Stereo Visual Odometry Algorithm based on SIFT descriptors

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CONTENTS

- INTRODUCTION
- STEREO VISUAL ODOMETRY ALGORITHM
- EXPERIMENTAL RESULTS
- CONCLUSIONS AND FUTURE WORK

Stereo Visual Odometry Algorithm based on SIFT descriptors

CONTENTS

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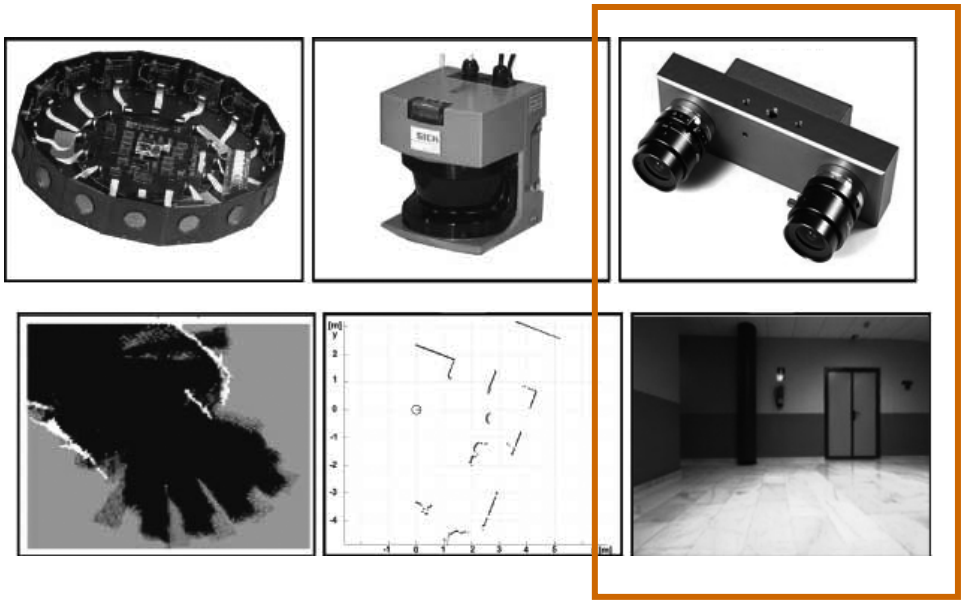
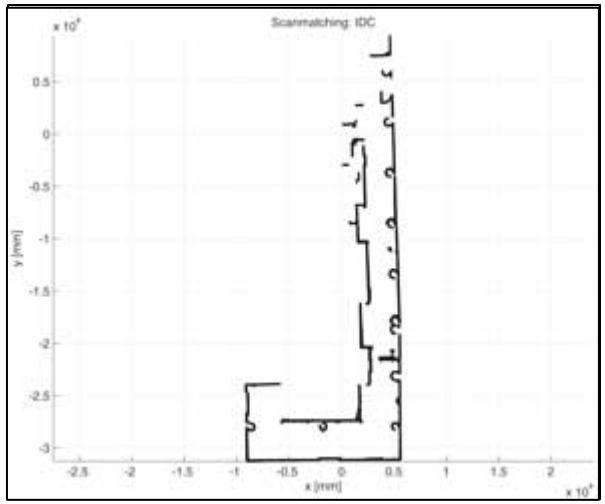
INTRODUCTION

- RELATIVE LOCALIZATION PROBLEM FOR AUTONOMOUS MOBILE ROBOT
  - KEY FUNCTION: TO KEEP TRACK OF ITS POSE WHILE MOVING
  - EXTERNAL SENSOR TO PERCEIVE THE ENVIRONMENT



