MAP-MATCHING FOR TRAIN LOCALISATION: FROM THE DIGITAL MAP TO THE MAP-MATCHING TECHNIQUES

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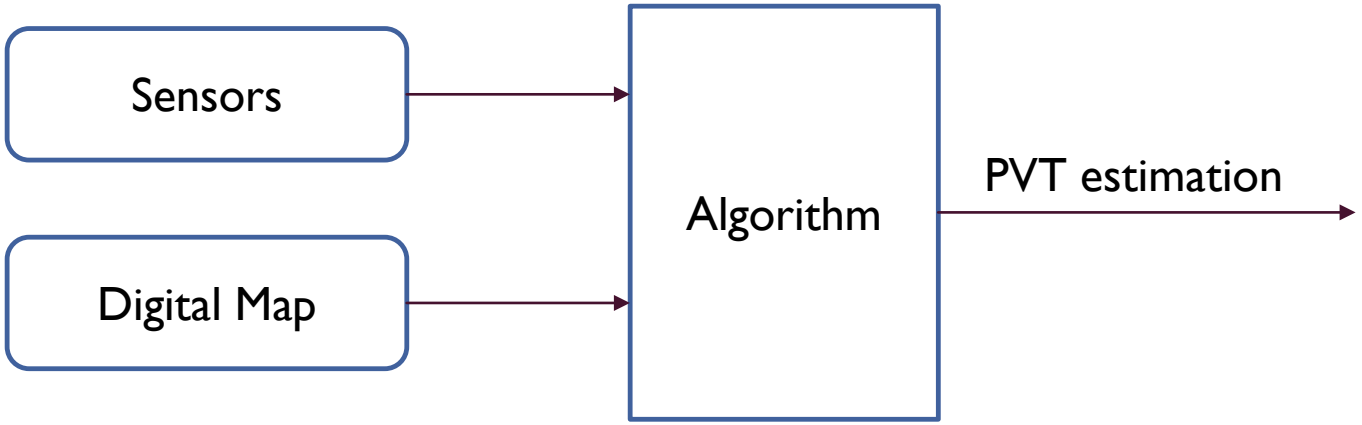
RESEARCH TOPIC

Development of a positioning system based on the fusion of sensor data using the digital map concept.



