Indoor positioning with the Microsoft Hololens

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Supervisors
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CGI Robert Voûte

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S Vermont Ave
toward W 5th St
S Mariposa Ave
S Alexandria Ave
W 3rd St
S Kenmore Ave
S Catalina St
S Berendo St
S New Hampshire Ave
W 5th St
S Vermont Ave
57 min
1
2
3
SCAN
FM
AM

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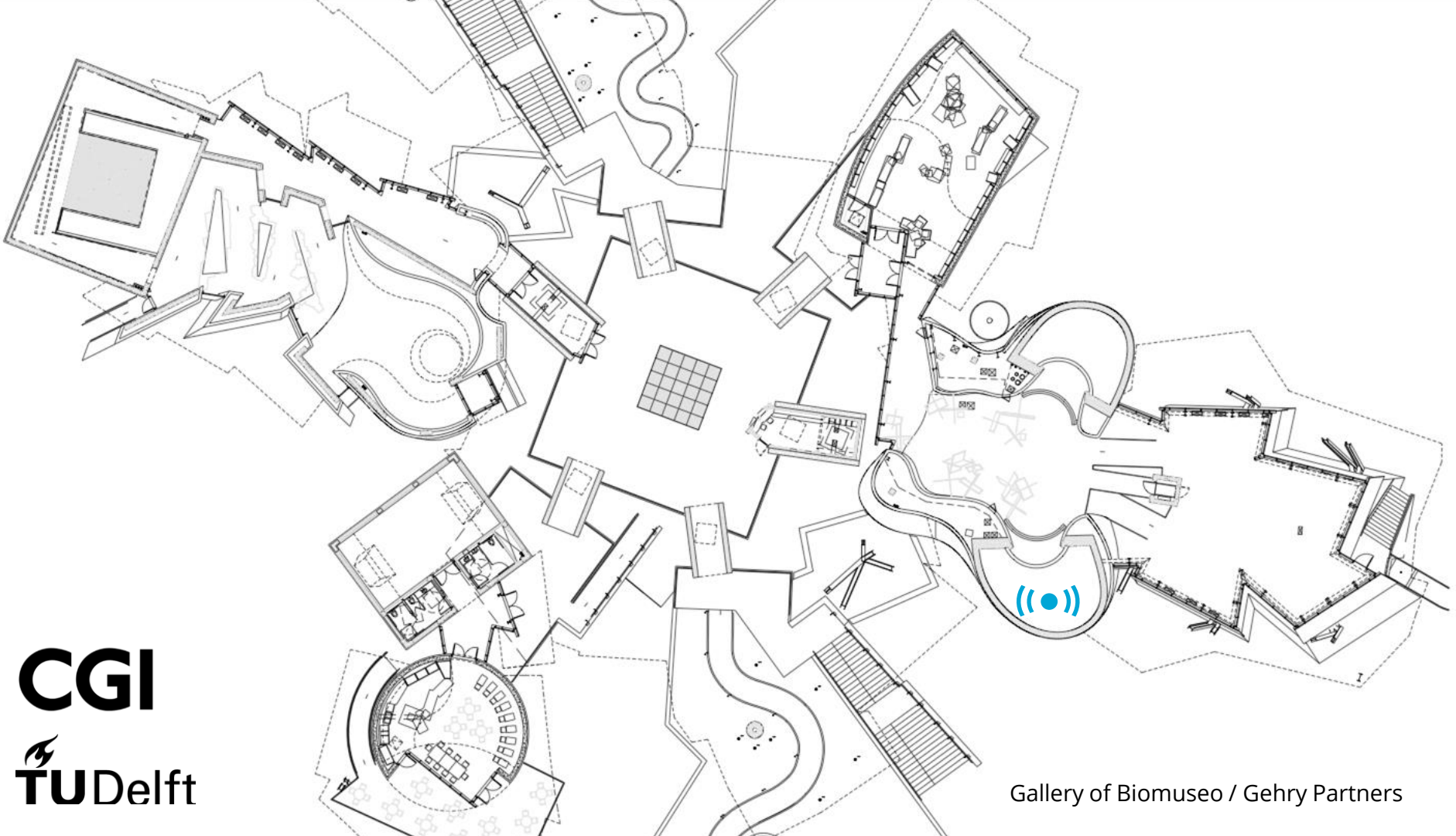

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Gallery of Biomuseo / Gehry Partners

