Global localization based on omnivision sensor for a guide mobile robot

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Vigo

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Outline

Introduction

Context

- Robot position
  - Required for most of the tasks
  - Reliability, robustness, run in real time
- Domus Museum
  - Large, dynamic and crowded environment
  - Modifications are not allowed
  - Irregular floor

Our Proposal

- Omnidirectional camera pointing to ceil
- Maps of natural Landmarks: spotlights
- Global localization algorithm based on a particle filter

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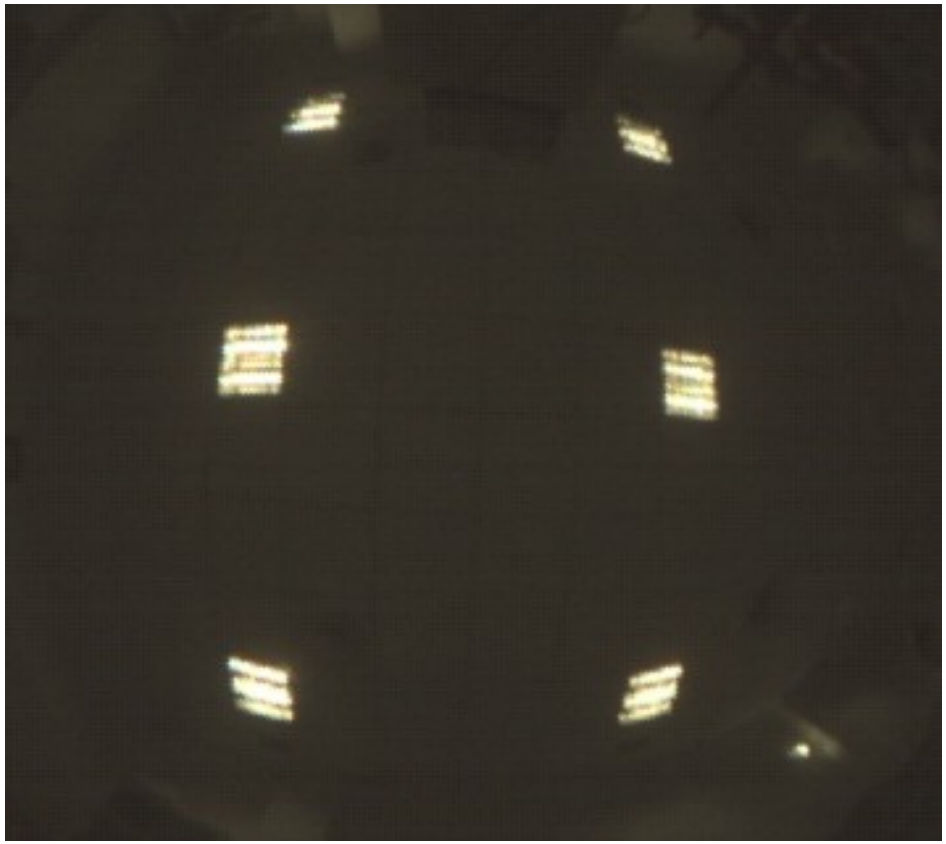
Landmark Detection

0. Infrared baseband filter
1. Preprocessing phase:
   a. Thresholding
   b. Closure operator
2. Segmentation:
   a. Edge detection
   b. Contour extraction
3. Features extraction
4. Selected landmarks



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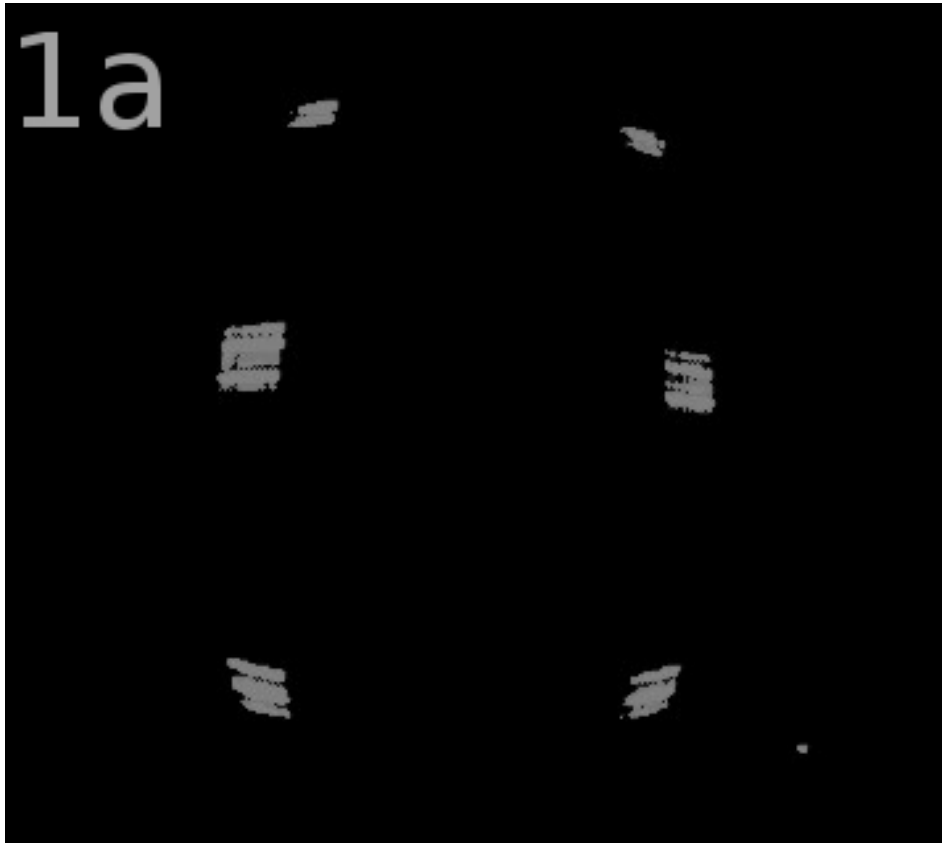

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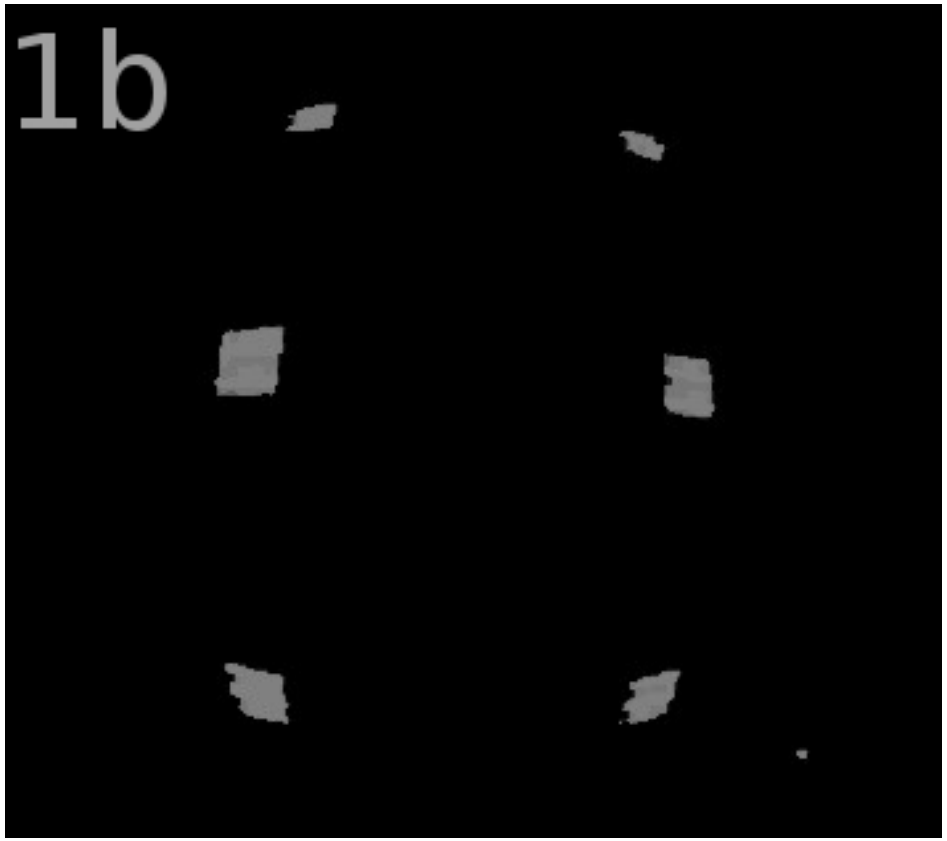

