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Building Consistent Laser Scan Maps

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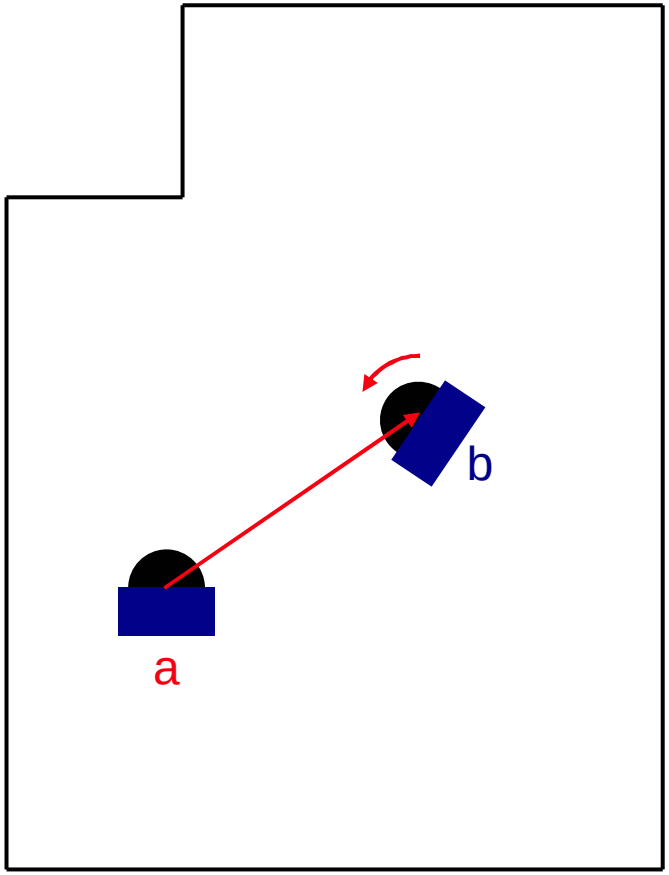
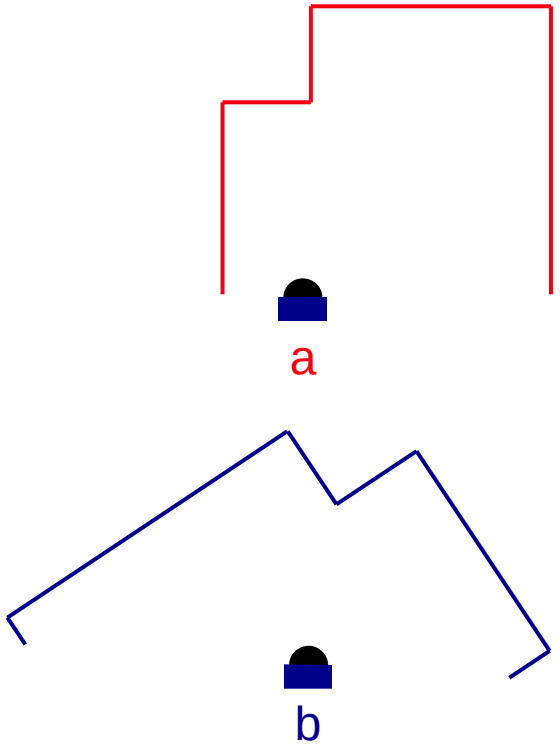
Contents

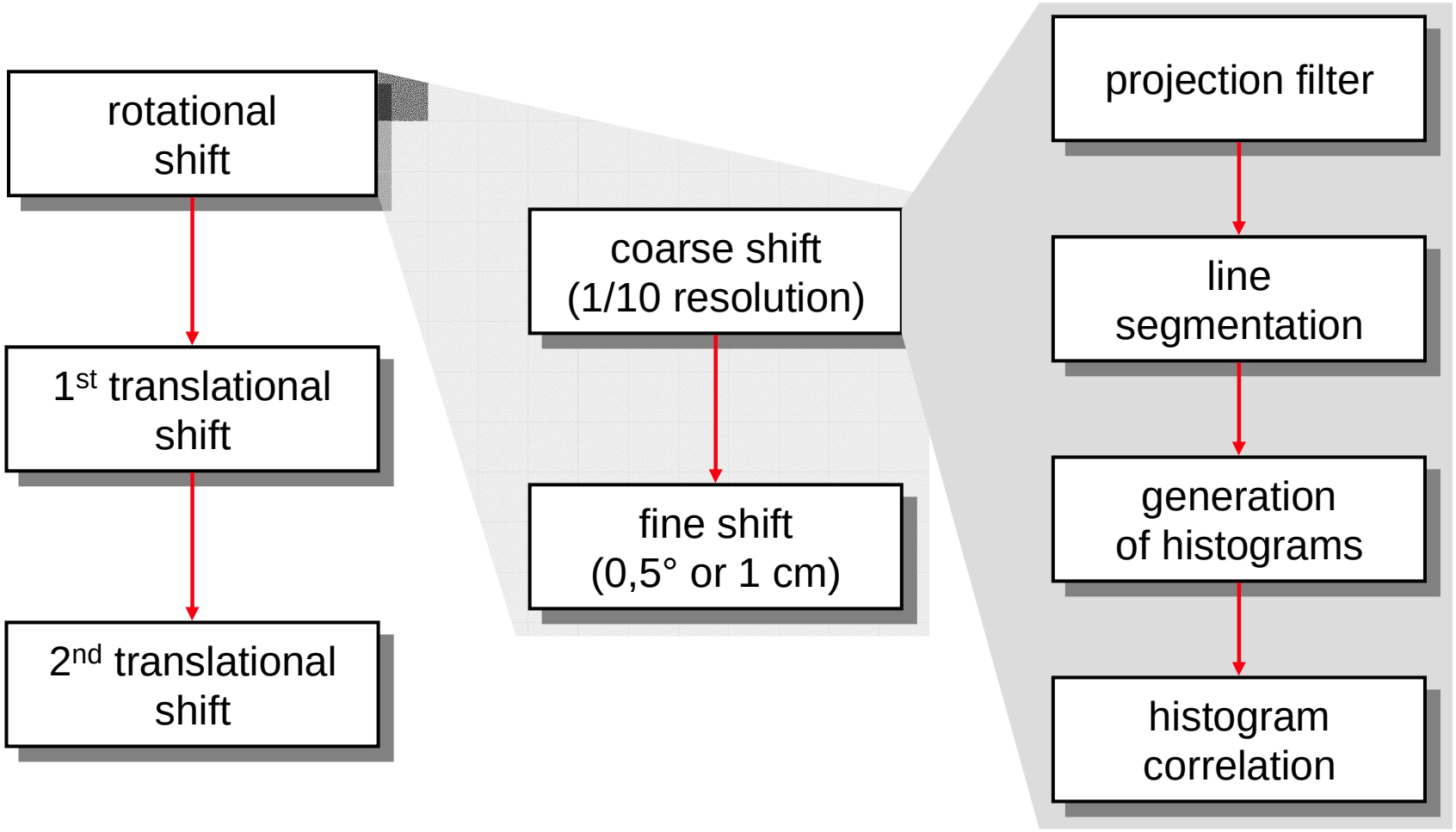
- **Scan Matching Approach**
  - Basic Idea
  - Projection Filter
  - Spatial Offset between Scan Positions
- **Map Building & Self-Localization**
  - Odometry vs. Scan Matching
  - Distribution of Errors
  - Examples
- **Conclusion & Outlook**

