AI System for Warehouse Automation

Introduction

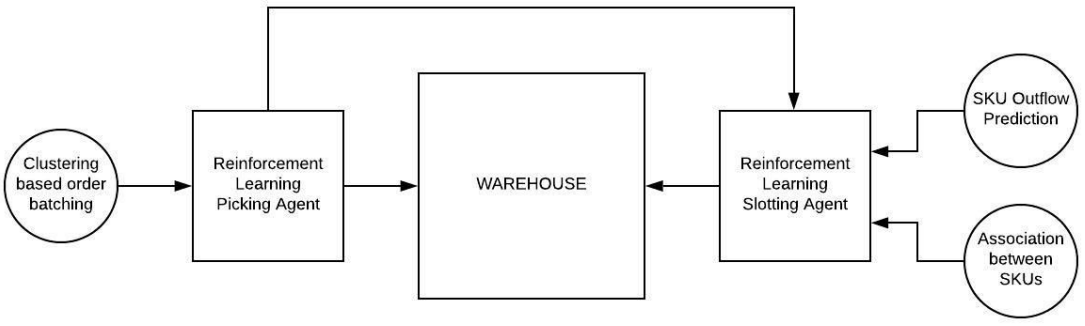
With the breakout of a plethora of innovations in Robotics, AI and Automation, many modern-day industries are moving towards a state where most of the involved activities no longer require laborious human effort. Most tasks, especially the ones that can benefit from the efficient and perpetual nature of Robotic Operations, are now being automated. One such industry is the warehousing and logistics industry. Logistics giant Vanderlande, being a prominent part of this industry had tasked us with developing a system that leverages AI to automate certain critical decision-making tasks in a warehouse in an efficient and data-driven manner.

The problem that our system solves

Every warehouse is characterized by two main activities that account for the majority of resource consumption - Picking and Slotting. Picking is the activity of gathering Stock Keeping Units (SKUs) from all over the warehouse to satisfy orders that have been received. To adopt the use of Robots, an intelligent guidance and decision system is needed that can produce near-optimal execution of picking tasks. Developing this system was the first part of the problem. The second part, Slotting, is the process of placing and arranging incoming goods into various locations of the warehouse. Since this placement will directly affect the picking and space efficiency of the warehouse, it is necessary to execute this task in a manner that reduces the cost of related activities. Thus, the challenge in front of us was to develop an AI system that could not just automate, but ensure highly efficient execution of these tasks.

Our AI-based intelligent system

The two tasks mentioned above are handled by two Reinforcement Learning Agents that together form the core of our system architecture. Reinforcement Learning is a category of Machine Learning techniques that act in an environment, and their actions are guided by reward policies that ensure the optimality of those actions. These two reinforcement learning agents have multiple support modules, described later, that help the AI agents in taking decisions regarding and executing their respective tasks.



Picking RL Agent -

The Picking Reinforcement Learning Agent uses simulations to derive an optimal policy that guides the agent to its target in the shortest possible time. The Agent is given a reward for reaching its target thus incentivizing this desire. On the other hand, the Agent is given a penalty (negative reward) for each unit of motion it makes, thus discouraging the agent from making inefficient decisions with regards to its movement. After considerable simulations, the Agent has learned to always follow the optimal path.

Support modules for picking -

1. **Clustering-based order batching** :
   Orders that are to be satisfied undergo Clustering based on the locations in the warehouse that the orders will require visiting. This way, each order within a cluster will consist of SKUs that are located in the nearby regions of the warehouse. This ensures that robots assigned with multiple orders won't have to roam about the warehouse, and their areas of operation will be concentrated in a specific region.

Slotting RL Agent -

Slotting should occur in a manner that reduces picking times and efficiently utilizes the space in the warehouse. These are the exact two goals used for rewarding and penalizing this Agent. The decision of placing an SKU in a given location is made on the basis of two parameters - ease of access for that location and the space utilization if the current assigned SKU is placed in that location. Thus, this becomes a two-way optimization problem. Traditional approaches fail to correctly approximate a function that can guarantee a space-wise and access-wise optimal placement. This is where Reinforcement Learning comes in and via simulations, it is able to derive a policy that can guide the placement decision making. The rewards and penalties can be fine-tuned to make the policy deriving highly adaptable for special situations like warehouses with critical space requirements or warehouses with inconvenient access locations.

Support modules for slotting -

1. **Deep Learning-based SKU outflow prediction:**
   Since slotting directly affects picking, the placement should be such that it reduces the time penalty of accessing SKUs. Thus this module provides SKU outflow predictions for specified time durations. Then the Slotting Agent uses this data to place the most frequently accessed SKUs in the most accessible locations, as deduced by the Picking Agent. We have used a CNN-LSTM architecture for this time series forecasting task.

2. **Apriori algorithm based association rules:**
   This module analyses the historical order data of the warehouse and generates association rules between different SKUs. The output of this module clearly indicates SKUs that are frequently present together in orders. The Slotting Agent leverages these insights to place associated items in the proximity of each other.