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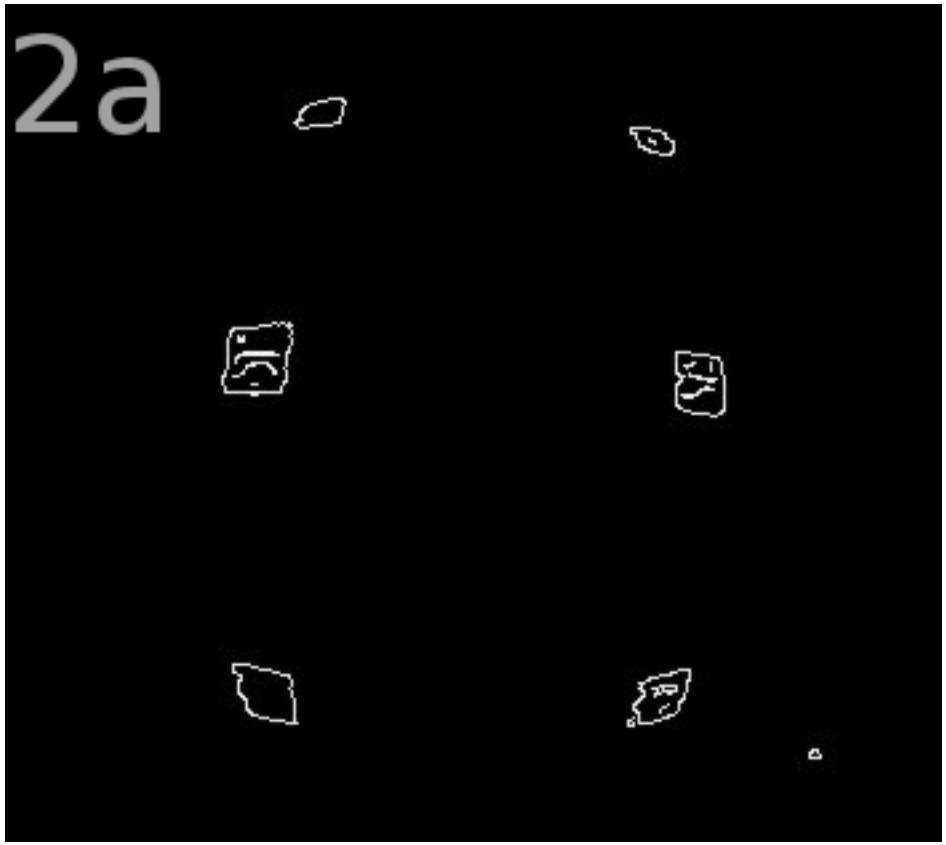

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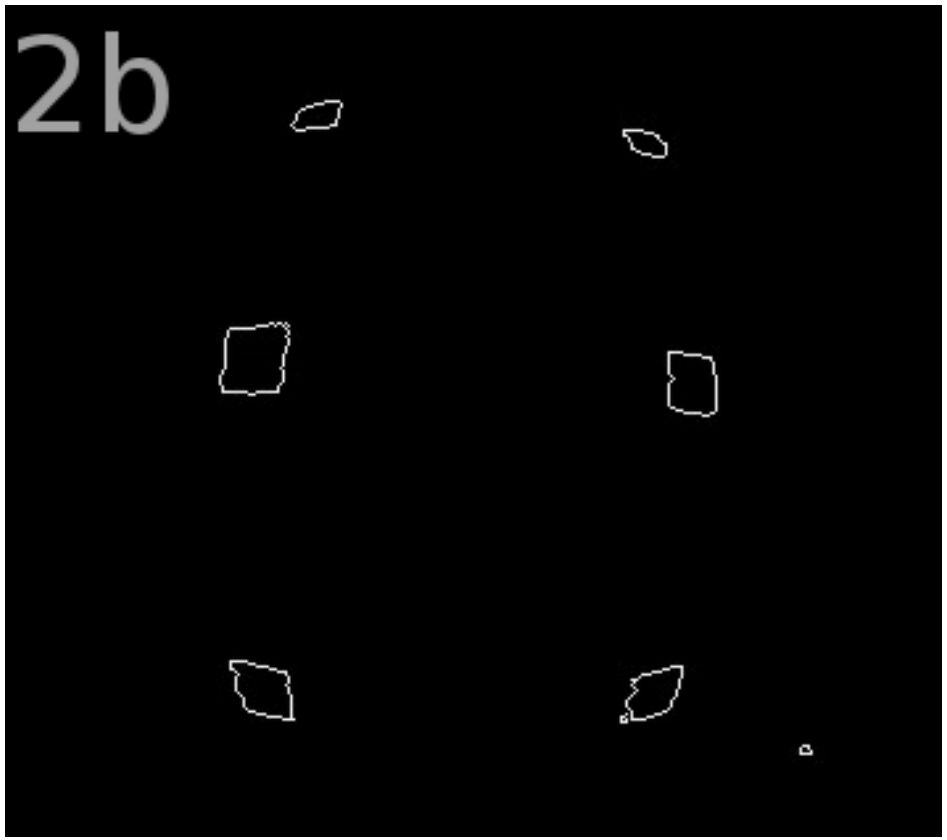