PVT: Position, velocity and time

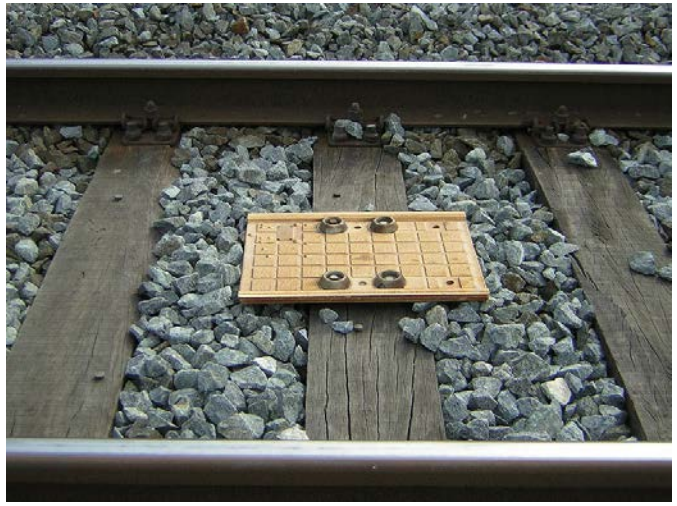
EURAIL

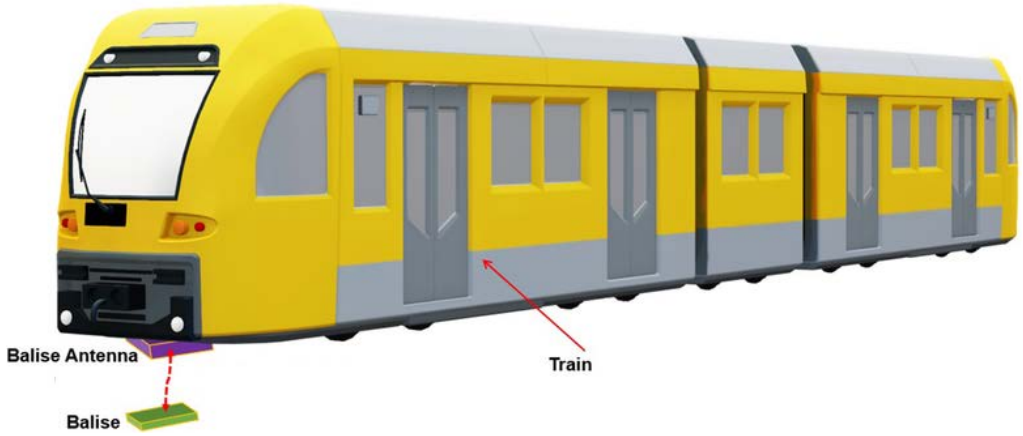
FP2- R2DATO structure:

- WP21 Absolute Safe Train Positioning (ASTP) - operational needs
- WP22 Absolute Safe Train Positioning - System Architecture, Design & RAMS
- WP27 Digital Register Specification, Development and Implementation

CURRENT TRAIN LOCALISATION

Current railway localisation technologies depend greatly on track-side equipment. The most popular used technology for train positioning is odometry in most of the cases complemented with balises





NOVEL TRAIN LOCALISATION

Main idea: Locate the train with just onboard sensors

Train localisation inherent property: the motion is constrained to the track.

Estimating the train position on a digital map of the track: Map-Matching

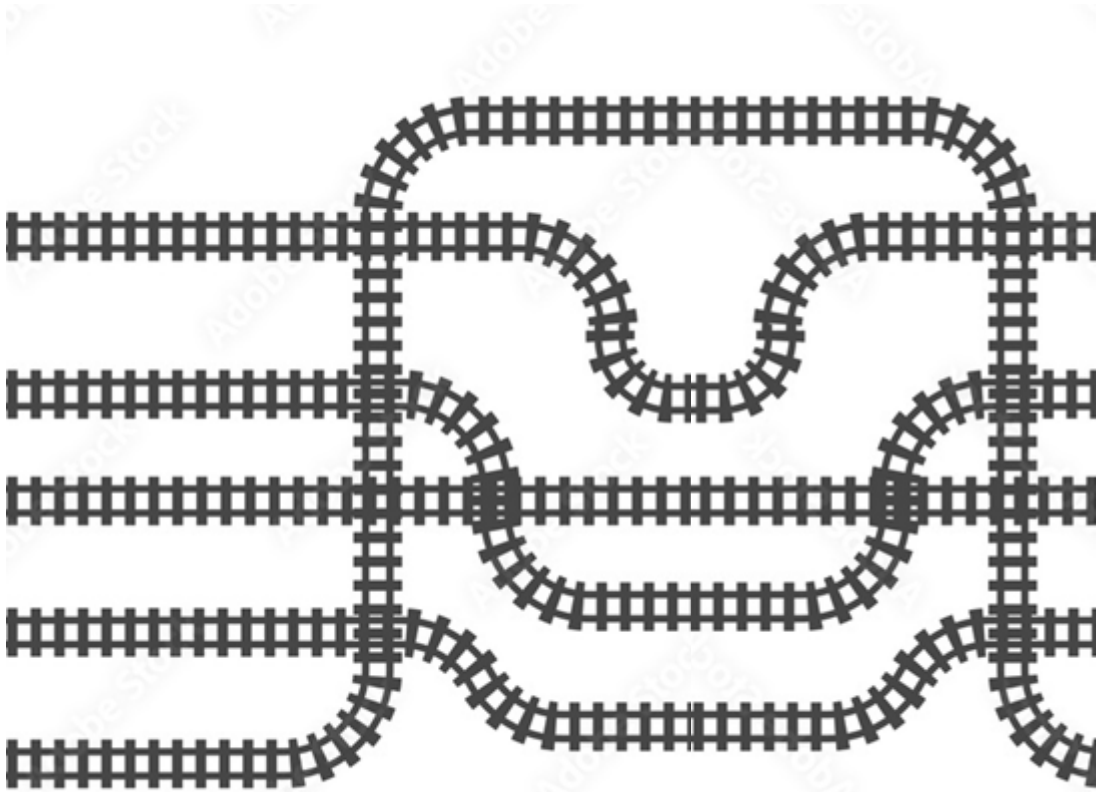
MAP MATCHING: ADVANTAGES AND REQUIREMENTS

