MCD412 B. Tech Project

Week 3 Report

Submission Due: 04-Feb-2025, 5:00 PM

Title of the project: Dynamic Freight Pricing

Area of the project: Industrial

Student Name with Entry number:

1. Sanchit Singla - 2021ME21063
2. Sanidhya Mittal - 2021ME21054

Supervisor(s): Prof. Amber Srivastava & Prof. Prashant Palkar

Week 3 activity (planned as per Gantt chart): Literature Review, Data collection, Hardware and Software Setup

Week 3 progress (Describe work done in the week to meet planned activity):

Literature Review:

Delved deep into the different research on the topic namely the deep reinforcement learning based approach and operations research based methods.

- **Research Papers**

1. **Dynamic Pricing in High-Speed Railways Using Multi-Agent Reinforcement Learning**: This study addresses the challenge of designing effective dynamic pricing strategies in high-speed passenger railways. The authors propose a multi-agent reinforcement learning framework based on a non-zero-sum Markov game, incorporating random utility models to capture passenger decision-making. They introduce RailPricing-RL, a versatile simulator modeling various railway configurations and demand patterns. Experimental results demonstrate how user preferences affect the performance of the proposed framework and how pricing policies influence passenger choices and system dynamics.

2. **Dynamic Pricing and Capacity Optimization in Railways**: This research analyzes the joint optimization of pricing and capacity in railways, considering the flexibility of capacity adjustments and the need for congestion management. The authors develop asymptotically optimal policies for pricing and capacity decisions, providing railway administrators with effective strategies for revenue management. The study offers insights into different contingencies that decision-makers may face in practice.

3. **Research on Dynamic Pricing Strategies for Multiple High-Speed Trains Based on Deep Reinforcement Learning**: This paper addresses the issue of fixed pricing strategies in high-speed railways and proposes a solution using revenue management theory. The problem is transformed into a Markov Decision Process, and the Double Deep Q Network (DDQN) from deep reinforcement learning is employed to solve it. Experimental results indicate that the DDQN model increases total revenue by approximately 7.70%

compared to fixed pricing strategies and by 3.89% compared to traditional dynamic pricing algorithms like Particle Swarm Optimization, highlighting its practical application value.

4. **Railway Operation Rescheduling System via Dynamic Simulation and Reinforcement Learning**: This study presents an automatic railway scheduling system leveraging reinforcement learning and a dynamic simulator that can simulate railway traffic and passenger flow of an entire line. The proposed system enables rapid generation of optimized schedules for the whole line, as the optimization process is conducted in advance during training. The system is evaluated using an interruption scenario, demonstrating its capability to generate optimized schedules in a few minutes.

5. **Dynamic Pricing on E-commerce Platform with Deep Reinforcement Learning: A Field Experiment**: Although not specific to railways, this paper presents an end-to-end framework for addressing dynamic pricing on e-commerce platforms using deep reinforcement learning methods. The authors model the dynamic pricing problem as a Markov Decision Process and propose approaches that extend the discrete price set to a continuous one, define a new reward function named difference of revenue conversion rates, and tackle the cold-start problem by pre-training with historical sales data. Field experiments suggest that their approaches significantly outperform manual pricing by operation experts.

Data Collection:

Discussed the data collection strategy with an MTech senior to refine key parameters and prepare for the upcoming railway meeting. Key points included:

- Identifying essential data such as freight rates, cargo types, weight classifications, fuel prices, seasonal demand variations, and route-specific pricing trends.
- Exploring data sources like railway freight management systems, historical transaction records, government transport databases, and real-time tracking APIs.
- Structuring a questionnaire for railway officials to gather insights on existing pricing strategies, operational constraints, and factors influencing dynamic pricing.
- Planning the agenda for the railway meeting to request access to freight-related datasets and discuss feasibility for continuous data updates.
- Addressing challenges such as data confidentiality, accessibility restrictions, and regulatory compliance to ensure a streamlined collection process.

Software Setup and Model Preparation:

Developed an ARIMA (AutoRegressive Integrated Moving Average) model using the existing freight transportation dataset to analyze historical trends and forecast future pricing

patterns. The model was designed to capture underlying seasonality, demand fluctuations, and long-term trends in freight rates.

Meeting with supervisor (Should be before 04-Feb-2025)

Date: NA

Time: NA

Minutes of meeting (point wise): NA

Difficulty faced in completing Week-3 activity (if any): NA

Declaration:

We have met our supervisor on 3|2|24 **(Date) at** 11:00AM **(Time) and discussed the report before submission.** *(Fill Date and Time by Ink Pen at the time of meeting before signature)*

(Student 1 Signature) **(Student 2 Signature)** **[Supervisor Signature]**