Emergency Response

. Location not known beforehand

. Little time available

. No extensive 3D data at hand

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SLAM

. Simultaneously Localization and Mapping

. No connection with existing data

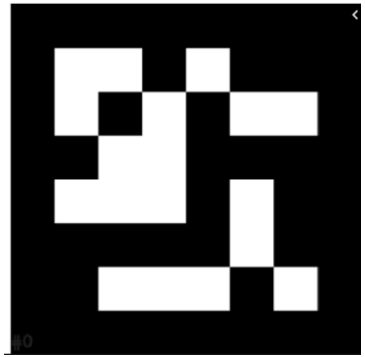
. Drift Error

Khoshelham et al. (2019)

Previous attempts

. Marker-Based

. ICP algorithm



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Research objectives

Develop a method to estimate **the position** of the **Microsoft Hololens** on a **2D floor plan**, without any pre-existing infrastructure.

. Position precision & reliability

. When does the method fail

Research Questions

How can the Microsoft Hololens improve indoor positioning, using the on-the-fly produced mesh with an existing 2D floor plan?

1. What **spatial matching techniques** are feasible to match a **3D mesh** acquired real-time with the Microsoft Hololens with an **existing 2D floor plan**?
2. What is the most promising spatial matching technique in terms of **accuracy** and **speed**?
3. How can the **indoor positioning** of the Hololens be improved by making use of the researched positioning method?
4. In which cases does the researched positioning method **fail** to estimate the position on a 2D floor plan?

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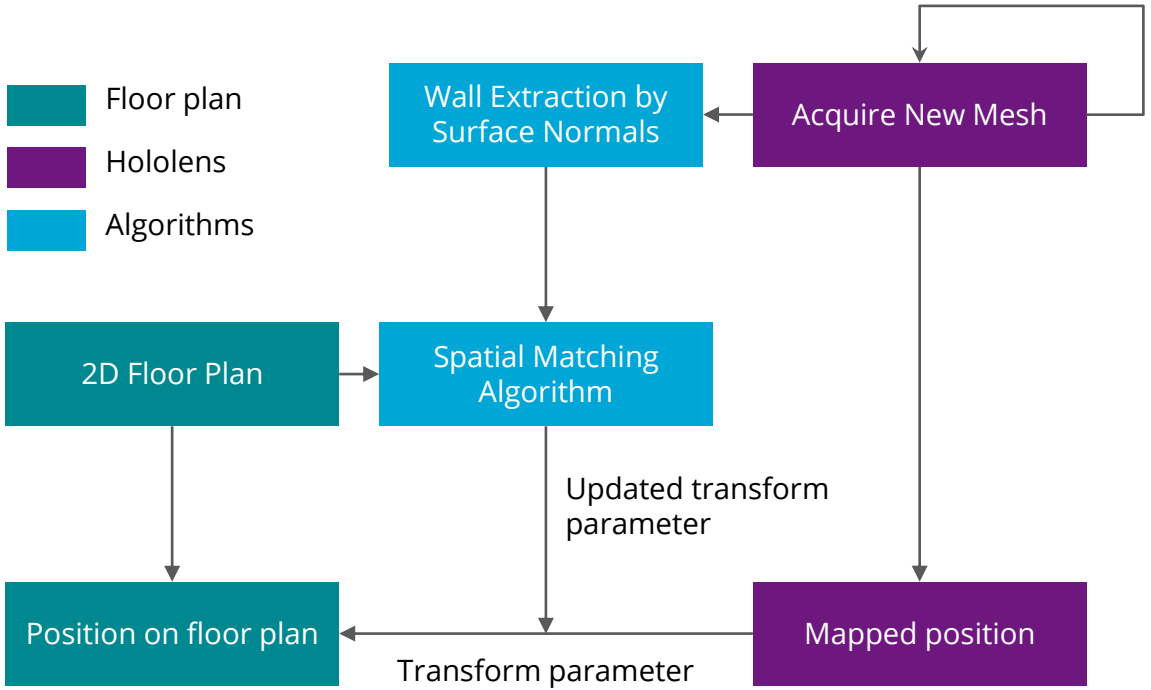
Methodology