Advantages:

- Can be done with just onboard sensors
- Cost-effective compared to the balises solution

Requirements:

- Onboard sensors
- Digital map

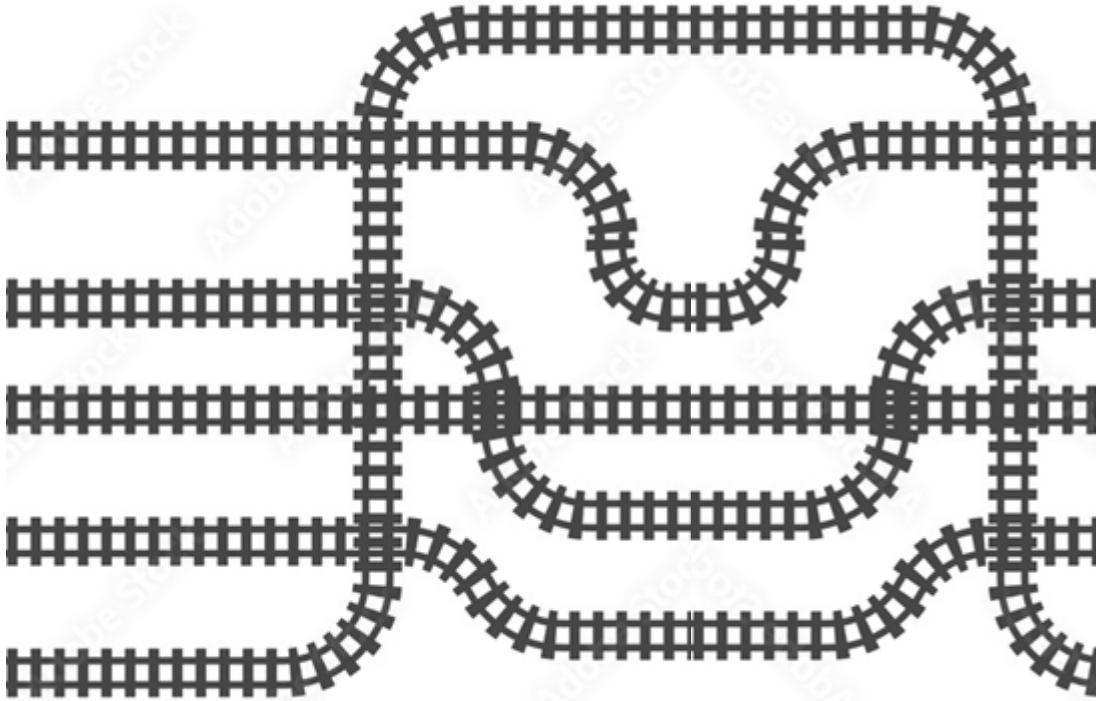


MAP MATCHING: DIGITAL MAP

Stores the topology and mileage of the railway network in absolute coordinates.