Data Integrated with the accurate odometry

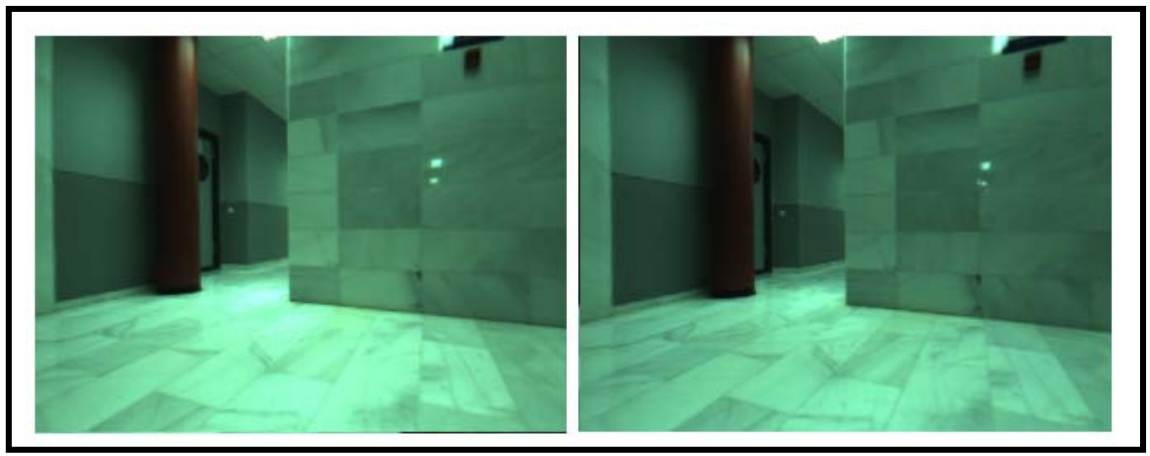


Stereo Visual Odometry Algorithm based on SIFT descriptors

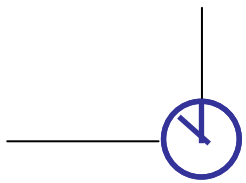
INTRODUCTION

• STEREO VISUAL ODOMETRY: FIND THE ROTATION AND TRANSLATION WHO MAXIMIZE OVERLAPING OF TWO SETS OF POINTS ASSOCIATED TO CONSECUTIVE VISUAL DATA

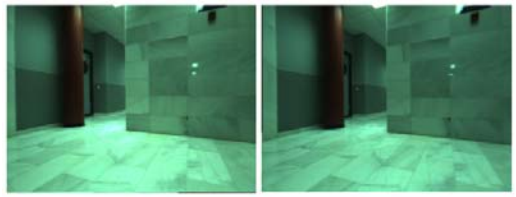
STH-MDCS Stereo head from Videre Design
1.3 Mpx
320x240



Instant of time t-1



Stereo Visual Odometry Algorithm based on SIFT descriptors



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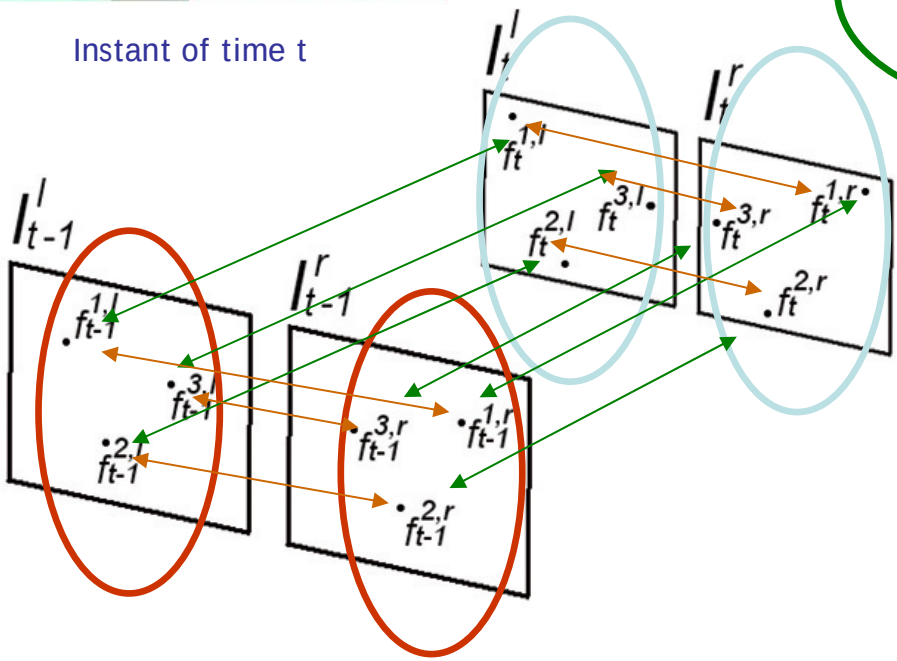
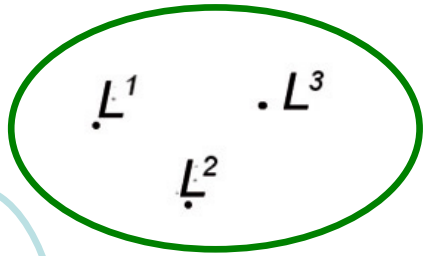
Instant of time t-1





- WHAT KIND OF IMAGE DESCRIPTOR ARE WE GOING TO USE?