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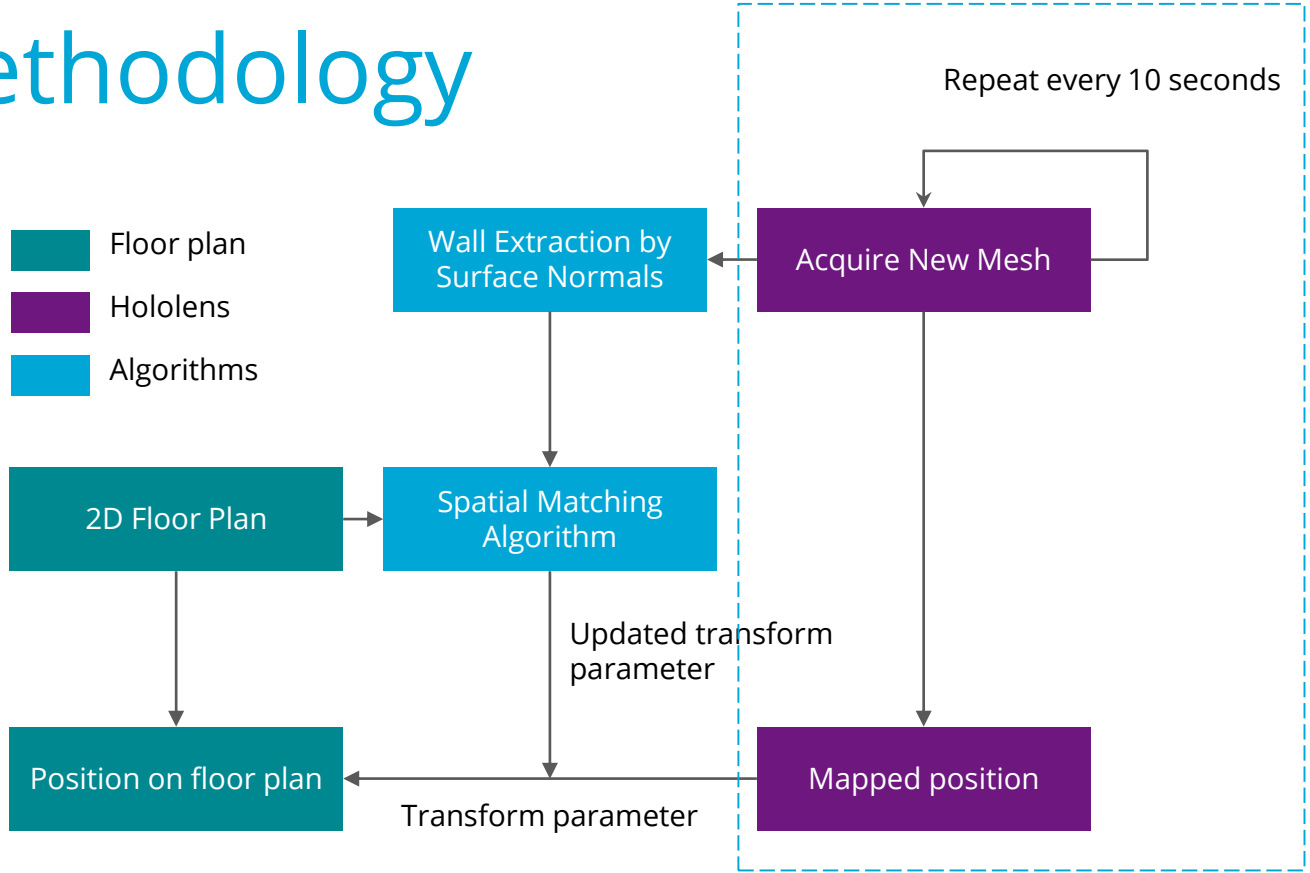
Methodology



