M2 Metro Line Timetable Optimization

Berker ERİŞ
150220315
erisb22@itu.edu.tr

Enes YEMENLİ
150220311
yemenli22@itu.edu.tr

Introduction

Project Description

In this project, we aim to optimize the waiting time of passengers on M2 line in Istanbul.

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Problem Definition

Istanbul’s population has doubled in 25 years, straining transportation. To reduce passenger waiting times, dynamic, optimized planning is essential.

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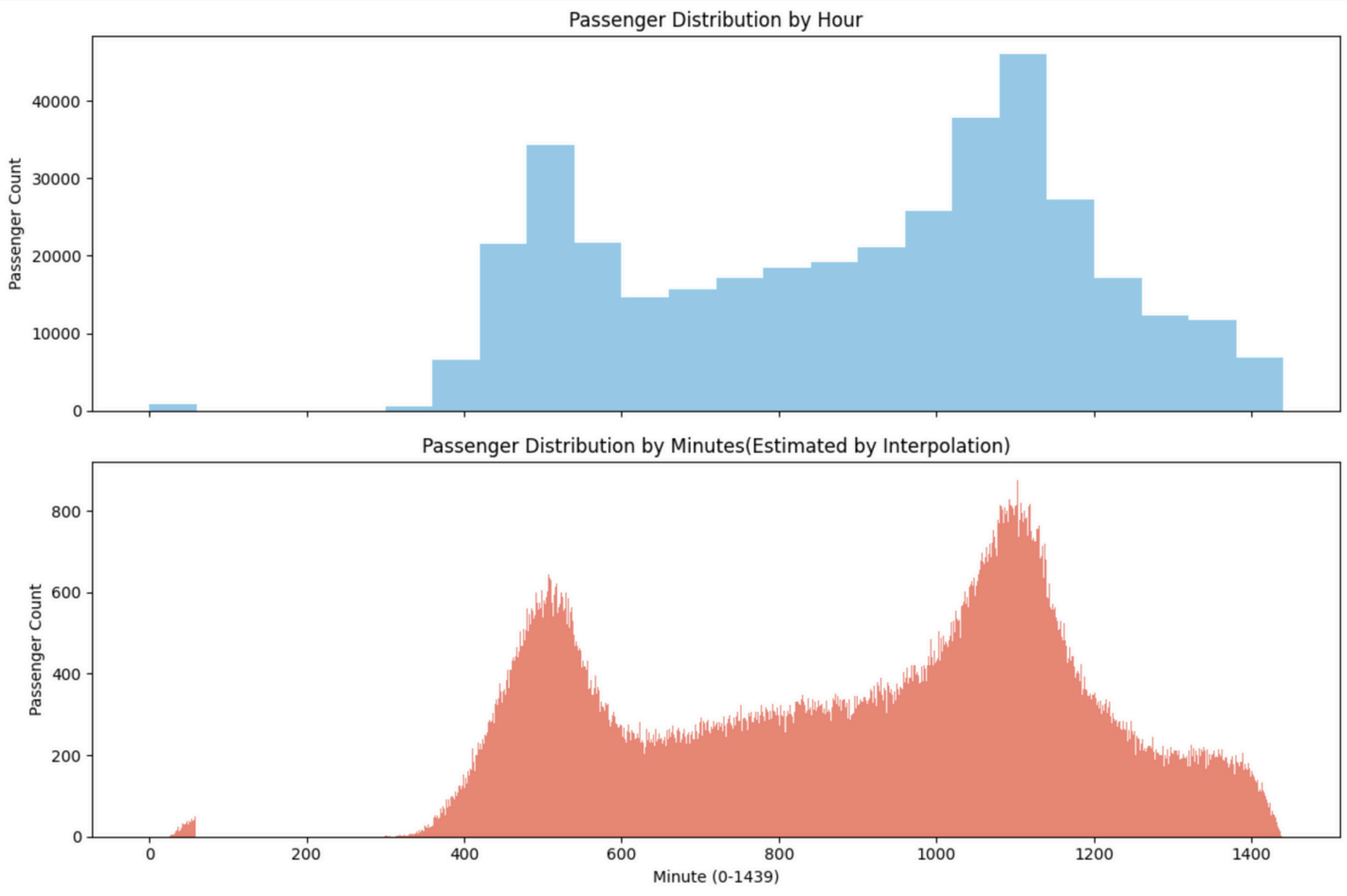
Preparing Datasets

1. Estimate destination with weighted probabilty

- To estimate the destination of passengers based on the usage density of the stops.

