Warehouse Digital Twin System with ML-Agent

Contents

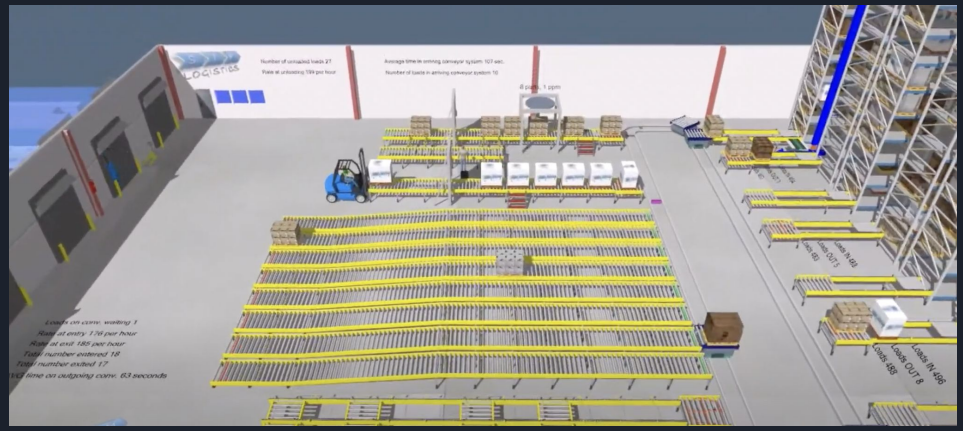
- Project Abstract
- Warehouse Simulation Cases
- Implementation with Reinforcement Learning
- Project schedule

Project Abstract (1)

- Maximize the efficiency of internal movement in logistics warehouses and distribution centers by operating simulations using ML-Agent

- Simulations would help the warehouse robot to organize where to place the most frequent items that go out, and where to place items that are fragile or vulnerable to external threats.

- Helps real time and high fidelity of physical twin to reflect the warehouse environment.



https://www.youtube.com/watch?v=Y7StDCjJ298, Sim Logistics - Short Film Warehouse Simulation

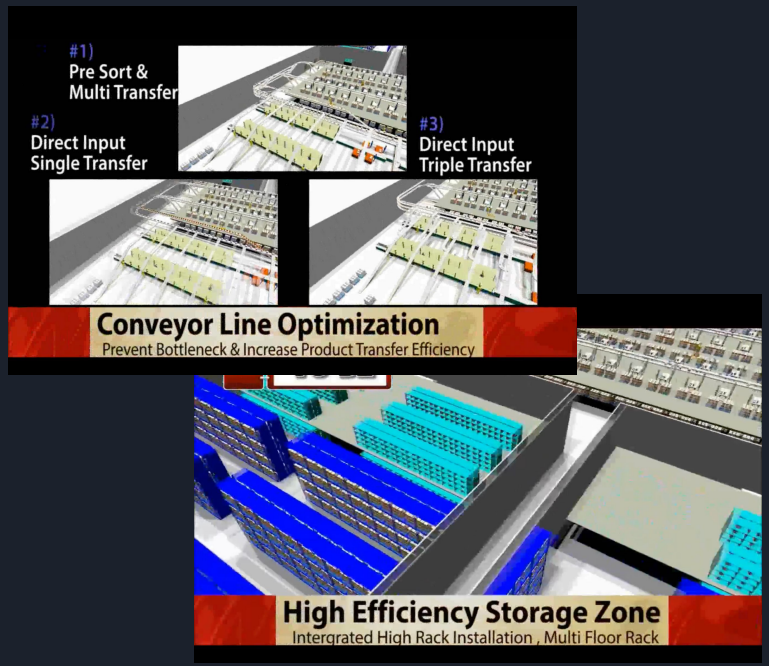
Project Abstract (2)

Positive effects expected from the Digital Twin System

- Bottleneck Prevention

  (Bottleneck : Delay of the warehousing due to the increasing job request from specific location
- Increasing the Efficiency of Inventory Allocation
- Minimize Work Flows
- Facility Efficiency Optimization
- Tracking the Cause of Product Damage or Robot Agent Failure
- Monitoring Equipments or Inventory Status

Warehouse Simulation Cases (1)
(CJ Logistics)

