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3D Maps – from geometry to semantics

(and the application thereof)

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Part I

map generation:
a step towards environment understanding

On Mapping…

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- Localization within a given map: ✓
  Mapping in case of stable localization: ✓
  Neither a-priori map nor localization is given: ✗

- Solution:
  SLAM (*simultaneous localization and mapping*)
  [CML (*concurrent mapping [and] localization*)]

- Generally based on:
  Scan registration

Scan registration

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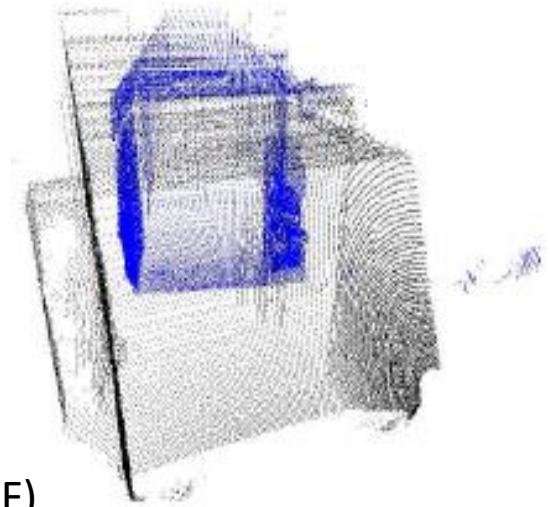
Iterative Closest Point (ICP) algorithm

- For prior point set M (“model set”) and “data set” D:
  1. Select point correspondences $w_{i,j}$ in {0,1}
  2. Iteratively minimize for rotation $\mathbf{R}$, translation $\mathbf{t}$

$$E(\mathbf{R},\mathbf{t}) = \sum_{i=1}^{N_m}\sum_{j=1}^{N_d} w_{i,j}\,||\mathbf{m}_i - (\mathbf{R}\mathbf{d}_j + \mathbf{t})||^2$$

  3. transform D, back to **1.**, until convergence



- works in 3 translation plus 3 rotation dimensions (6 DoF)
- registration of 2 3D scans with 100.000 points: 1 sec

Scan registration (example)

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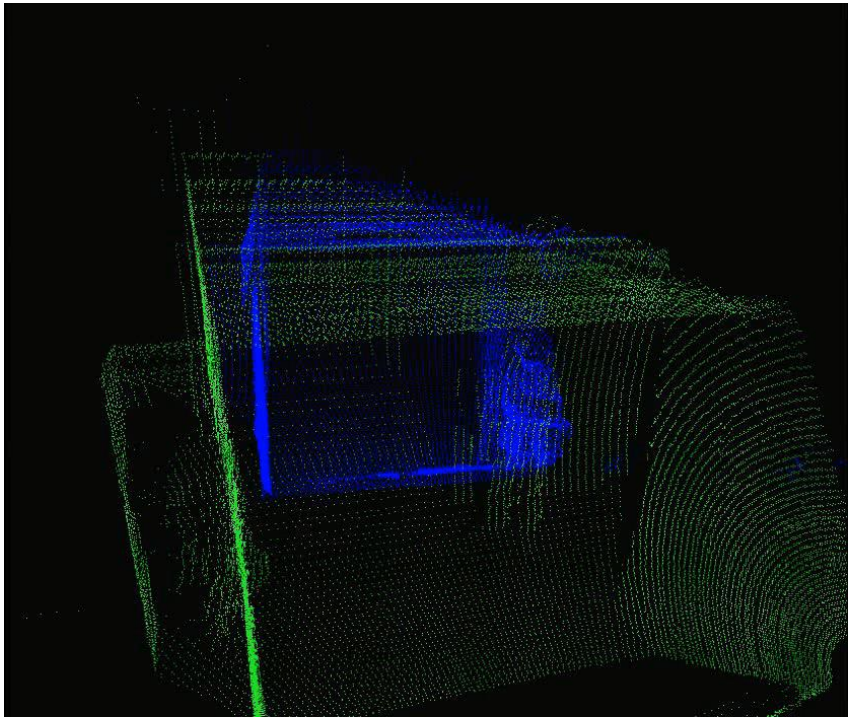

