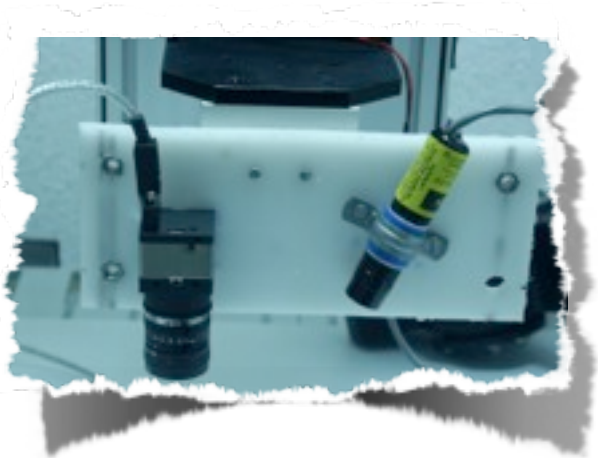
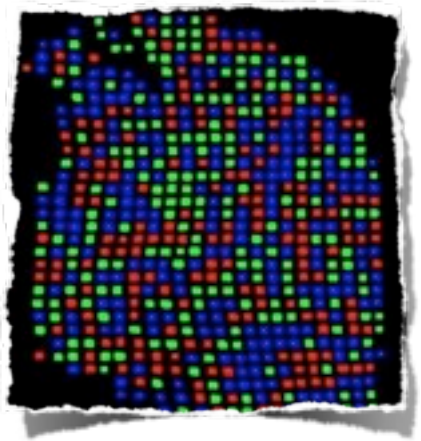
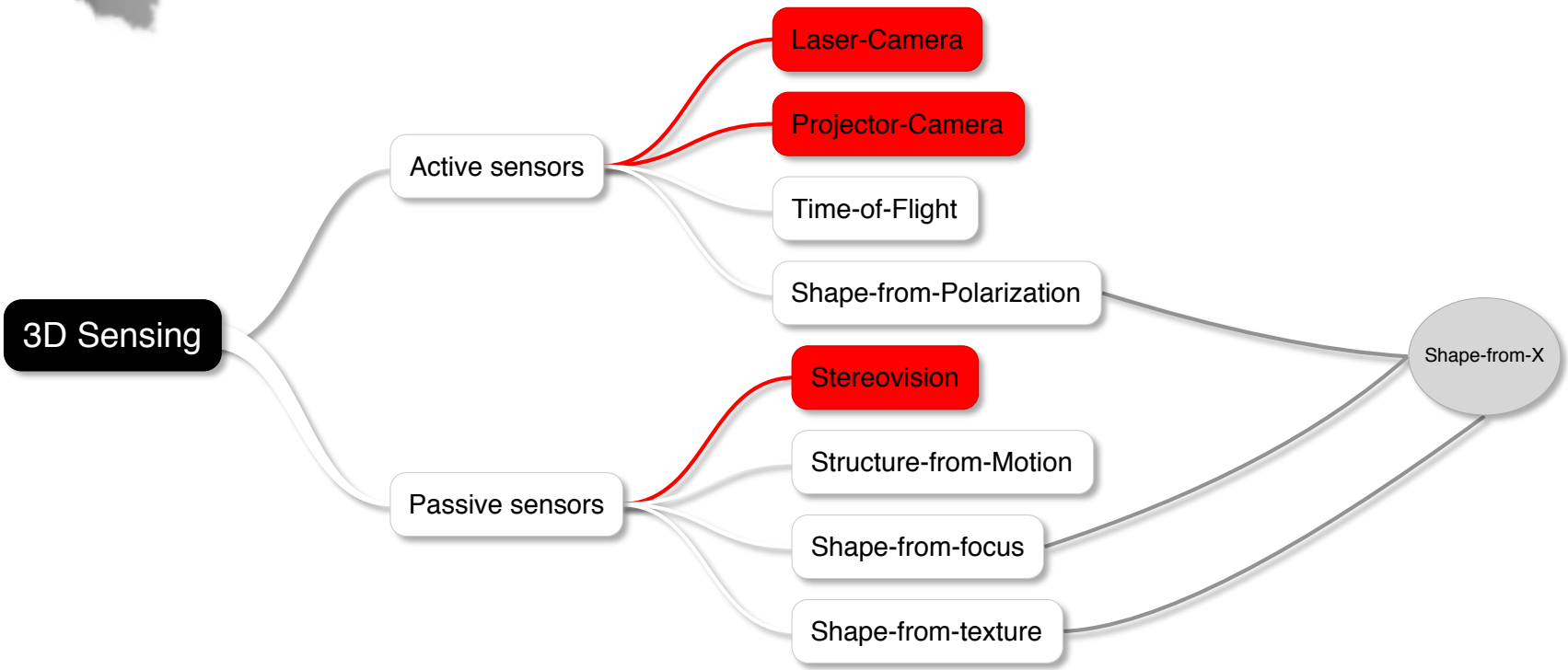
An Introduction to 3D Vision