DESCRIPTORS IN THE IMAGE

- SIFT (Scale Invariant Feature Transform)

D.G. Lowe, "Object recognition from local scale-invariant features", in *Int. Conf. on Computer Vision*, Corfu–Greece, pp. 1150-1157, 1999.

Invariant to:

- Scale
- Rotation
- Translation

Robust to:

- Changes in illumination
- Noise
- Minor changes in the point of view

CONTENTS

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CONTENTS

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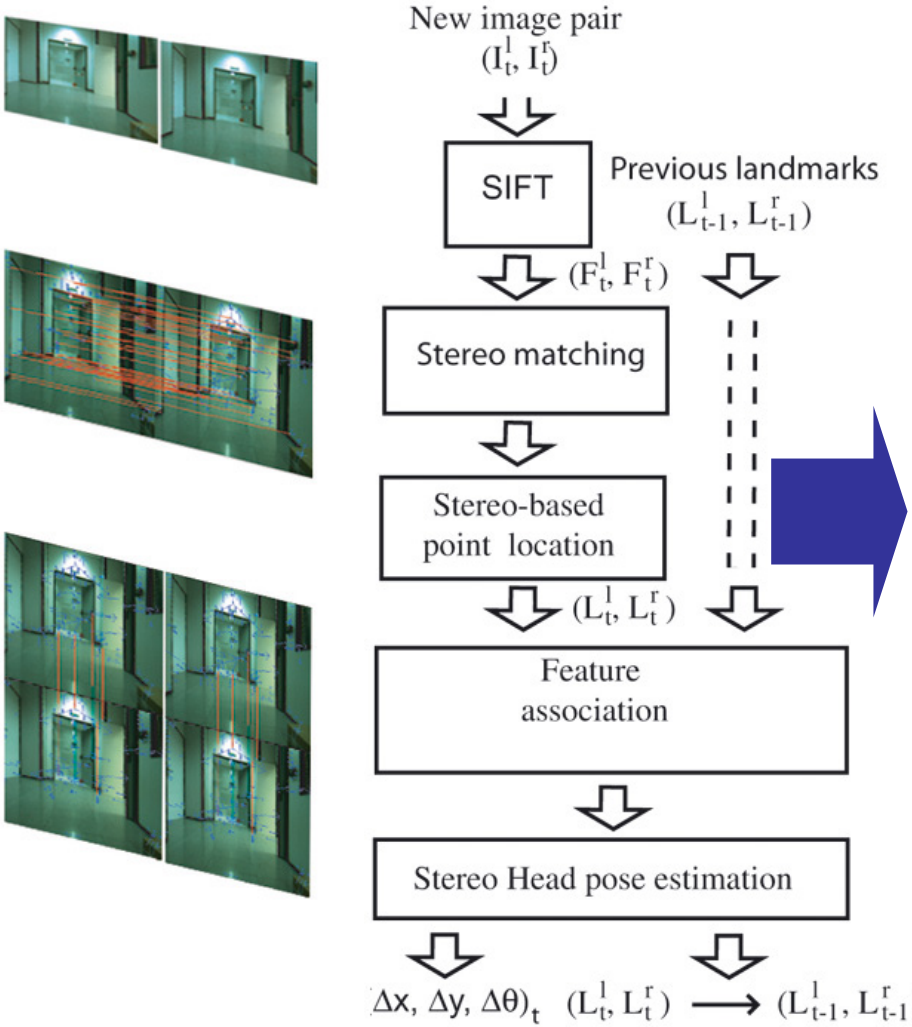
The proposed approach