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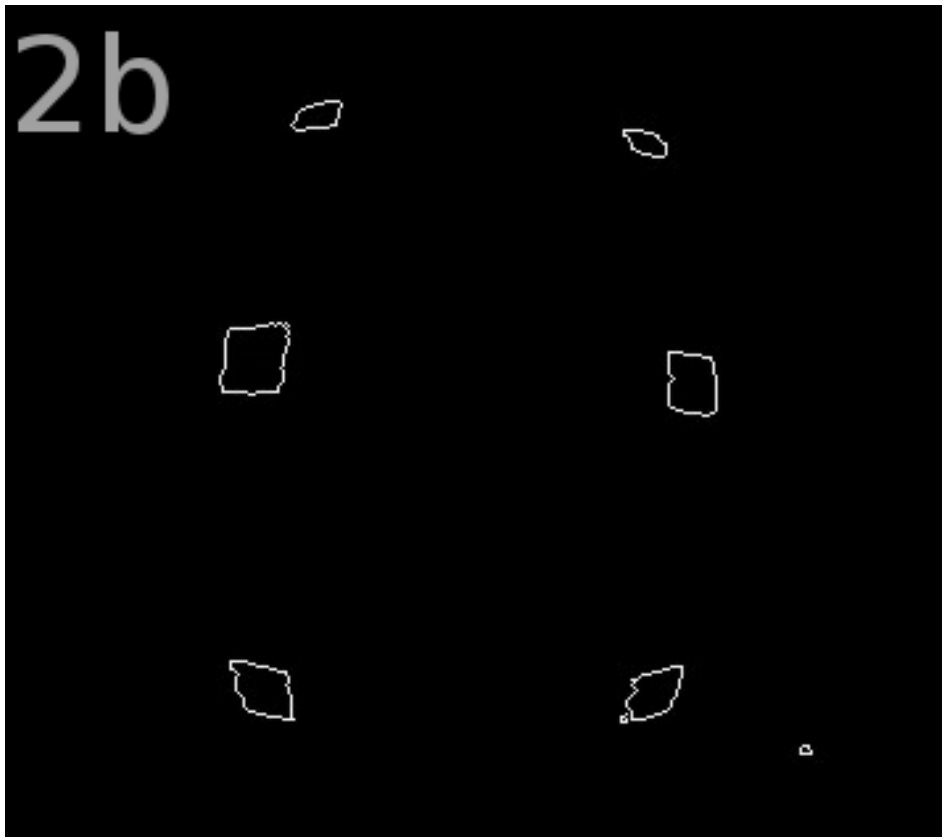

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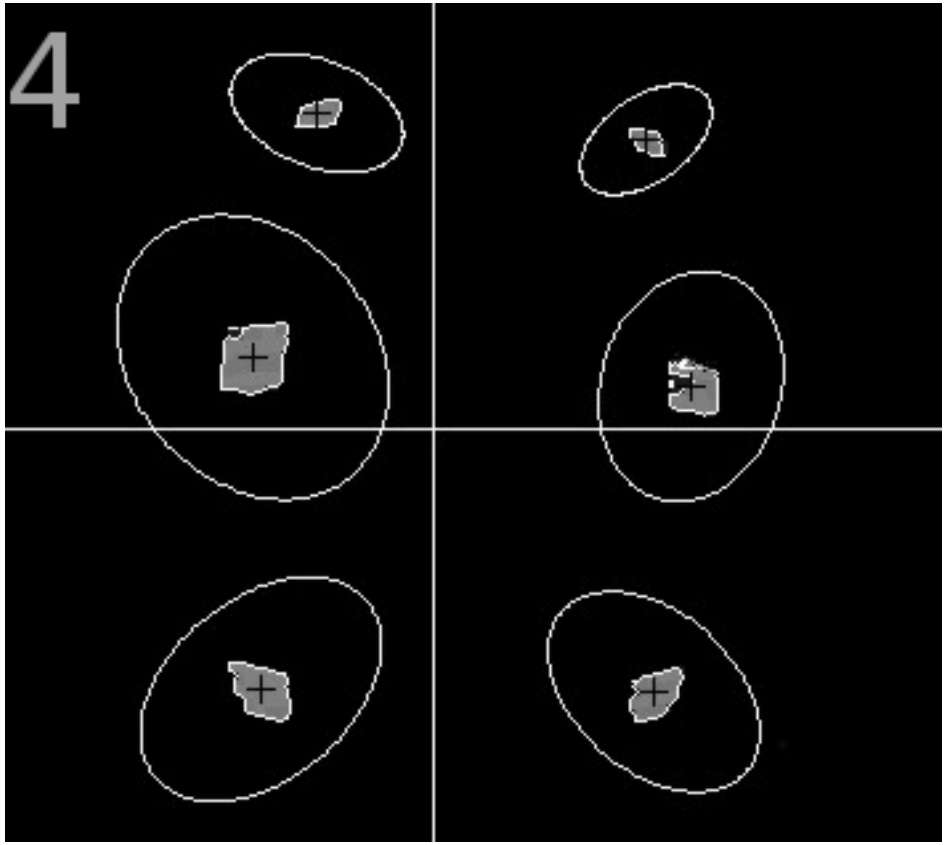
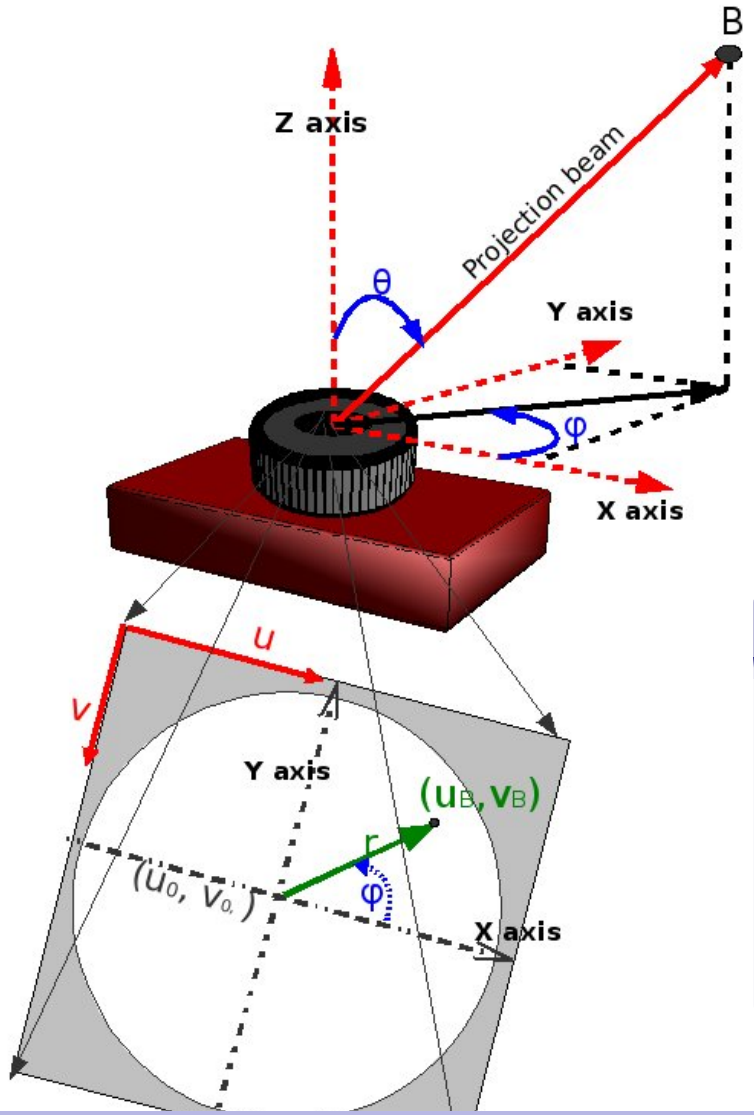