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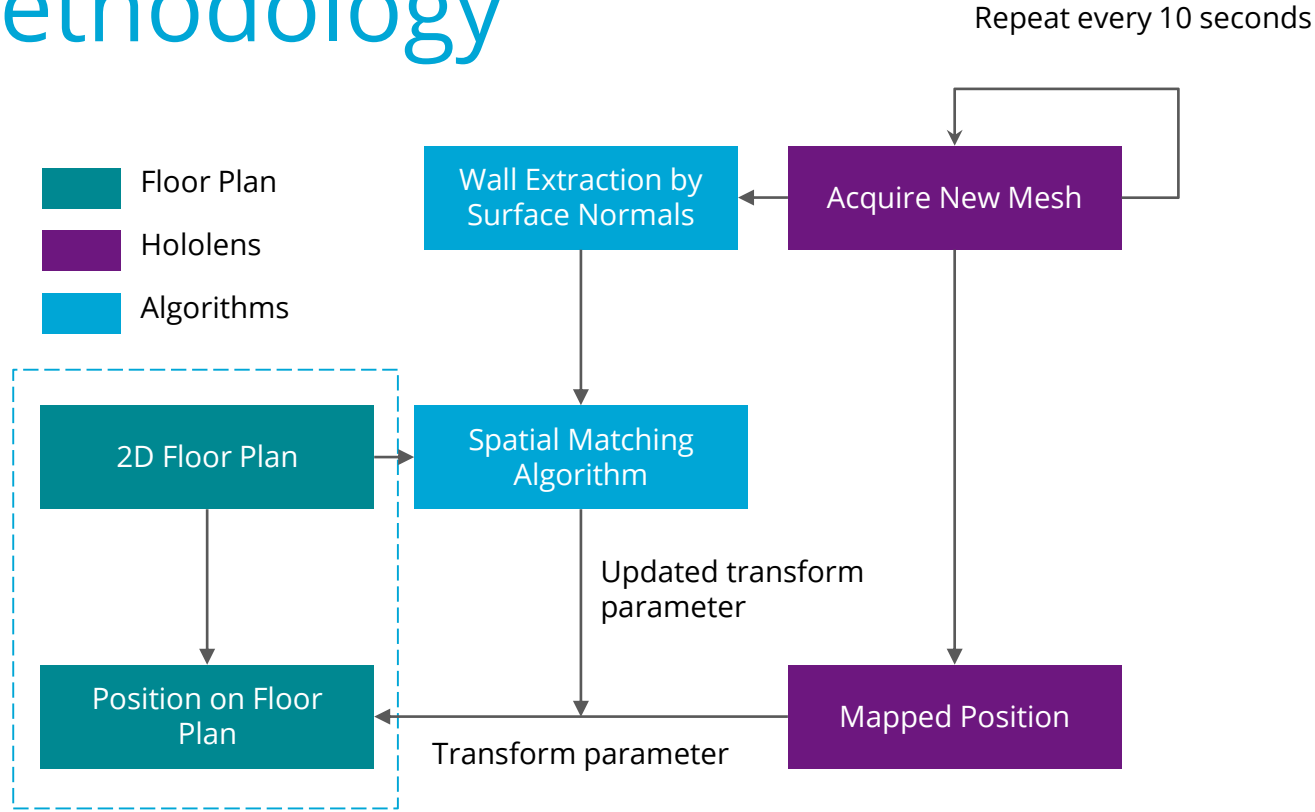
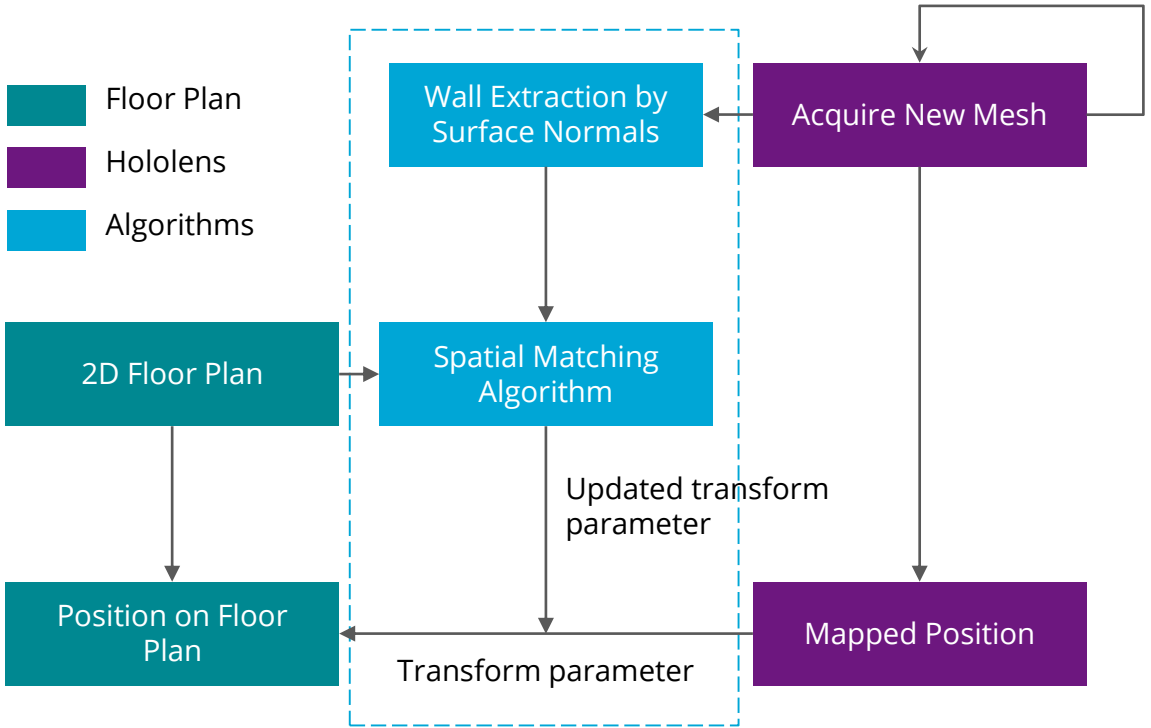
Methodology



