Abstract

Job Shop Scheduling Problems (JSSP) are one of the scheduling tasks in Operations research that come under combinational optimization problems. It is a well-researched area in Operations Research. But it remains as NP-Hard problems due to the intractable nature of the solution. NP - Hardness has been tried to be solved using heuristic methods and recently artificial intelligence methods, yet only sub-optimal solutions are found. In this thesis, a new method is proposed to solve the JSSP by implementing Reinforcement Learning (RL) algorithms using Graph Networks.

Many solutions have been developed for JSSP using RL as alternative to traditional algorithms wherein the RL algorithms learn by interacting with the JSSP environment. But there are some problems such as long processing times, instability, etc, which can be eliminated by incorporating Graph Neural Networks (GNN) in RL algorithms. In recent times, GNNs have shown remarkable performance by improving accuracy in supervised learning tasks. So, using GNNs in RL by restructuring the JSSP as a graph, it can provide a faster and stable solution to the JSSP problem.

This thesis aims to develop smart systems that operate autonomously by learning and adapting to the given environment and tasks. The powerful mechanism of GNN helps in getting more information during the learning process. The novelty of this thesis comes from the combination of RL with GNN to improve the learning and evaluation performance of the RL agents.

The RL algorithms, Actor-Critic and PPO are implemented in this thesis, in combination with the graph networks. Initially, a simulated version of JSSP with fixed targets is tried and later dynamic targets are introduced. A new Message Passing Neural Network (MPNN) has been proposed which shows improved performance when combined with RL using graph neural networks. Later, a bigger and more complex environment has been used to perform similar tasks. The results show that the MPNN outperforms other methods.

The results presented in this thesis show that the JSSP environments developed using graph network structure outperform the non-graph structured environment. The agents reach the convergence faster for both fixed and dynamic target setting compared to the non-graph structured small environment. The improvements are even starker in the case of the bigger JSSP, where the graph network structured agent converged to and improved the solution over successive iterations while the non-graph structured agent did not even converge.