Requirements:

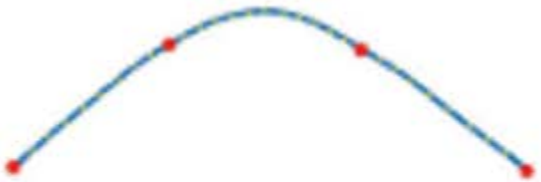
- Accuracy
- Storage efficiency
- Usability



MAP MATCHING: DIGITAL MAP GENERATION

From a set of coordinates, the most common digital maps reconstruction geometries:

Interpolation



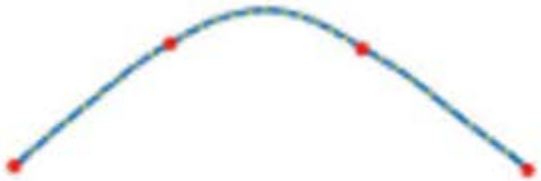
Curve

Geometric

MAP MATCHING: DIGITAL MAP GENERATION

Interpolation

- Least accurate
- Compact



Curve

- Trade-off in terms of accuracy
- Extra steps to calculate parameters

Geometric

- Most accurate
- Extra steps to calculate the parameters

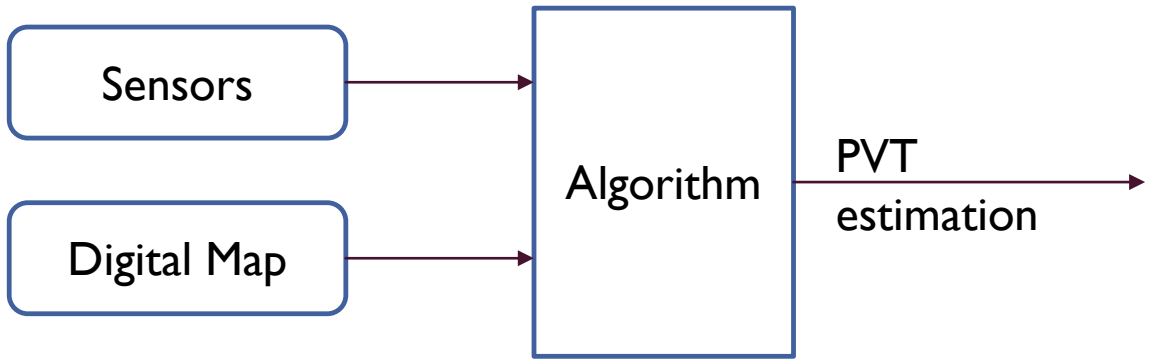
MAP-MATCHING CATEGORIES

Map-matching categories for train localisation:

I. Geometric

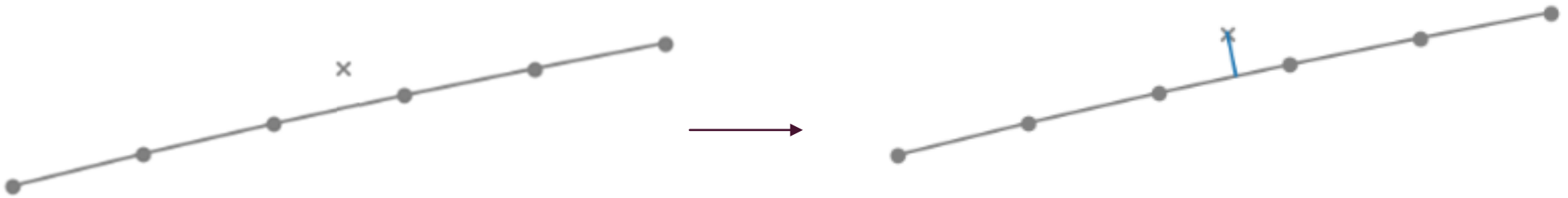
II. Similarity

III. Hypothesis



MAP MATCHING: GEOMETRIC

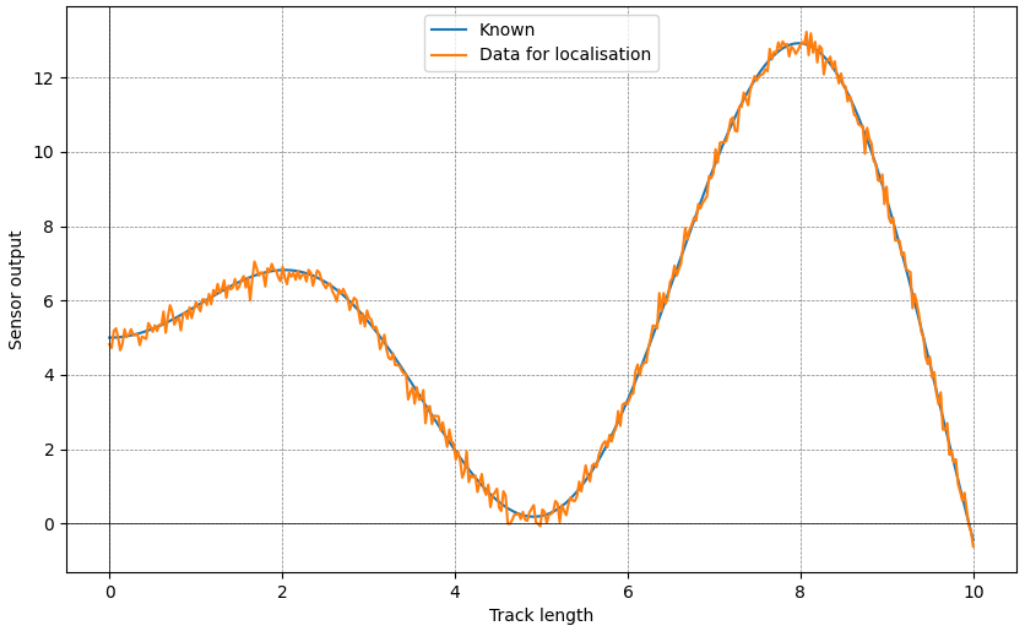
Considers only geometric information in a naïve approach



MAP MATCHING: SIMILARITY I

Compares the measurements from onboard sensors with known location-dependant data.

1. Topological: location-dependant data is known (Digital Map)
2. Feature matching: location-dependant data needs to be recorded

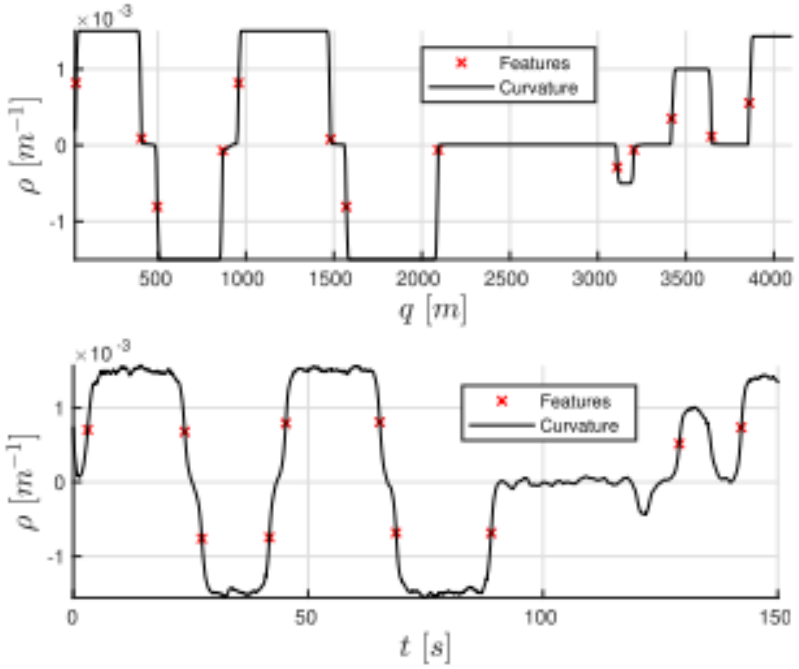


MAP MATCHING: SIMILARITY I

Compares the measurements from onboard sensors with known location-dependant data.

