Center for Sustainable Future Mobility (CSFM)

# Point cloud based deformation monitoring of railway tracks

Philippe Bättig[1], Julian Bleiker[1], Chiara Sabato[1], Annelies Voordendag[1], Pia Ruttner-Jansen[1,2], Nicholas Meyer[1], David Haener[3], Andreas Wieser[1]

[1]Geosensors and Engineering Geodesy (GSEG), Institute of Geodesy and Photogrammetry, ETH Zurich

[2]WSL Institute for Snow and Avalanche Research SLF

[3]SBB

## 1 Introduction

In a heavily used railroad network, reliable infrastructure maintenance is crucial. Increased track moisture is a common cause of deterioration, typically difficult to detect. Airborne laser scanning (ALS) can help to determine proxies. This project aims to automate and improve deformation analysis along large stretches of the tracks. Given the difficulty posed by the irregular, changing railroad ballast surface, the focus is on:

- Detecting rails and sleepers and assessing deformation in different airborne LiDAR datasets
- Matching displacements with information in SBB databases

## 2 Rail detection

An algorithm was developed to detect rails from the ALS data. This method involves three main steps:

1. Cutting profiles across the tracks
2. Identifying the peaks as the rails within the profiles
3. Merging results of all profiles and filtering for outliers

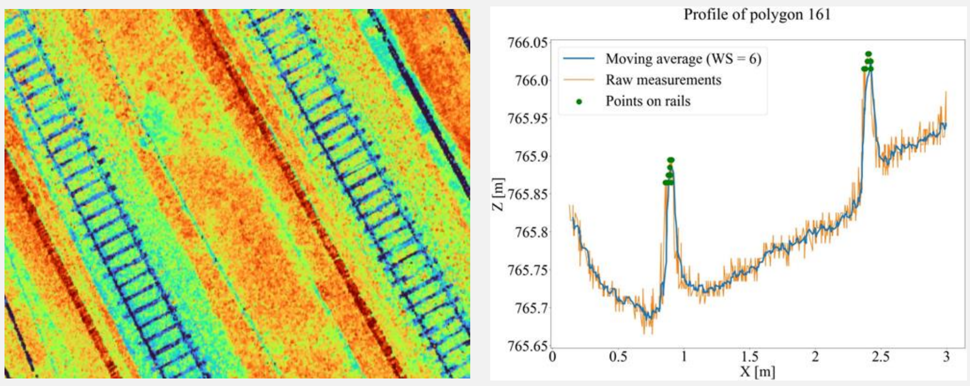


Figure 1: Intensity images of railway tracks (left) and an example of a the profile across a track (right)

## 3 Sleeper detection

The sleeper detection algorithm assumes that sleepers differ from the surrounding track in intensity and geometry. As an initial step, a handcrafted algorithm was developed as follows to find points lying on sleepers:

1. Identify LiDAR points along the center of the track, using the detected rails or prior location information
2. Find local extreme values of intensity and height
3. Keep points that close to intensity minima and height maxima

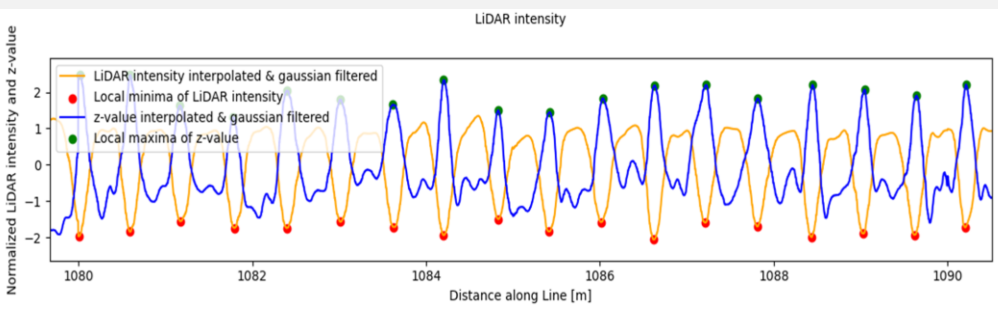


Figure 2: Gaussian smoothed z-value (height) and the LiDAR intensity vs the distance along the middle line of the railway

## 4 Matching displacements with SBB databases

Deformations between epochs are derived with the M3C2 algorithm, and the objective was to determine the causes of these displacements. This is achieved by:

1. Establishing clusters geometries
2. Visualizing displacements on an interactive map
3. Integrating information contained in SBB databases

To ensure precise alignment of data, a conversion tool was developed to transform LV95 coordinates into the SBB kilometer system and vice versa.

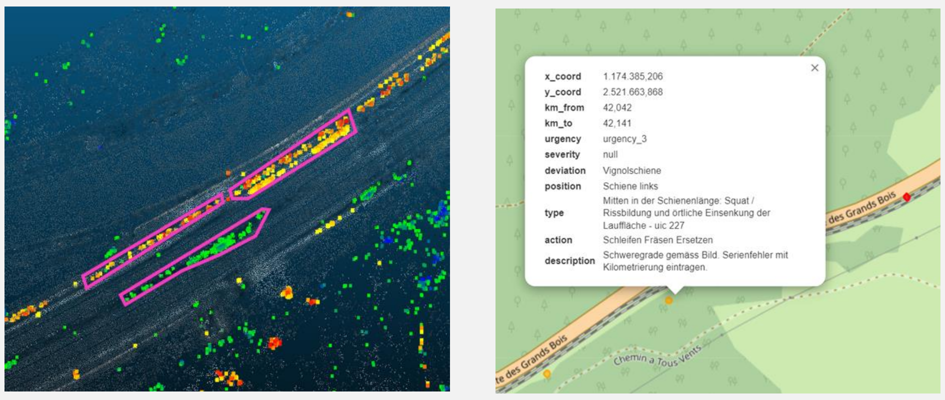

Figure 3: Displacement clusters (left) and interactive map with information from database (right).

## 5 Results and discussion

**Rail and Sleeper Detection**

To classify points on rails and sleepers, height information is beneficial, while LiDAR intensity should be interpreted carefully. The proposed methodology allows for identifying points on rails regardless of the point cloud resolution. Sleeper detection is more challenging due to the minimal height differences compared to the neighboring ballast and the different materials used for sleepers. This detection algorithm is currently being generalized. However, it already allowed showing that sleeper detection helps to detect deformation with higher sensitivity.

**Data Matching**

Interpreting the content of the SBB database automatically can be quite difficult. However, visual representation of instances helps to identify possible problems along the tracks.

## 6 Conclusion

The study shows the challenges of using LiDAR for displacement analysis of railway infrastructure. With the current data and collection setup, infrastructure with known properties can be identified and classified effectively. However, for more detailed analysis, higher resolution datasets collected closer to the ground (less than the current ~250m) are recommended.

The tools developed during this project enable the extraction and analysis of features from point clouds measured on railway sections. These tools can be combined and integrated into systems to support SBB's efforts in maintaining and monitoring railway infrastructure.

Partner: amag, SBB CFF FFS, SIEMENS