Basic Idea

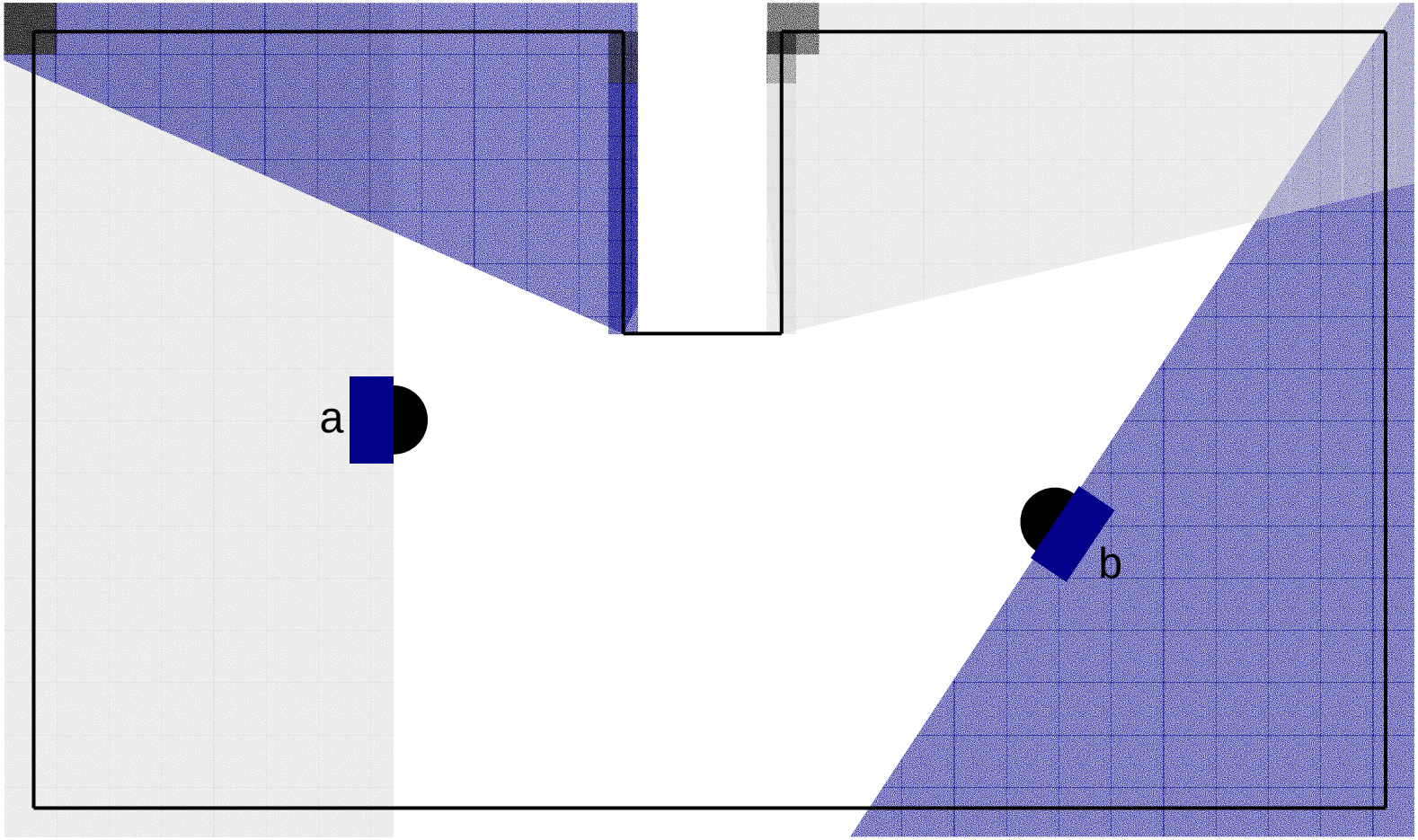




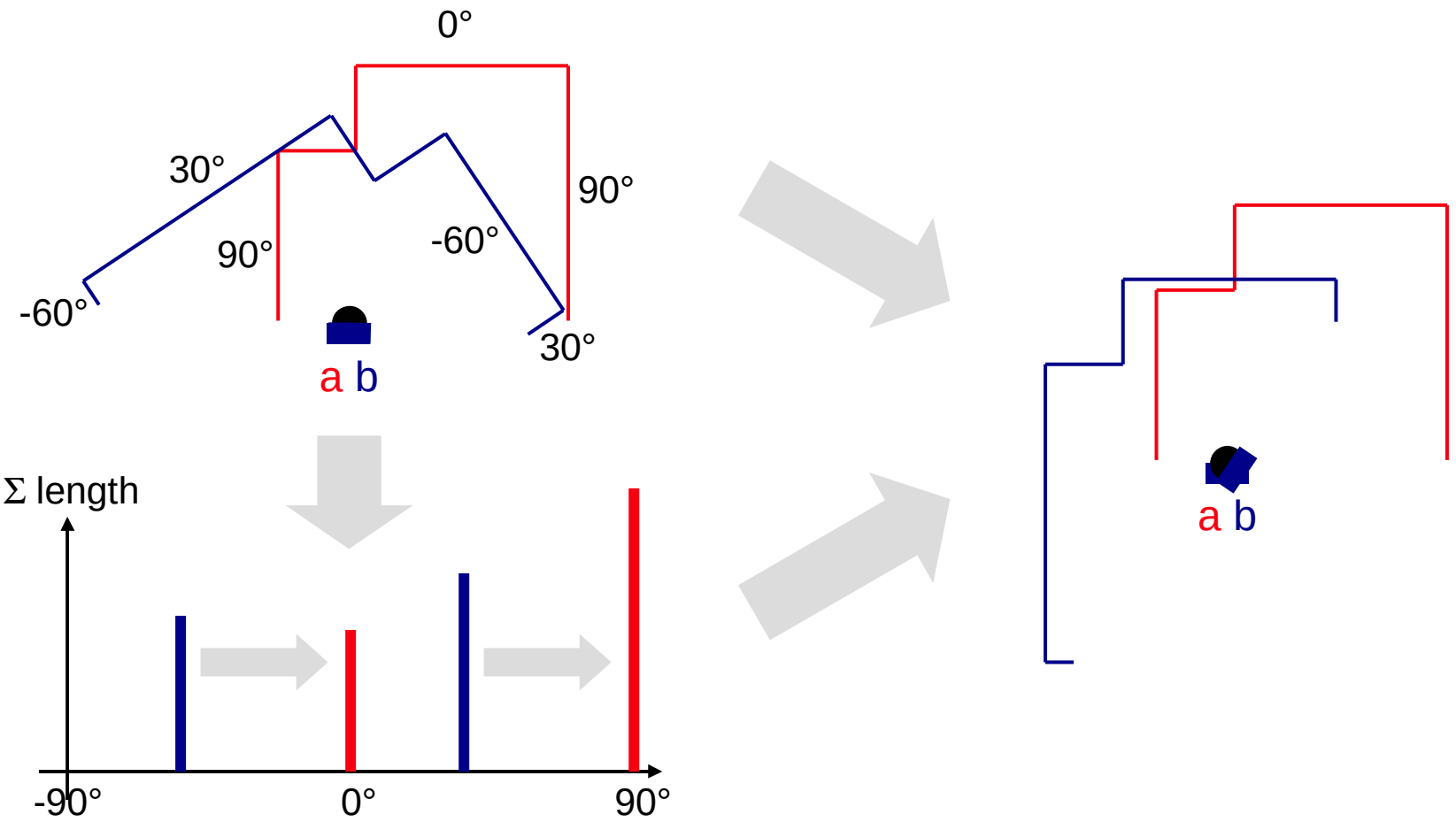
Approach


rotational shift
1st translational shift
2nd translational shift
coarse shift (1/10 resolution)
fine shift (0,5° or 1 cm)
projection filter
line segmentation
generation of histograms
histogram correlation

