

Optical train localization

 SBB CFF FFS

AMIDEPFL



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Optical train localization



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> @ SBB booth



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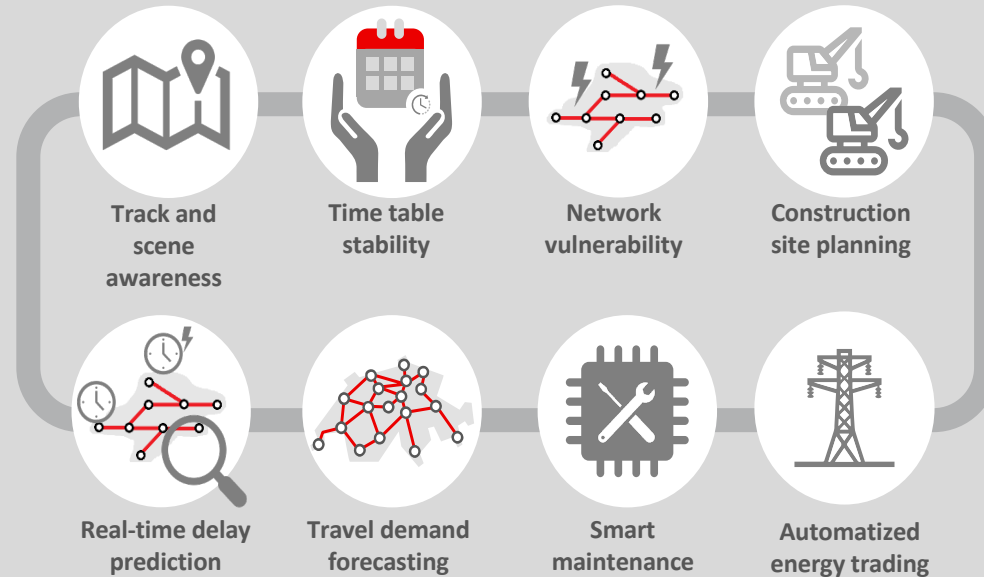
> @ SBB booth



Nima Riahi

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> @ Workshop «Theory meets Practice»



Delay prediction

Autonomous traffic management



Adrian Egli

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Erik Nygren

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> @ FLATland challenge
(Challenge track, 15:35)