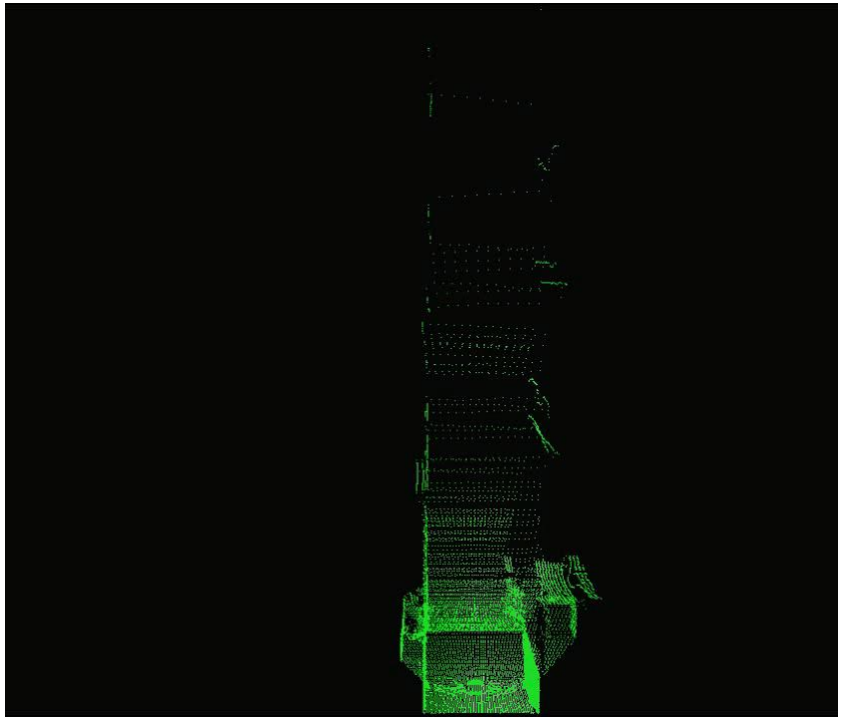

Constraint network – idea in 2D

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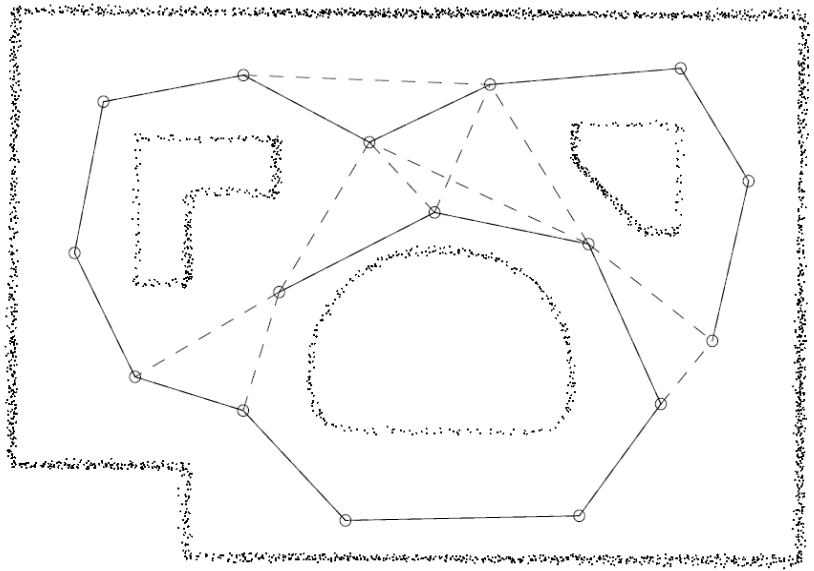
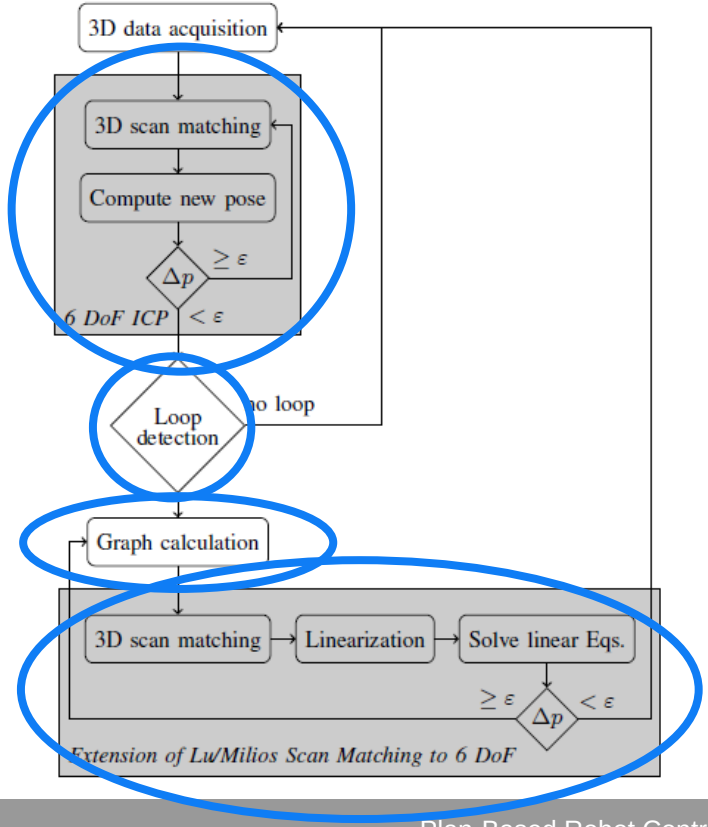