Stages of the algorithm

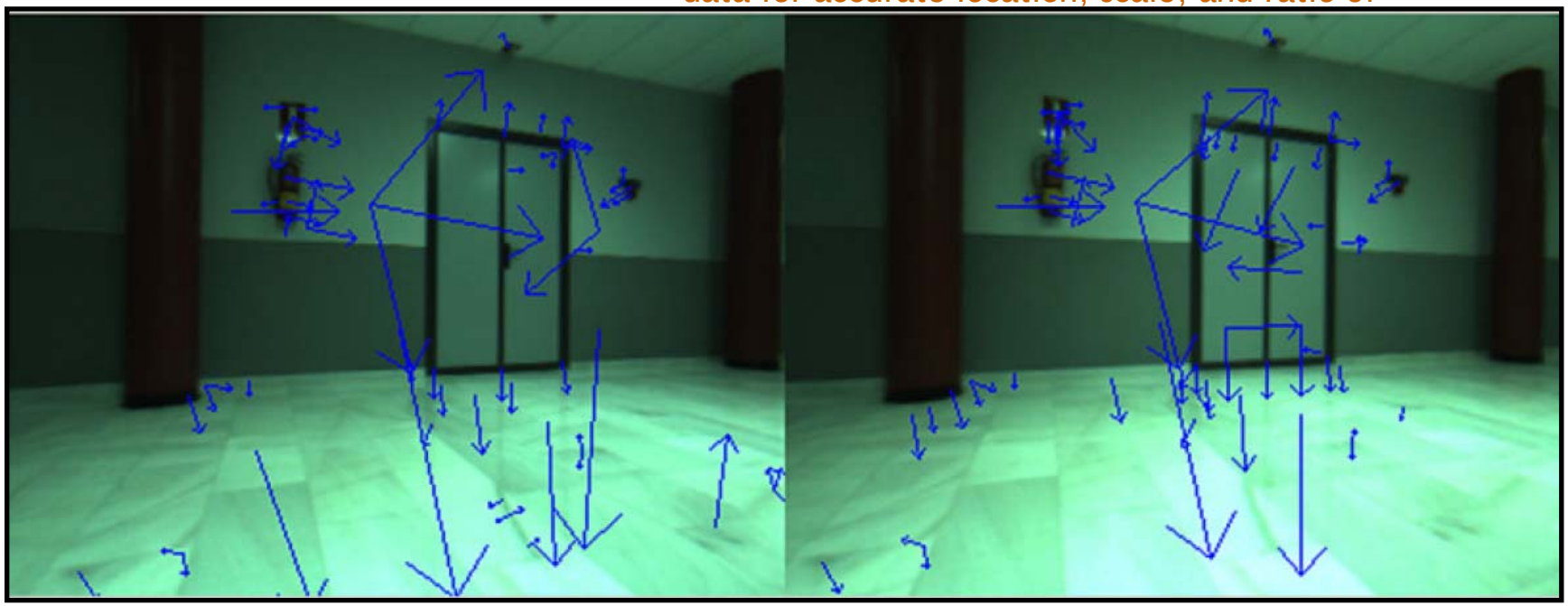
- SIFT descriptor
- Stereo matching
- Stereo based point location
- Feature Association
- Stereo Head pose estimate

Stereo Visual Odometry Algorithm based on SIFT descriptors

SIFT descriptor
Stereo matching
Stereo based point location
Feature Association
Stereo Head pose estimate

Scale-Invariant image features: Lowe's Algorithm

• *Scale-space extrema detection*. A scale spaced is constructed from the original image to identify those locations and scales that are identifiable from different views of the same object.
• *Keypoint localization*. A detailed fit to the nearby data for accurate location, scale, and ratio of