FLATLAND

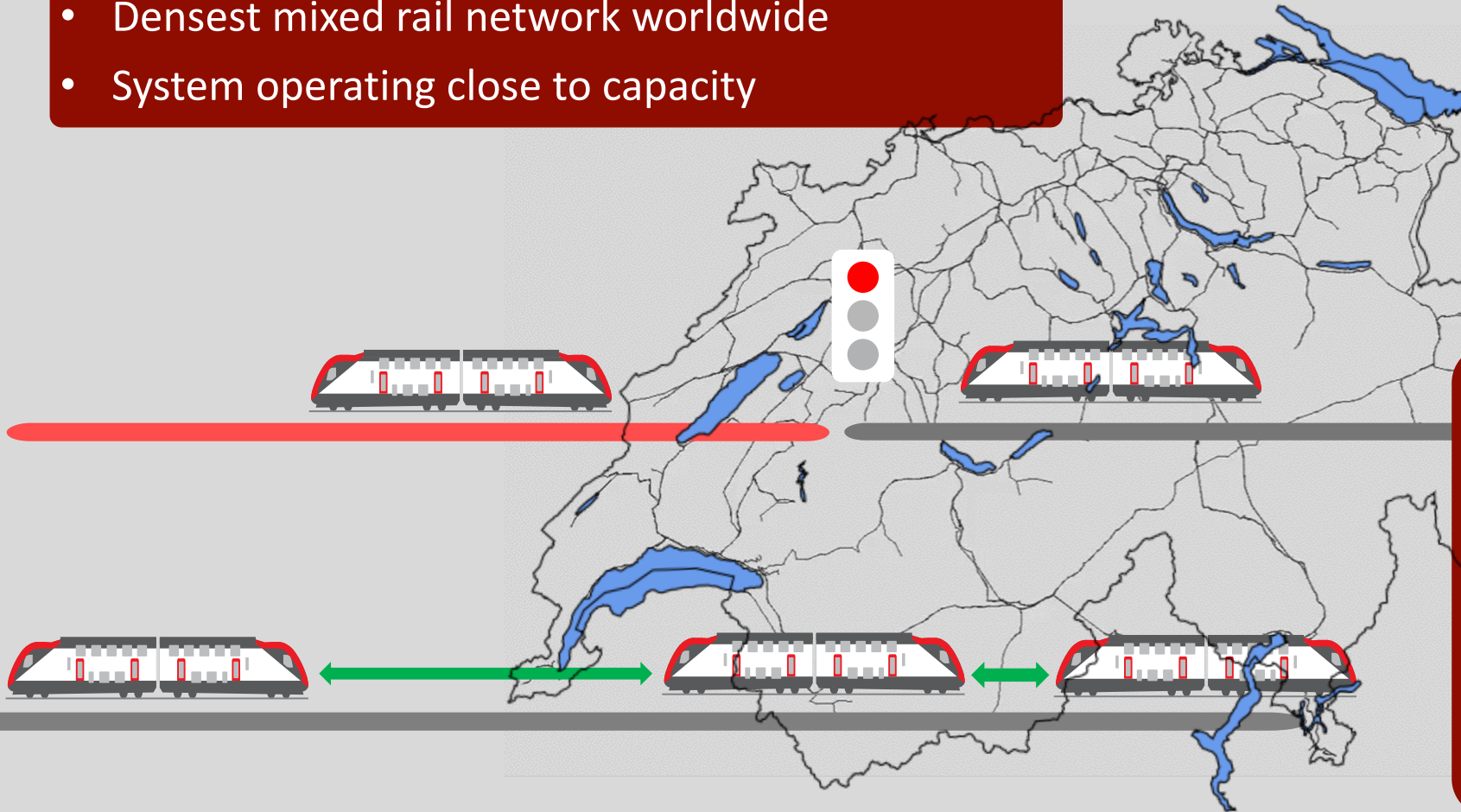
SmartRail 4.0

Goals and Vision 2040



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- Densest mixed rail network worldwide
- System operating close to capacity



Goals and Vision 2040!

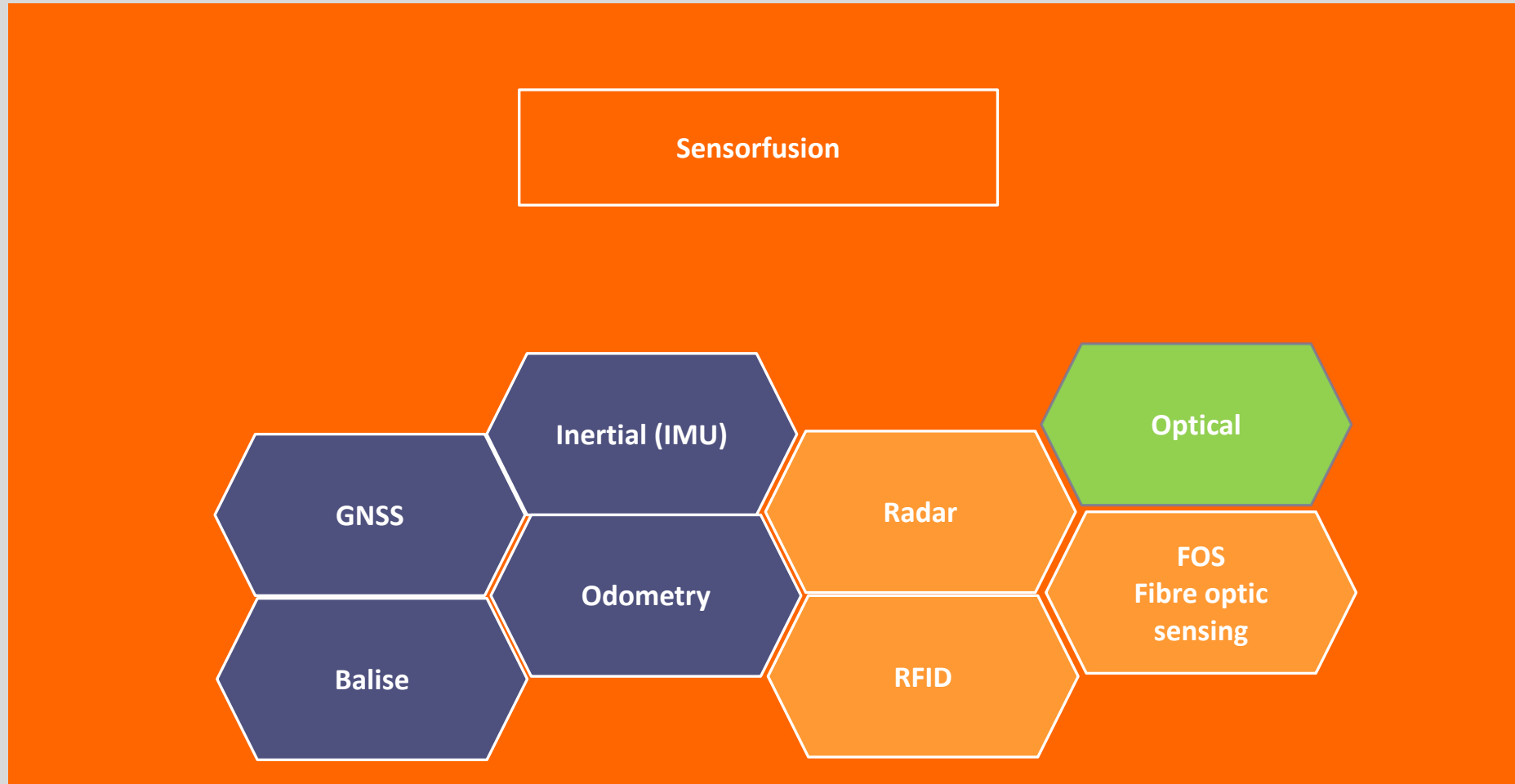
- **Increase capacity**
- Increase safety
- Reduce costs
- Improve punctuality
- Better customer service