Methodology



“ I’m in the bedroom ”

Location

“ I’m at point (0.5, 10) with a precision of 3m ”

Position

221B Baker Street / Lizarralde (2017)

“ I’m in the bedroom ”

Location

“ I’m at point (0.5, 10) with a precision of 3m ”

Position

221B Baker Street / Lizarralde (2017)

Floor Plan

. Correct scale

. Vector format

. Semantics

. No noise

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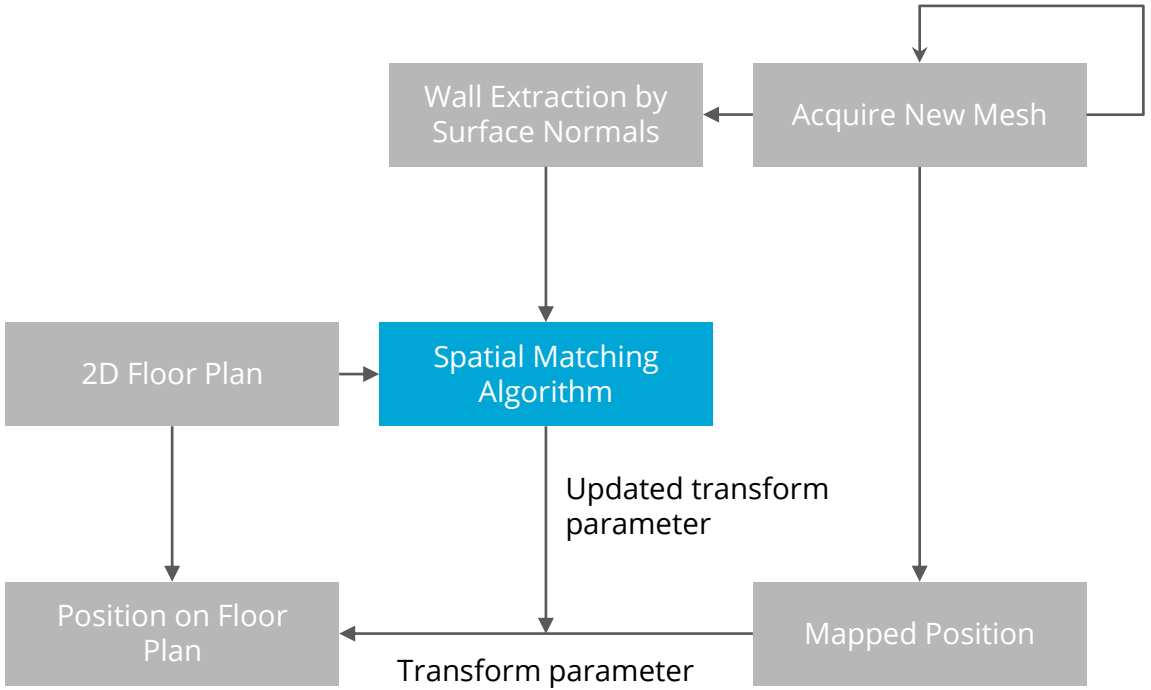
Methodology



. Iterative Closest Point (ICP)

