Universität Bremen

Using Histogram Correlation to Create Consistent Laser Scan Maps

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Motivation
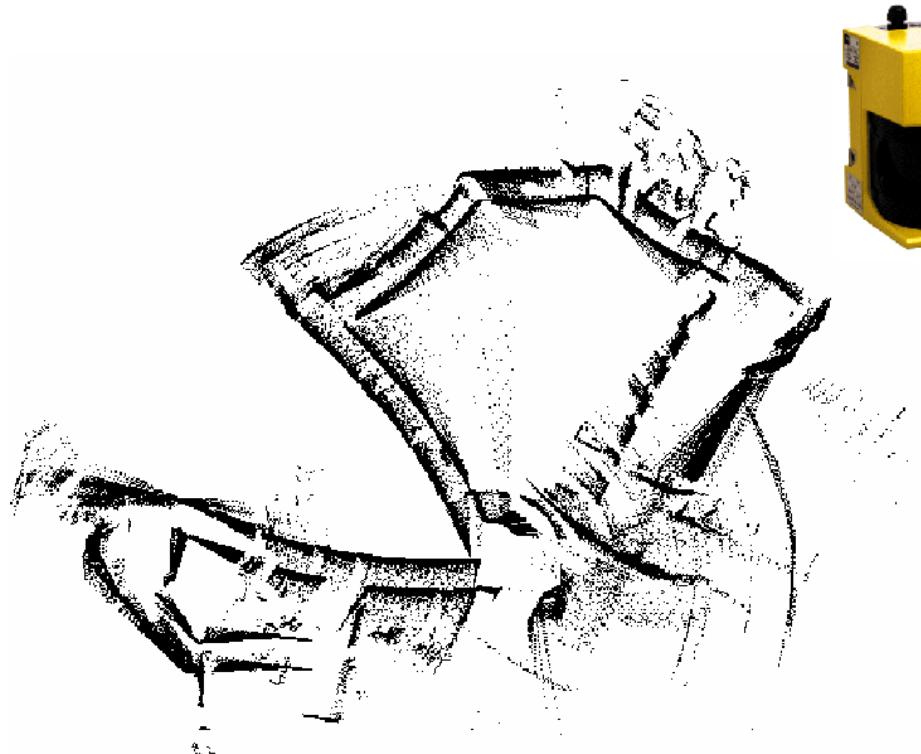
without scan matching
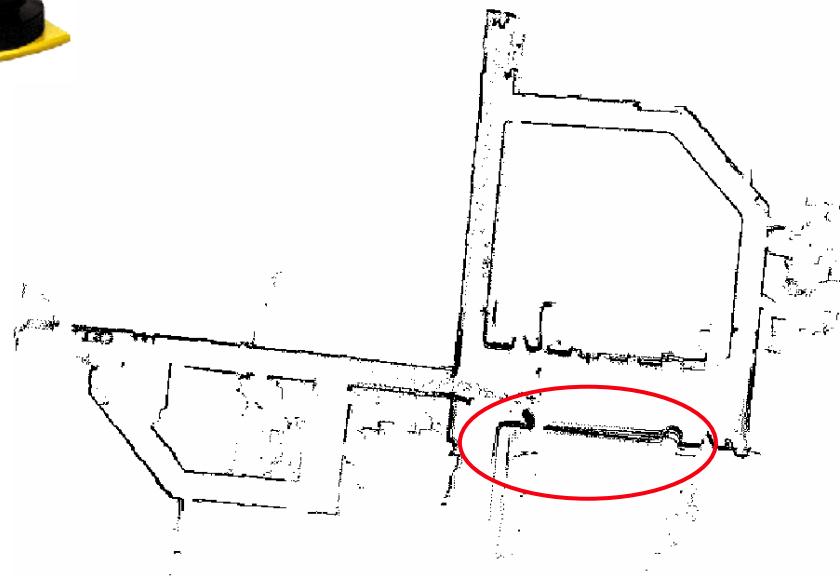
with scan matching