Increase safety and capacity by precise train localization

Reliable localization using sensor fusion



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Optical train localization

Motivation and advantages



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Motivation

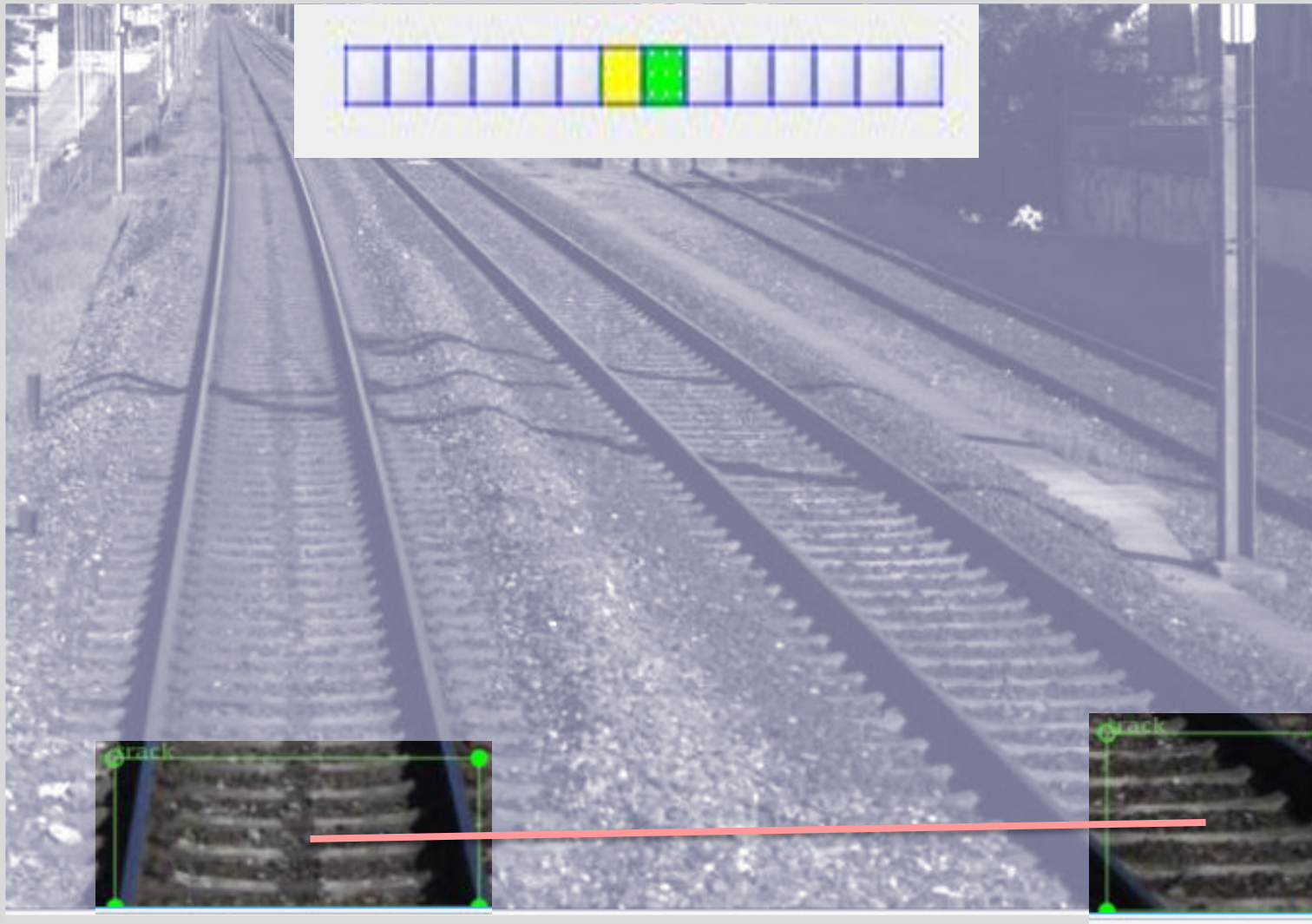
- Current approach (Balise) depends on additional external hardware
- **In dense urban environments (near stations) GNSS not precise enough for lateral localization (track wise positioning)**
- GNSS requires permanent connection
- **GNSS interference (jam signals) in urban environments**
- Odometry and IMU have to be periodically recalibrated (w. GNSS or Balise)
- **Position of Balise is not exact and can vary with time**