2. Estimate time with cubic interpolation

- Estimating when passengers enter from hourly data



Final Dataset

- 184080 passengers information with enterance time and final destination.
- 196 metro trips
- 950 capacity for each train

transition_date	transition_hour	line_name	station_poi_desc_cd
2024-09-04	0	M2	YENIKAPI

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transition_date	transition_hour	line_name	station_poi_desc_cd	destination	direction
2024-09-04	00:00:00 - 00:59:59	M2	YENIKAPI	VEZNECILER	1

↓

passenger_id	boarding_station	destination_station	enterance_time	boarding_station_id	destination_station_id
184040	YENIKAPI	DARUSSAFAKA	23:44:00	0	13

Method

Lineer Programming

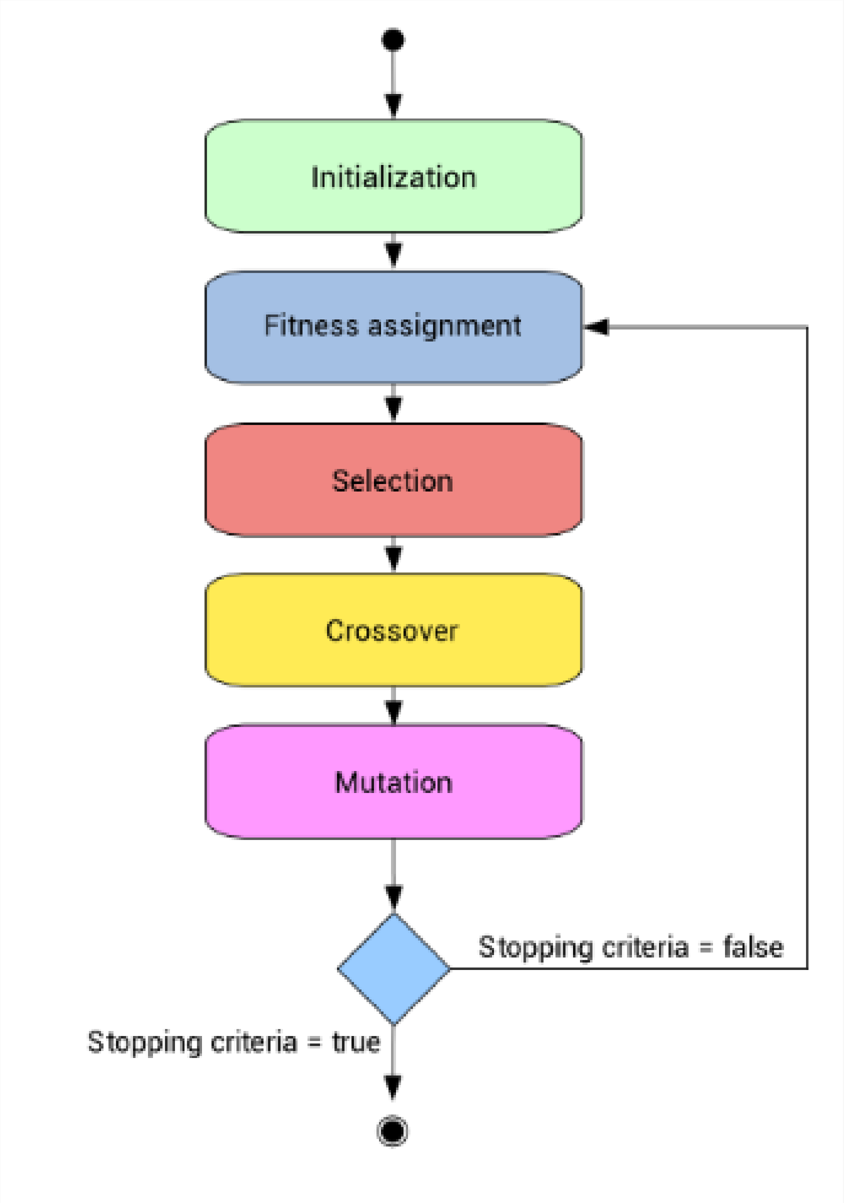
🚫 Non-linear objective: Passenger waiting time depends on train arrival times and is not linear.

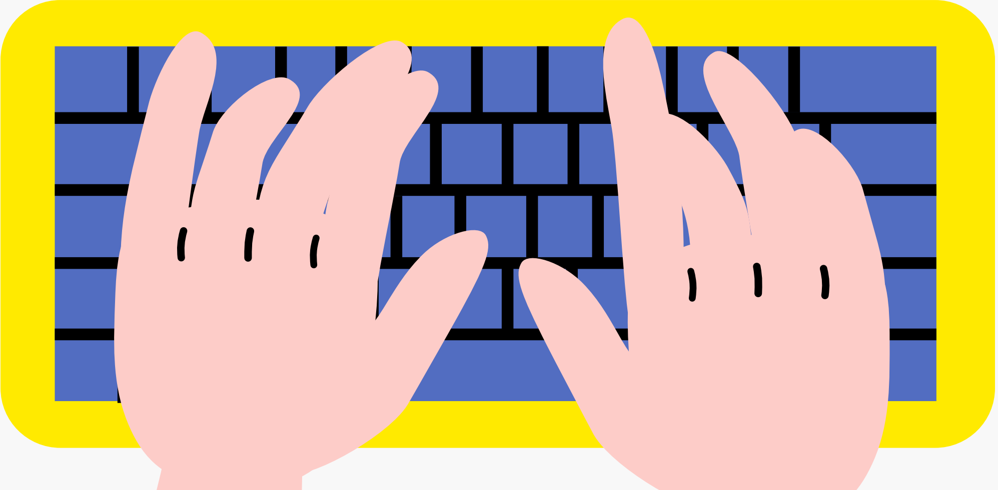
$$\min \sum_{l \in L} \sum_{t \in T} w_{l,t}(x_{l,t})$$

