Development of an Integrated Computing Platform for Measuring, Predicting and Analyzing Profile-specific Fixity of Railway Tracks

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I INTRODUCTION

What is "track fixity"?

Track fixity refers to the degree to which the position of a railway track remains unchanged over time; it is a key measure used to calculate clearances between rolling stock and structures.

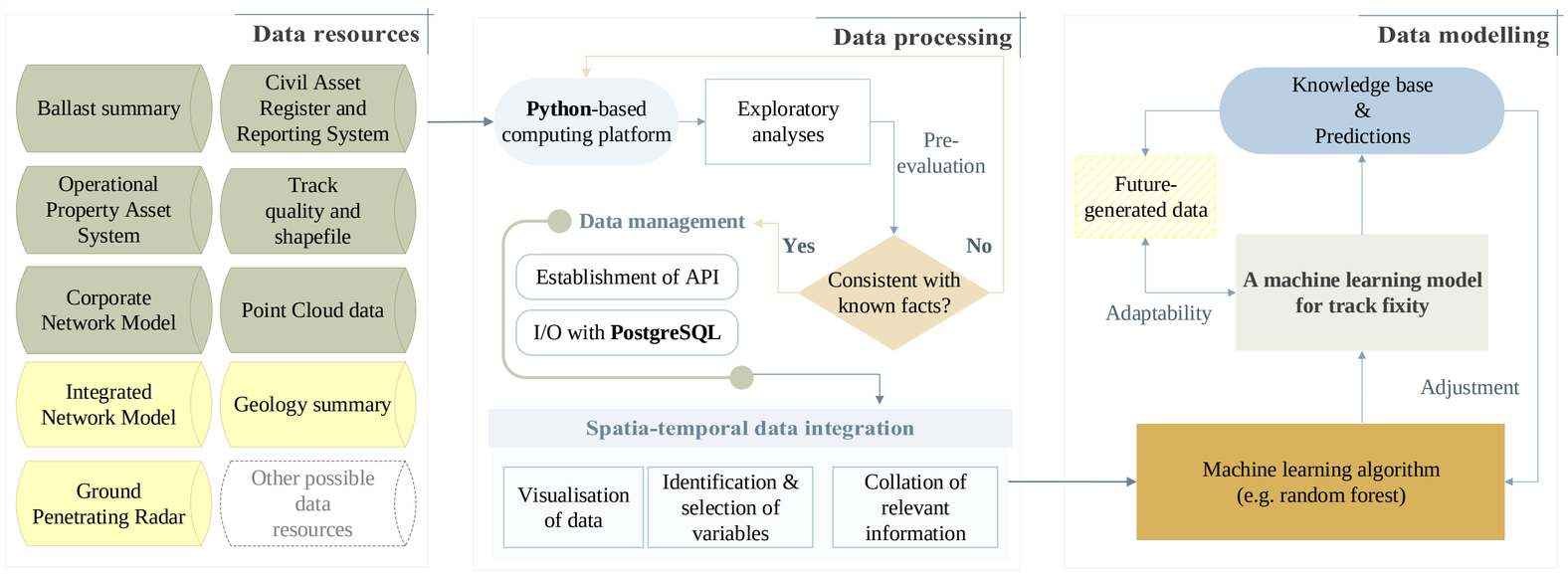
Contextual background

- The UK's current measurement of track fixity lacks granularity.
- There is a lack of predictive tools that can provide more detailed information about the movement of tracks through a continuously updated, ongoing automated process.

II OBJECTIVES

1. Propose an effective metric and method for calculating track movements using LiDAR (Laser Imaging, Detection, and Ranging) data.
2. Create an integrated data model using a machine learning algorithm (e.g. a random forest model), trained on calculated track movements and a selection of factors influencing track movement.
3. Verify the key factors that cause track movements.

III METHODOLOGY



1 Calculation of track movement

Calculating the displacement of rail heads in terms of both rate and direction.