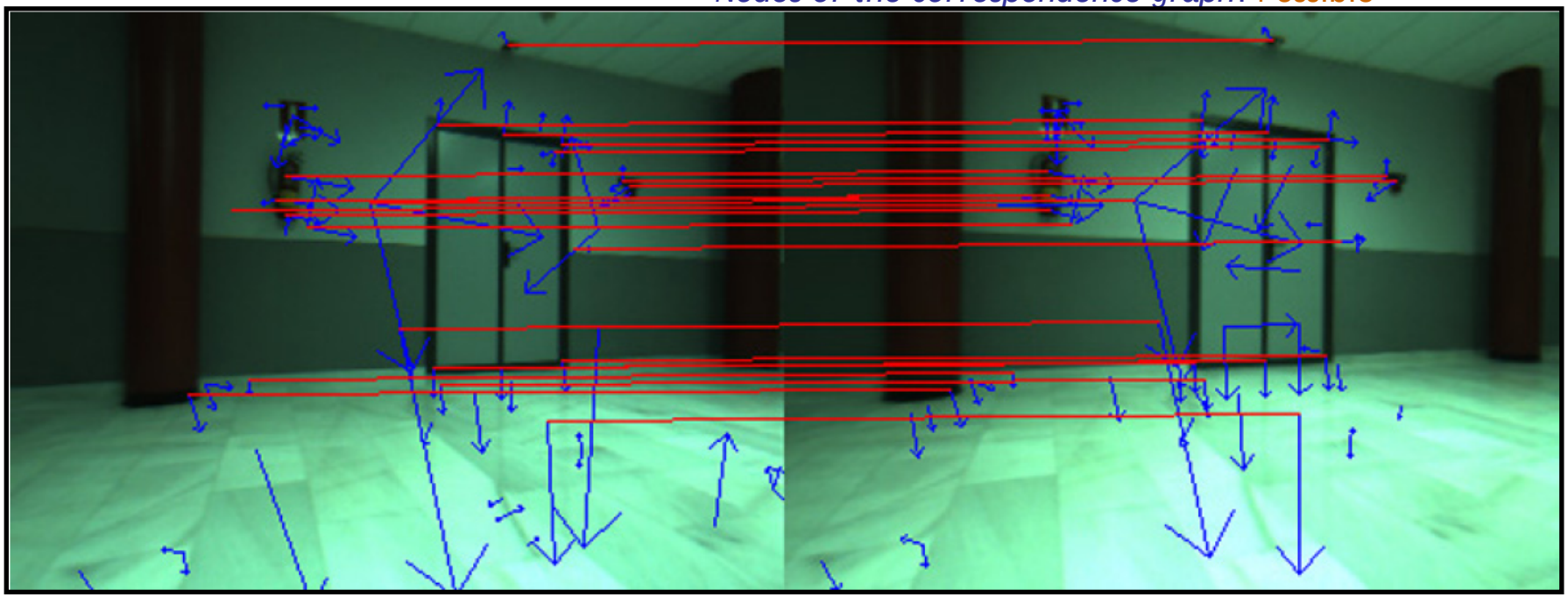
Stereo Visual Odometry Algorithm based on SIFT descriptors

SIFT descriptor
Stereo matching
Stereo based point location
Feature Association
Stereo Head pose estimate

Graph-theoretic data association problem

Correspondence graph. Represents valid associations between the two SIFT descriptor sets. Construction of the correspondence graph is performed through the application of relative and absolute constraints over the set of descriptors.

- *Nodes of the correspondence graph*. Possible



Stereo Visual Odometry Algorithm based on SIFT descriptors

SIFT descriptor
Stereo matching
Stereo based point location
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Each detected feature is readily characterized by the Cartesian localization of the region centroid provided by the stereoscopic vision system.

$$z = \frac{b \cdot f_c}{d} \qquad x = \frac{(u - C_x)}{D_u \cdot f_c \cdot s_u} z \qquad y = \frac{(v - C_y)}{D_v \cdot f_c} z$$

(x, y, z)	3D point coordinates
b	Stereo camera baseline
(Cx, Cy)	Image center
d	Disparity
f	Camera focal length
Du·su	Number of pixel per mm (x axis)
Dv	Number of pixel per mm (y axis)

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Graph-theoretic data association problem

Correspondence graph. The correspondence problem is achieved between the set of landmarks associated to consecutive frames applying absolute and relative