Camera Model



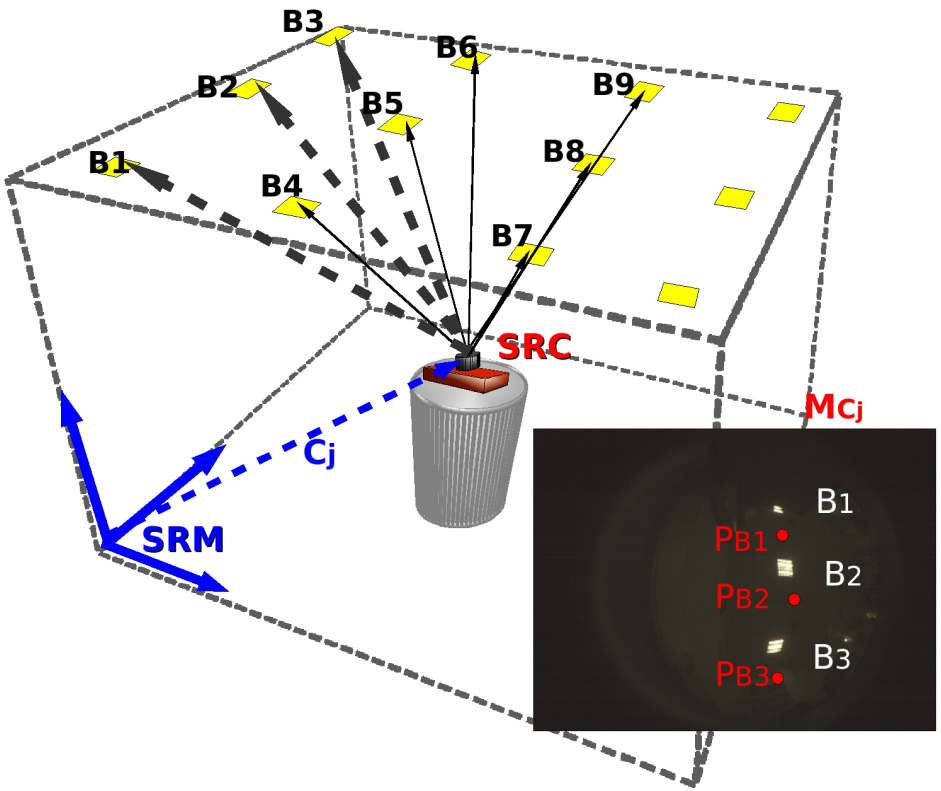
- Transform 3D scene into 2D image
- Pin-Hole Mode: $F.O.V << 180^0$
- Pajda−Bakstein Model: $F.O.V \simeq 180^0$

Equations

$$r = a * \tan\frac{\theta}{b} + c * \sin\frac{\theta}{d} \quad (1)$$

$$\left.\begin{aligned} u &= u_0 + r * cos\varphi \\ v &= \beta * (v_0 + r * sin\varphi) \end{aligned}\right\} \quad (2)$$

Ceiling Map Projection



Landmark Projection

- $\mathbf{B}_i^P = R_P \cdot \mathbf{B}_i^W - \mathbf{P}$
- $Proj(B_i^P) = (u_{B_i^P}, v_{B_i^P})$

$Map(P)$ for one position P

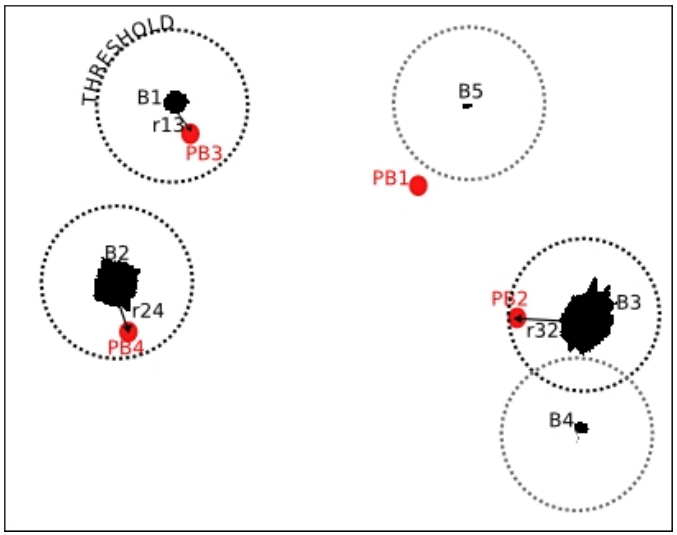
$$Map(P) = \left\{ Proj(B_i^P) \right\}$$

Outline

Merit Function

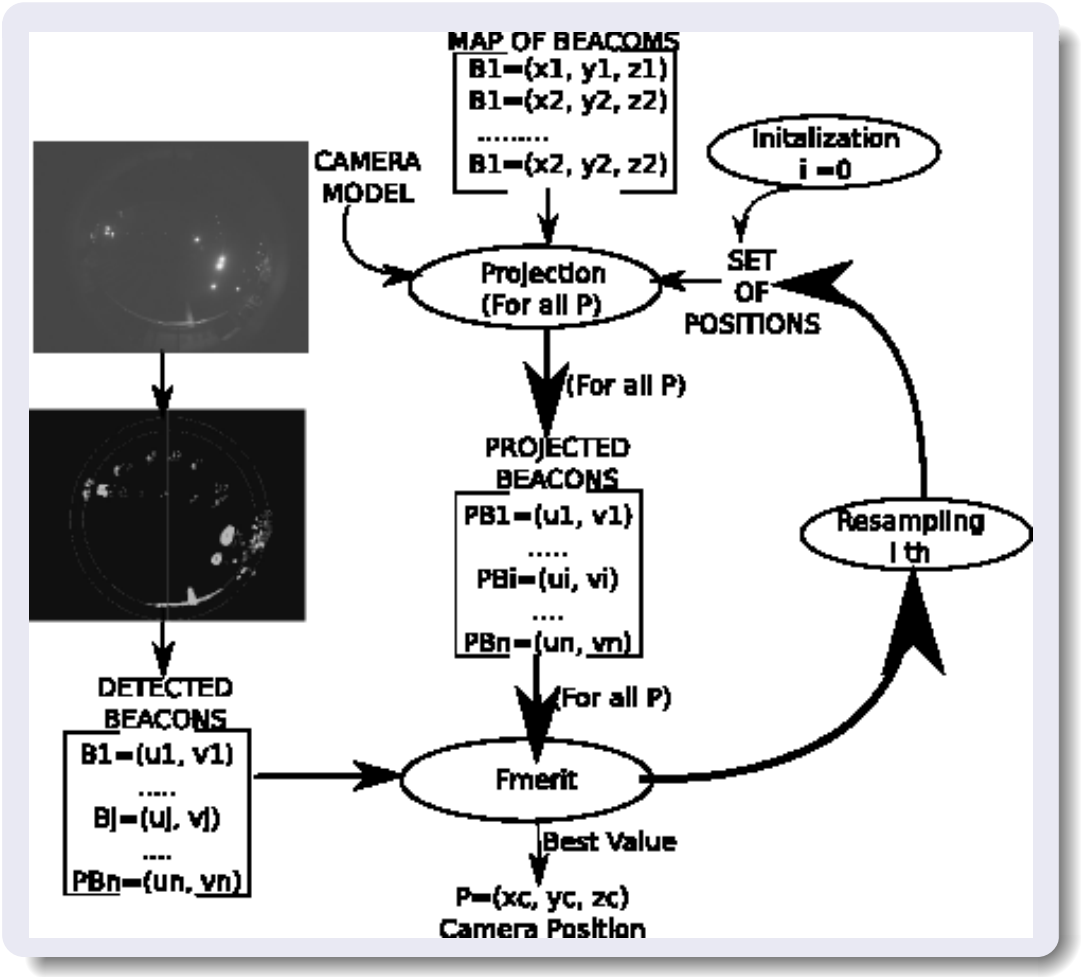
$$M(P) = \frac{1}{N_P} * \varepsilon_P$$

