Finding Train Type Patterns in the Train Unit Shunting Problem

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Introduction

- The Train Unit Shunting Problem (TUSP) outlines the challenge of **parking**, **maneuvering** and **recombining** train units in a shunting yard.

- TUSP **planning** is done **manually.** Algorithms exist, but are **slow** or the solutions are **incomplete** [1], [2].

- Researchers suggest that **incorporating patterns** present in good TUSP solutions can help improve **algorithm performance** [2], [3].

- **Train type** is a prominent characteristic and **patterns** in this could be very useful.

- Research question: What **patterns** of **train type** can be found **in realised solutions** of the Train Unit Shunting Problem?

- Parking **track** and parking **time** are important subtasks in the TUSP.

- Train **subtype**: main type + number of carriages.

Method

Finding patterns

- **Track**: use statistical testing to find biases between types and parking tracks.

- **Time**: use kernel density estimation to find differences in total time a unit is parked.

Compare with subtype

- **Repeat** experiments **for train subtypes** to determine **differences** in patterns. between type (e.g. VIRM) and subtypes (e.g. VIRM-IV).

Results

Parking Track

- **Strong biases** between many tracks and types.

- In most shunting yards the **majority** of the parking **tracks** is **biased**.

- **Parking tracks** can have **biases** for **multiple train types**.

- **Train types** can have **biases** for **multiple parking tracks**.

- Amersfoort shunting yard has a **geographical split** in tracks biases for **Intercity** train types and **Sprinter** train types.

- Table 1 shows some of the biases for Amersfoort.

Type	361AV	381R	383L
DDZ	2.47	0.38	0.47
ICMm	1.19	0.26	0.24
SLT	0.61	0.66	2.46
SNG	0.73	1.82	1.23
VIRM	2.24	0.40	0.11

Table 1: Biases between train types and parking tracks for Amersfoort shunting yard. The further the score from 1, the greater the bias.

Parking Time

- **Parking time** is very **similar** between train types.

- Most train units stay for **around five hours** in a shunting yard. This is the **same for all train types**.

- There are some **notable differences** in probability for **longer parking times**.

- - Figure 1 shows **ICMm being twice as likely** to be parked for **12 to 17 hours**.
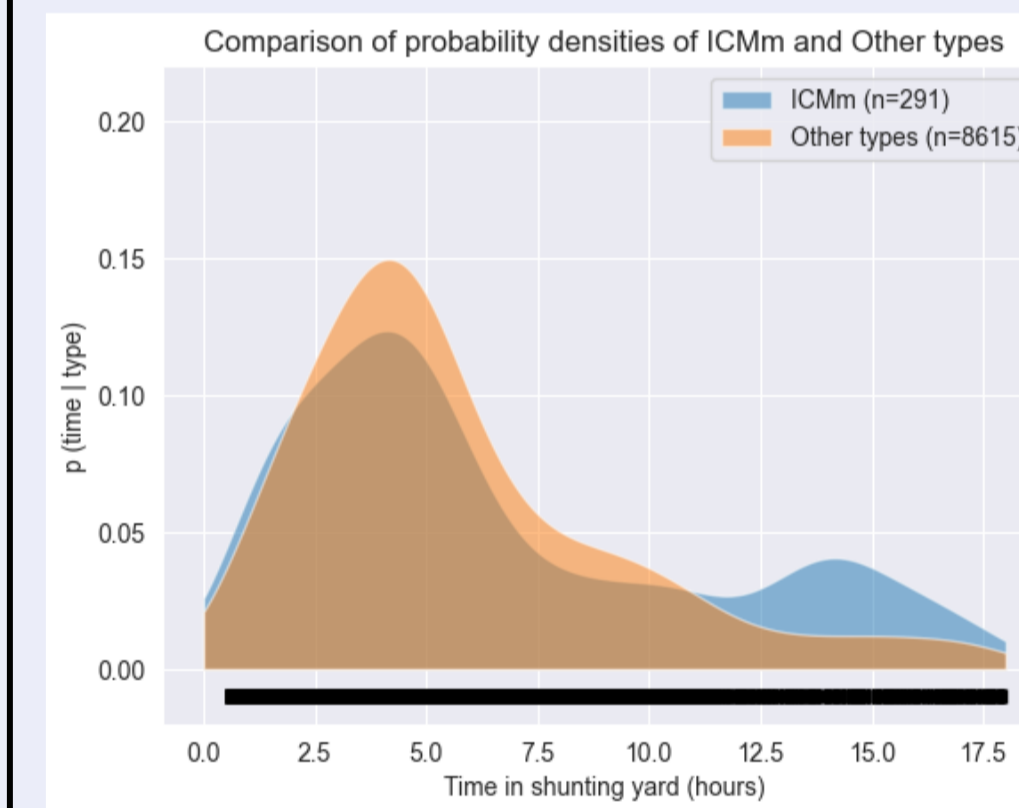

Figure 1: Class conditional probability density functions for parking time for type ICMm and all other train types in Utrecht shunting yard.

Subtype comparison

- Looking at **subtype** makes the **differences more specific**.

- Some parking **tracks** that are biased for a main train type are a lot **more biased** for **one** of the **subtypes**.

- Some sets of parking tracks are **equally biased** for a **main** train type, but each is **biased more** for **one subtype**.

- Table 2 shows **two tracks** being **biased** almost **equally** for type **SNG**. However, **379L** is **more biased** for the **SNG-III** subtype and **381R** is **more biased** for the **SNG-IV** subtype.

- **Parking times** for **subtypes** are again very **similar**.

- **Notable differences** in parking time are **more prevalent** for subtypes.

Type	379L	381R
SNG	1.85	1.82
SNG-III	1.60	1.96
SNG-IV	2.15	1.66

Table 2: Biases between train subtype and parking track in Amersfoort Shunting yard.

Discussion

- The found patterns are only characteristic for **manual/realised solutions**.

- Patterns are likely **strategies** used by **human planners**.

- The results are **only valid** for some shunting yards **in the Netherlands**. Patterns could be **different** in **other countries**.

Conclusions

- **Pattern** between **train type** and **parking track** in all investigated shunting yards.

- **No clear pattern** between **train type** and **parking time**.

- The **pattern** in **track** is **more specific** for train **subtype**, but still **no pattern** in **parking time**.

References
[1] R. van den Broek et al., "A local search algorithm for train unit shunting with service scheduling," Transportation Science, vol. 56, pp. 1–264, 11 2021.
[2] I. K. Hanou et al., "Increasing the capacity of shunting yards within the current infrastructure: A computational perspective," 2023.
[3] L. van de Gevel, "How human knowledge can support algorithmic decision-making in the train unit shunting problem - an exemplary study," 2022.

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