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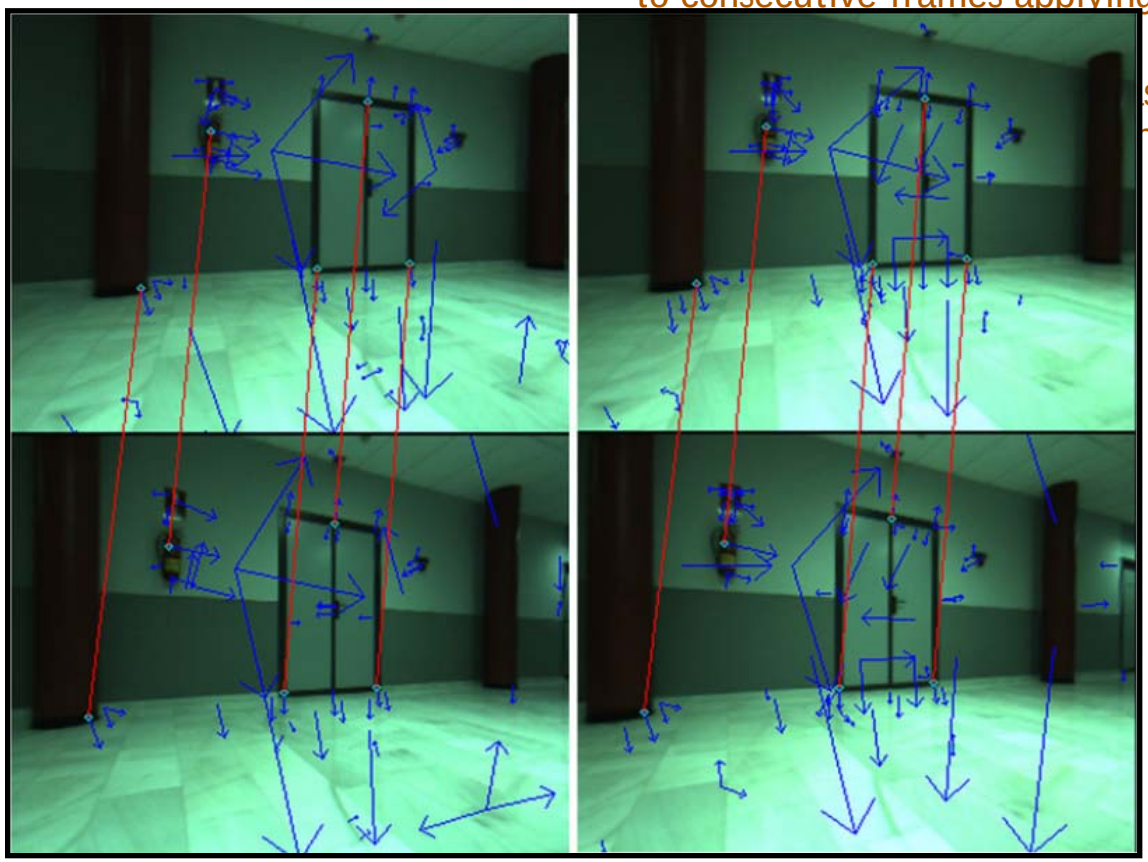
ndmarks between two



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$$E(R_{\Delta\theta}, \Delta T) = \sum_{i=1}^{N_M} \sum_{j=1}^{N_M} \omega_{ij} \left\| m_{t-1}^{i} - (R_{\Delta\theta} m_t^j + \Delta T) \right\|^2$$

K. Lingemann, A. Nüchter, J. Hertzberg and H. Surmann, "Highspeed Laser Localization for Mobile Robots", *Robotics and Autonomous Systems*, vol. 51, pp. 275-296, 2005.

$$R_{\Delta\theta} = \begin{pmatrix} \cos\Delta\theta & \sin\Delta\theta \\ -\sin\Delta\theta & \cos\Delta\theta \end{pmatrix} \qquad \Delta T = \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix}$$

N_M	Number of matched points
w	Weight (1: matched 0: non-matched)
m_t, m_{t-1}	Location of the 3D points

