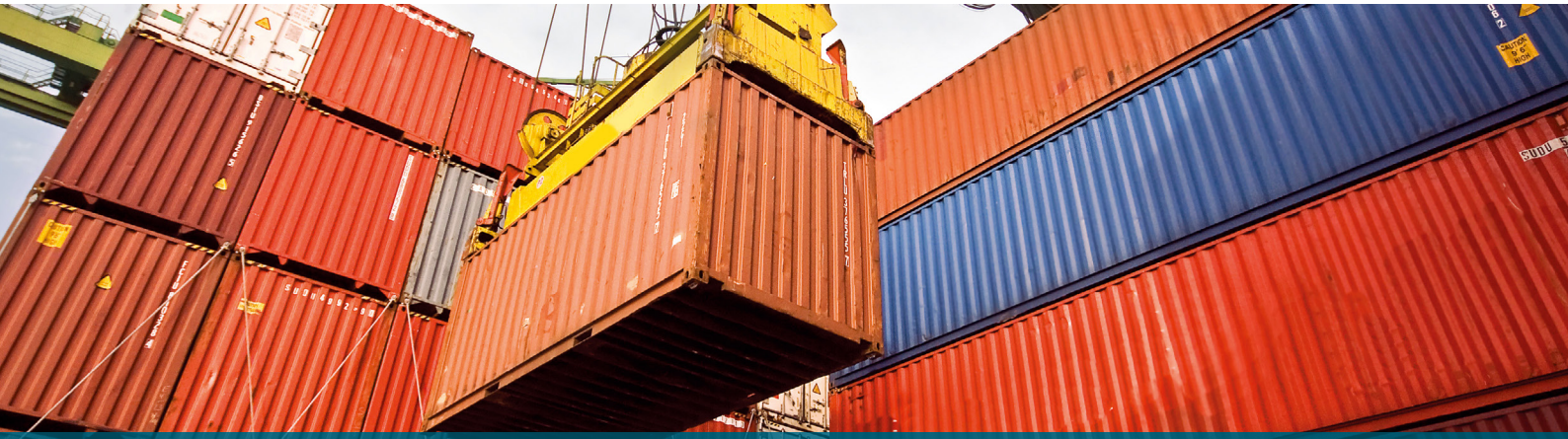
ICT GROUP
ICT Netherlands
Smarter Solutions



Reinforcement Learning for Terminal Operations Optimization

Operating a container terminal comes with many optimization problems regarding for example equipment scheduling and stack strategy.

Containers that need to be exported or imported are temporarily placed in a stack on the container terminal using a specific stacking strategy. Because it concerns large surfaces, with a lot of container moves and transportations meters, it is important to place the containers in this stack as smart as possible. This is to minimize unnecessary movements and distances. An optimal stacking strategy saves fuel, time and thus costs.

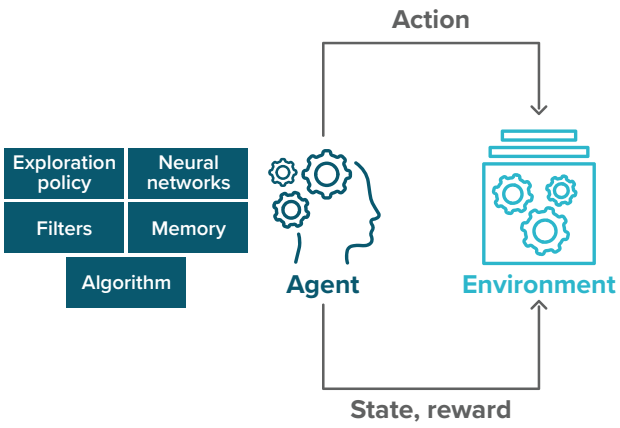
This can be done, for example, by placing an export container close to the ship that will export it. But that is often not yet known when a container arrives at a terminal. Moreover, there are many other variables that influence the optimal stack location of a container. Container terminals still often determine the best location on the basis of experience or on automated algorithms that take a limited number of variables into account.

A new development is applying machine learning (ML) to improve on traditional algorithms. The benefits of ML over traditional, static algorithms are:

- A ML algorithm is constantly learning
- ML implicitly takes into account all possible variables and situations
- ML improves over experts by taking into account more variables and complete history with a perfect memory

ICT has performed a PoC with the ML method “Reinforcement learning”. Reinforcement learning brings machine learning options to improve solutions for optimization problems. The main idea of reinforcement learning is that a computer can learn to take good or near optimal actions for an optimization problem, given the state of the environment, i.e. the terminal. The key advantage of using reinforcement learning is that better solutions

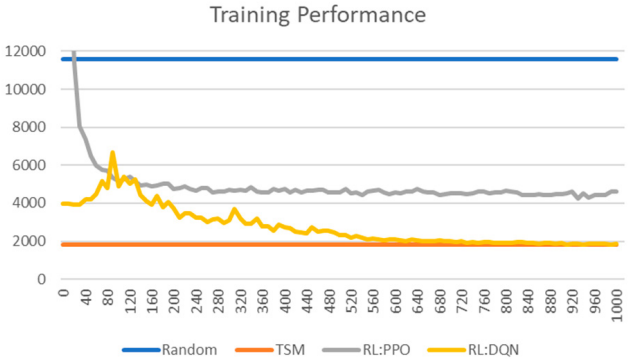
can be found for optimization problems, increasing the efficiency of a container terminal. Machine Learning and specifically Reinforcement Learning can bring the next level of stack optimization to the container terminals.



In order to come up with a good stacking strategy, which minimizes container dwell time and reduces container rehandling, the agent or algorithm requires an environment to test the effect of certain actions. The environment is a simulation of the container terminal and is the first part required for reinforcement learning. If a certain action is provided, for example: place container X at location Y, the environment will process this action and returns two elements. The first is the new state, that is the new situation at the terminal. The second is called the reward or cost and measures the effect of the performed action. Part of the reward or cost is for instance the driving cost to bring the container to location Y, but can also contain penalties for stacking the container in an illegal row or higher than allowed. The state and reward are the feedback for the agent to learn the consequence of a certain action. Part of the learning process is done in a neural network, which enables the agent to learn even in difficult environments. The integration into the slot allocation of an existing TOS system ensures its user-friendly usability. The algorithm works in the background and further optimizes its prediction, based on the running operational data.

For creating a good agent that performs well in the specific environment of a container terminal, domain knowledge is an important key. ICT Group has been involved in container terminal automation since 1991 and has gained a lot of experience in the operational processes of container terminals over the years. Utilizing machine learning and artificial intelligence and integrating these technologies in existing IT infrastructure are the success factors for reaching the next level of optimizations.

In the graph below, the results of the first PoC can be seen. In this scenario, it was possible to find the optimal stacking strategy with the help of Reinforcement Learning.



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