Globally consistent 3D maps

- Extension to 3D
- Allows arbitrary graph topology
- Edges: weighed by covariance

- Innovation price for free software



Example of a global optimization – poses

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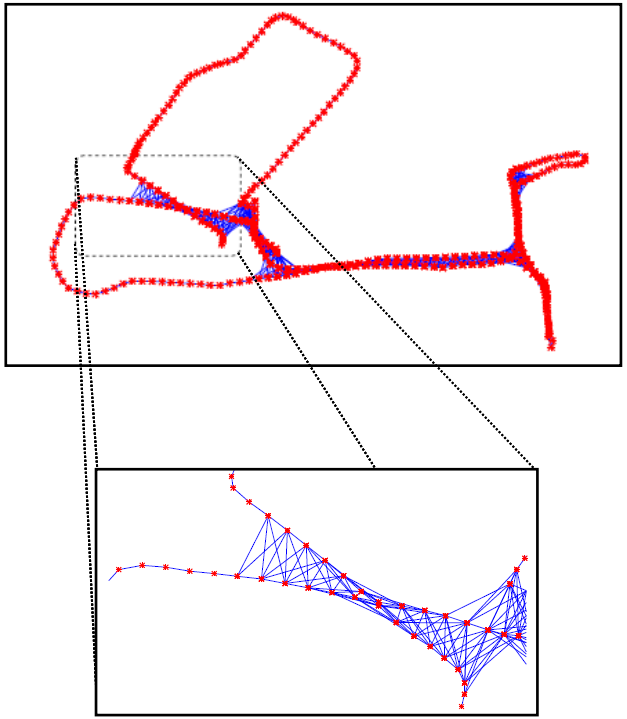