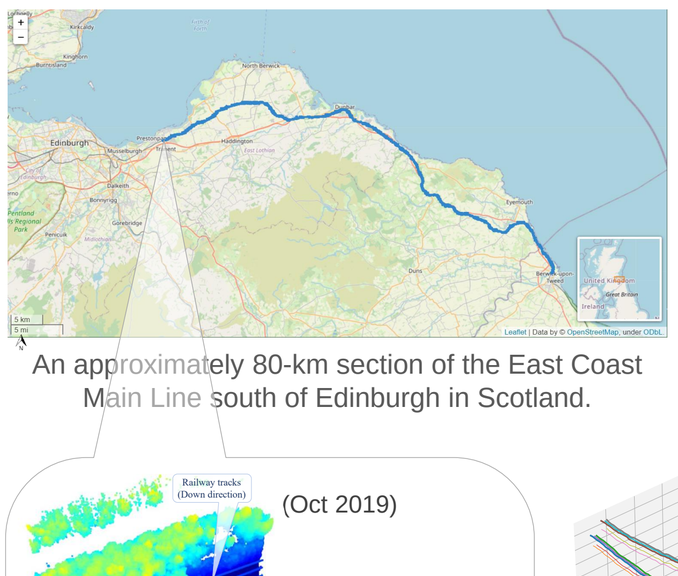
2 Data integration

Creating a comprehensive database for factors influencing track fixity.

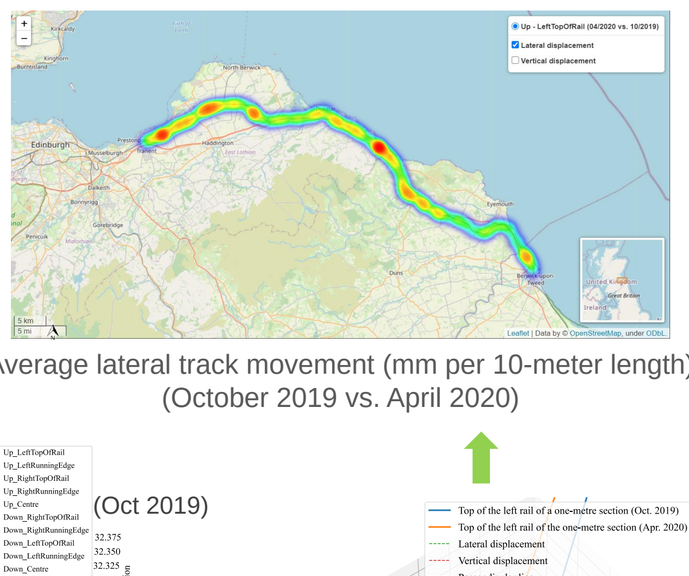
3 Predicting track movements

Developing and applying a machine learning model to predict and analyze track fixity.