$Map(P)$
for all Beacons j in the image **do**
  for all Beacons i in Map(P) **do**
    $\varepsilon(B^P{}_{ij}) = \|Proj(B^P{}_i) - Detected(B_j)\|$
    if $\varepsilon(B^P{}_{ij}) < THRESHOLD$ **then**
      $\varepsilon_P = \varepsilon_P + \varepsilon(B^P{}_{ij})$
      $N_P = N_P + 1$
    else
      $\varepsilon_P = \varepsilon_P + THRESHOLD$
    end if
  end for
end for



- $N(P) = 3$
- $\varepsilon_P = r13 + r24 + r32 + TH.$

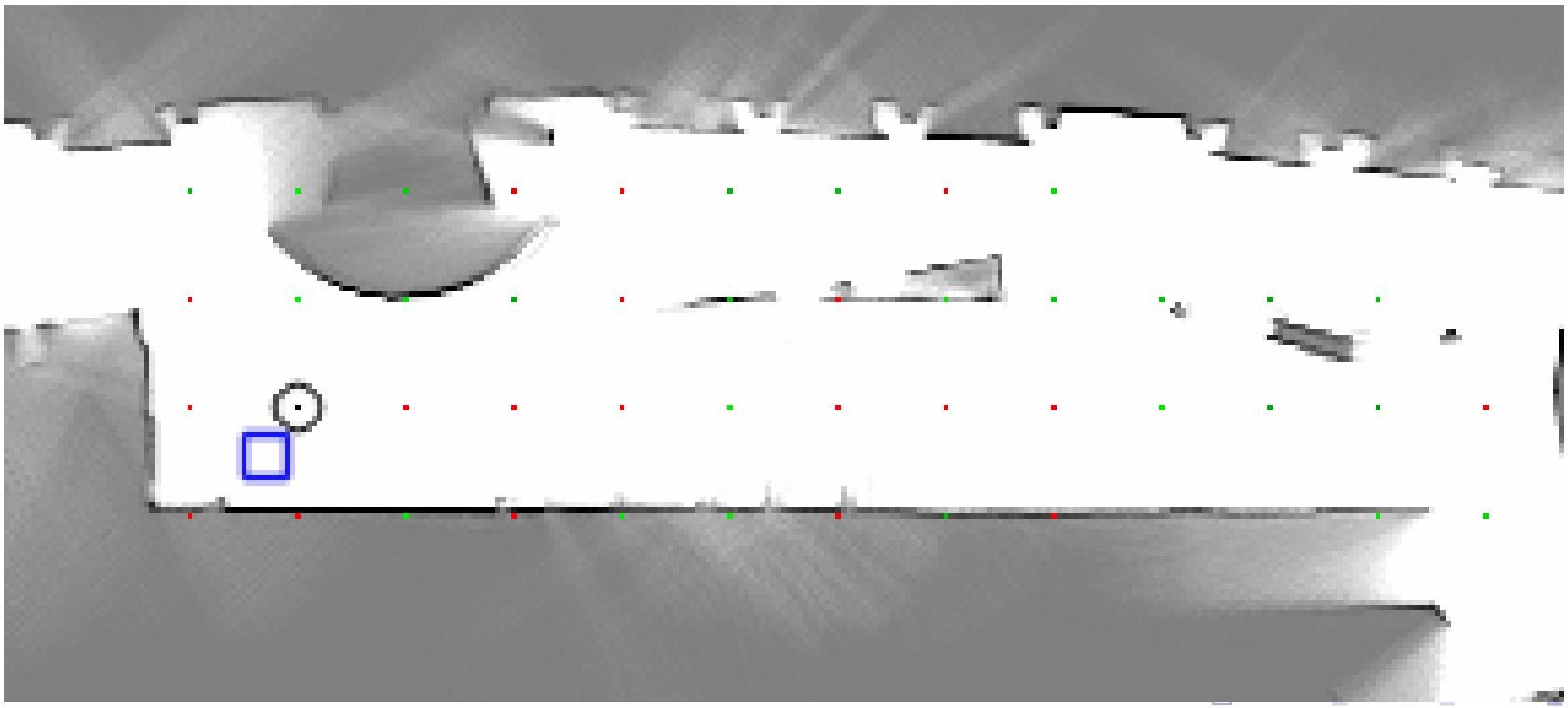
Minimizing Process



- Set of particles
  - Initially: uniformly distributed
- Resample
  - Select the best ones
  - New particles
  - Gaussian noise
- Repetitive

Minimizing Process

- Intialization $[2m/2^o]$
- $\sigma_{x,y} = 0.50m$ and $\sigma_\theta = 5^o$
- Top 200 positions
- 6 Iterations: 0, 1, 3 , 5



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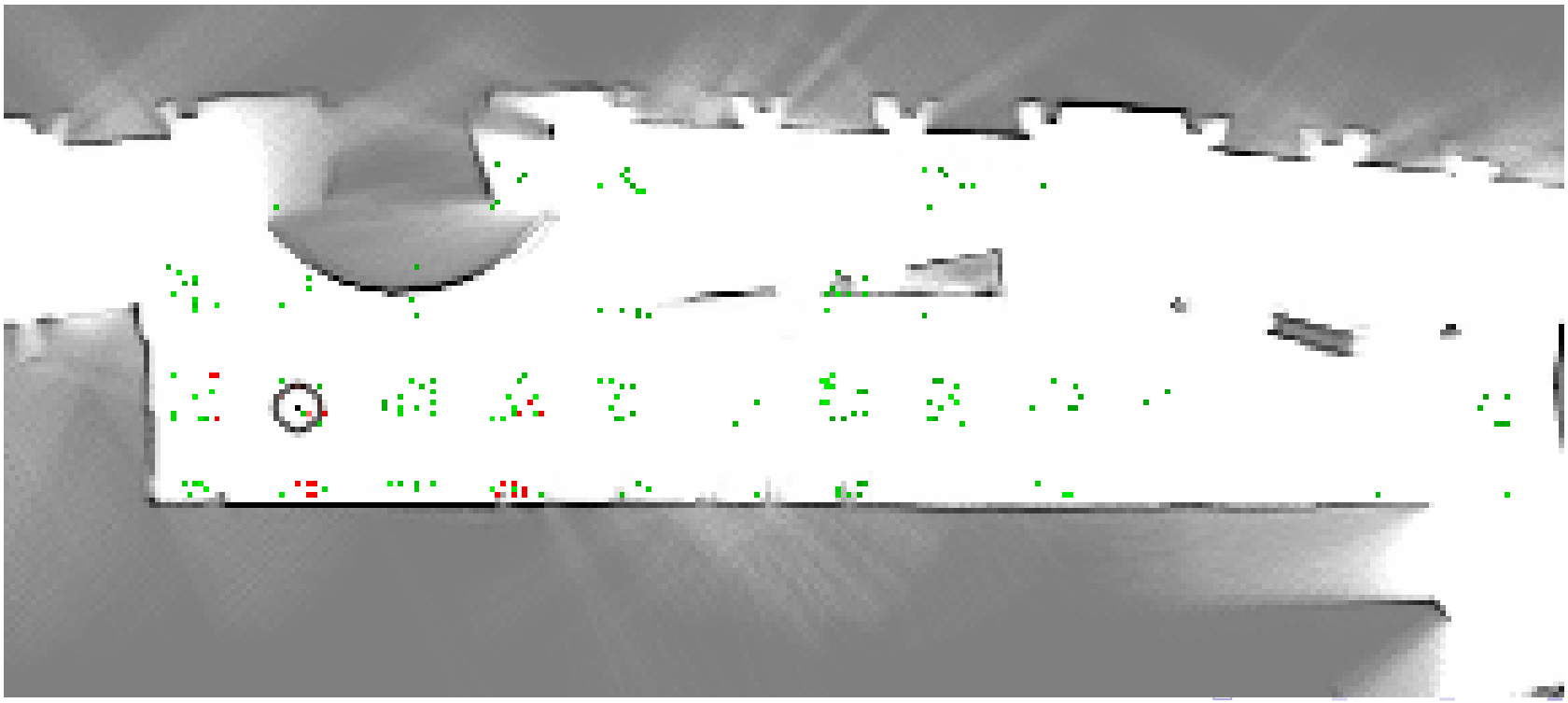