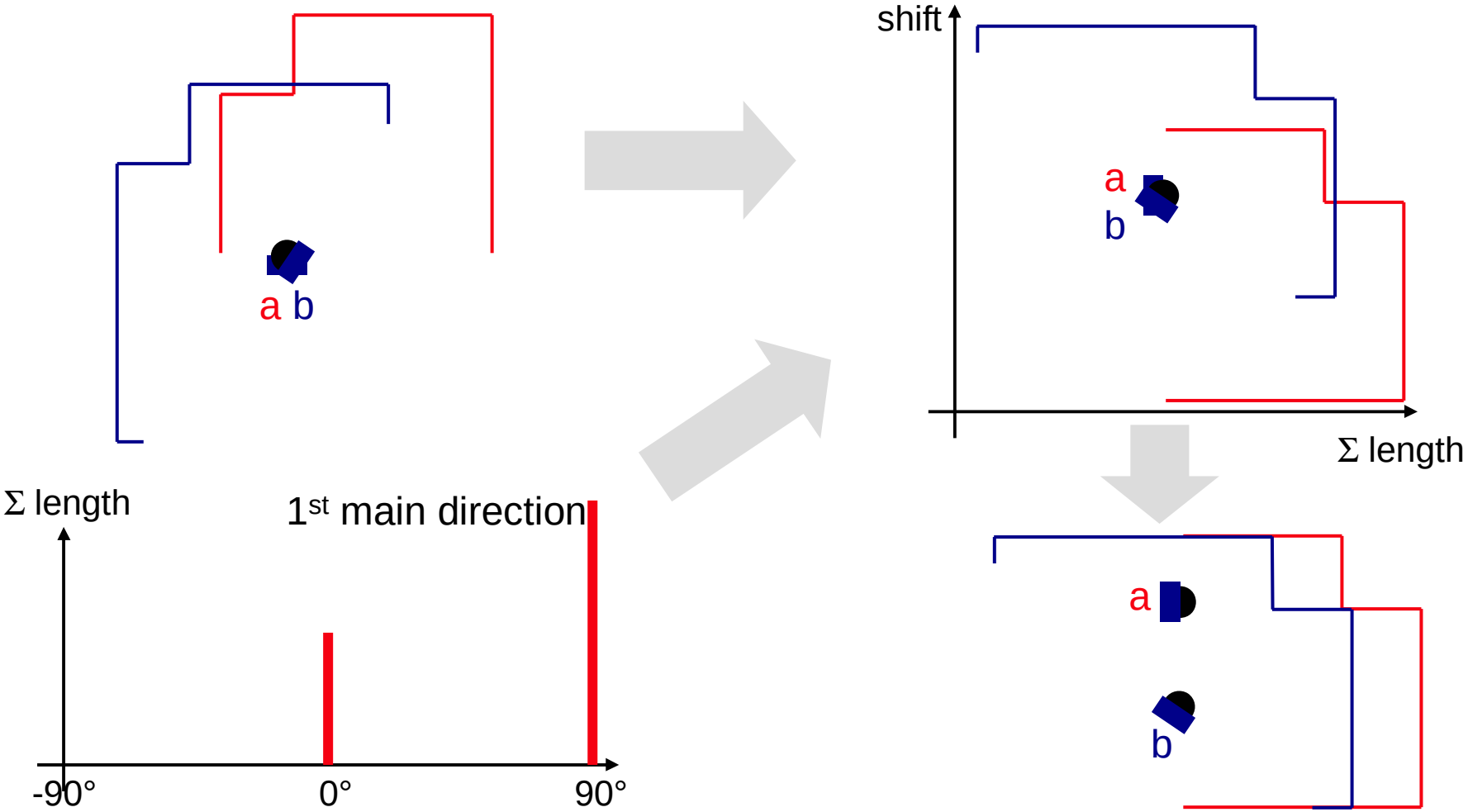
Projection Filter



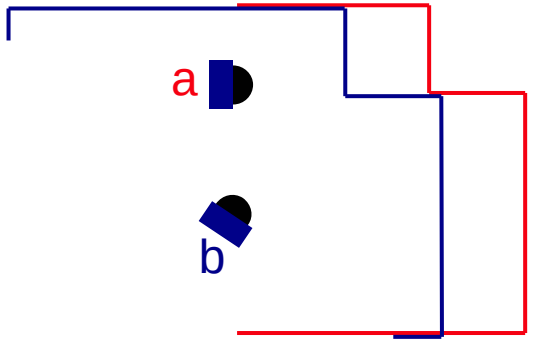
Rotational Shift

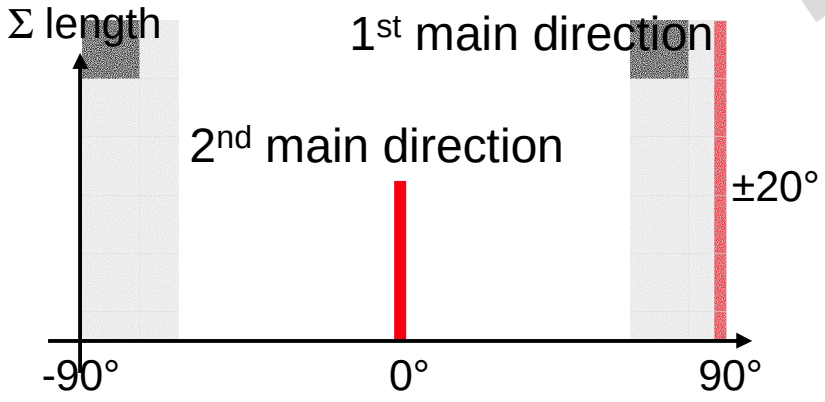


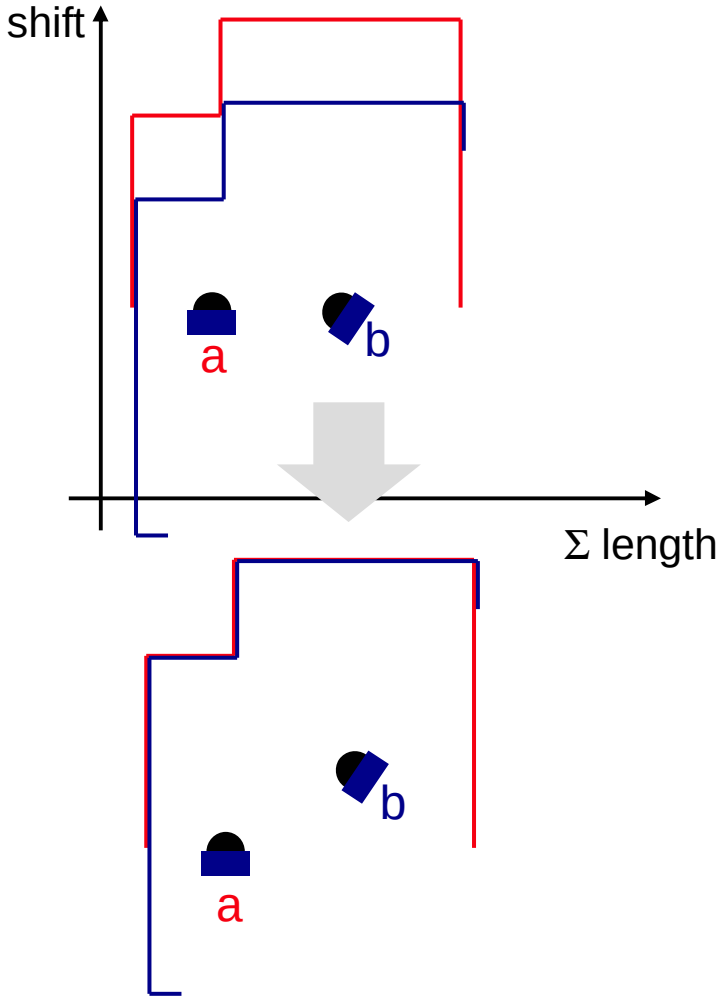
1st Translational Shift



2nd Translational Shift

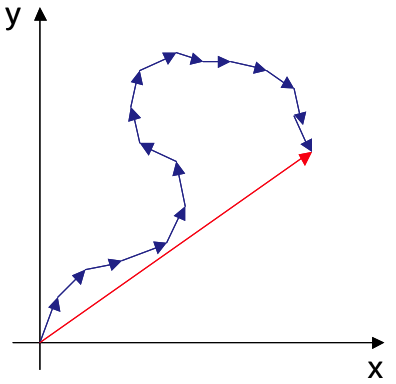


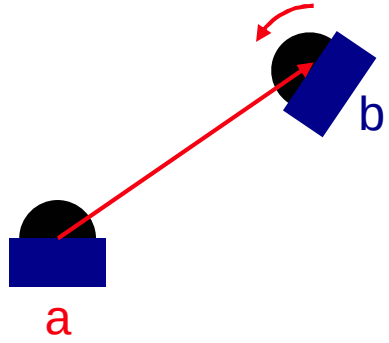




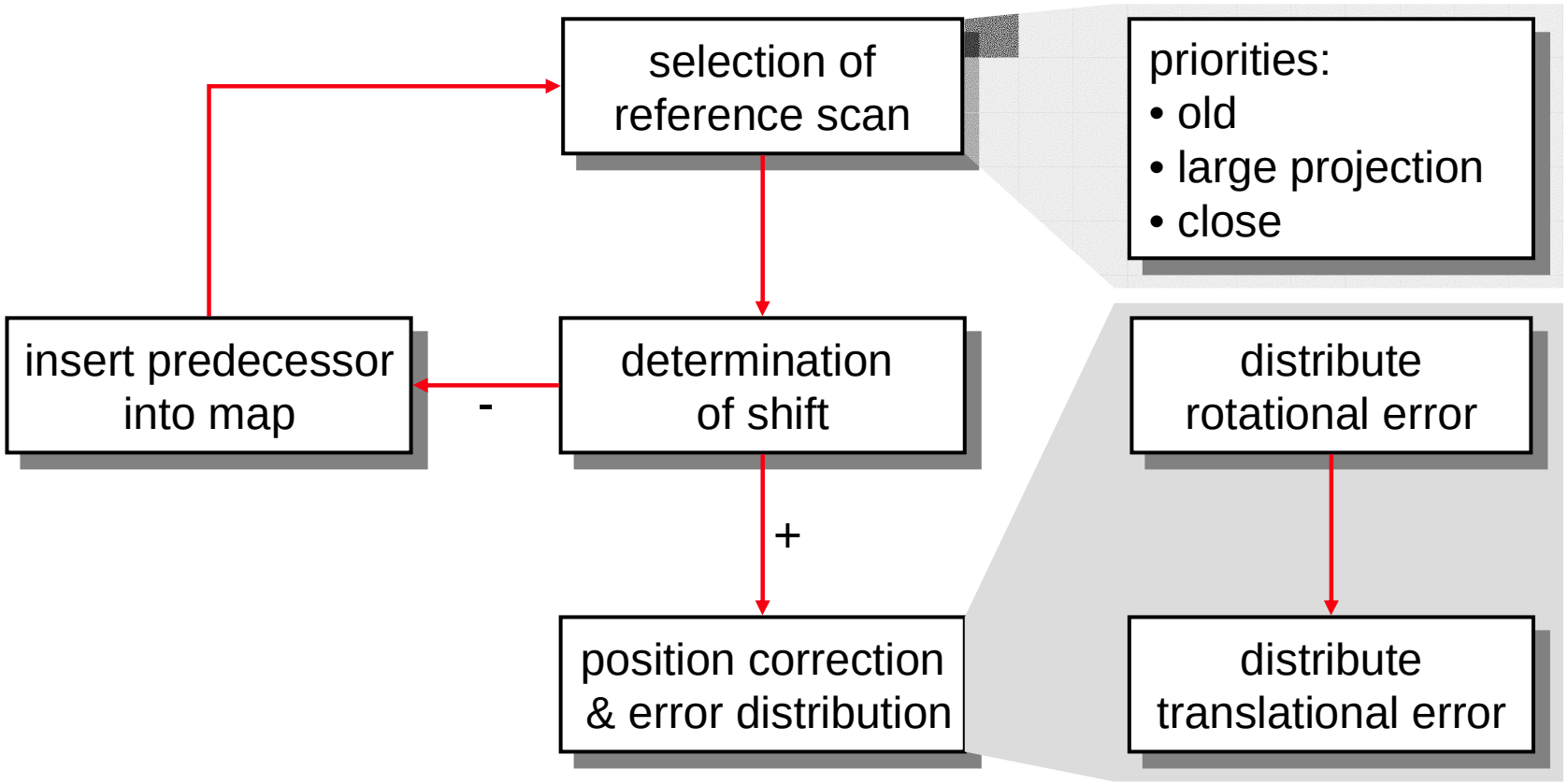
Odometry vs. Scan Matching

- **Odometry**
  - Stringing together small offsets
  - Each error affects all successive positions
- **Scan Matching**
  - Stringing together small offsets
  - Each error affects all successive positions
- **But:**
  - The offset can be significantly larger, and therefore a smaller number of scans is required (reference scans)
  - Using a map, the errors can be corrected when returning to a known area