Iteration 1:

Network learns 'tracks'



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Initial setup

- Training data from measurement vehicle
- Front camera
- YOLO CNN for object detection

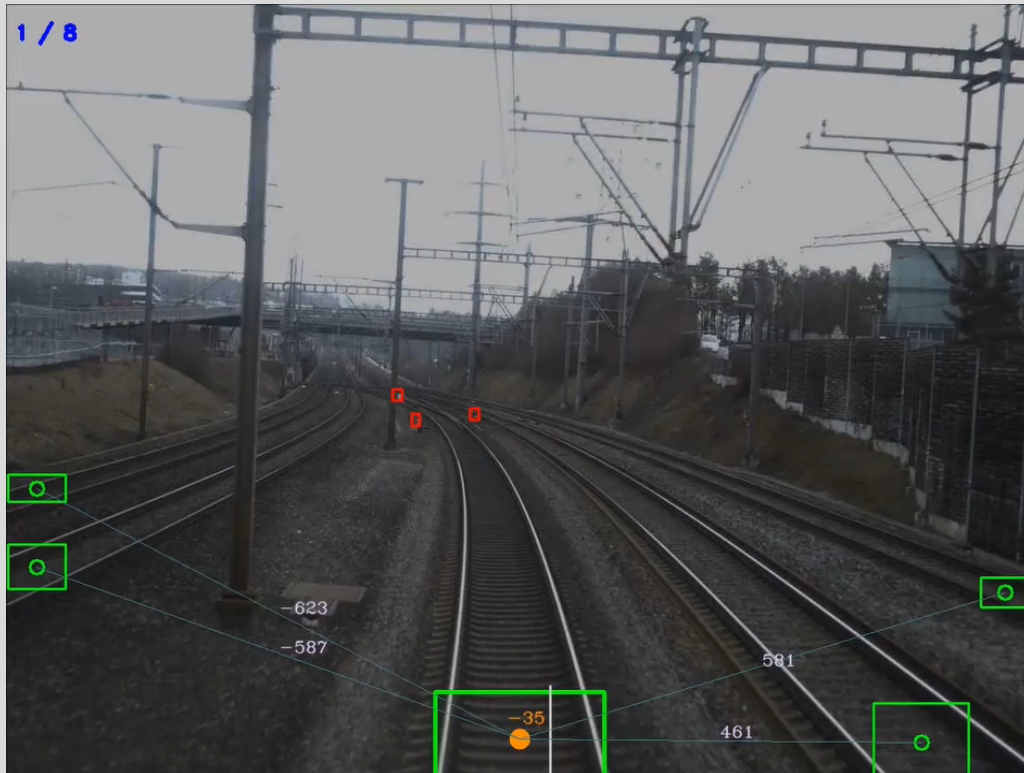
Iteration 1:

Network learns 'tracks'



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- Track selectivity recognition rate > 95%
- Tested at different weather conditions (fog, snow, ...)
- Classification of other objects (signals, balise, ...)

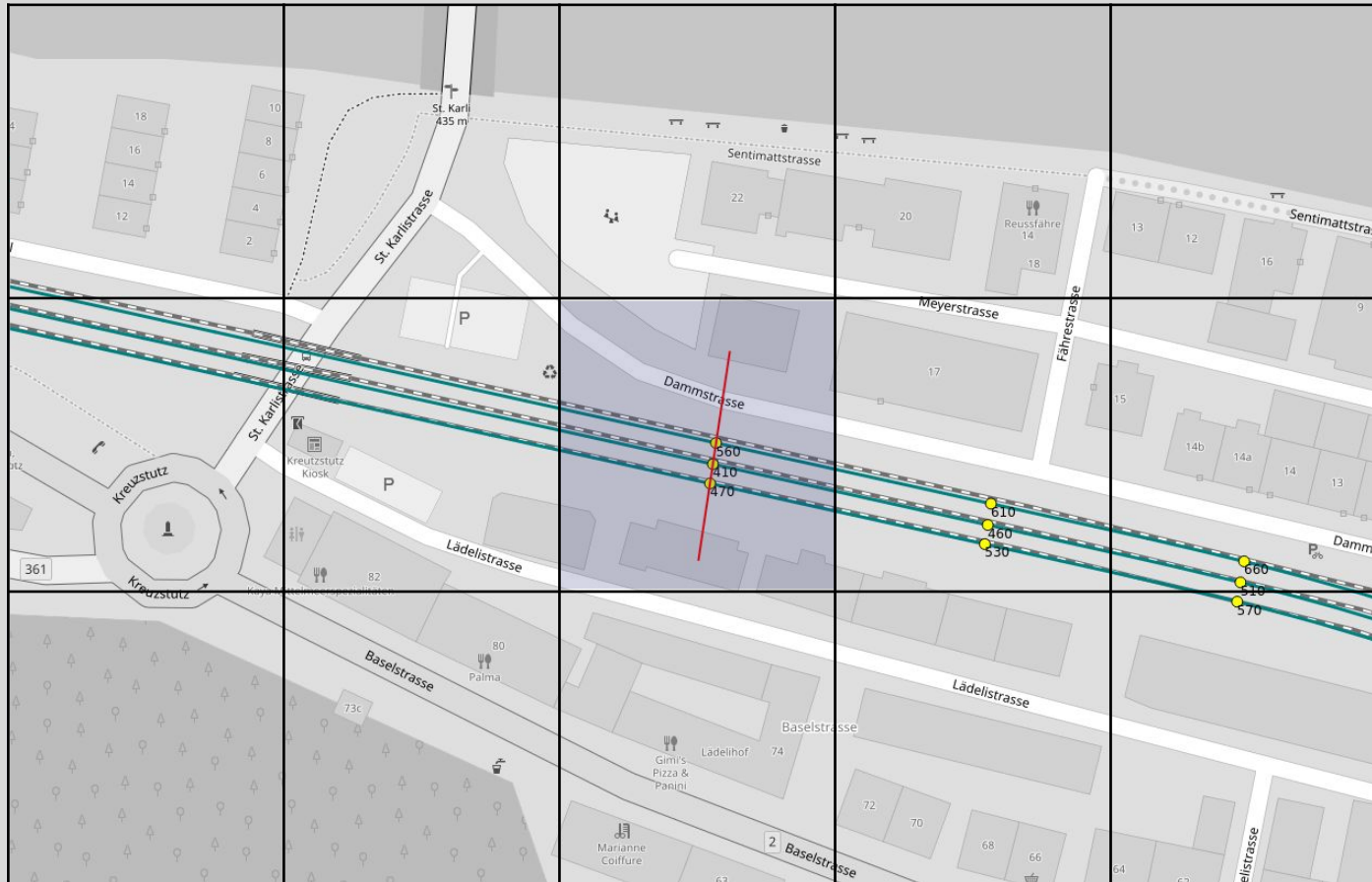


Iteration 2:

Track selective mapping



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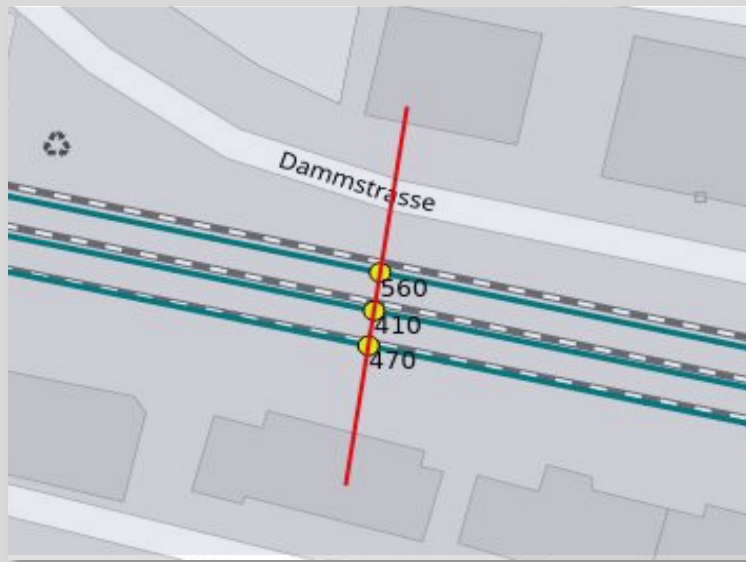
- Integration via topology database (DfA) to obtain track layout
- Longitudinal position from GNSS (square in track topology)
- ...

Iteration 2:

Track selective mapping



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Matcher algorithm
/ topology lookup

Track selective train localization

- Integration via topology database (DfA) to obtain track layout
- Longitudinal position from GNSS (square in track topology)
- Lateral position (track selectivity) from optical detection
- Integration of longitudinal and lateral positions matcher algorithm / topology lookup

Iteration 3:

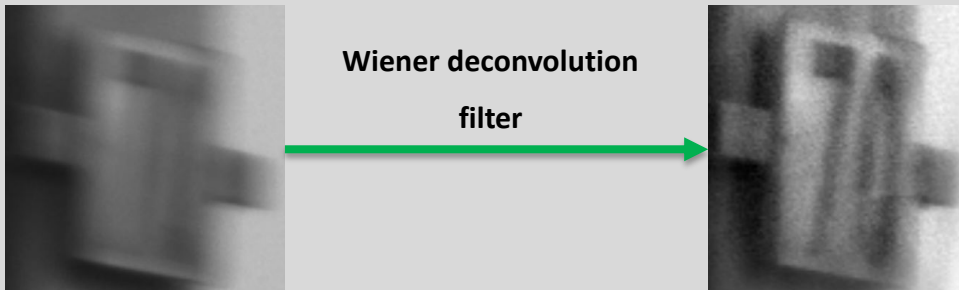
GNSS independent longitudinal position



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Detect longitudinal position by km-sign on poles

- Pole position is exactly measured in topology database
- Poles have short distance to train
- Km-signs not readable from front camera
 - > use 45° side camera
- YOLO network to detect and read km-signs
- Obtain longitudinal position by topology database mapping algorithm



Iteration 3:

GNSS independent longitudinal position



The screenshot displays a software interface with several panels:

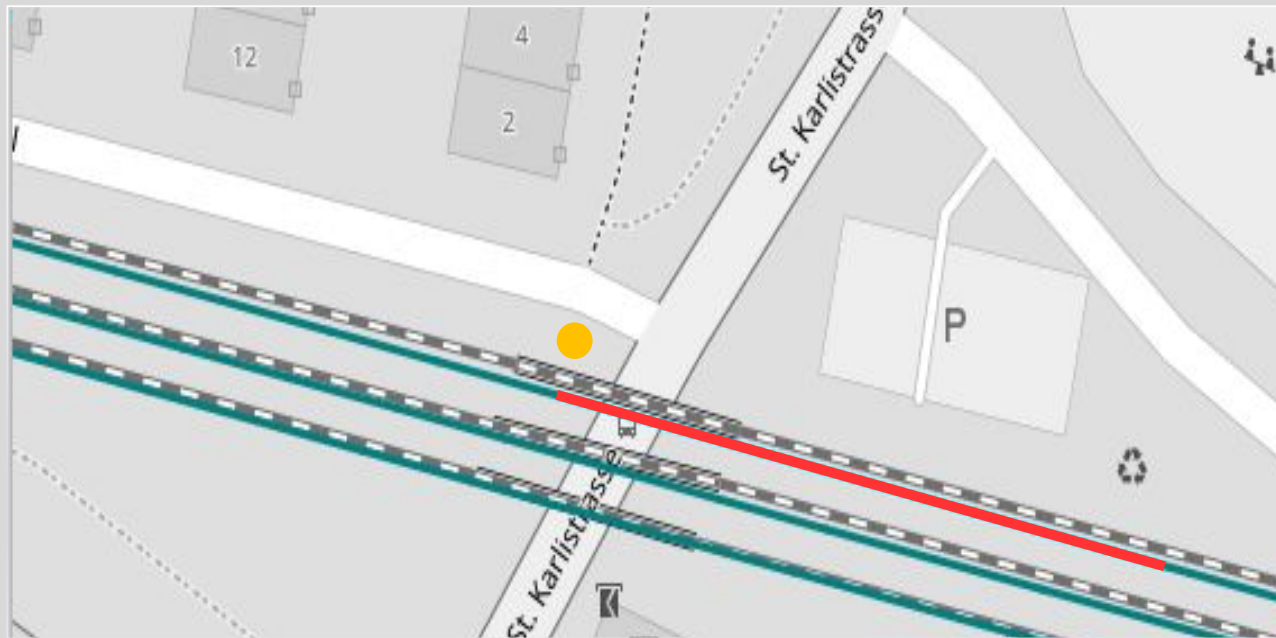
- DFZ Data:** A file explorer on the left showing a directory structure. The 'Topology_Match' folder is selected. The structure includes folders for 'validation' (with sub-folders for dates like 20170725_150030), 'chiasco', 'einfahrt_bern', 'einspur', 'grayscale', 'kmtafel', 'regen', 'schneedecke', 'tunnel', 'zweispur', 'zweispur_daemmerung_schnee', and 'zweispur_nacht'.
- Topology Matcher:** A panel on the top right with a progress bar and labels for 'Betriebspunkt: -' and 'Gleisstrang: -'.
- Tracks:** A central video frame showing a railway track scene. It includes a frame counter 'Frame: 2', 'Detections: 5', and 'fps: 0'. The video shows tracks with overhead power lines and a train in the background. Green bounding boxes highlight detected track segments, with labels like '-687' and '516'.
- Map:** A bottom-left panel showing a map of the railway tracks with colored lines (green, blue, pink) representing different track segments or data points.
- KM Tables:** A panel at the bottom right, currently empty.
- Status Bar:** A bottom status bar showing speed '77 km/h', coordinates '47.05487 Lat 8.28940 Lon 7 Deg', and distance '5293276 m'.