Contents

Basic Idea

Approach

```
┌─────────────────┐          ┌─────────────────────┐          ┌─────────────────────┐
│   rotational    │          │    coarse shift     │          │  projection filter  │
│      shift      │          │  (1/10 resolution)  │          └─────────────────────┘
└─────────────────┘          └─────────────────────┘                     │
         │                              │                                 ▼
         ▼                              ▼                      ┌─────────────────────┐
┌─────────────────┐          ┌─────────────────────┐          │         line        │
│ 1st translational│          │     fine shift      │          │     segmentation    │
│      shift      │          │  (0,25° or 1 cm)    │          └─────────────────────┘
└─────────────────┘          └─────────────────────┘                     │
         │                                                                ▼
         ▼                                                     ┌─────────────────────┐
┌─────────────────┐                                           │     generation      │
│ 2nd translational│                                          │    of histograms    │
│      shift      │                                           └─────────────────────┘
└─────────────────┘                                                      │
                                                                         ▼
                                                              ┌─────────────────────┐
                                                              │      histogram      │
                                                              │     correlation     │
                                                              └─────────────────────┘
```
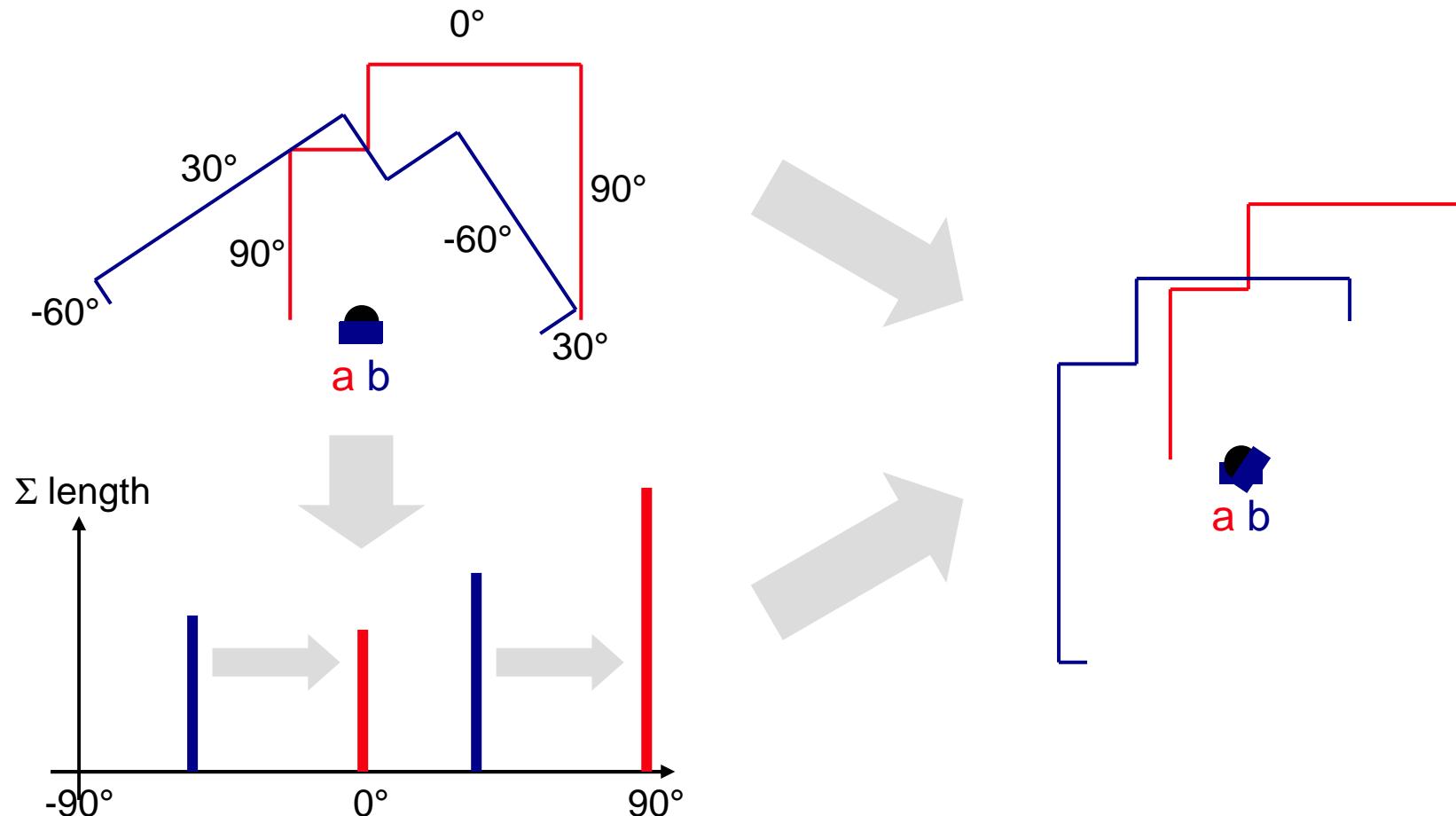
Rotational Shift