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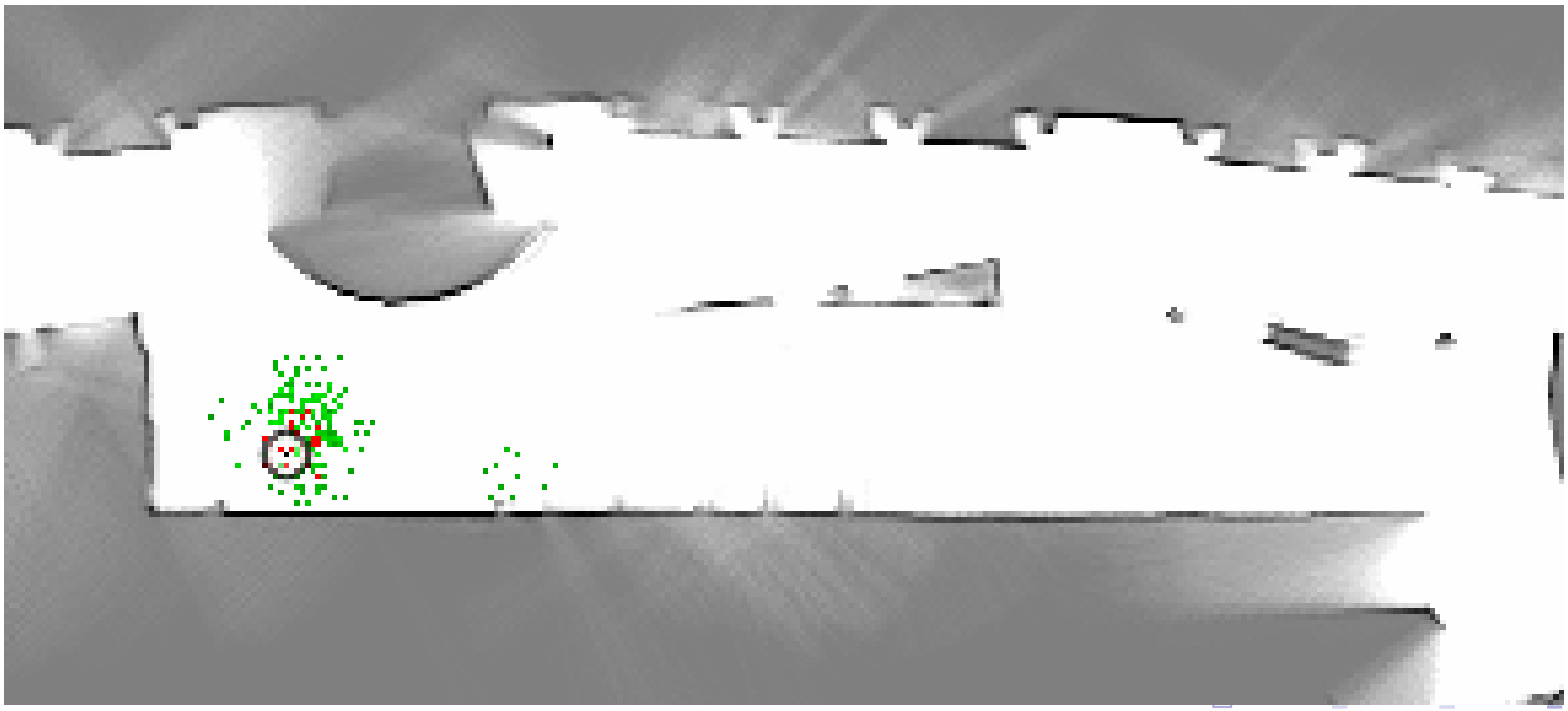

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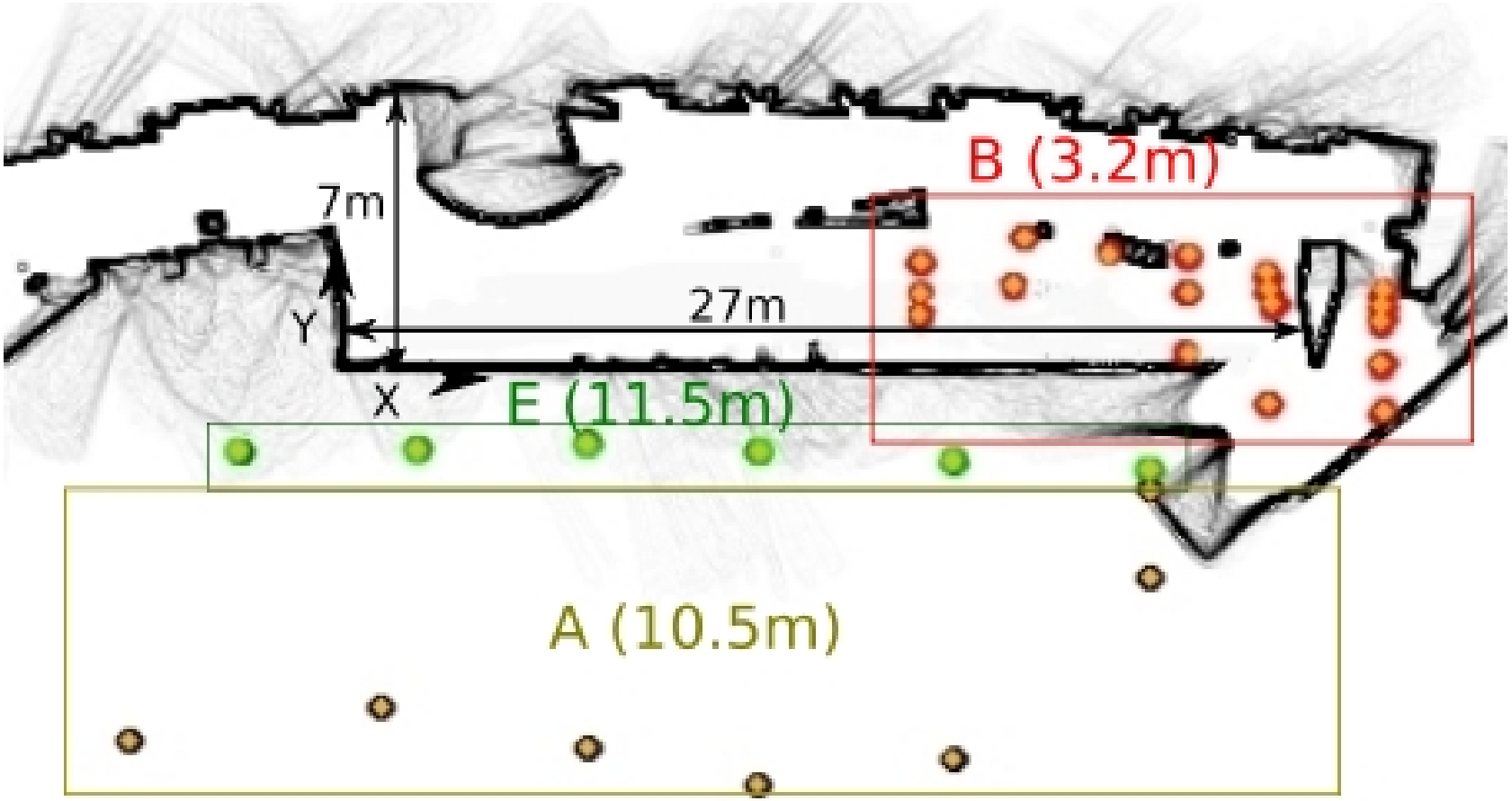
Experiments on the Domus Museum