1. Topological: location-dependant data is known (Digital Map)

- Curvature classification: Matches the inertial measurements, corresponding to the track curvature, with the digital map
- Dead Reckoning Determines the present position by projecting the past courses steered and speeds over the ground from a known past position



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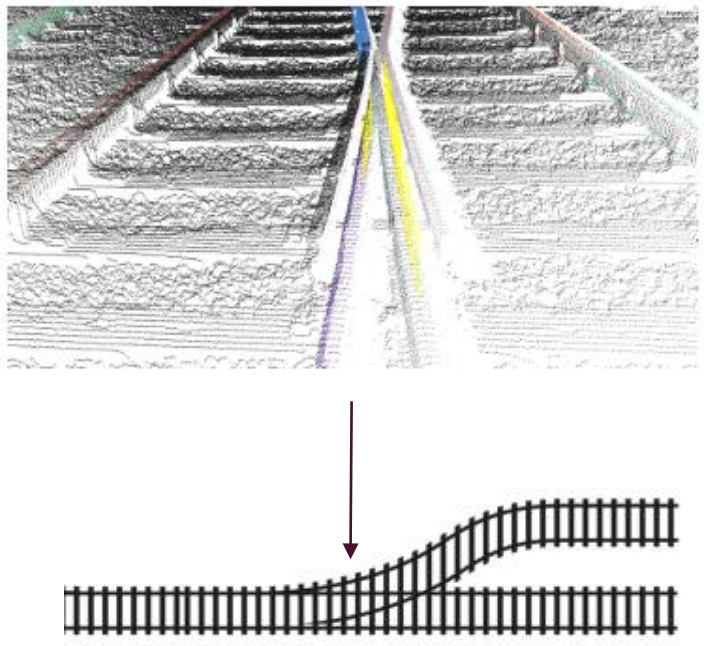
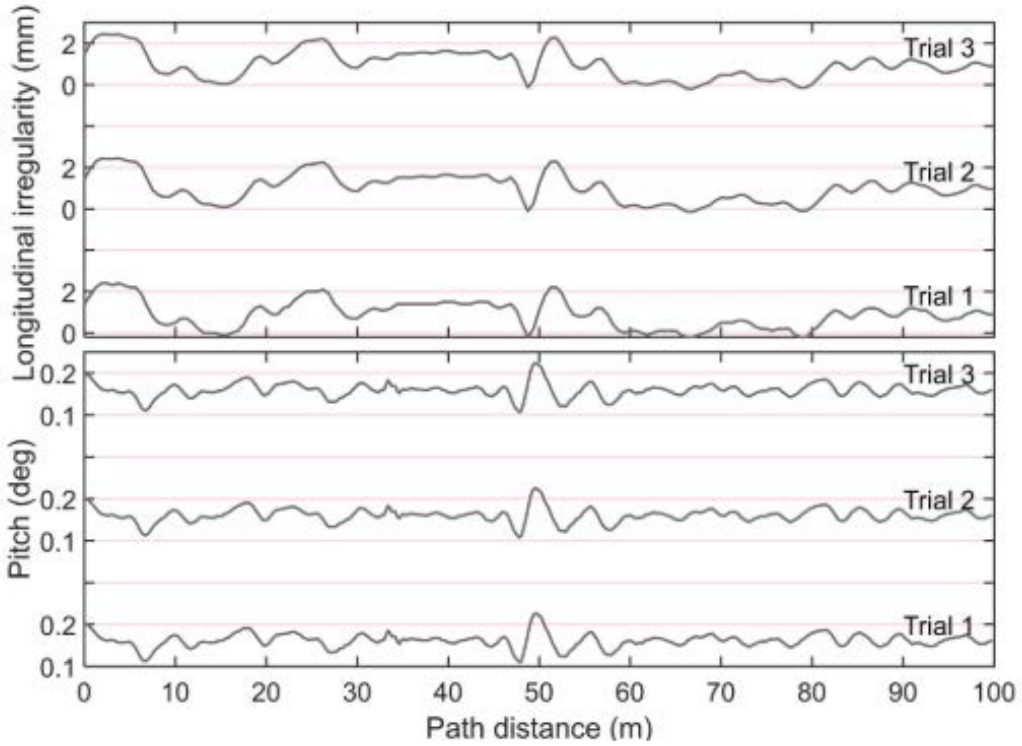