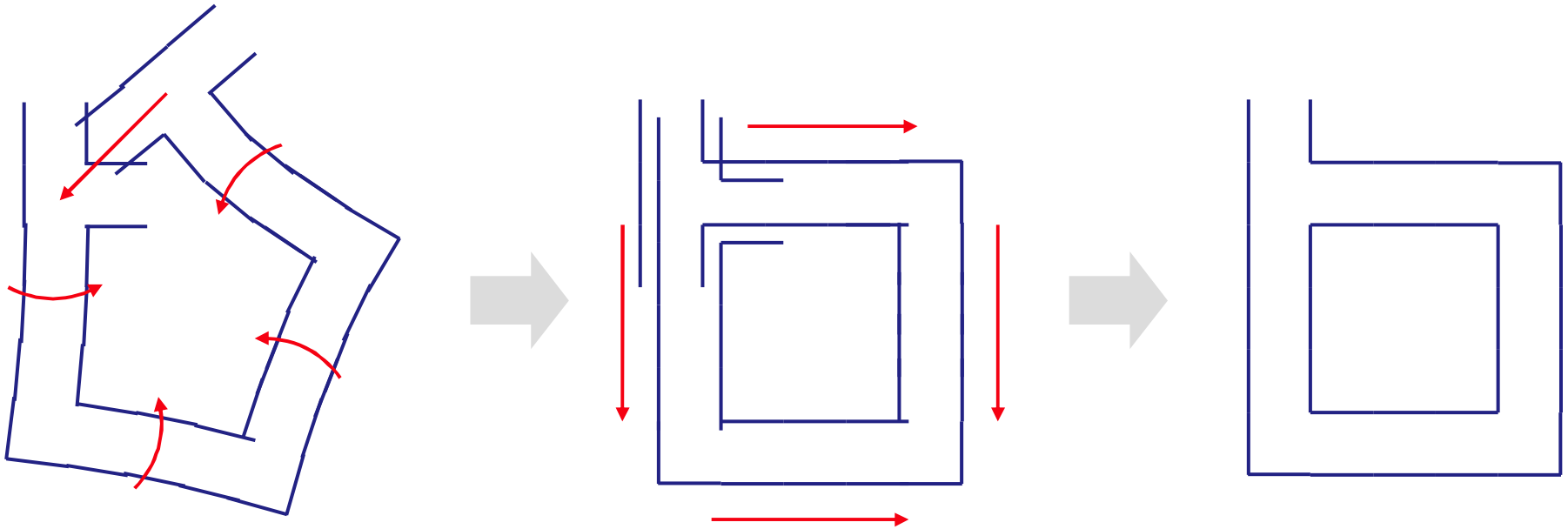




Map Building & Self-Localization



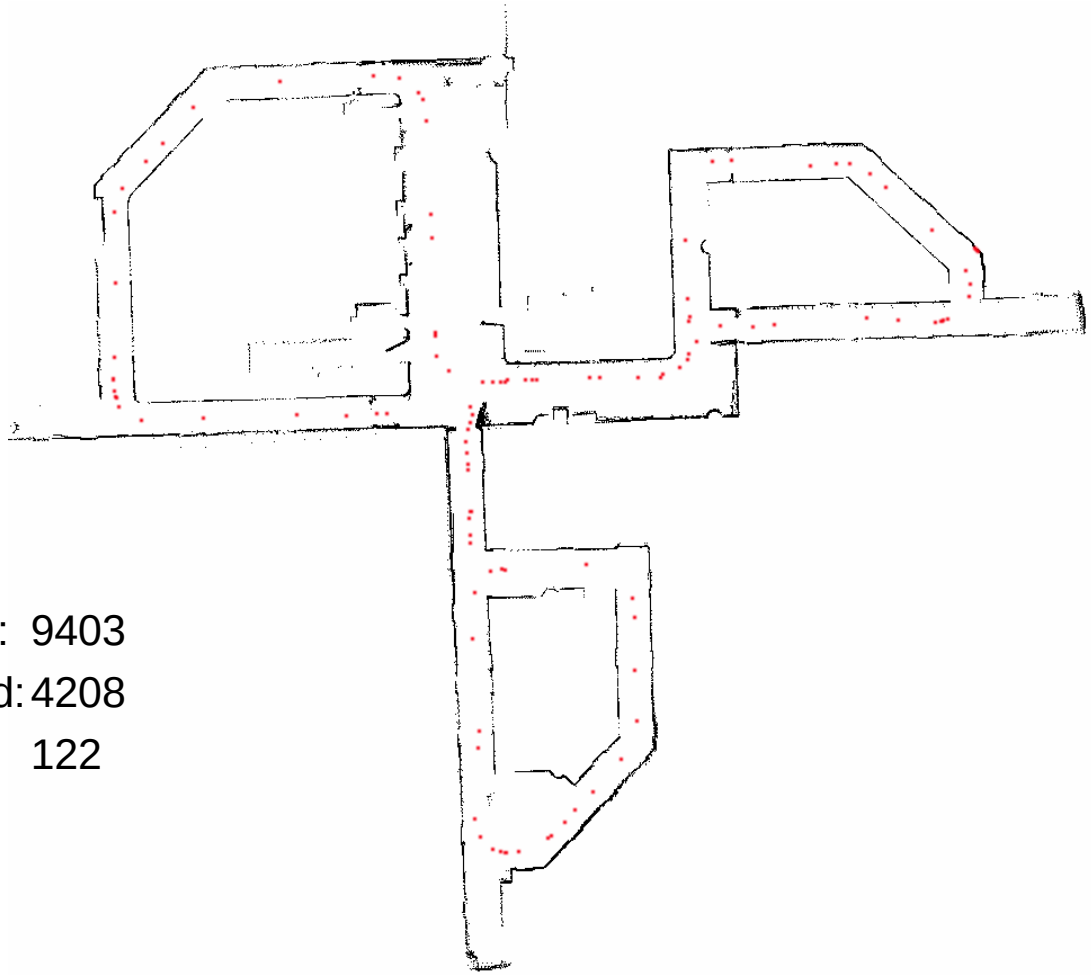
Distributing the Errors



Correction of Rotation

Correction of Translation

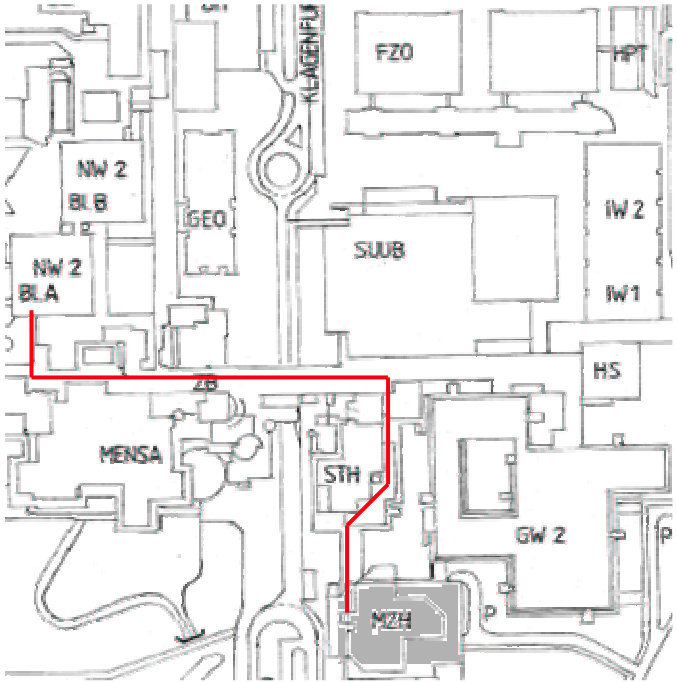
Example 1

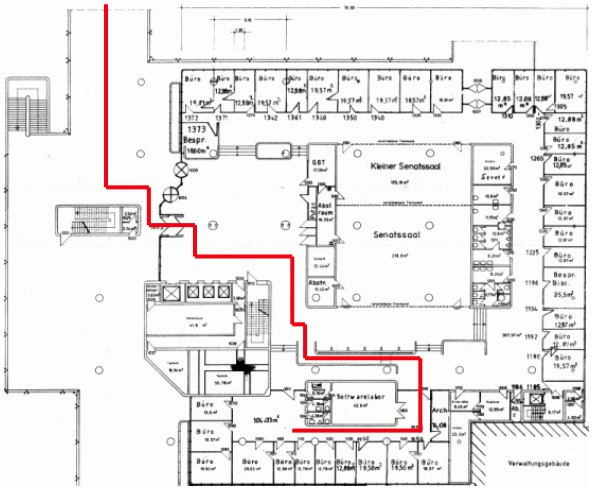


50 m

- **Scans**
  - Recorded: 9403
  - Processed: 4208
  - Stored: 122