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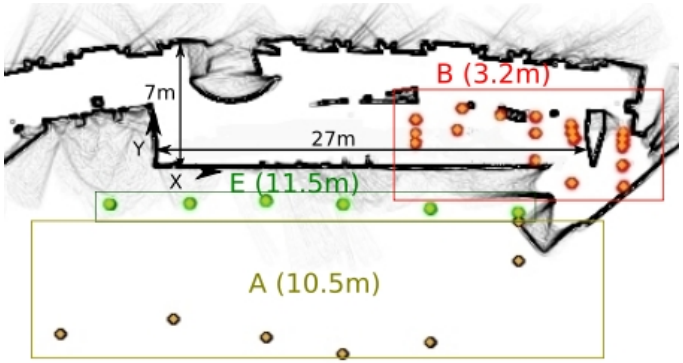
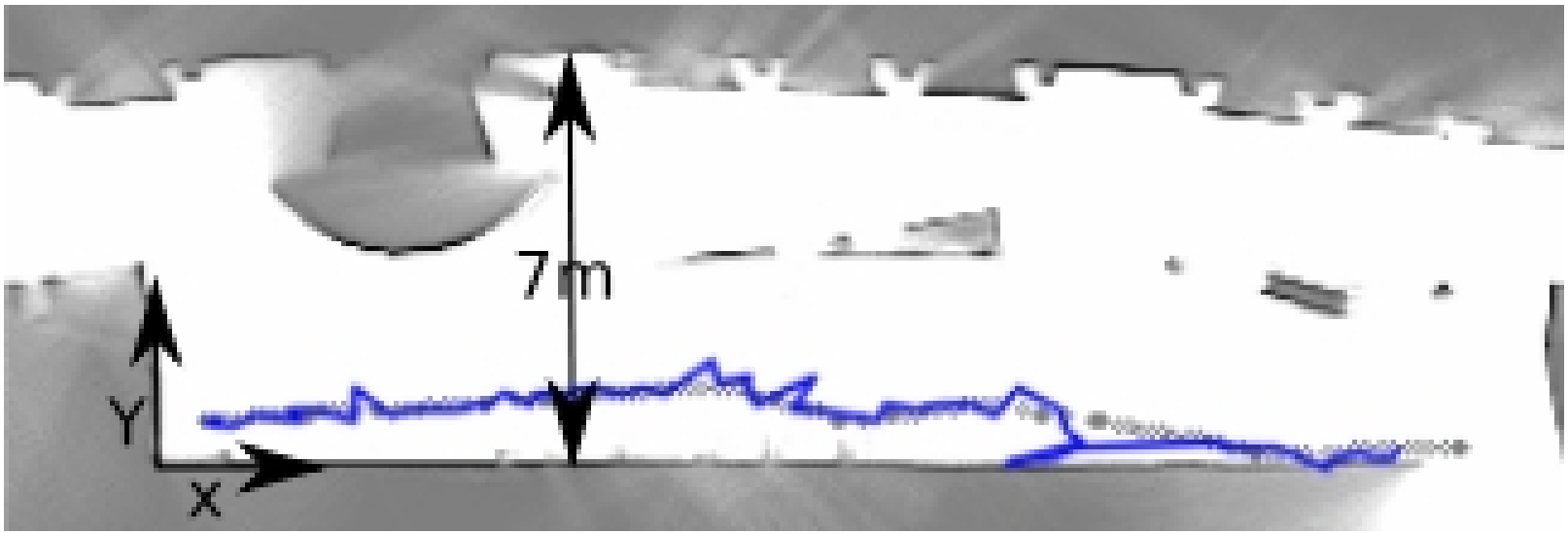
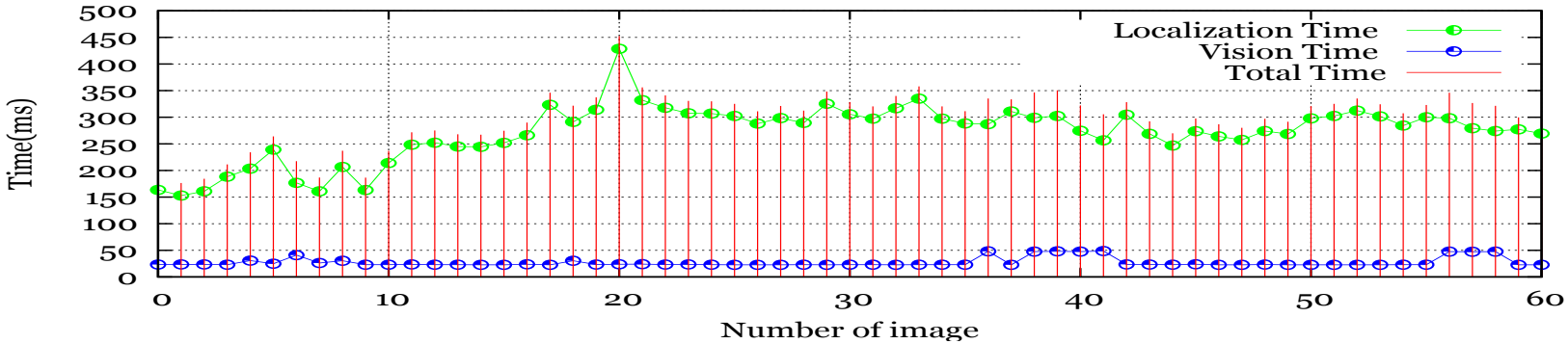
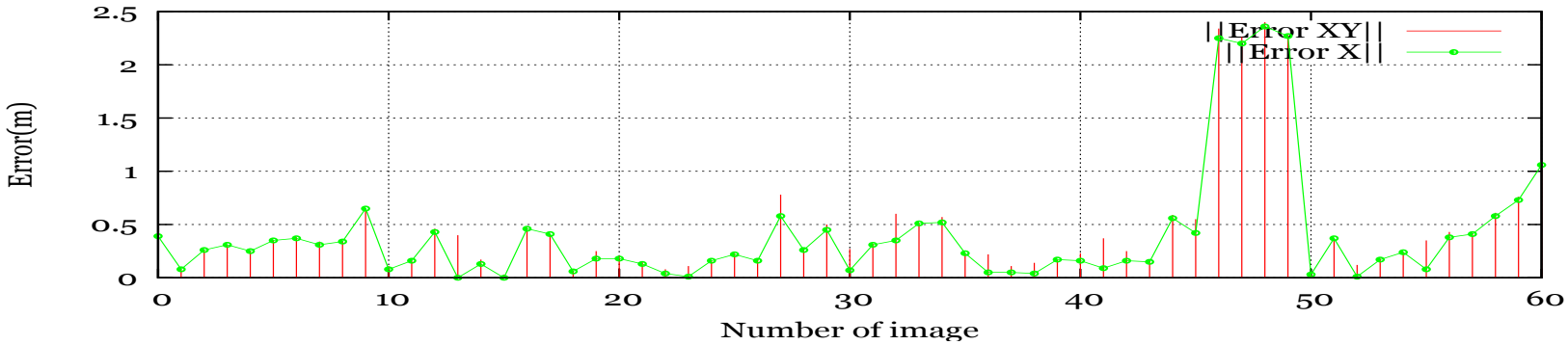
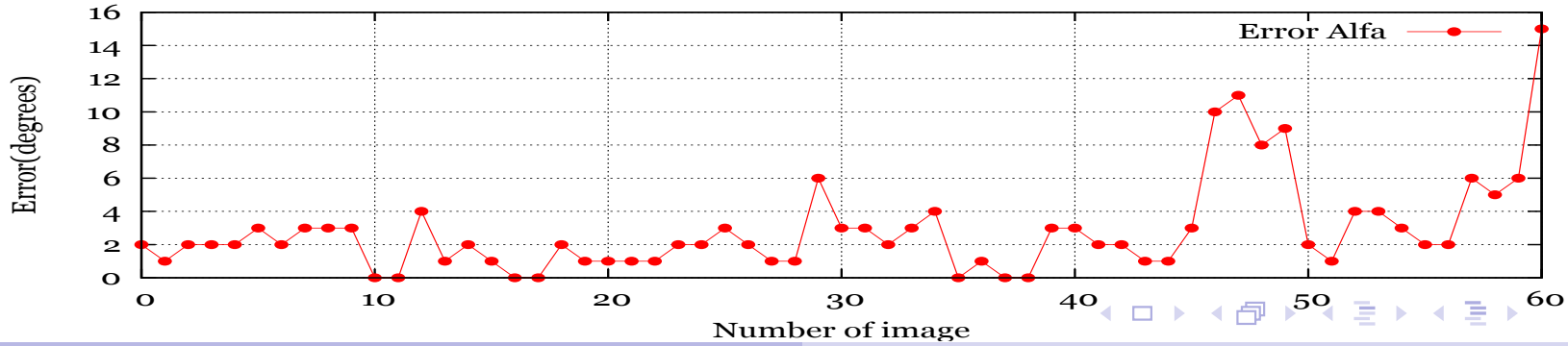