MAP MATCHING: SIMILARITY II

Compares the measurements from onboard sensors with known location-dependant data.

2. Feature matching: Matches the output of a sensor with previously recorded location-dependant measurements. Main sensors:

- IMU
- Magnetometer
- Lidar
- Camera



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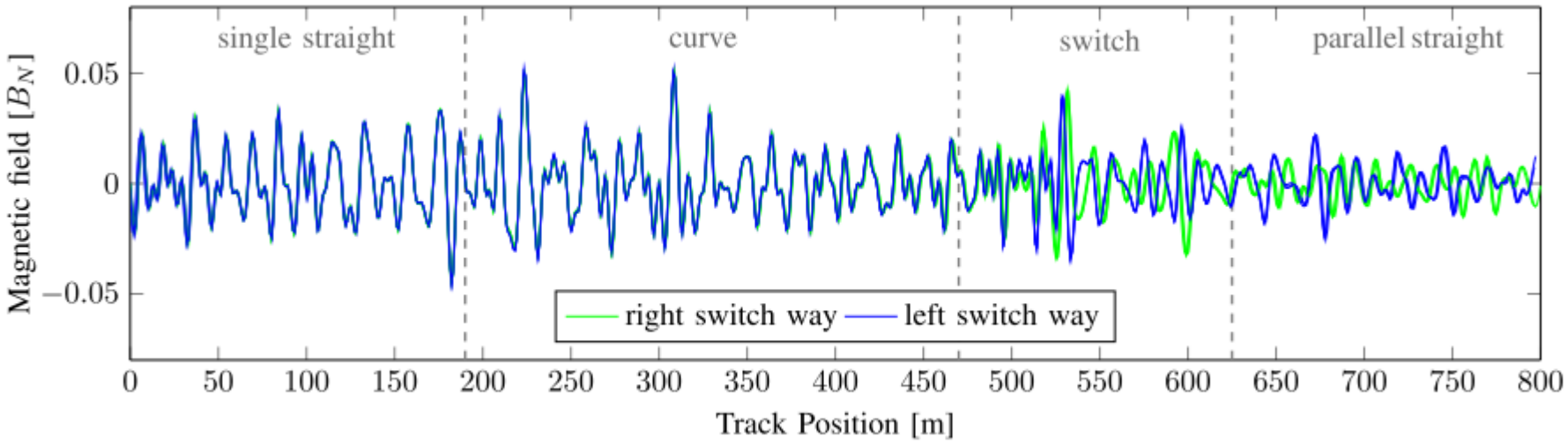
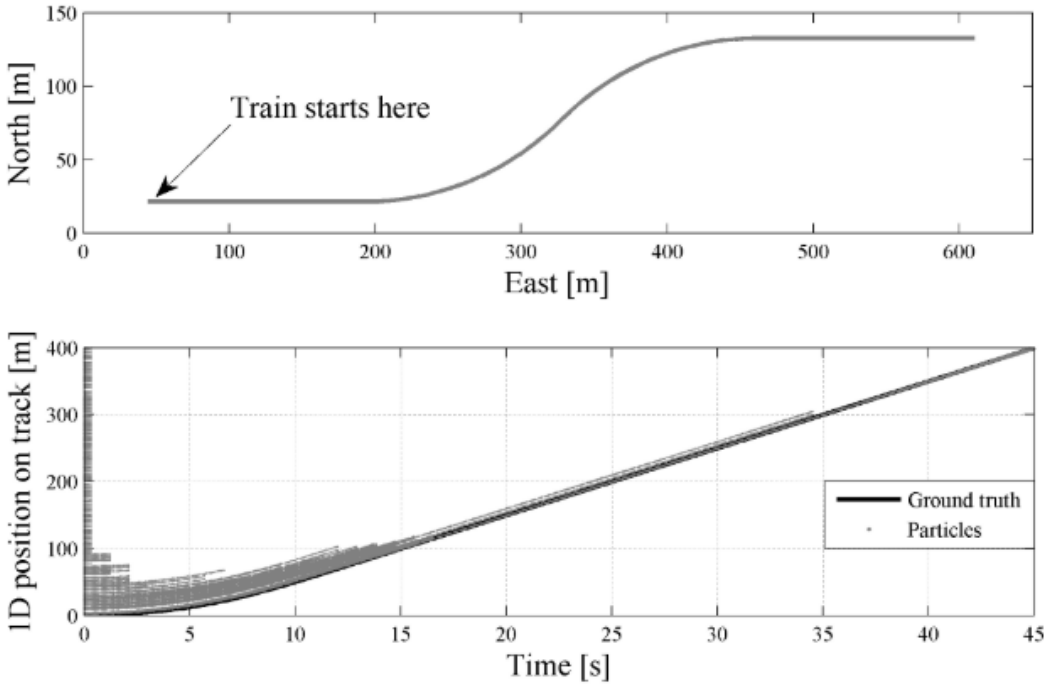