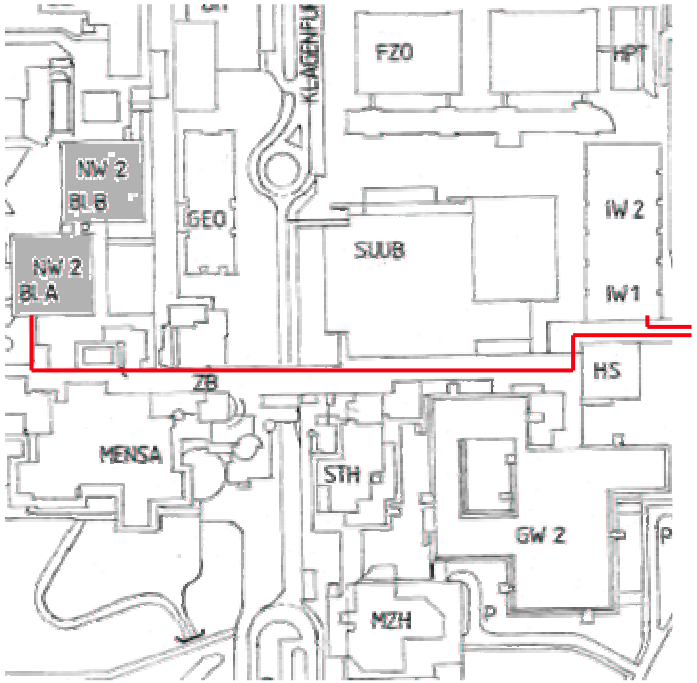
Example 2 – Environment

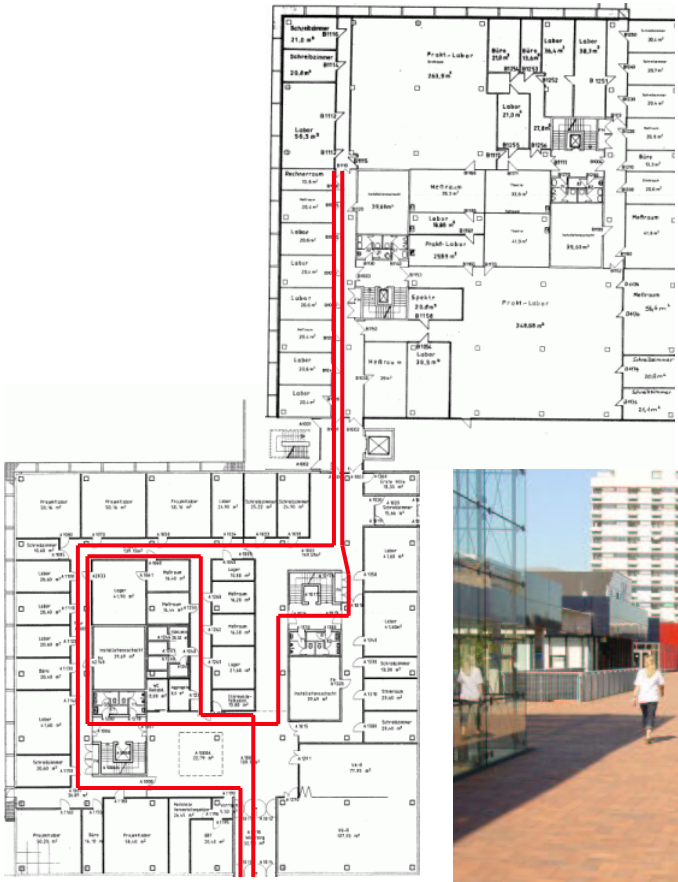




- **Building: MZH**

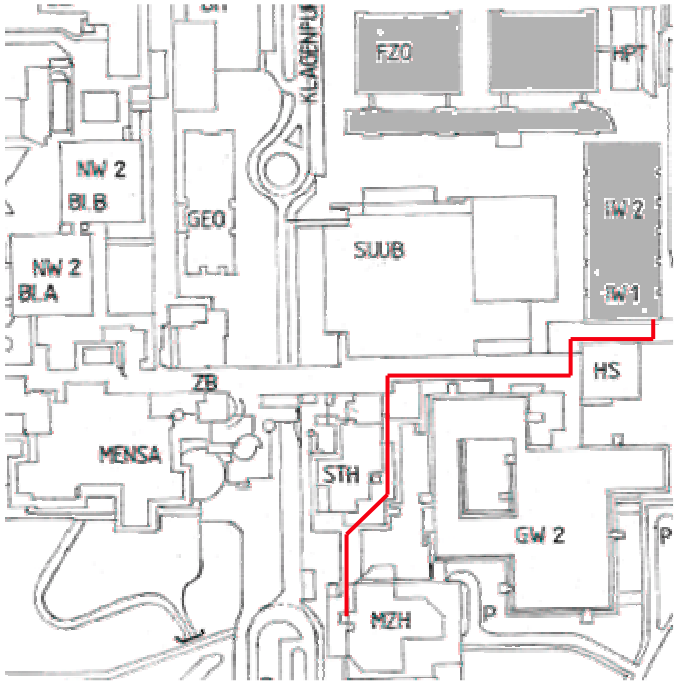
Example 2 – Environment

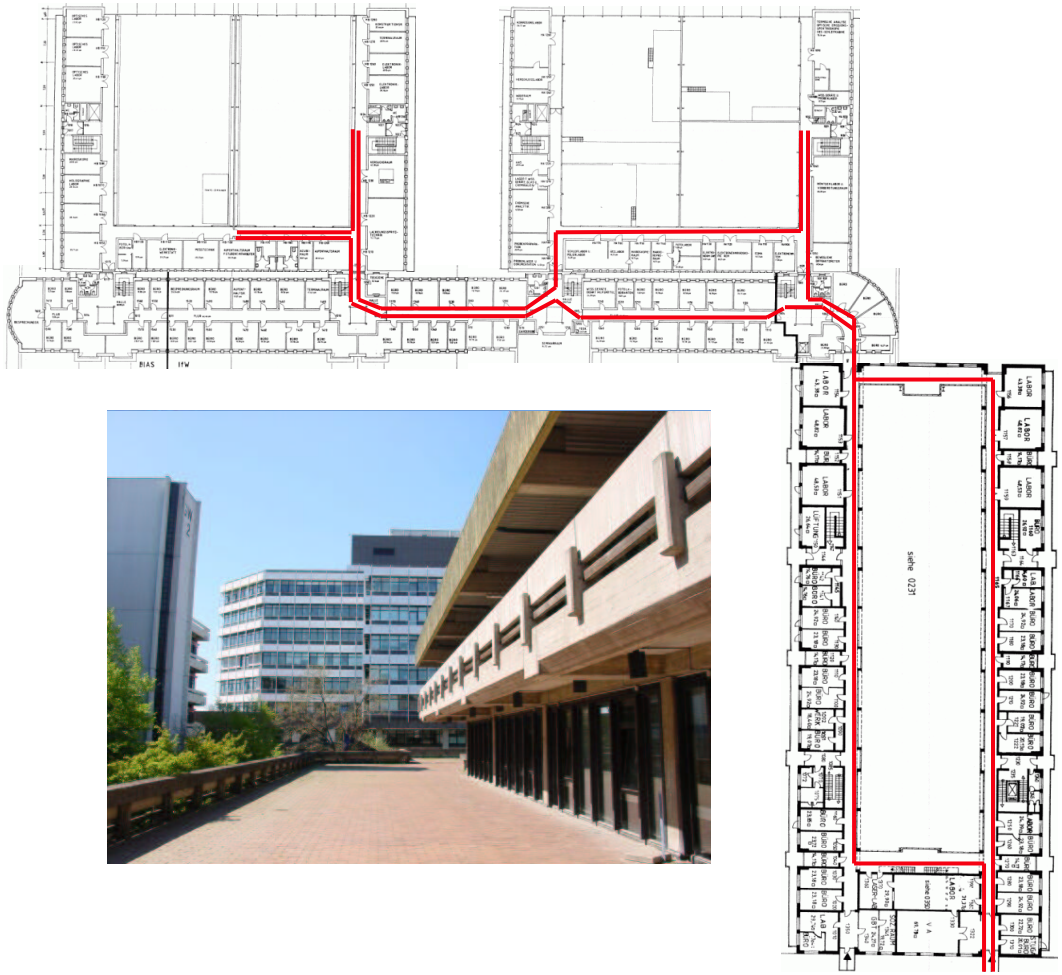




- **Building: NW 2**

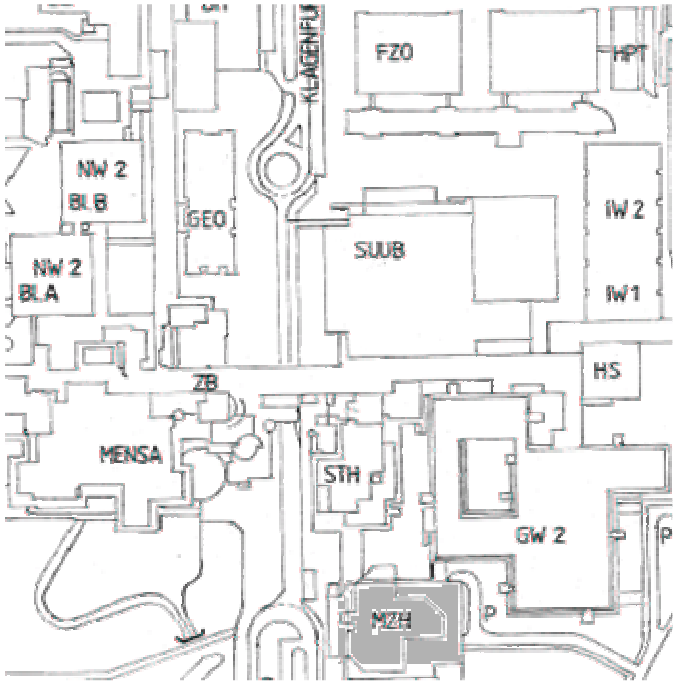
Example 2 – Environment

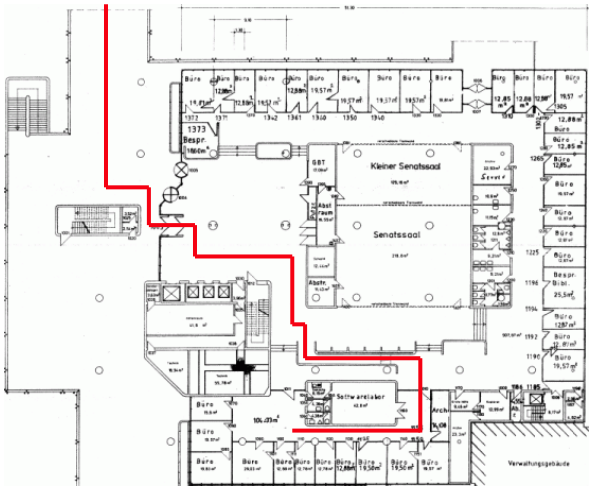




