Discrete Event Simulation of a Multi Robot Pick and Place System for Reinforcement Learning Research

Xi Lan, Dr.Brian Lee, Dr.Yuansong Qiao

Software Research Institute (SRI), Technological University of the Shannon(TUS)

Introduction

This poster described a implementation of simulation environment for a Pick and Place conveyer belt for multi robot system based on the Gym library to be used to train Reinforcement Learning agents - see figure below. Our goal is to build this simulation as close as real world conveyer with robots working system. The factors included inside simulation are robot arm speed, conveyor speed, the probability of part distribution, conveyer length , conveyor width, 5 scheduling disciplines for pick and place and robots workspace size.

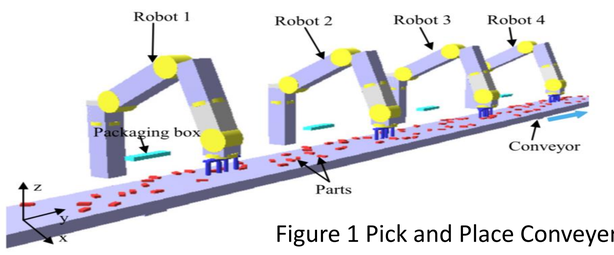

Figure 1 Pick and Place Conveyer

Problem

Conveyor systems are at the heart position in manufacturing environments in many ways because all forms of automation[1], [2], optimization efficiency, and production throughput. Our research aims to optimize the number of parts picked from the conveyer using an RL agent – see Fig 2. Although there are existing robotic simulators (Gazebo, V-Rep) they are not suitable for this task and so we needed to build our own Python based discrete event simulator

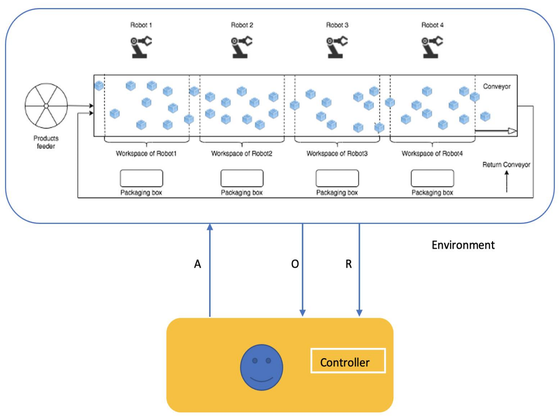

Figure 2 – RL agent control for Conveyer

Methodology

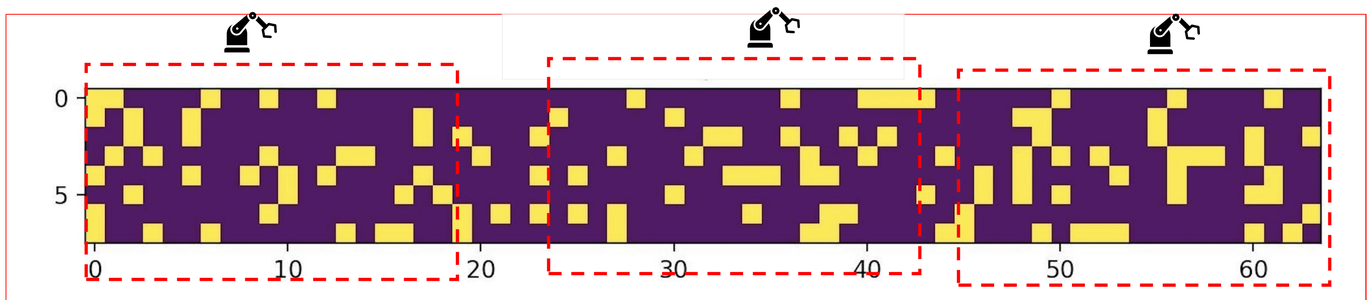

Figure 3 – Simulator representation of Conveyer using 64*8 double ended queue with three workspace
Yellow squares indicate parts placed on the belt

Figure 3 The conveyor belt set up as length 64 and width 8 . The belt running with parts randomly distributed on the belt with the editable probability. Figure 3 is shown probability as 0.8:0.2. The parts update speed based on the parameter we set up called ***SIM_SPEEDUP_FACTOR***, it allows the belt simulation to be increased up to 1000 times real world time speed.
In a RL model the agent need according to the current state give a action to env, then env will give reward as feedback to action, and according to the reward agent will optimise the action.