MAP MATCHING: HYPOTHESIS

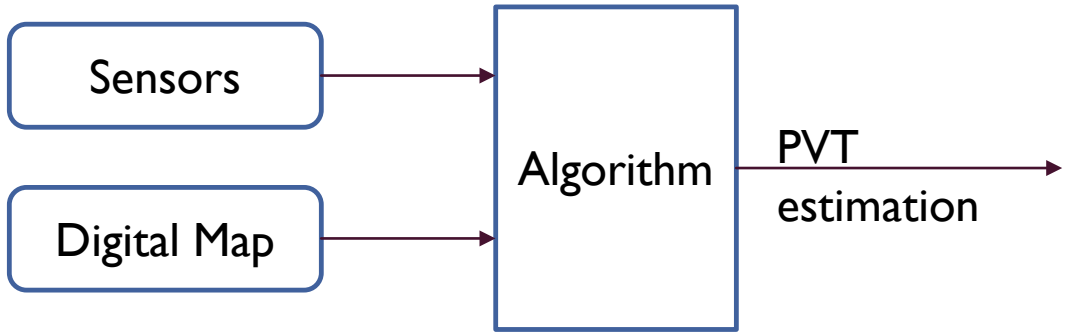
Exploits nonlinearity of the map-matching by considering positions on the tracks as hypothesis

- Particle Filter: Estimates a topological position directly in the track map, as the particles only exist on tracks
- Multi-Hypothesis: Different hypotheses are examined, defined as possible vehicle positions within the rail network



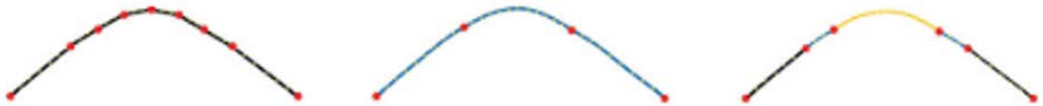
CONCLUSIONS I

Foundational research behind the map matching for train localization approach. Development of a positioning system based on the fusion of sensor data using the digital map concept.



CONCLUSIONS II

Three main geometries:



Interpolation Curve Geometric

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