# 1st Translational Shift

2nd Translational Shift

shift

Σ length

Σ length

1st main direction

2nd main direction

±20°

-90°   0°   90°
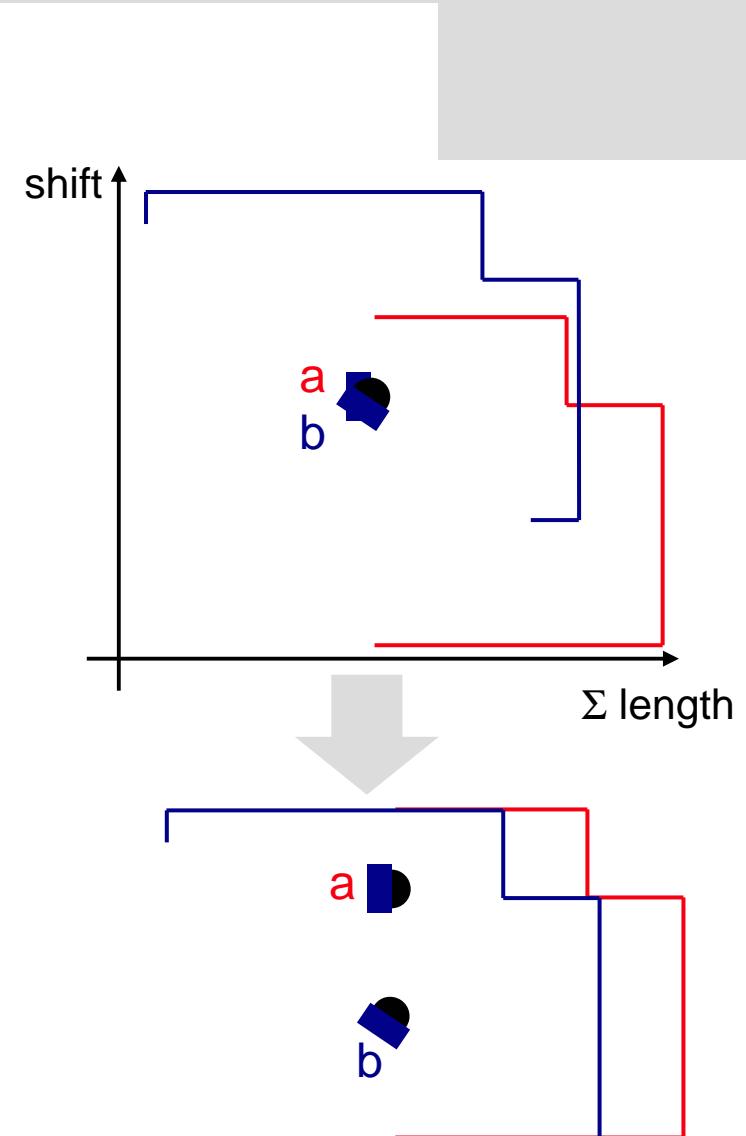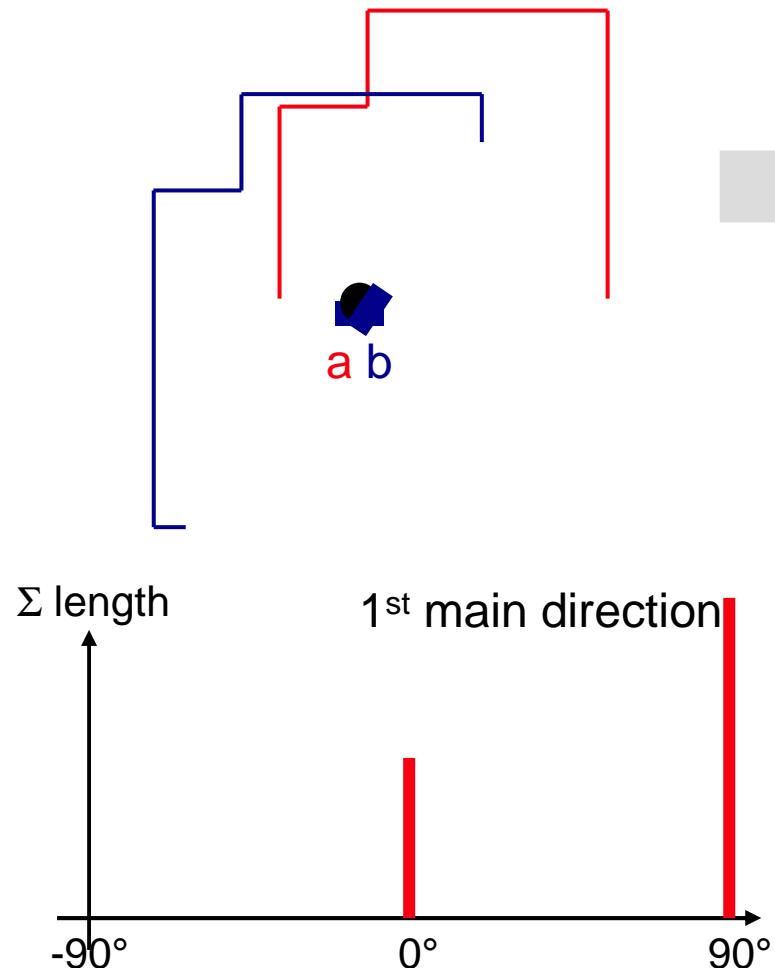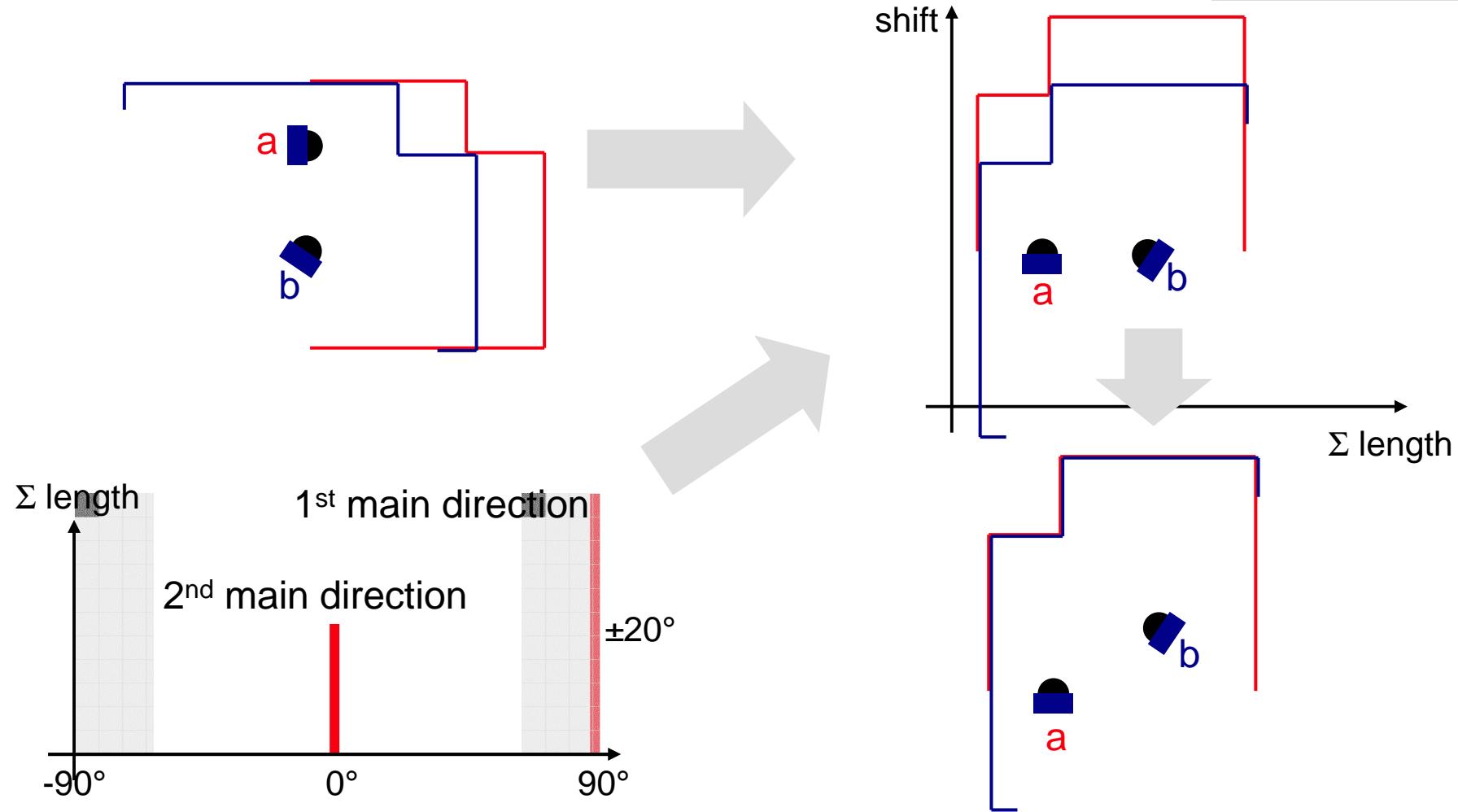
Uniqueness & Contrast