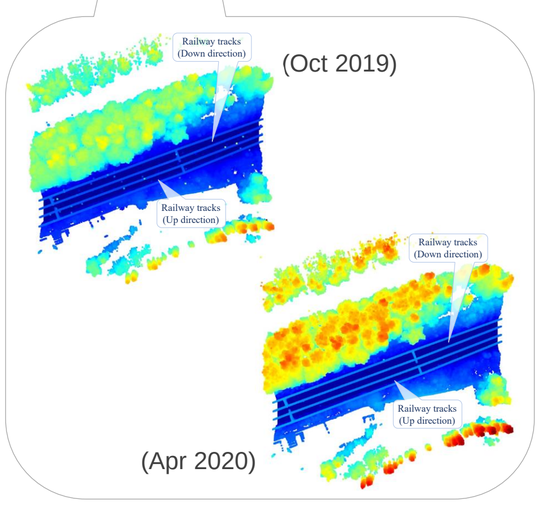
IV A CASE-STUDY EXAMPLE



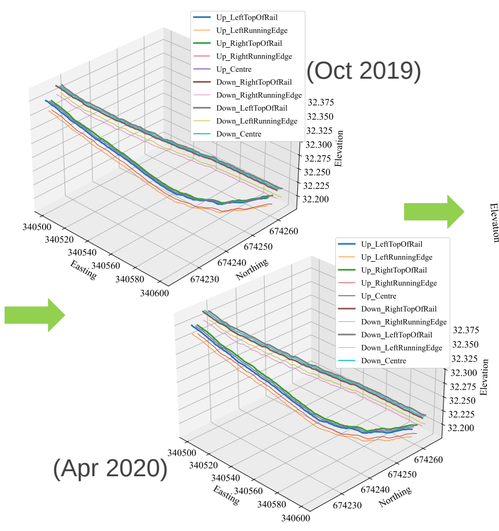
An approximately 80-km section of the East Coast Main Line south of Edinburgh in Scotland.



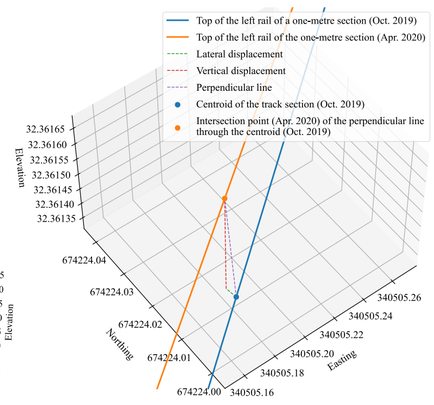
Average lateral track movement (mm per 10-meter length) (October 2019 vs. April 2020)



LiDAR data in a 100m×100m grid

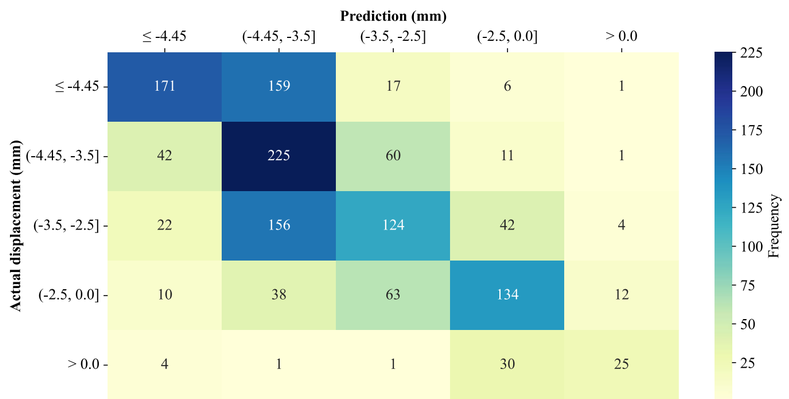


Point cloud for the railway tracks in the grid



The movement of every 1-m length of the rail head in the grid

Modelling results (based on a random forest model)



Factors affecting track fixity	Relative importance
Curvature	0.3887
Cant	0.3725
Maximum speed	0.2016
Presence of underline bridges	0.0095
Presence of over-line bridges	0.0073
Maximum axle load	0.0067
Presence of retaining walls	0.0060
Presence of tunnels	0.0058
Presence of stations	0.0019

V FINDINGS

- **Curvature** and **cant** proved to be the most important factors among those considered in the model. **Axle load** and **train speed** are also expected to significantly impact track fixity.
- In terms of the presence of structures,
  - Track fixity of **ballasted track** can be more vulnerable than fixed structures such as **retaining walls** and **tunnels**.
  - Track sections within **station** areas are much less likely to suffer from fixity issues due to slower train speeds and the absence of track curvature.

VI CONCLUSIONS

1. We propose and demonstrate an innovative approach to measuring, predicting and analyzing profile-specific track fixity over a given period.
2. We have developed the most comprehensive (prototype) integrated computing model to date for track fixity in the context of the UK's railway system.

REFERENCE

Fu, Q., Easton, J. M. & Burrow, M. P. N. (2024). Development of an integrated computing platform for measuring, predicting and analyzing profile-specific fixity of railway tracks. Transportation Research Record, 2678(6), 1-13. doi:10.1177/0361198123119152.

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