. Local Quadratic Approximation &

  Instantaneous Kinematics

. Hough Transform

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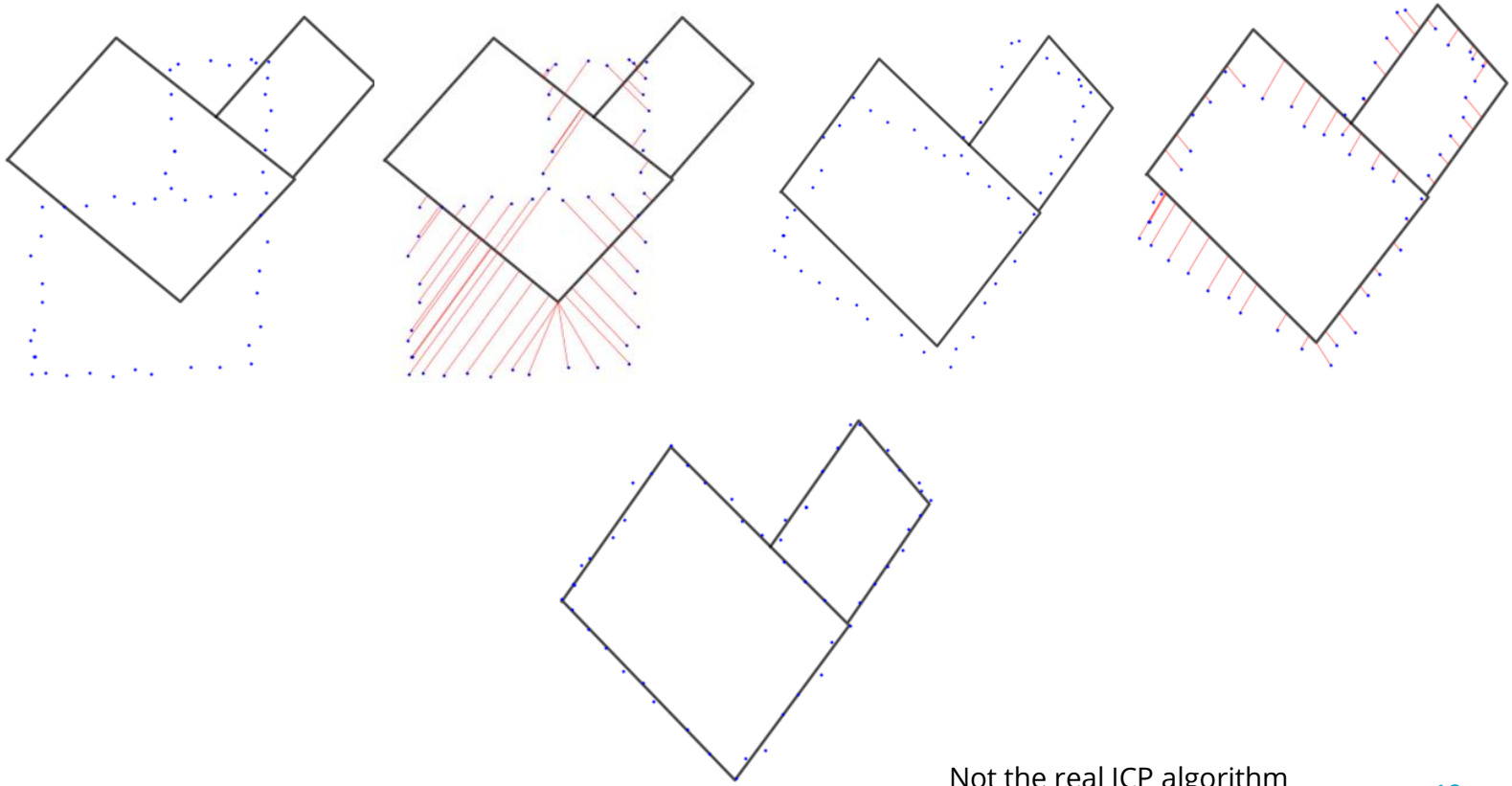
Algorithms

Iterative Closest Points



Not the real ICP algorithm

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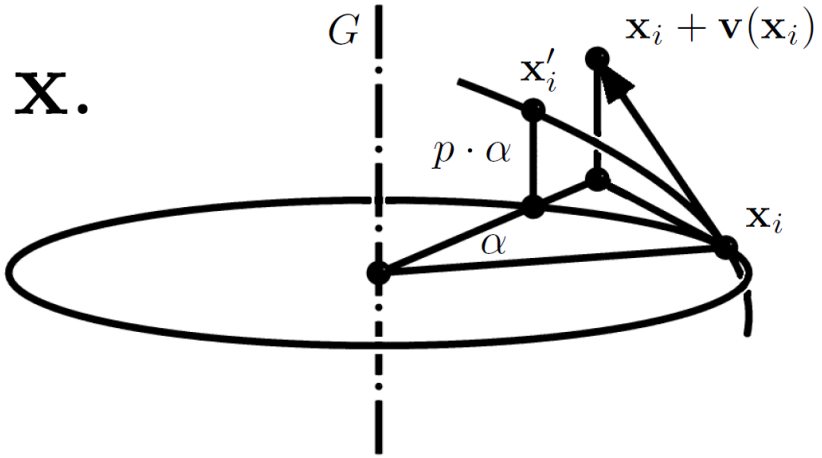
Local Quadratic Approximation & Instantaneous Kinematics