Genetic Algorithm

✅ Handles non-linearity: GA can optimize irregular and discontinuous functions.

$$\min \sum_{i=1}^{N} \left(\text{departure\_time}_{s(i)} - \text{arrival\_time}_{i}\right)$$

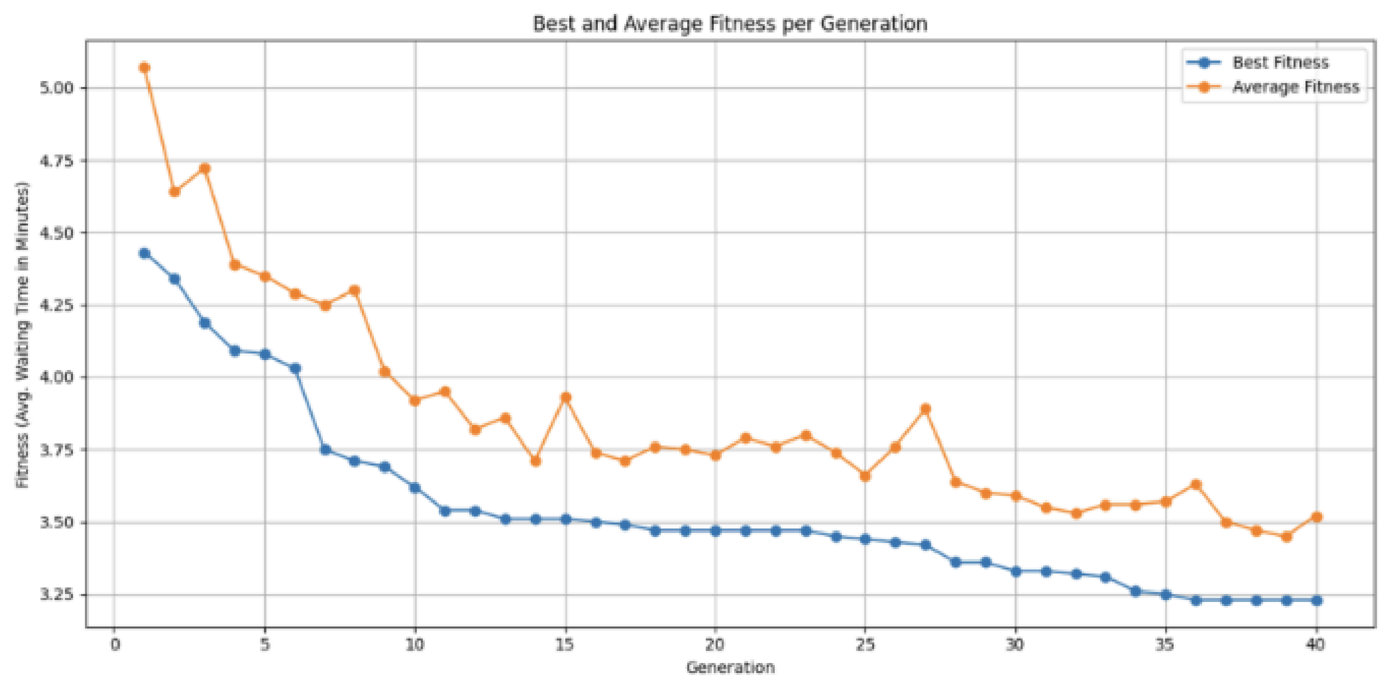




Results

💯 The genetic algorithm successfully reduced the average passenger waiting time compared to the original schedule, demonstrating its effectiveness in optimizing train departure times.

Avg. Waiting Time =3,23



Comparision

After Optimization

- The genetic algorithm reduced the average passenger waiting time from **3.65** minutes (real-world schedule) to **3.23** minutes, showing a clear improvement through optimization.

- By adjusting train departure times during peak and off-peak hours to reduce waiting times, the efficiency was improved by approximately **11.5%.**

Current Schedule

Thank you