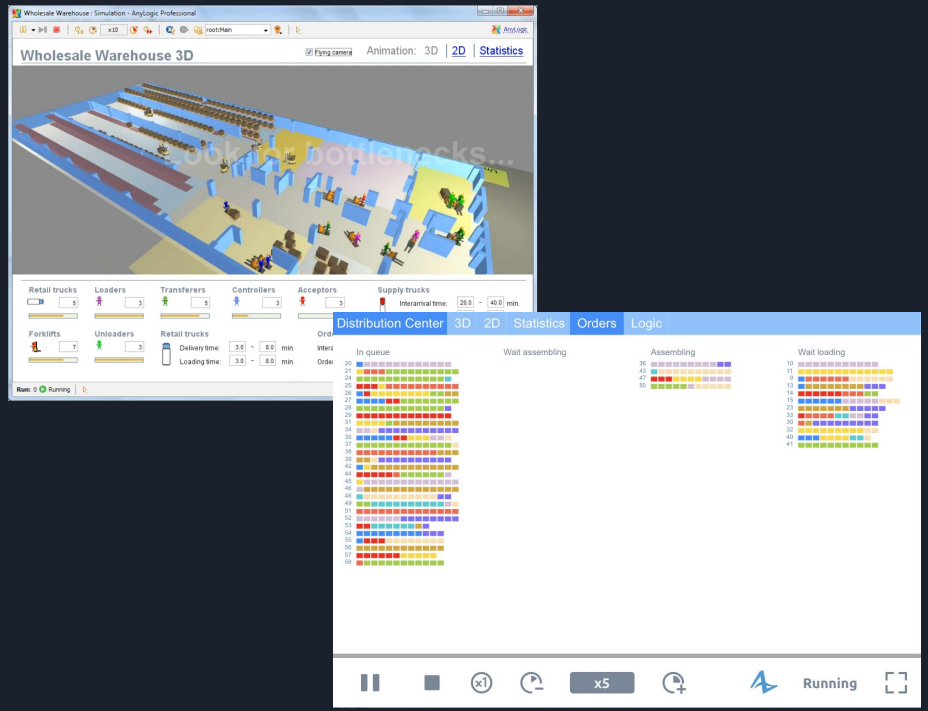


- CJ has increased the efficiency of its work through 'logistics center simulation' by the TES Engineering.
- CJ developed some following technologies as below.

1. Consulting on the design and stabilization of new distribution centers.
2. Logistics infrastructure/facility improvement and automation infrastructure and layout optimization design.
3. Development/Application of Operation Optimization Algorithm Technology through Facility Logic and Data Characteristics Analysis.
4. Solutions for predicting/verifying simulations of appropriate equipment/human resources such as sorting, storage, picking, packing, etc…

https://www.cjlogistics.com/ko/tes/story/engineering

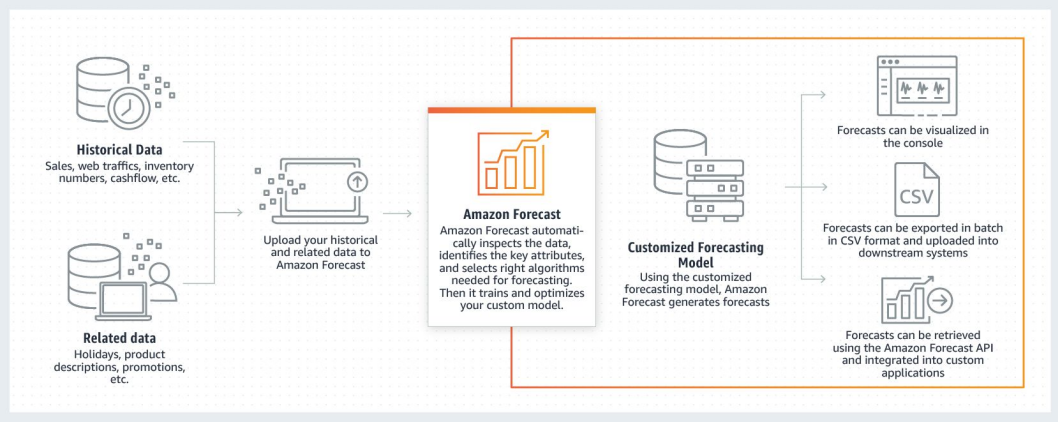
Warehouse Simulation Cases (2)
(The Anylogic Company)



- Anylogic Company have been developing the warehouse simulations programs.
- The program manages 2D/3D simulation, delivery statistics and orders.
- Users can check the conditions of what they manage.

[Anylogic company],https://www.anylogic.kr/warehouse-operations/

Warehouse Simulation Cases (3)
(Amazon Forecast)



- The prediction system used by Amazon is being sold by AWS under the name of Amazon Postcast.
- Input data such as sales data during a specific period, weather, and discount events that have been held, we can receive demand forecast results through API.

https://aws.amazon.com/forecast/

Implementation with Reinforcement Learning (1)

Why Reinforcement Learning?