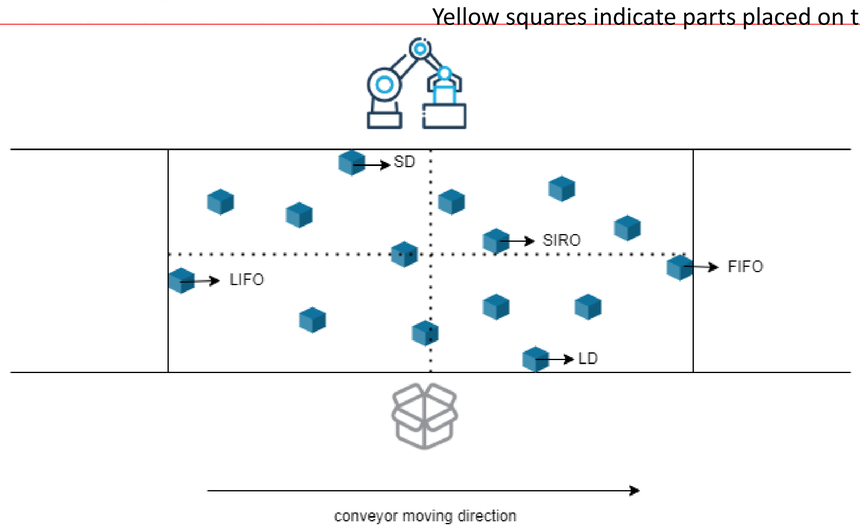

Fig 4 – Workplace scheduling disciplines

Figure 4 Each robot uses a particular **scheduling discipline** to pick and place parts in the workspace:

- FIFO(first in first out)
- LIFO(last in first out)
- SIRO(service in random order)
- SD(shortest distance with upper conveyer)
- LD(longest distance with upper conveyer)

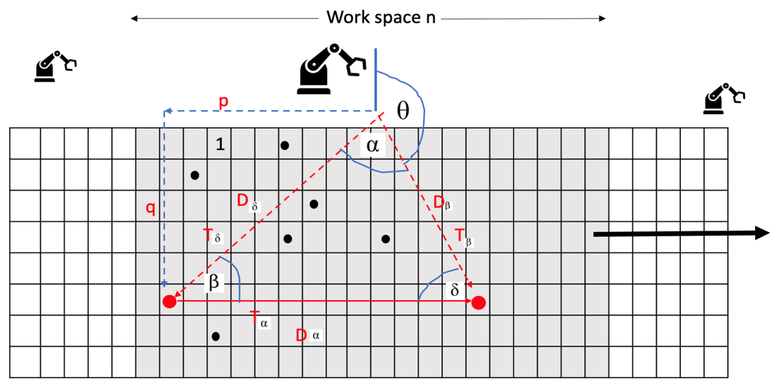

Fig 5 –Scheduling discipline simulation using Relative Velocity using Sine Rule

Figure 5 The belt is keep moving during robot pick and place. The factors including belt velocity, robot arm moving time, robot arm moving speed, during the moving time where the part will be located.
For each robot workspace as figure shown, we calculate the specific position of moving parts according to relative velocity problem:
We know the original parts positions before moving, according to ***Pythagorean theorem*** will get the distance between robot position and parts. Use ***trigonometric function*** and ***usual methods of vector addition*** will further get the angels **{α, β, δ, Θ}** show in figure 5. According to the angles combine with belt speed & robot moving speed, therefore we care able to calculate the future position of the original parts and can simulate robot pick up

Conclusion

The poster describes our simulation of a multi robot system for reinforcement learning research.). Conveyor systems showed as the heart position in industry 4.0 manufacturing environments. Reinforcement learning has shown recent success on many fronts and a natural next step is to test multi robot scenarios. In this simulation, we implement the environment which can test reinforcement learning algorithms with multi robot system.

References

[1] Conveyor industry and industry 4.0 are intertwined and this relationship will continue to go even stronger. (https://conveyorconceptsinc.com/blog/conveyor-industry-4-0/)
[2] The Role Of Conveyors In Industry 4.0 Manufacturing Environments (https://www.conovey.com/the-role-of-conveyors-in-industry-4-0-manufacturing-environments/)