Map Representation
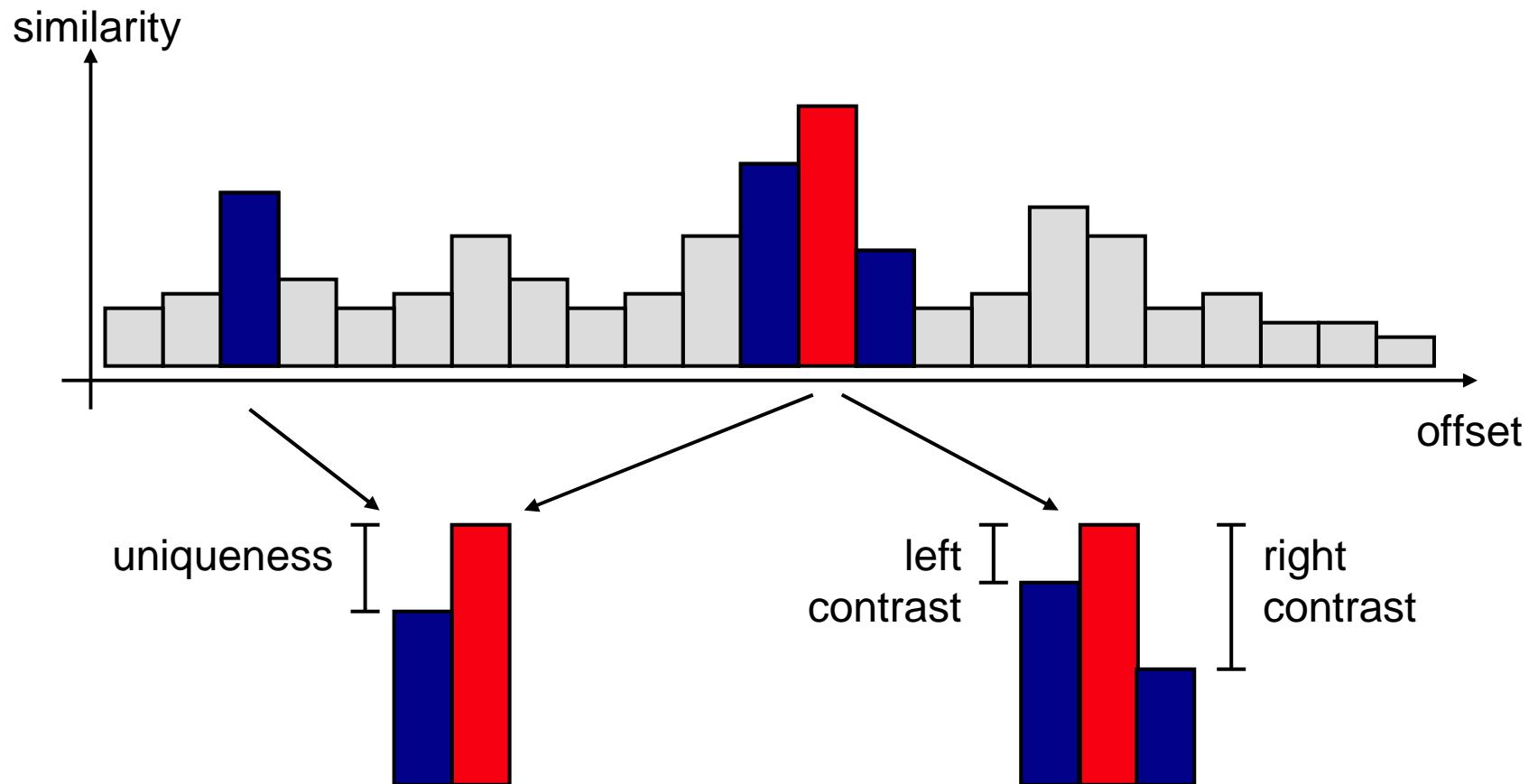
scan 1	▸ distance data
	▸ pose
	▸ frame of reference (age)
scan 2	▸ 1st main direction
	▸ 2st main direction
scan 3	▸ left/right contrast
	▸ rotation
. . .	▸ 1st main direction
	▸ 2st main direction
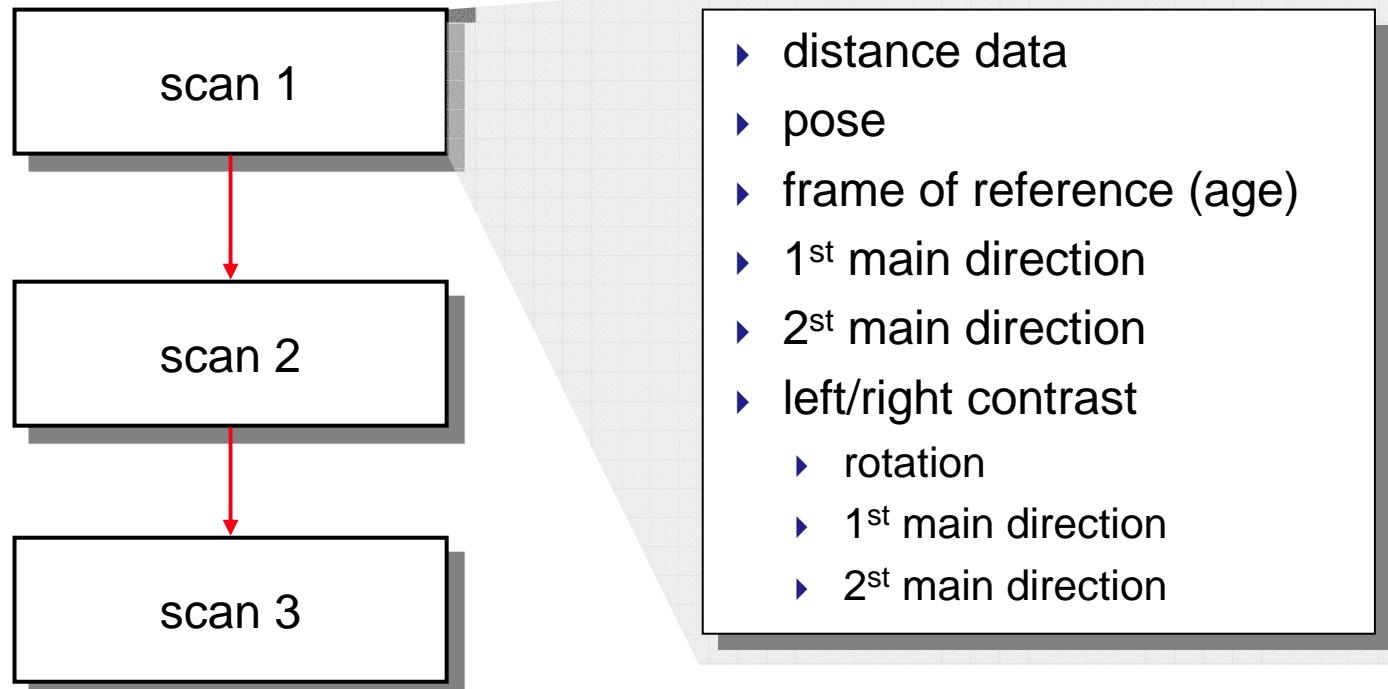
Map Building & Self-Localization

```
                    ┌──────────────────┐          ┌──────────────────────┐
                    │  selection of    │          │ priorities:          │
        ┌──────────→│  reference scan  │          │ • old                │
        │           └──────────────────┘          │ • large overlap      │
        │                    │                     │ • close              │
        │                    ↓                     └──────────────────────┘
┌──────────────────┐   ┌──────────────────┐        ┌──────────────────────┐
│ insert predecessor│← │ determination    │        │ distribute           │
