REINFORCEMENT LEARNING FOR INTELLIGENT AND AUTOMATED OPERATION PLANNING

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Abstract

Reinforcement learning (RL) refers to a paradigm of machine learning algorithms that may be applied to several business use cases. RL learns optimal behaviours through interactions with the environment and its feedback. The term reinforcement indicates the process of forming and strengthening of these associations by the reinforcer, which encompasses both rewards (positive reinforcers) and punishments (negative reinforcers). RL is increasingly being incorporated into a broad range of complex business operations such as product recommendation where customer behaviours and preferences change rapidly; solving complex logistics problems that combine packing, routing, and scheduling; cutting stock problem and automated layout planning. These problems are provably hard to solve by traditional combinatorial optimization methods, so we deploy RL algorithms for efficient decision making. The stochastic cutting stock problem consists of cutting smaller items from larger objects in stock, given the demand from customers, with the objective of minimizing trim loss. Heuristic solution approach is developed based on reinforcement learning. An approximate policy iteration algorithm is used in contrast with the traditional value-based RL algorithms such as Q-learning and SARSA (State Action Reward State Action). Automated Layout Planning is the generation of a layout that includes a coarse spatial representation of functional units (e.g., machines) and consequently predefines multiple characteristics of the future plant, like the throughput time, utilization, and area demand. An optimized layout planning process is very important as it can reduce material handling costs in production by 10-30%. The generation process of a factory layout is highly complex due to a variety of partially conflicting planning objectives.

Introduction

Reinforcement Learning(RL) is a type of machine learning technique that enables an agent to learn trough trial and error in an interactive environment using feedback from its own actions and experiences.

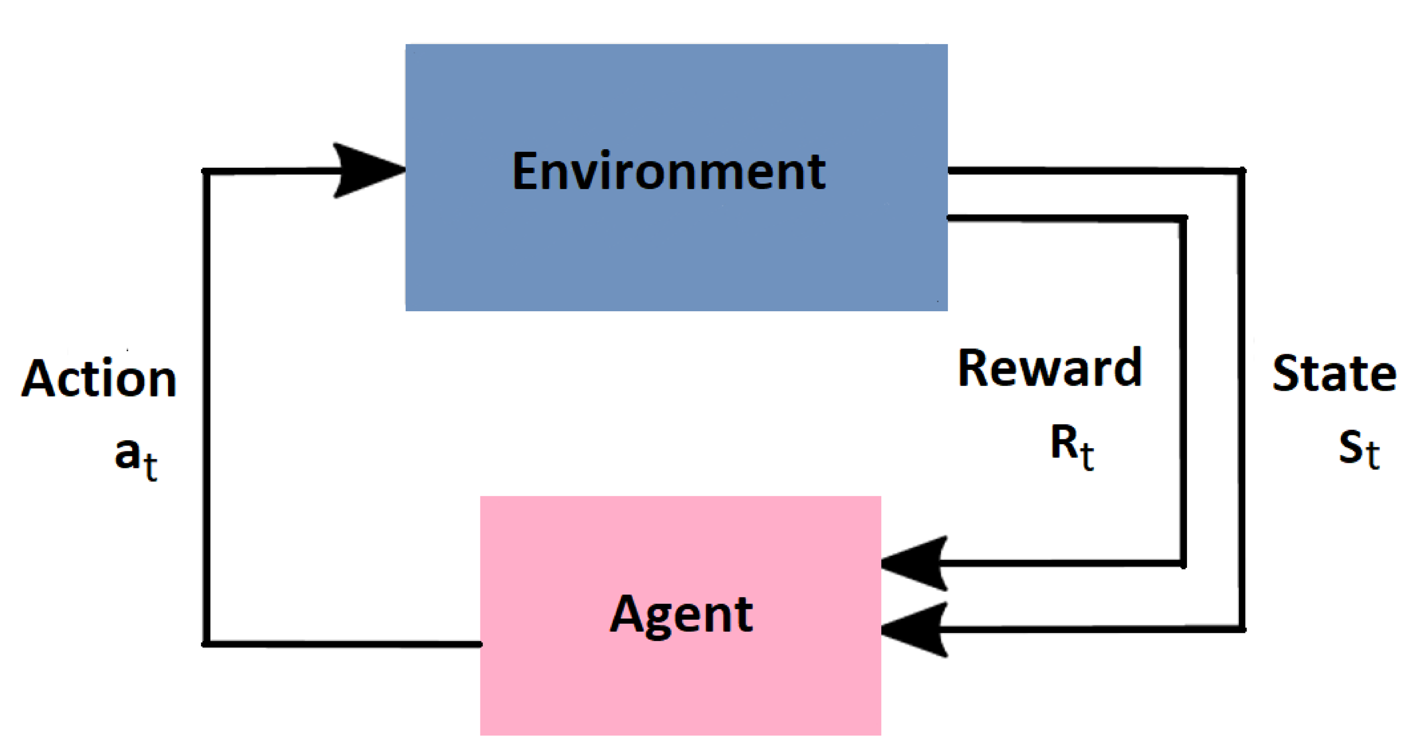

Figure 1: Reinforcement Learning Model [3]

Methodology

We use Markov Decision Process (MDP) framework, which is a sequential decision-making framework in the stochastic environment. Our goal is to find a policy, which is a map that provides all optimal actions for each state of your environment.

