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ANALYSIS OF AUTONOMOUS MOBILE ROBOTS IN WAREHOUSING USING A DIGITAL TWIN SIMULATION

Michael Sellen

CreateASoft, Inc
3909 75th St, Ste 103 - 105
Aurora, IL 60504, USA

ABSTRACT

Post pandemic labor shortages and the continued acceleration of e-commerce growth have presented a challenge for fulfillment centers to manage growing SKU counts and increased demand volatility while continuing to satisfy customer delivery expectations and maintain control over costs. Many fulfillment centers are turning to automated solutions such as Autonomous Mobile Robots (AMRs) in an effort to increase throughput and efficiency from existing facilities. AMRs move throughout the warehouse environment guidance-free and can be deployed bringing goods to person, bulk material movement such as truck unloading and can work collaboratively with employees for picking applications where the AMR will travel to pick locations and an employee will place the inventory on the robot to complete the pick operation before continuing to the next inventory location. For warehouse operations management teams and AMR solution providers, identifying the optimum fleet size and deployment logic for current and projected demand is a crucial step in a successful adoption of this technology. Data-Driven modelling and simulation can be a useful asset when evaluating different solutions and requirements before installation as well as identifying opportunities for increased efficiency or expansion in existing operations.

1 INTRODUCTION

The AMR fleet study was performed on a large direct-to-customer apparel warehouse with a variety of SKUs, assigned storage locations and daily demand profiles. AMRs were released into the operation based on daily demand and ranged in number from 150 to 400. In addition, a picking support crew was deployed to load order to the robots, with each robot carrying between 2 and 8 orders.

Outbound orders utilized multiple induction point for the AMRs. The control system would assign orders to each robot and send it through the aisles for picking. Upon arrival at the pick location, an associate would pick the inventory and place it on the robot based on the order requirement and number of items to pick. In the case where an item exists in multiple orders on the robot, all items were picked during the same stop. After all of the assigned items are picked, the robot load is sent to a sortation area for final packaging and shipping.

For inbound inventory, the AMRs would be loaded with boxes from the inbound / receiving area. Transporting single SKUs at a time, the robots would deliver the inventory to a location where an associate would handle the inventory placement. The AMR would then return to the inbound area to deliver the empty boxes for processing before being assigned their next inbound mission.

There were a number of goals targeted for the simulation analysis:

1. Identify the optimum number of robots needed for inbound and outbound operations
2. Identify the number of associates needed and their allocation
3. Optimize the order assignment to the robots based on path, congestion, and order content.

The digital twin model was developed using Simcad Process Simulator and included;

- Facility layout (CAD) and model scaled to match distances
- All physical locations that the AMR could access including pick locations, sortation lanes, induction positions, charging stations and inbound receiving areas
- Travel path information including speed and capacity
- Operational KPIs including active robot count, Units Per Hour (UPH) system wide, per AMR and per associate, mission lead times and robot wait for associate for each pick
- Operational information from the WMS and AMR Management Software including SKU, pick location, pick date / time

The model was run into 2 different modes, the first was used for validation purposes to make sure it has all the AMR and operational logic required. The second mode was used for model optimization of future order requirements.

The validation model was designed load the current order sequence and run it through the digital twin in order to validate all the rules in place and movement of the AMRs. Constraints such as charging/discharging rates, travel speeds, associates' shifts and others were included in the model validation process. The final model represented a behavior that is 98.85% as accurate as the live system, using multiple days and data sets. The same model was then used to generate the optimized states based on demand, congestion, order releases, and order grouping. Integrated heat maps, spaghetti diagrams and congestion analysis were used in the optimization fine tuning.

In the optimization state, the model was run prior to the start of the shift in order to identify the number of robots needed, associates to be allocated, and the optimized order release sequence. The initial implementation was run manually, then transitioned to direct WMS connectivity to retrieve the data sets directly. Upon the simulation start, the model would retrieve the data and perform the required optimization analysis.

The digital twin model has proven to be a valuable tool for the day-to-day operation of the warehouse and enable managers to better schedule the order releases and robot assignment. The optimization generated all the moves required for the robots and generated a 4.6% efficiency improvement on average. The efficiency improvement resulted in $545k per year savings over current traditional implementation.

REFERENCES

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