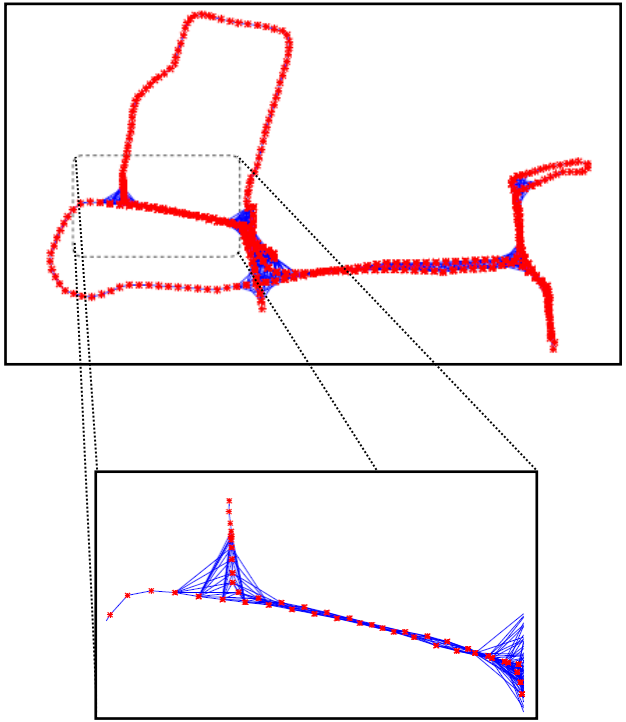

Example of a global optimization – scans

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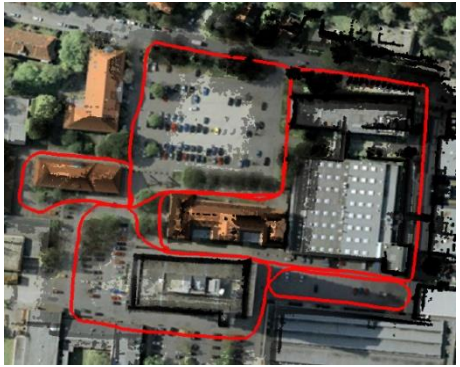

