925	213	68	382	90	99,1	19	0	57	83
3	7.500	630	740	177	63	345	93	99,8	18	0	49	92
4	9.000	510	1015	270	69	349	88	99,8	17	0	55	88
5	11.500	620	1100	245	64	362	91	99,5	20	0	42	86
6	7.250	510	675	226	59	328	91	99,5	16	0	39	79
7	9.000	590	845	169	65	371	89	99,5	17	0	38	81
8	9.000	810	775	182	58	368	84	99,5	19	0	51	84
9	6.500	710	730	178	69	369	92	99,5	15	0	63	89
10	7.500	640	715	235	66	352	88	99,5	17	0	42	86
11	10.750	1450	945	244	59	383	87	99,2	21	0	46	85
12	9.500	730	790	195	67	297	88	99,5	18	0	49	91
Average:	8.875	689	833	209	64	352	89	99,5	18	0	47	85

The values specified for each store in Table 1 have been collected for four months after the introduction of Collaborative Robots in the respective stores. This approach allows for the measurement of efficiency changes that occurred within the same time frame for each store, resulting in comparable values.

The parameters mentioned in Table 1 demonstrate the store's performance, and these indicators are additionally evaluated by the company headquarters. Therefore, the information obtained on a store-by-store basis, along with the total efficiency measurements for each store, can be carried out in real-time.

4. Discussion

This study explains the contribution of Collaborative Robots to the workforce and operational efficiency. Particularly, the efficiency improvements at the enterprise level have been achieved during the pandemic period with the rapid increase in online orders from warehouses and accurate, fast, and cost-effective order picking processes.

After examining the contribution of Collaborative Robots to the workforce and operational efficiency in picking products from the shelves, the next step will be to measure the efficiency they will provide in put-away operations (replenishment) – loading the products onto the shelves to be picked later on.

5. Thanks