Iteration 4 (future work):

Exact longitudinal position by train-pole distance estimation



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Optical distance estimation

- **Stereo camera system (front and 45° side camera)**
 - Limited recognition of km-sign if front camera
 - Only limited overlap of field of view between the two cameras
 - Requires exact relative calibration of cameras
- **Stereo camera system (two 45° side cameras)**
 - Requires additional camera and exact relative camera calibration
- **Sequential information from 45° side camera**
 - Requires additional sensor to estimate movement between sequential images
- **Single image from 45° side camera**
 - Distance based on size of km-sign
 - Distance based on geometric information (pole position in image and topology database)
 - Distance from Deep Learning approach

Iteration 4 (future work):

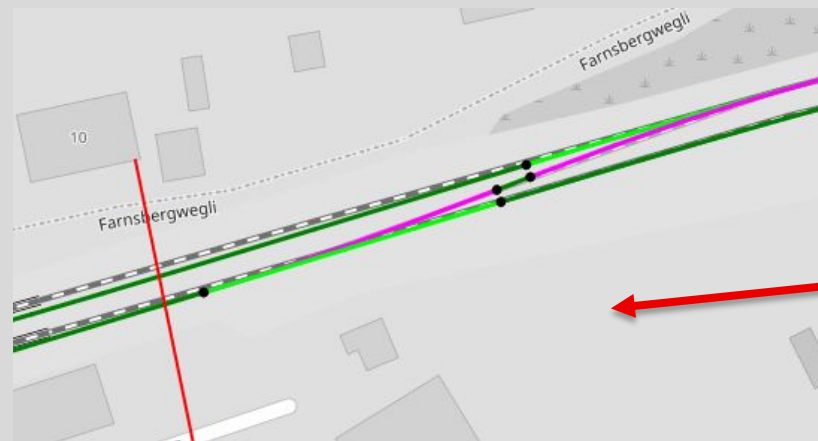
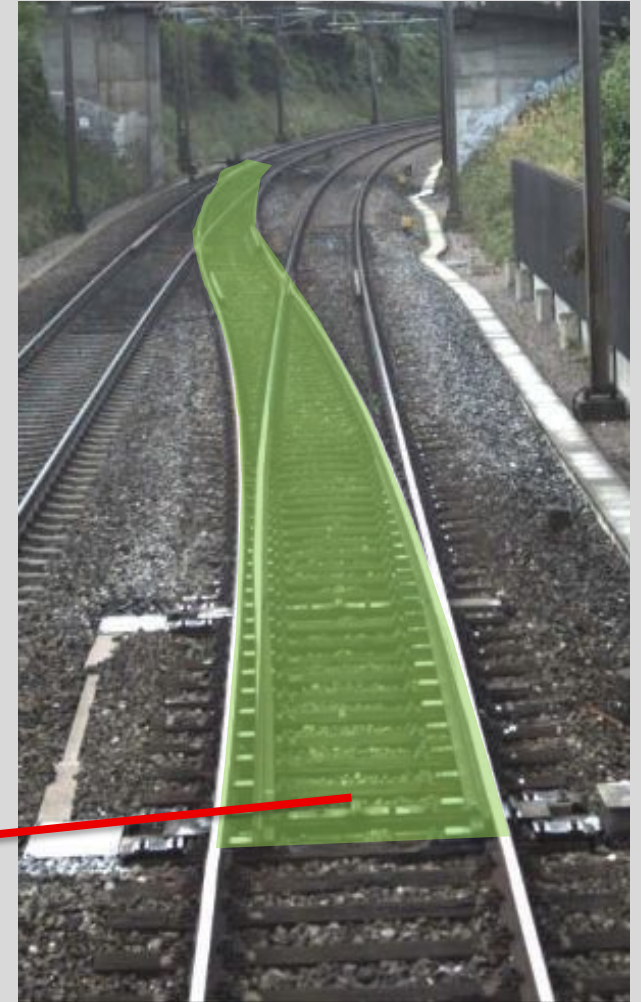
Prediction of pathway / position



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Optical pathway prediction by recognizing tracks and switch positions

- Recognition / segmentation of active track
- Recognition of switch position
 - Matching with topology can lead to optical pathway / position prediction
- Additionally, switch-train distance estimation can lead to improved longitudinal position



Pascal Linder

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> @ SBB booth

Iteration 4 (future work):

Prediction of pathway / position

Current status:

- Track segmentation using CNN's
- Semantic segmentation trained on RailSem19* data-set
- Switch position not viable by classification
 - > Use segmentation approach
 - > Generate segmentation data-set with only active track

* O. Zendel, M. Murschitz, M. Zeillinger, D. Steininger, S. Abbasi, C. Beleznai:
RailSem19: A Dataset for Semantic Rail Scene Understanding. CVPR Workshops
2019: 32-40



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