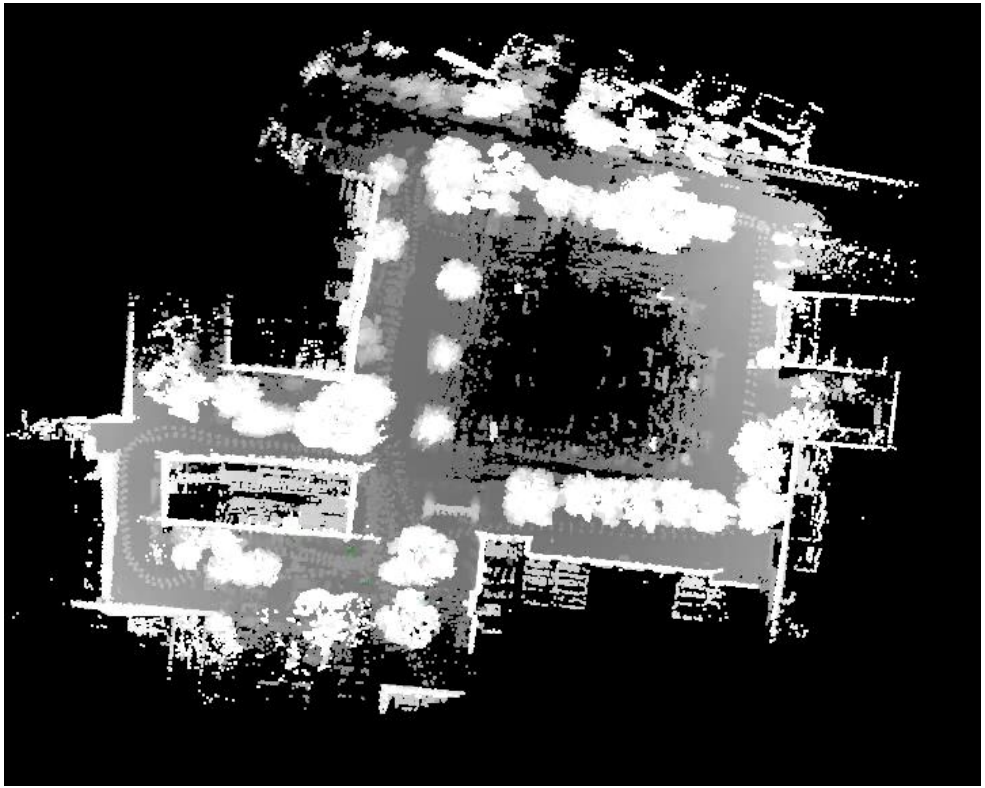

Part II

industry application / system development

System: MEYER WERFT

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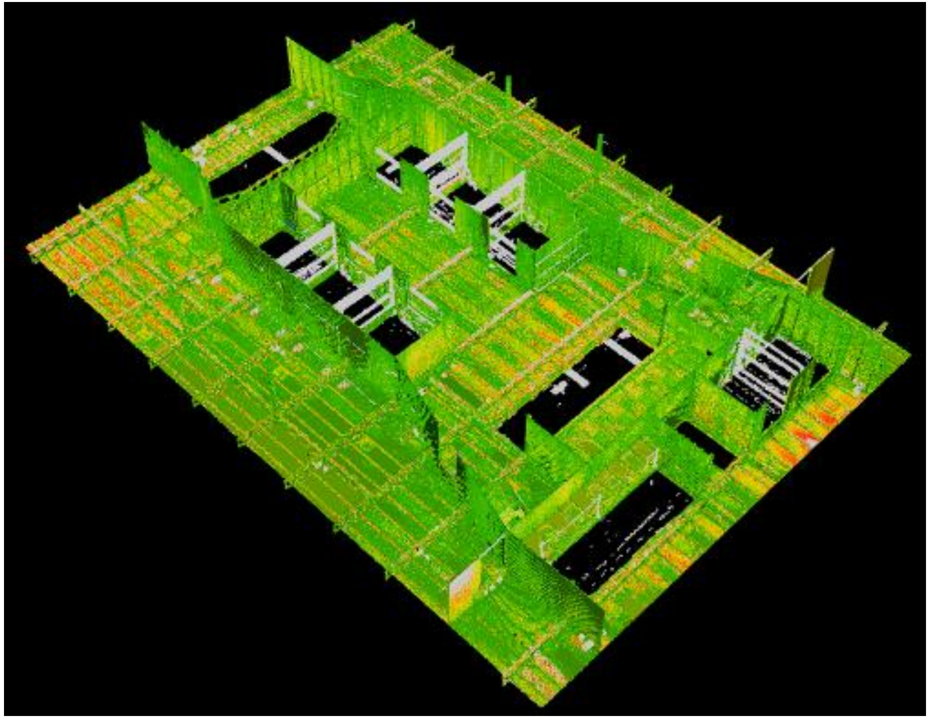
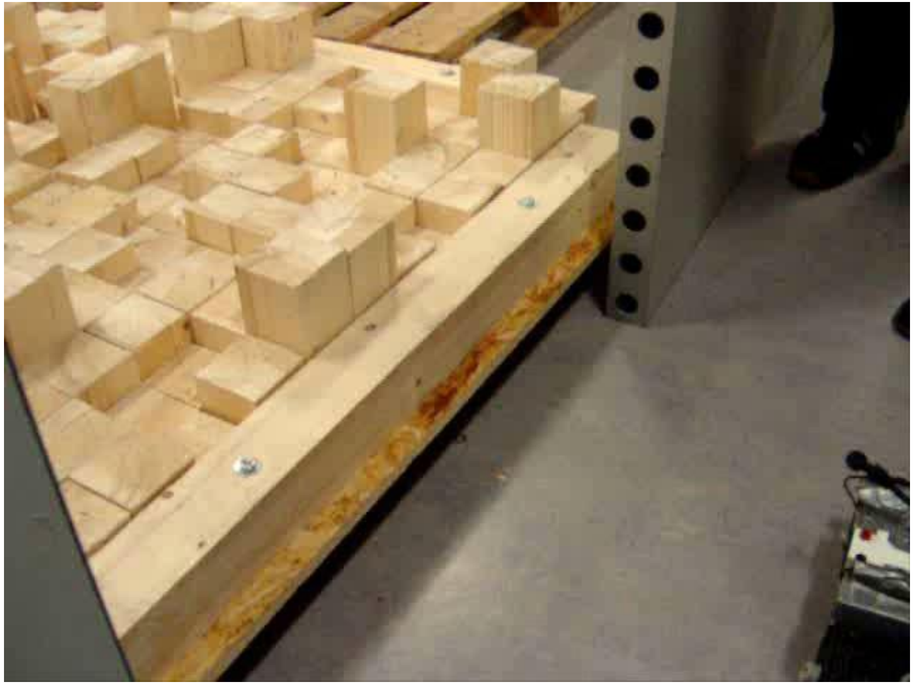


