

INTRODUCTION

Shunting yards are where trains are positioned overnight and serviced. **Usage statistics** can be incorporated into shunting yard planning algorithms by **rewarding delegating activities** outside busy periods.

Research questions:

Q1: What are the usage statistics of Amersfoort Bokkeduinen?

- Temporal vs Spatial
- All trains vs number of parked, serviced, or moving trains
- Daily vs Monthly vs Seasonal scales

Q2: How can further usage analysis be facilitated?

Q2.1: Splitting train paths into Sub-paths and classifying them

Q2.2: Clustering Train Units moving together as part of a train composition

BACKGROUND

Q2.1: Path segmentation has been successfully used in finding patterns in animal movements [1]. Trajectories are split into segments based on many characteristics.

Q2.2: Coherent Moving Cluster (CMC) algorithm identifies clusters of points consistently moving together [2]. **Density-based clustering** is ran every frame in search of points in the same cluster for k consecutive frames.

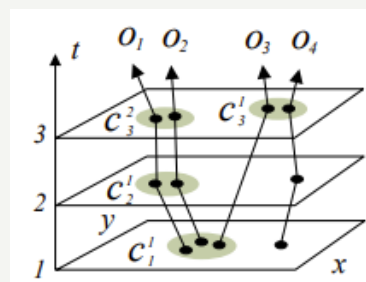


Figure 1: Density Clustering over multiple time frames. Source: [2]

RESULTS

Q1:

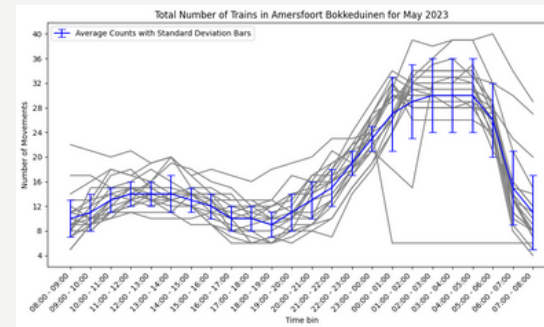


Figure 2: Average Number of Trains in Amersfoort Bokkeduinen over May 2023

Busiest periods:

- Total number of trains: **12:00 - 14:00** and **1:00 - 5:00** (see Figure 2)
- Train servicing: **23:00 - 6:00**
- Trains arriving and shunting: **21:00 - 1:00**

Q2.1:

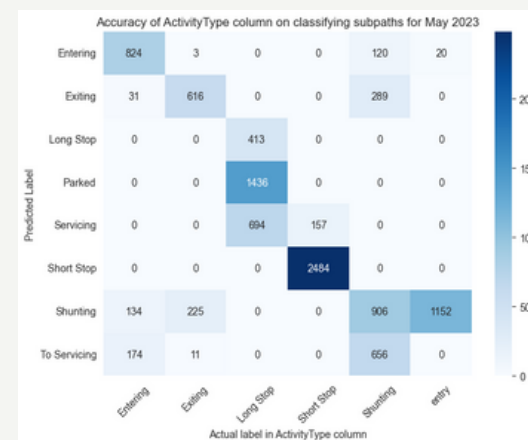


Figure 3: Predicted classification of subpaths (rows) vs actual subpath classification in dataset (columns)

Q2.2: Clustering Train Units results:

- No train units from different cities were clustered together
- The longest identified train compositions consist of 3 train units

SOURCES

- [1] H. Edelhoff, J. Signer, and N. Balkenhol, "Path segmentation for beginners: an overview of current methods for detecting changes in animal movement patterns," 2016
- [2] H. Jeung, M. L. Yiu, X. Zhou, C. S. Jensen, and H. T. Shen, "Discovery of convoys in trajectory databases," 2010.

METHODOLOGY

Individual locations and timestamps are grouped into **trajectories**.

Amersfoort Bokkeduinen shunting and service yards are identified manually (Q1 and Q2.1).

Q1:

- The day is split into hourly bins.
- Trains are counted into a bin if meeting a criteria (stopped in a yard, or moving).

Q2.1:

- Paths are segmented **based on train stops**.
- Segments are classified according to start and end locations.
- Classifications are **compared** with the provided "activity type" of the first movement point of a segment.

Q2.2:

- Coordinates are interpolated on a 10-second interval from 7 shunting areas.
- Trajectories are **clustered** and the units moving together in 10 consecutive frames returned.

CONCLUSIONS

Q1: The minima and maxima of activity within Amersfoort Bokkeduinen was identified.

Q2.1: The included movement classification is somewhat inaccurate for use in shunting yards.

Q2.2: The CMC algorithm has been shown to have promising initial results in identifying train units moving together.