Application I

Plant layout ideally includes planning and integrating the routes of the product's components to achieve the most effective and economical flow between operating equipment and personnel, material movement, storage facilities, service functions, and auxiliary equipment. A better layout could not be achieved in less time with a manual planning approach. RL framework is developed to learn the placement of functional units in a given layout to optimize planning goals. The algorithm framework consists of two central elements: the environment and the agent.

Agent is trained to choose the best possible action based on the current situation.The environment provides the agent with the information it needs and consists of two parts: the state representation, and the reward function[1].

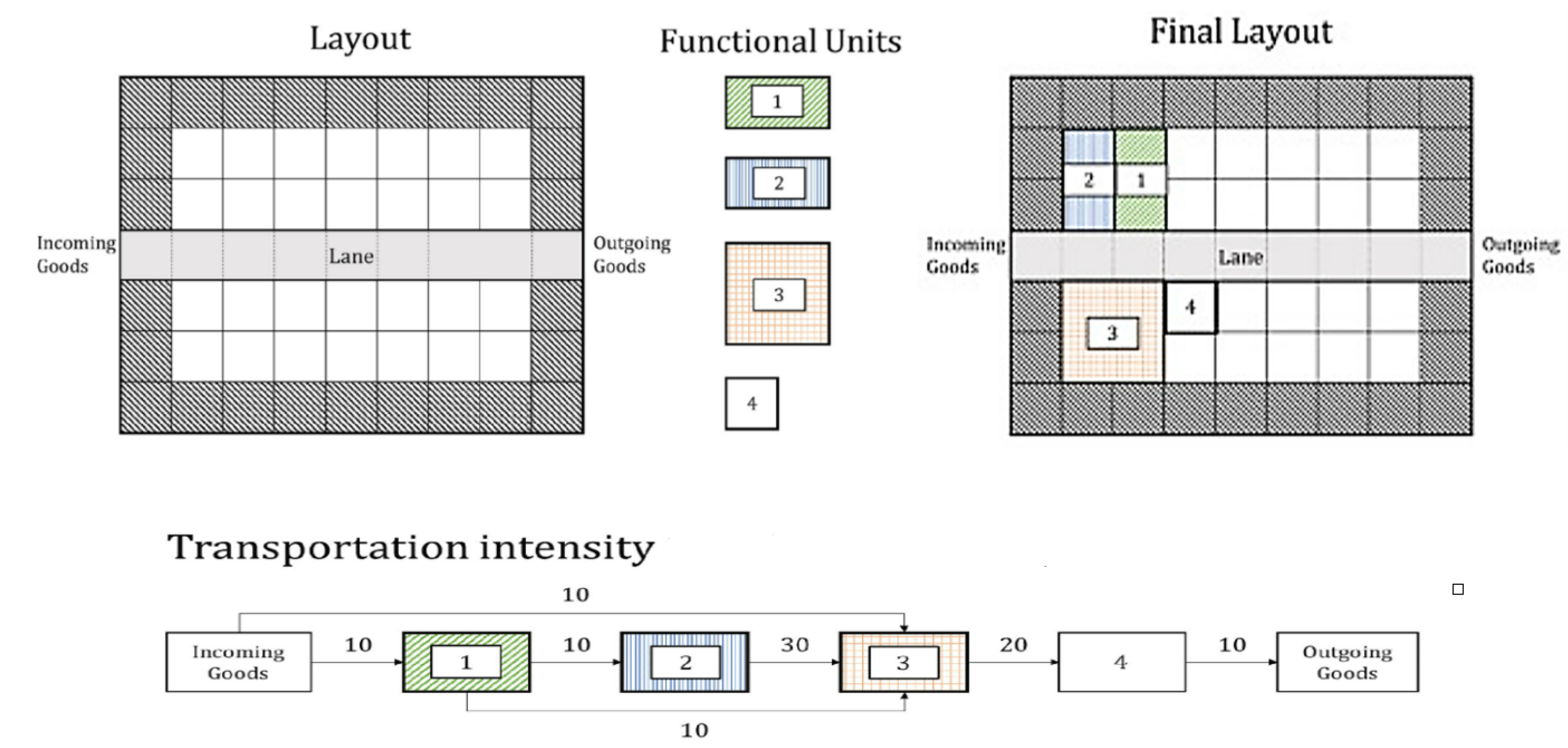

Figure 2: Plant Layout [1]

Application II

When it comes to cutting, the issue of inventory and lot size are conflated, creating a complex issue where the production of one-off pieces is linked by cutting patterns. This decision problem under dynamic and uncertain scenarios is the Stochastic Cutting Stock Problem (Stochastic CSP)[2].