System: Robocup Rescue



Further applications

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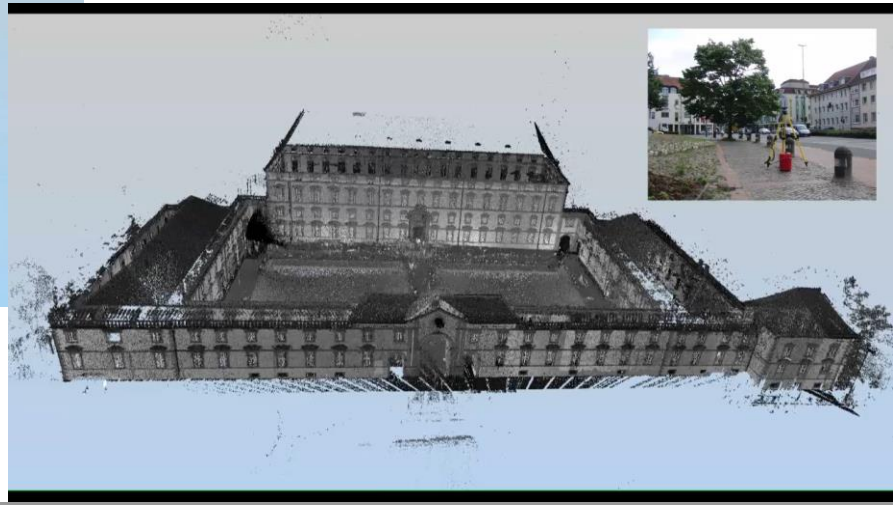

(in charge: Thomas Wiemann)

Part III

adding semantics…

From sensor data to semantic maps

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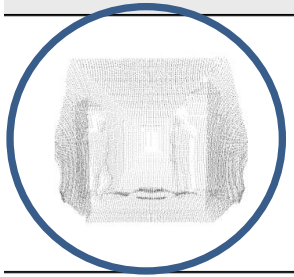
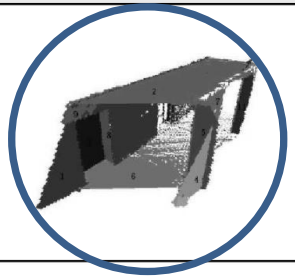
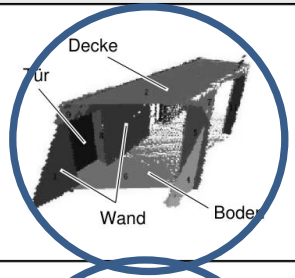
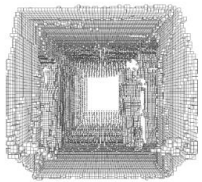
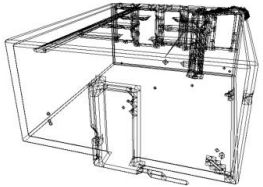
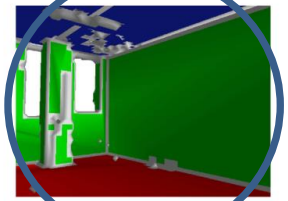
3D		
Sensordaten	syntaktische Merkmale	semantische Merkmale
		
		

(from: *Mobile Roboter – Eine Einführung aus Sicht der Informatik*. Joachim Hertzberg, Kai Lingemann, Andreas Nüchter)

(in charge: Sven Albrecht)

Part IV

further development / current projects

… now, 9 project leads and 80 publications later ☺ …

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Further develoments in our group:

- Object recognition (many projects, mostly agricultur use-cases)
- Localization + map building
  - Search & Rescue, incl. SLAM (research & industry)
  - Long term autonomy (e.g., a robot on a field)
- Planning & Reasoning (projects that require some kind of „understanding“ of the environment)

Some current projects from that realm…

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