. ICP & small distances

. Helical motion

$$\mathbf{v}(\mathbf{x}) = \bar{\mathbf{c}} + \mathbf{c} \times \mathbf{x}.$$



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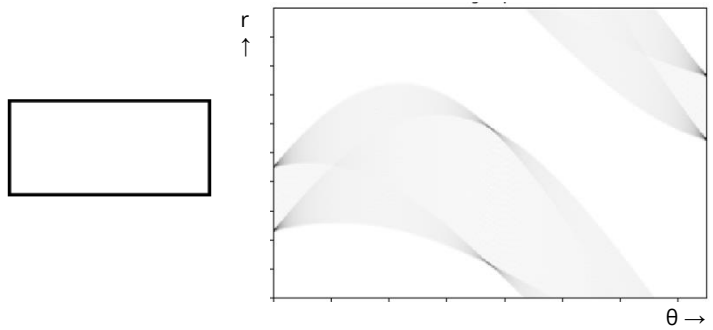
Hough Transform



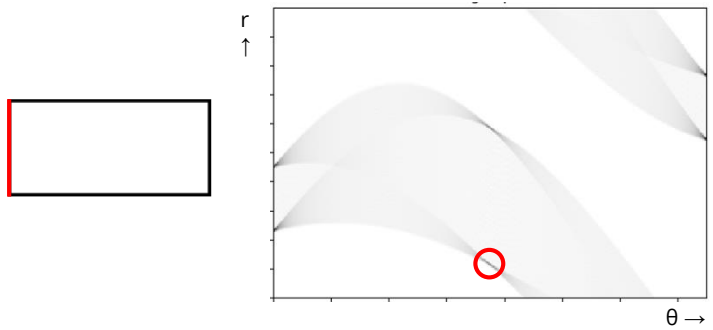
Reference image

Translation

Rotation

Translation + Rotation

Hough Transform



Reference image

Translation

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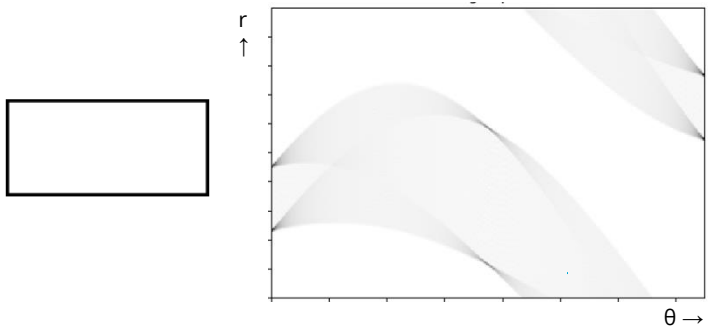
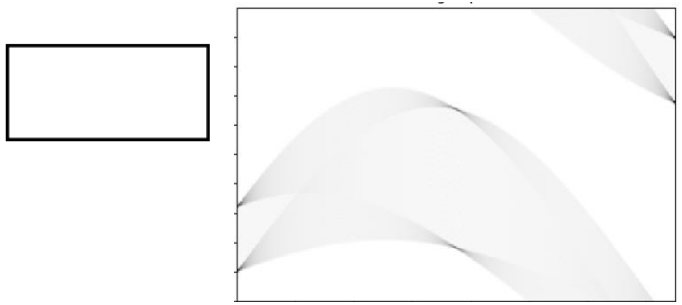
Translation + Rotation

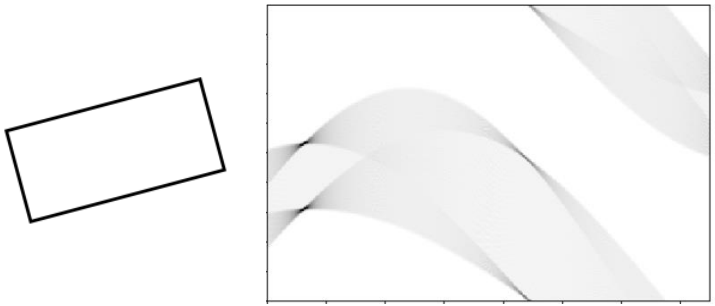
Hough Transform



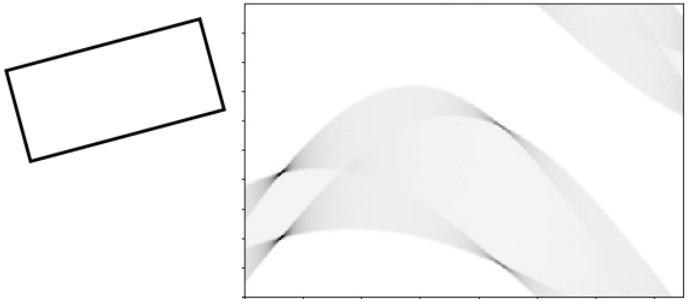
Reference image



Translation



Rotation



Translation + Rotation

Evaluation

. Accuracy and speed of algorithms

. On-the-fly error metrics

. Accuracy of position

. Robustness (failures)