│ into map          │ -│ of shift         │        │ rotational error     │
└──────────────────┘   └──────────────────┘        └──────────────────────┘
                            │                                  │
                            │ +                                ↓
                            ↓                       ┌──────────────────────┐
                    ┌──────────────────┐            │ distribute           │
                    │ position correction│          │ translational error  │
                    │ & error distribution│         └──────────────────────┘
                    └──────────────────┘
```
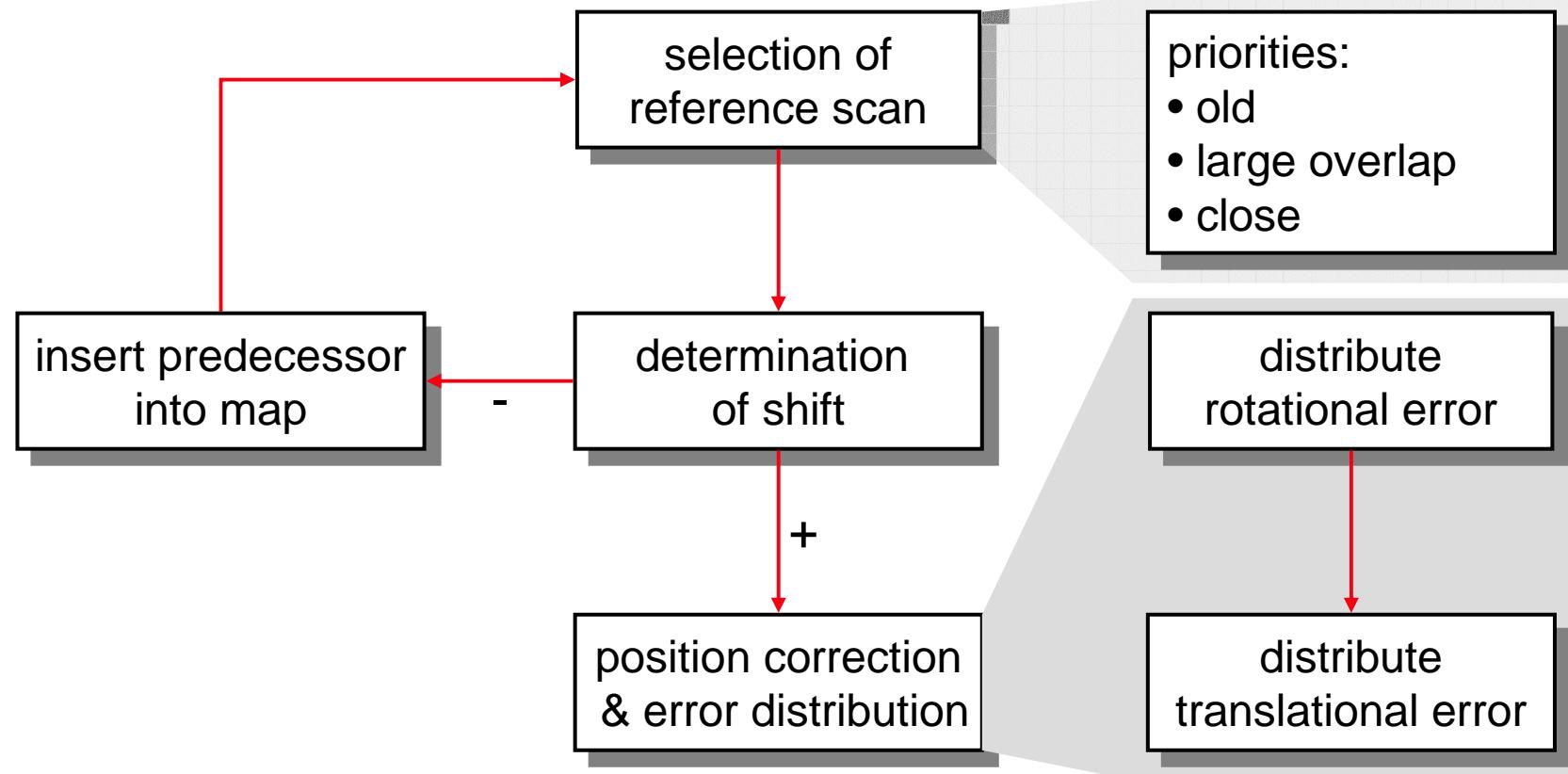
# Distributing the Errors
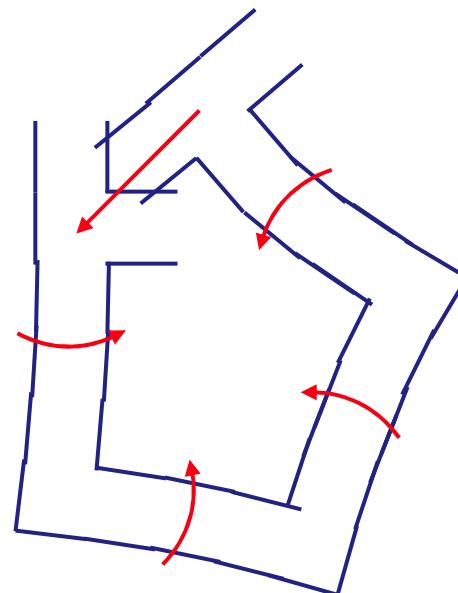
correction of rotation   correction of translation
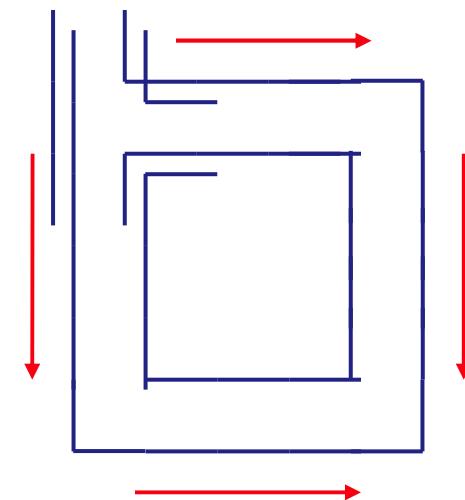
Frame of Reference
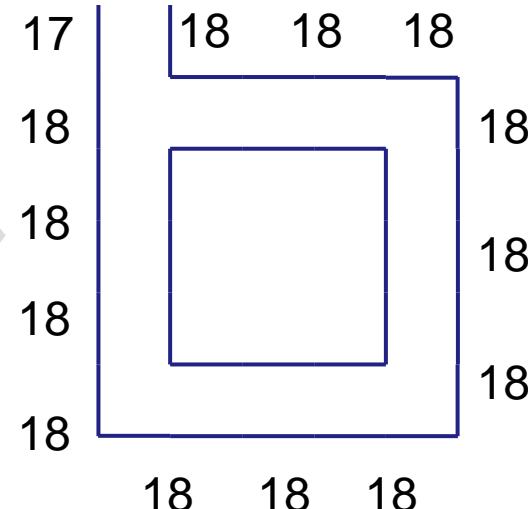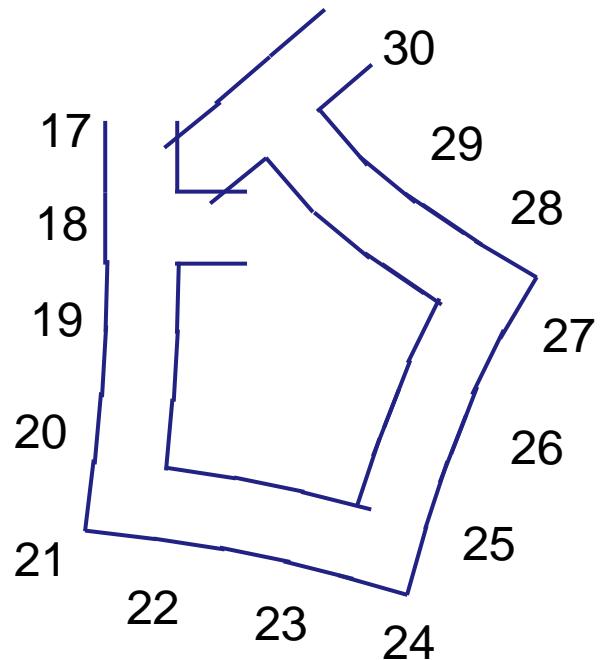