Results on the Domus Museum:







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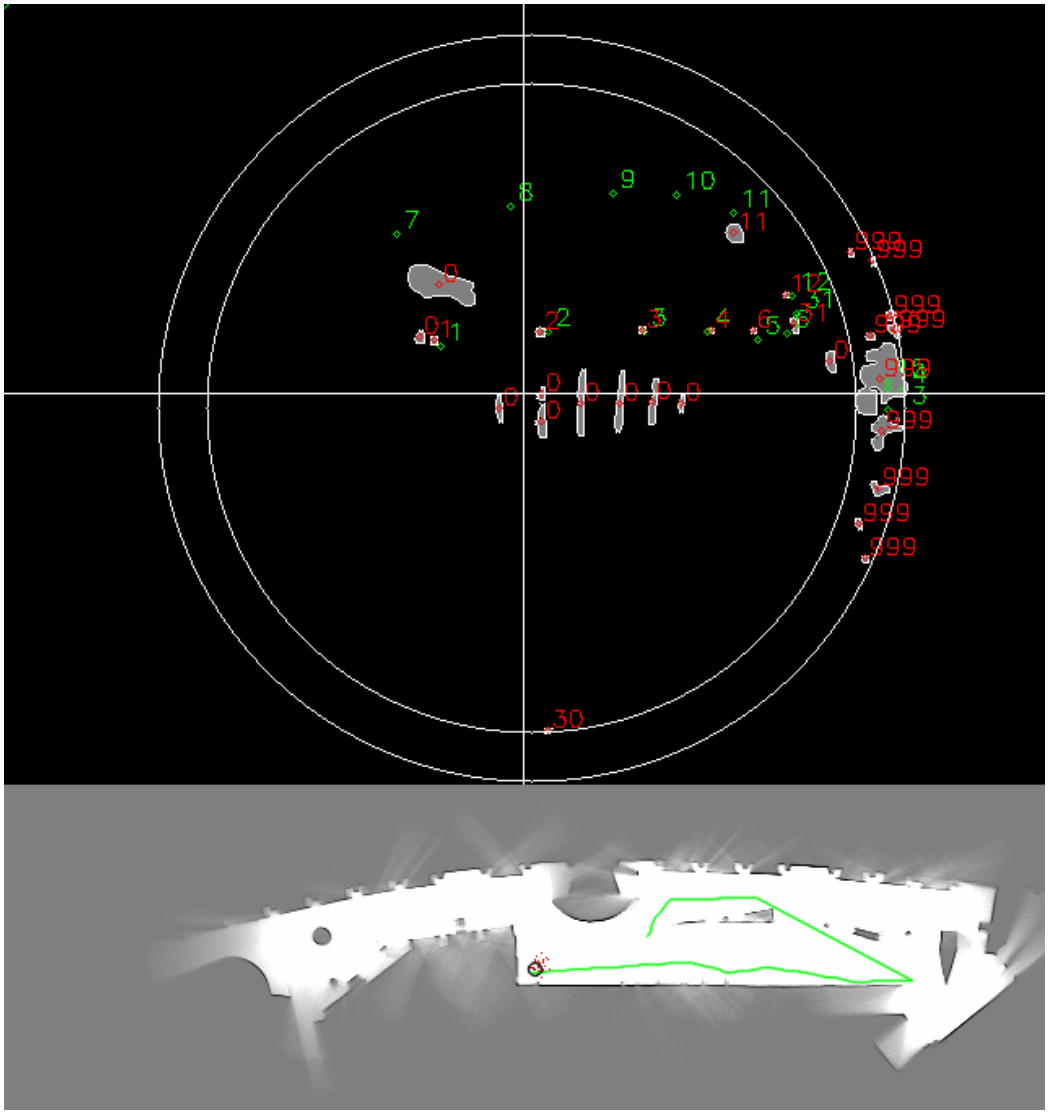

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Conclusions

Locate a guide robot at the Domus museum using omnivision

- Robust landmark Detection
- Based on a Merit Function
- Crowded and medium-large environment ($168m^2$).
- Only 31 spotligths

	$E_{mean}\|\|xy\|\|$	$E_{max}\|\|xy\|\|$	α_{mean}	α_{max}	$Tiempo(ms)$
GLOBAL	0.53	2.42	15	3	300
$MCL_{TAROS2008}$	0.41	1.07	20	3	40

Future work

- Global Localization based on MCL
- Simultaneous localization and mapping (*SLAM*)

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