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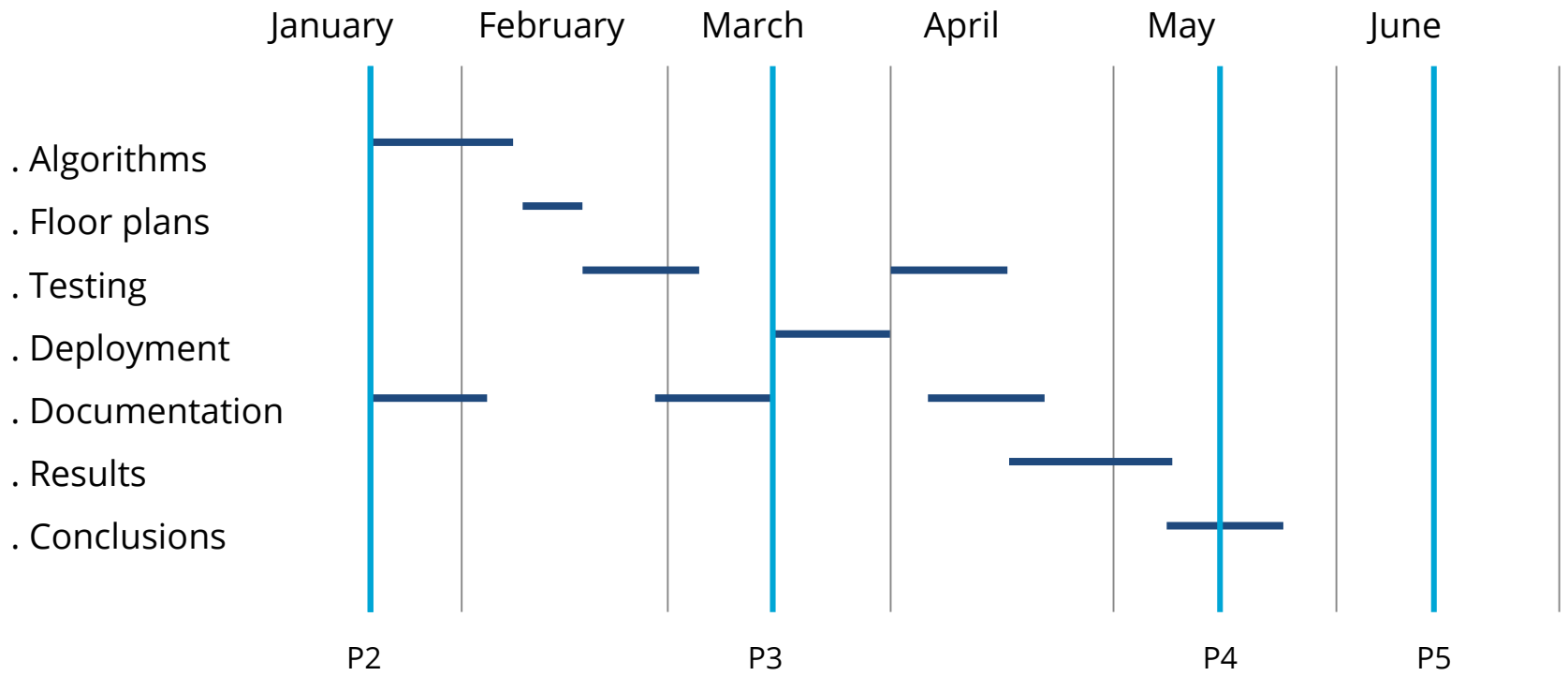

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Time planning

Questions?

Local Quadratic Approximation & Instantaneous Kinematics

. Distance to tangent plane for x(i) + v(x(i)) $d_i + \mathbf{n}_i \cdot (\bar{\mathbf{c}} + \mathbf{c} \times \mathbf{x}_i)$.

. Instead of the regular distance function

$$F(C) := F(\mathbf{c}, \bar{\mathbf{c}}) = \sum_i (d_i + \mathbf{n}_i \cdot (\bar{\mathbf{c}} + \mathbf{c} \times \mathbf{x}_i))^2$$

. Squared distance approximation:

Hough Transform extra slide