- **Buildings: IW + BIBA**

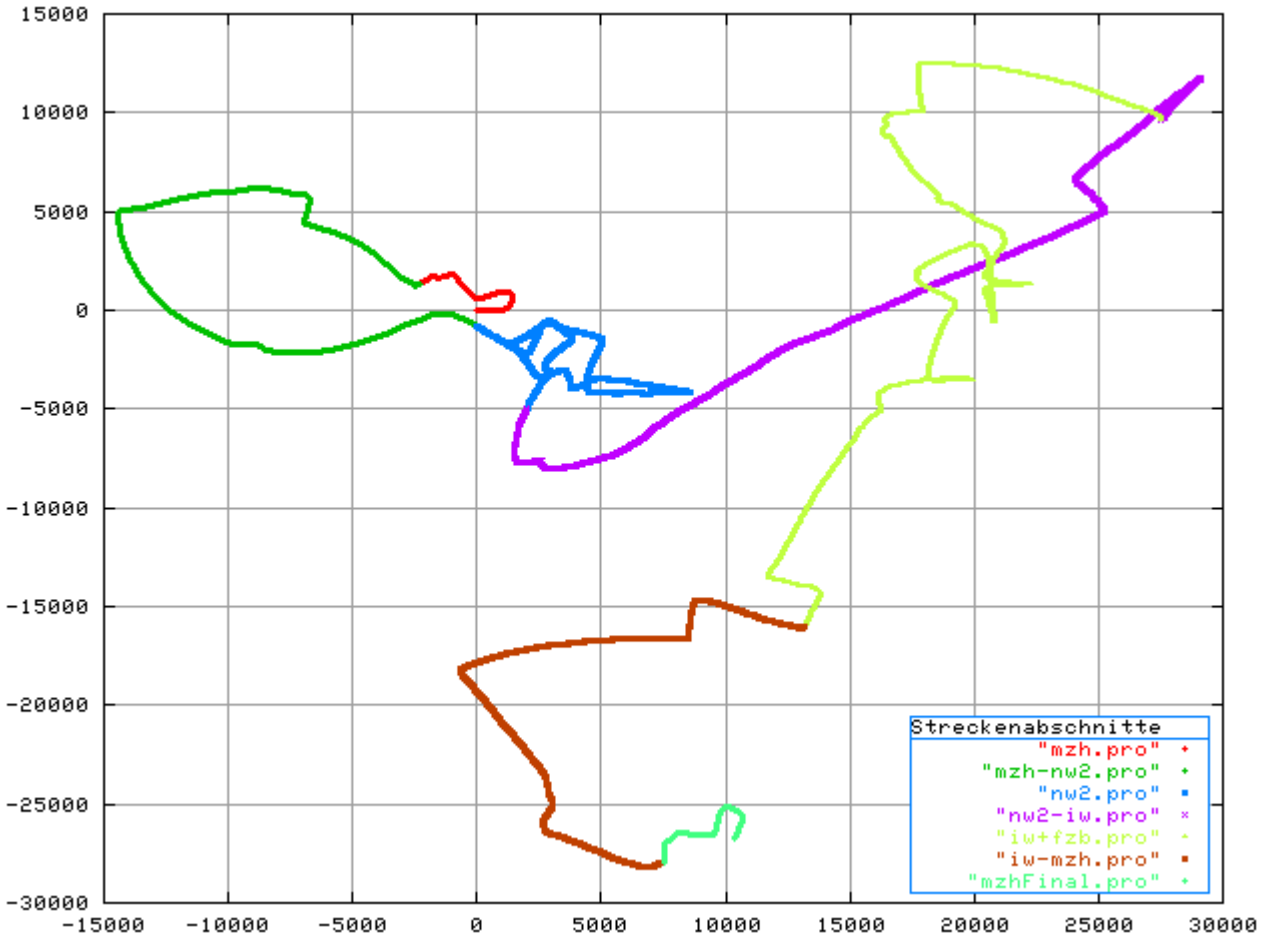
Example 2 – Environment



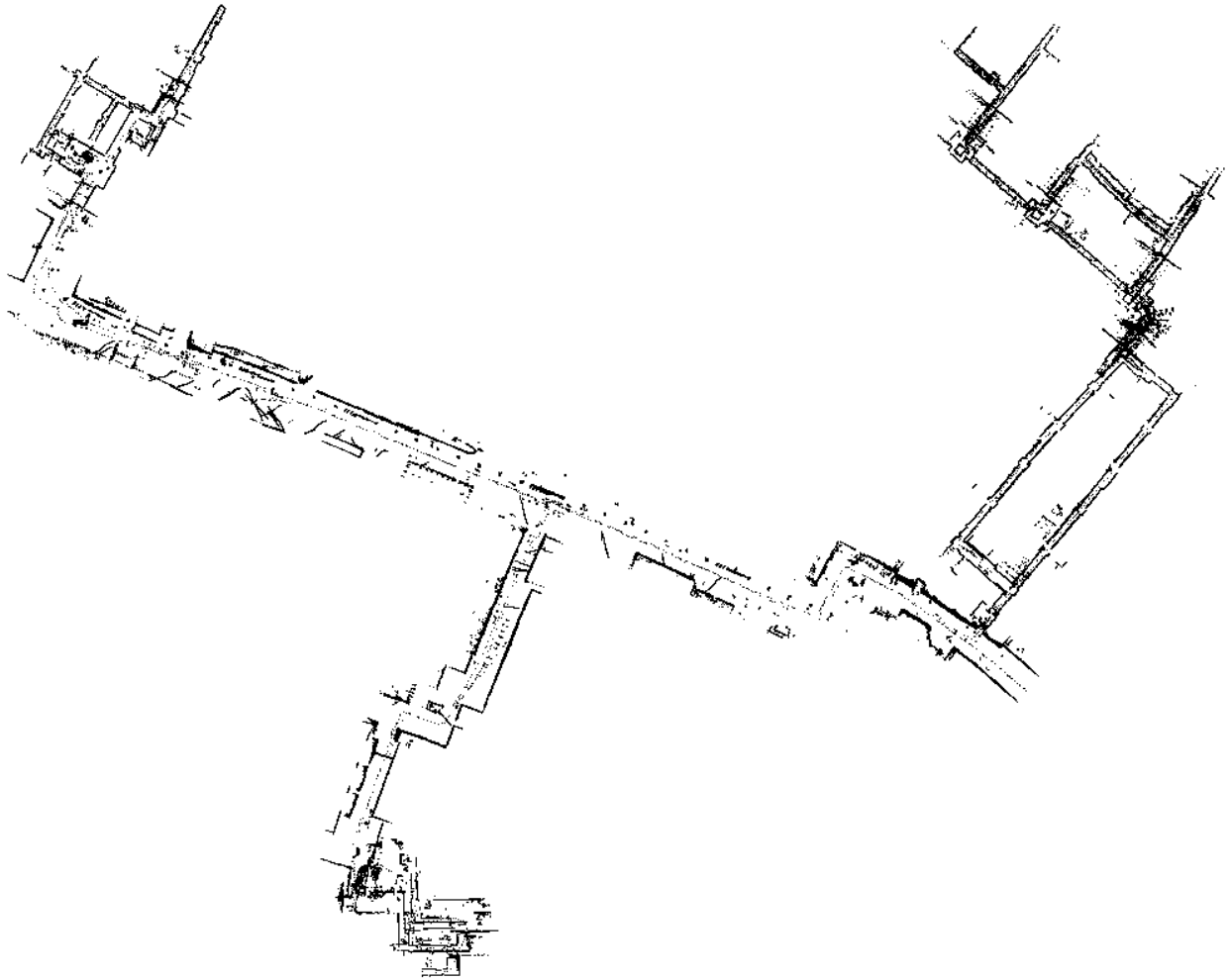


- **Building: MZH**
- **Total Length: 2176 m**

Example 2 – Odometry

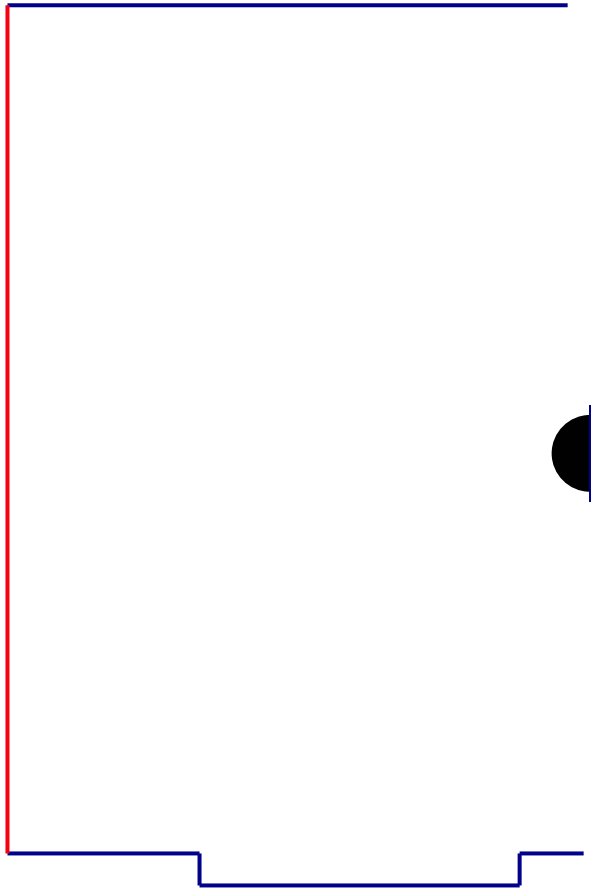


Example 2 – Laser Scan Map



400 m

Laser Scans & Glass



Conclusion & Outlook

- **Scan Matching with Histograms**
  - Projection Filter
  - Line Segmentation
  - Correlation of Histograms with different Resolutions
- **Map Building**
  - In Real-Time (at 84 cm/s)
  - Automatic Selection of the required Scans
  - Distribution of Errors
- **Outlook**
  - Tests in Populated Environments
  - More Robust Line Segmentation
  - Probabilistic Approaches