- Setting up the policy and value for the ML-Agent is based on training (simulation)
- Routing problem in physical layer with RL has already done in several research
    - Mobile Robot Path Optimization
- Not much implementation with warehouse DT system based on ML-Agent
- Easy to train ML-Agent with DQN and easy to simulate on Unity environment
- ML-Agent from Unity is easy to trained by Tensorflow or PyTorch

Implementation with Reinforcement Learning (2)

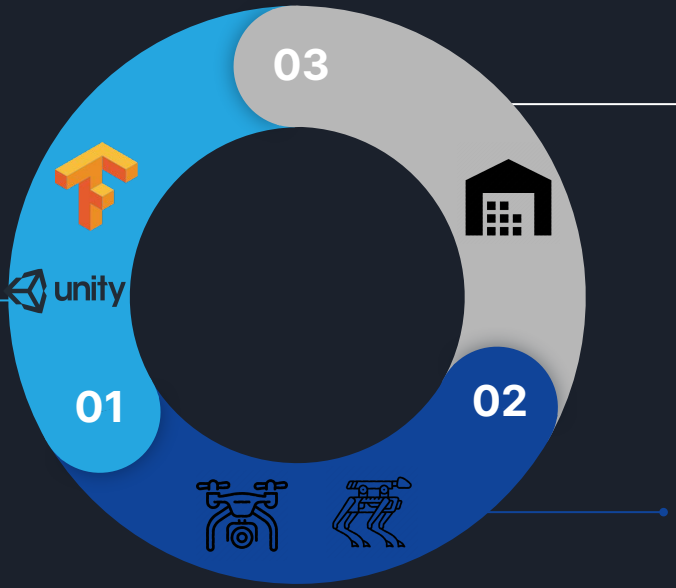
The Big Picture

Digital Twin ML-Agents

New state for ML-Agents and choose the next action based on simulation.

Unity ML-Agents will send the next action to the physical agents based on the policies.

ML-Agents initially trained by Tensorflow RL.



Warehouse Environment Status

Interact with Unity digital twin system to reflect the physical asset.
(Agent location, Agent status, Packages status etc...)

Physical Agents

Load, Clean up, and Move the packages based on the ML-Agent action.

The location and status of physical agent should be considered in a real-time.

Implementation with Reinforcement Learning (3)

1. **Setting up warehouse environment Digital Twin with Unity modeling**
    a. Implement the physical asset
    b. Setting up the goals of ML-Agent for the training
2. **Train the ML-Agent**
    a. Find the appropriate policies for ML-Agent
    b. Understanding the surrounding environment while training
    c. Path optimization during the training
    d. Dynamic-Q or Q-Learning
3. **Test on the real scenario and hyper-parameter tuning**
    a. Test on the unity warehouse environment
    b. Test hyper-parameter values and reward values
4. **ML-Ops (tentative)**
    a. Connection between real physical asset and digital twin system
    b. Auto training and policies revision during the system life cycle

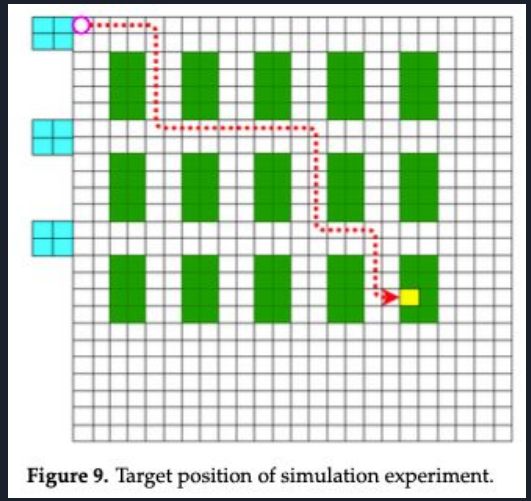


Figure 9. Target position of simulation experiment.

Lee, HyeokSoo & Jeong, Jongpil. (2021). Mobile Robot Path Optimization Technique Based on Reinforcement Learning Algorithm in Warehouse Environment. Applied Sciences. 11. 1209. 10.3390/app11031209.

Project schedule

[Mar 21 ~ Mar 27] More idea development and more case studies

[Mar 28~ April 4] Prototype demonstration with Grid/Sokoban world

[April 5 ~ May 25] Main project development

[May 26 - May 30] Final report and revision

[June ~] Capstone project exhibition

Thank you!

More in April...