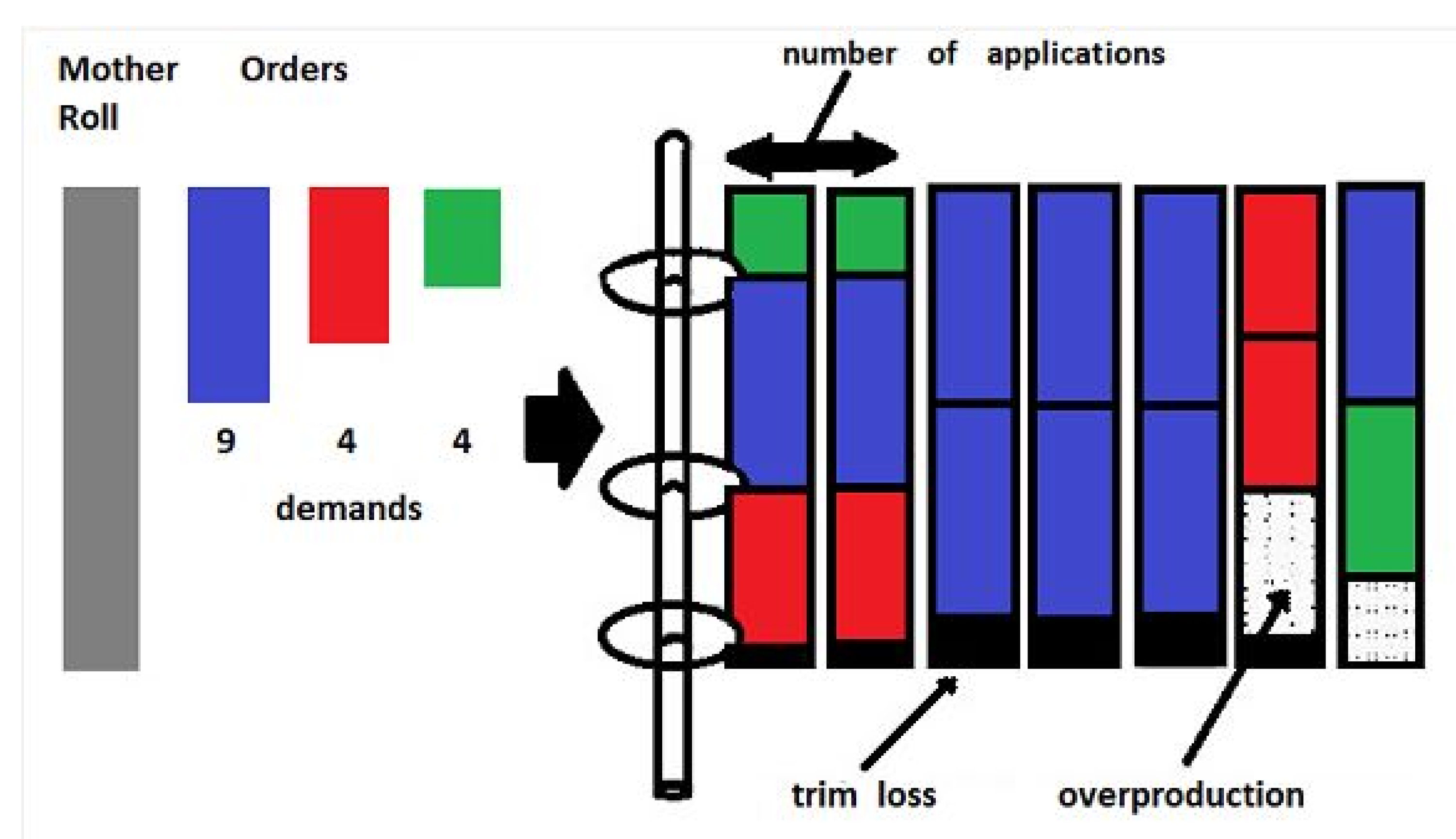

Figure 3: Cutting Stock Problem

Conclusion

We have developed a stochastic cutting stock problem solving approach based on reinforcement learning. These promising results provide experimental evidence that a decision system based on reinforcement learning for cutting stock problems can lead to significant cost reductions in the industry, especially when demand is uncertain. The objective of layout planning is to minimize transportation time. After training, the algorithm can place functional units in an optimized way by placing the functional unit with the highest transportation intensity as the central element of the layout.

References

[1] M. G. Klar, Matthias and J. C. Aurich. An implementation of a reinforcement learning based algorithm for factory layout planning. Manufacturing Letters 30, 2021.

[2] A. R. Pitombeira-Neto and A. H. Murta. A reinforcement learning approach to the stochastic cutting stock problem. `https://doi.org/10.1016/j.ejco.2022.100027`, 2022.

[3] R. S. Sutton and A. G. Barto. Reinforcement learning:an introduction. The MIT Press, Cambridge, Massachusetts, London, England, 31 May 1992.