adjusting the frames of reference
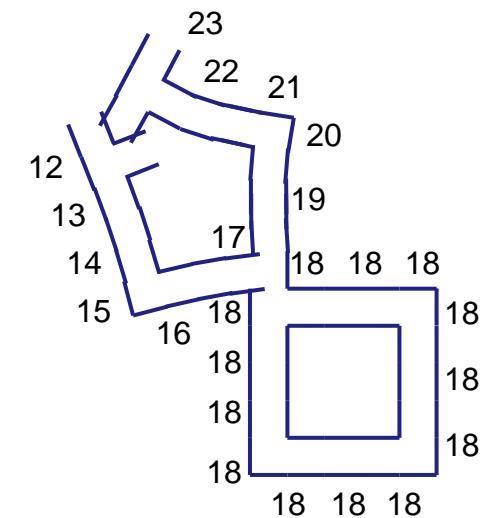
cycle in a cycle

# Example 1 – MZH 3th Floor

50 m

Example 2 – MZH 2nd Floor

50 m

▸ **Scans**
  ▸ recorded: 9403
  ▸ processed: 4208
  ▸ stored: 122
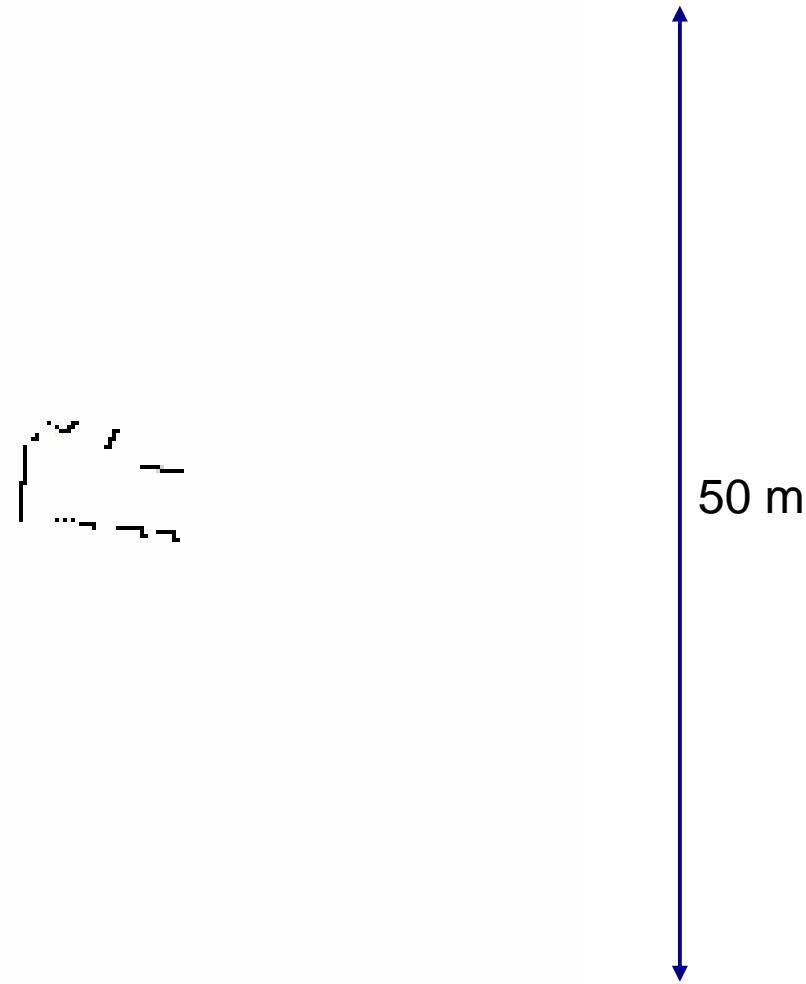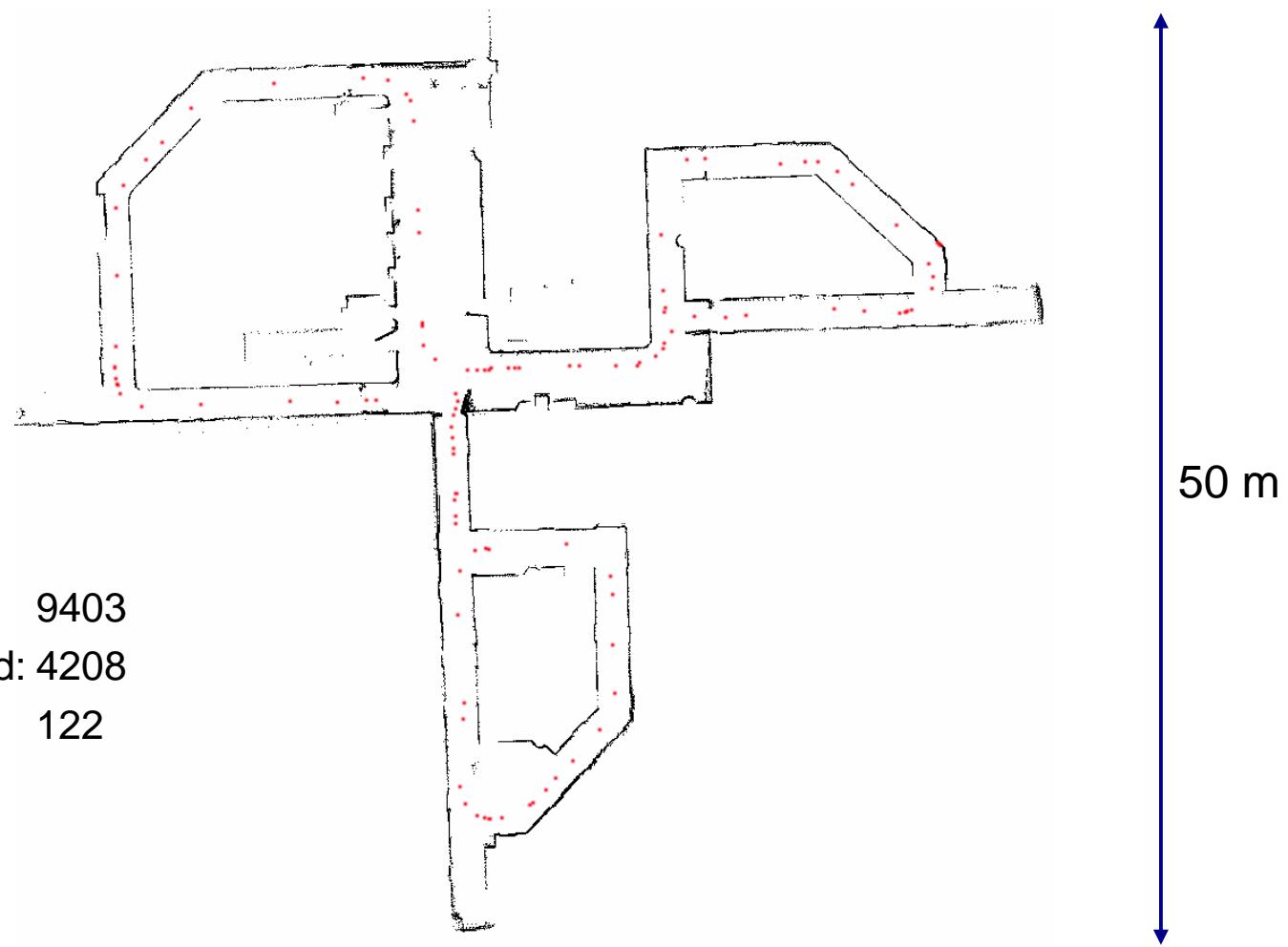
Example 3 – University Campus
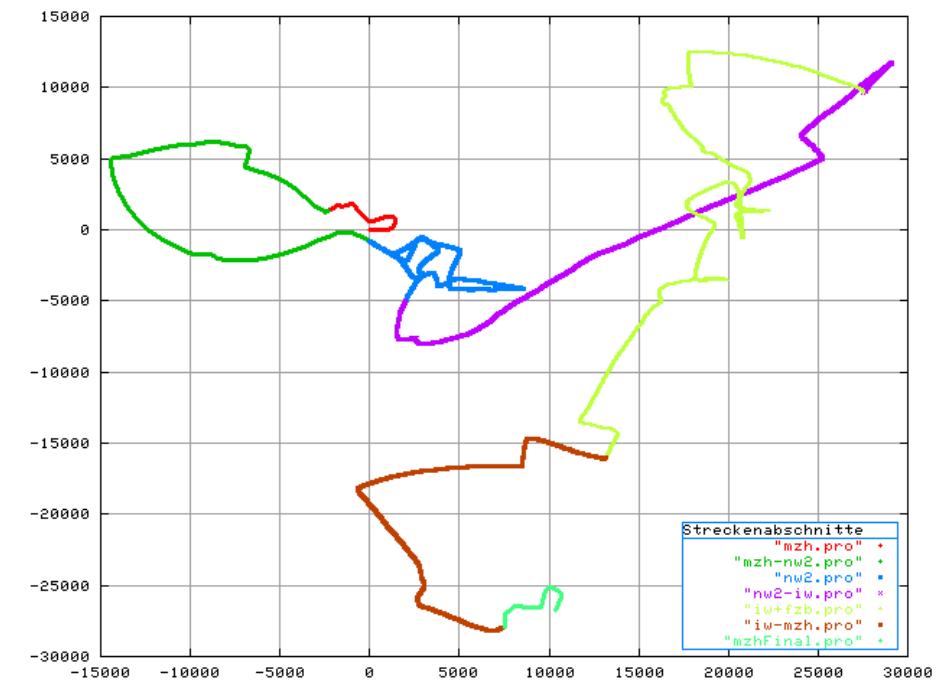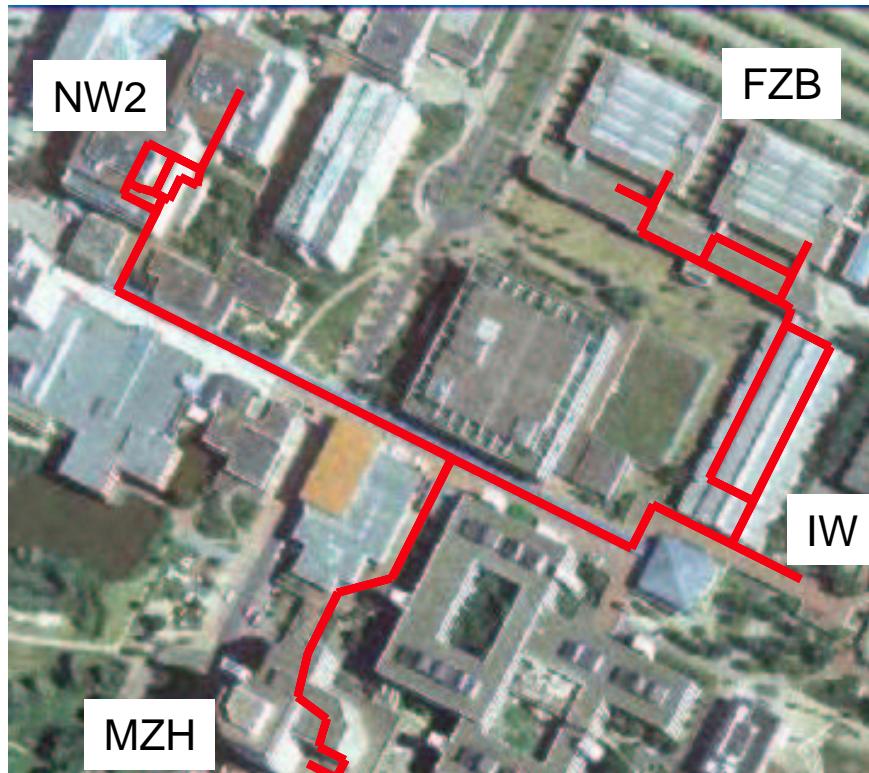
Example 3 – Laser Scan Map
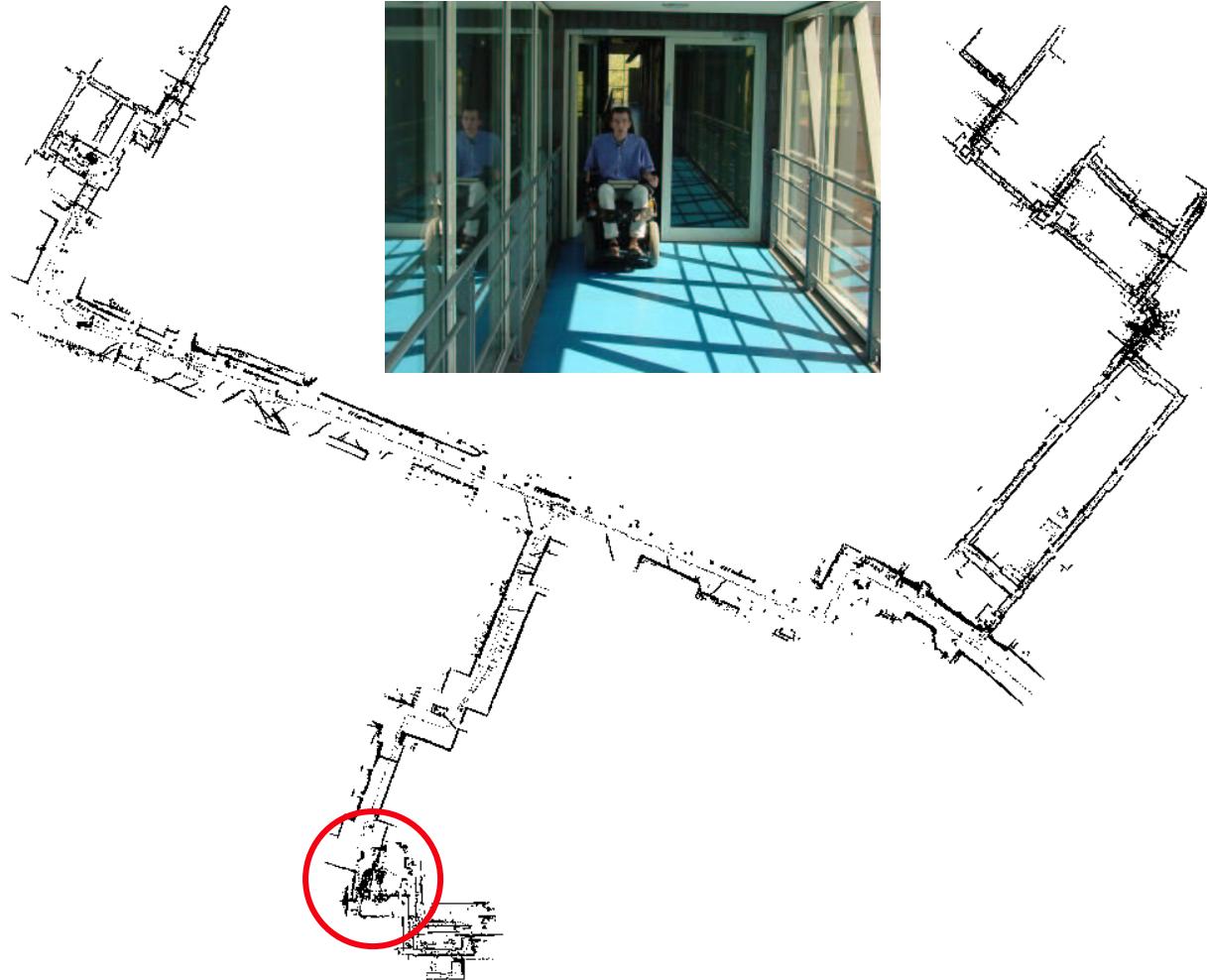
400 m

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 Scans Required
  - Distribution of Errors
- **Outlook**
  - Geometric Map Representation
  - Tests in Populated Environments
  - Probabilistic Approaches