CONTENTS

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CONTENTS

EXPERIMENTAL RESULTS

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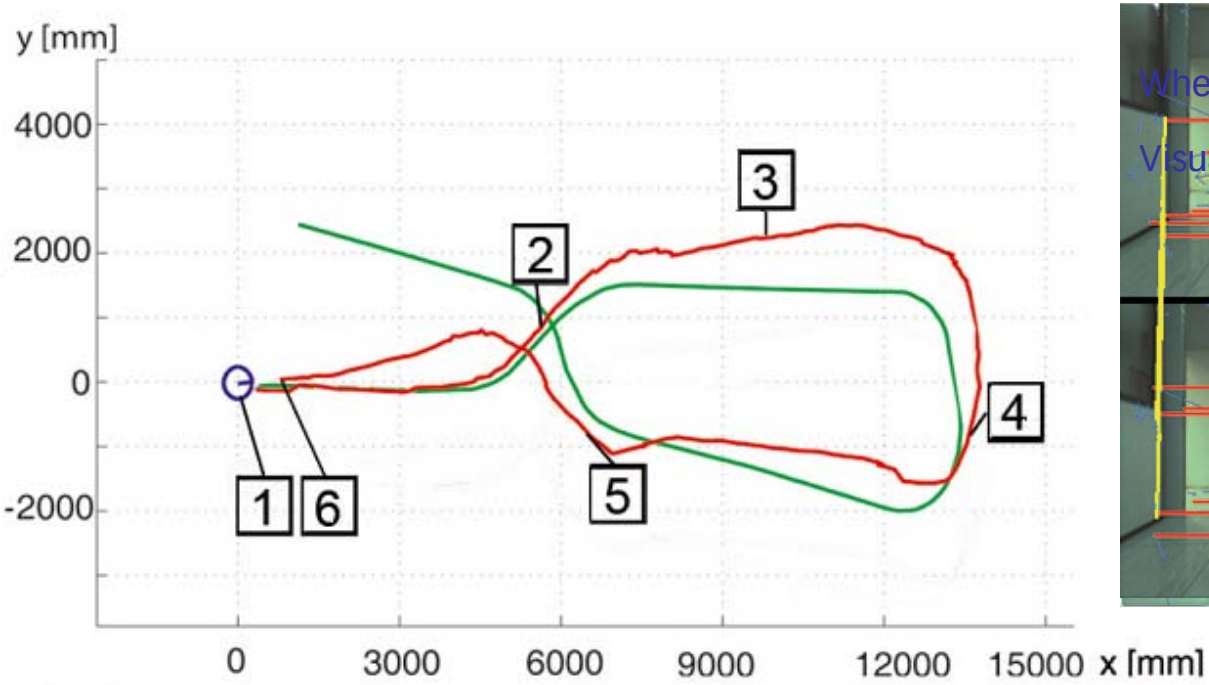

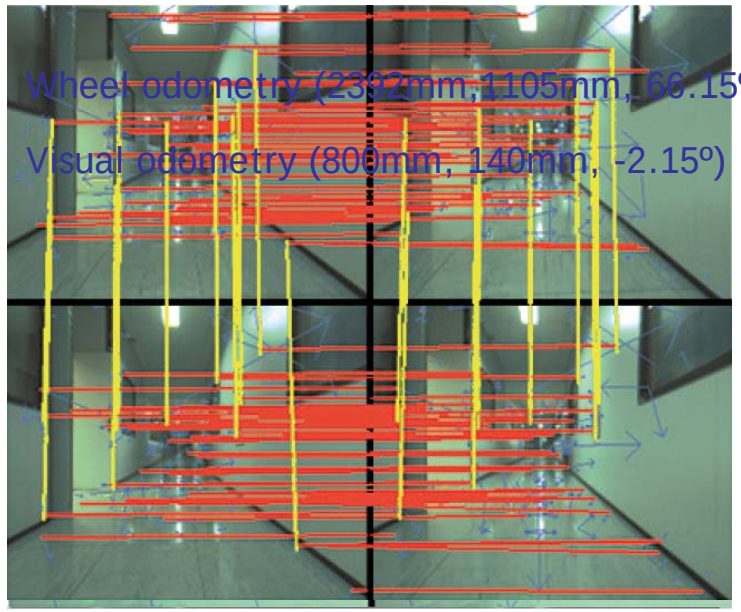

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CONTENTS

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CONTENTS

CONCLUSIONS

- We have presented a Stereo Visual odometry algorithm based on image features.
- SIFT descriptor has been used to characterize the image: invariant to rotation, translation and scale. Robust to changes in the environment illumination.
- Combined Constraint data association algorithm for stereo matching and for correspondence between two consecutive frames.
- Results improve the real odometry of our Activmedia Pioneer 2-AT robot.

FUTURE WORKS

- Visual odometry can be combined with the laser odometry in order to improve the displacement estimate in some risk situation
- Visual odometry using other image features: SURF, harris corners...
- SIFT features can be used in a EKF-SLAM based on features.

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- **Thanks for your attention!!**
- **Any questions/advise?**

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