David Fofi

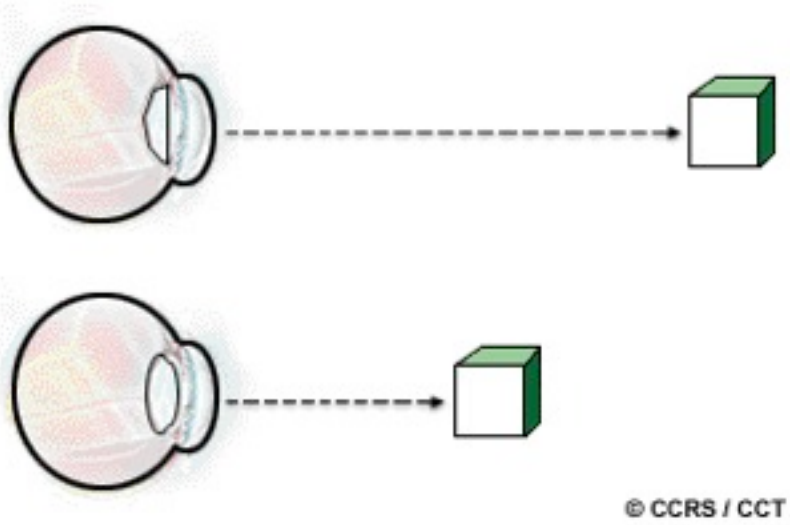




3D Sensing Technologies

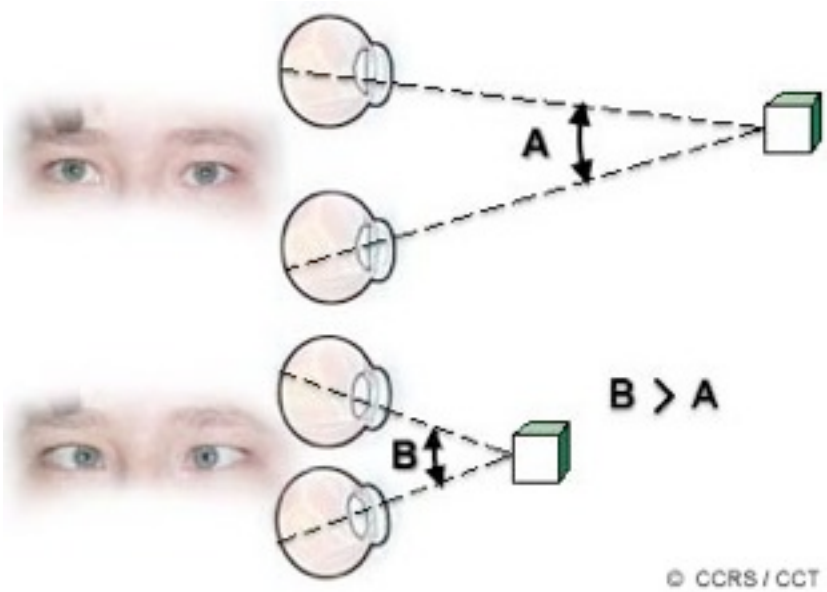


Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.



Accommodation : adapting the focal length of the crystalline lens
minor clue

Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.

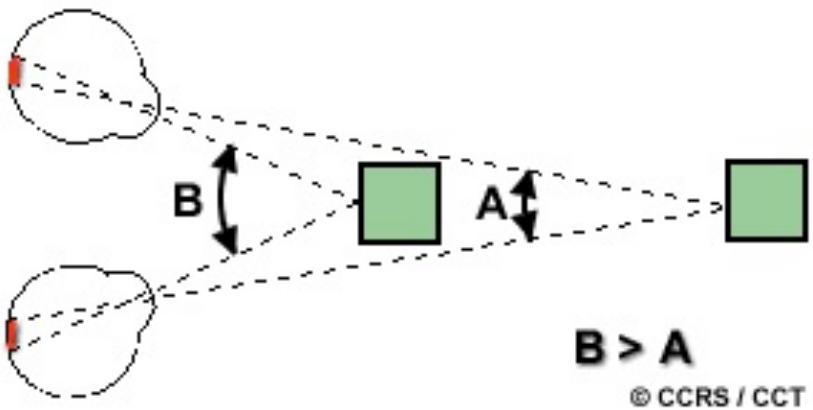


Convergence : angle between the line of sight of each eye

minor clue

Depth perception relies on 10 different clues:

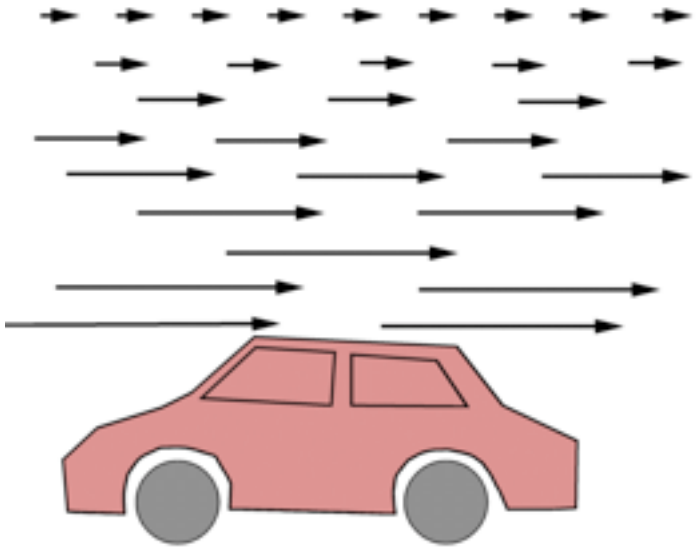
- 4 are physiological clues;
- 6 are psychological clues.



Disparity : differences between two images of the same object

major clue

Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.



Motion parallax: distant objects appear to move slowly compared to near objects

Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.

Size of the retinal image: the bigger the closer

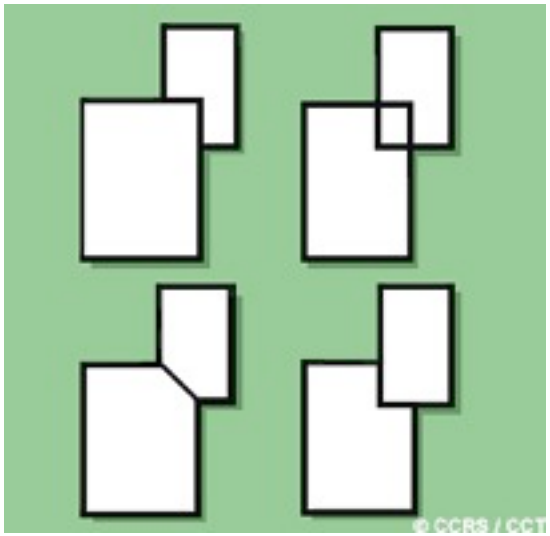
Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.

Linear perspective: gradually reducing the image size as the distance of the object increases

Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.

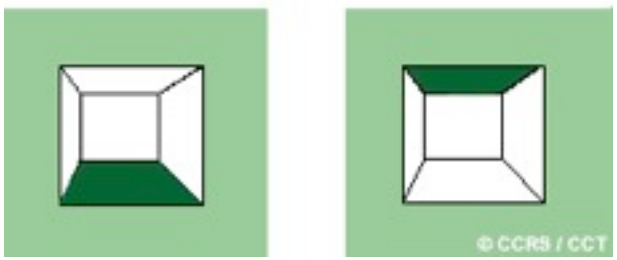
Aerial perspective : blur appearing with the distance

Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.



Occlusion: continuous outline appears closer to the observer

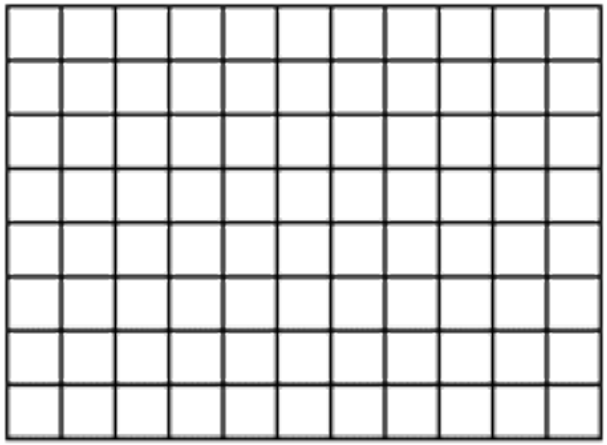
Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.



Lightning and shading: impression of concavity/convexity caused by...

Depth perception relies on 10 different clues:
- 4 are physiological clues;
- 6 are psychological clues.

Texture gradient: fine details on nearby objects can be seen clearly, whereas such details are not visible on faraway objects



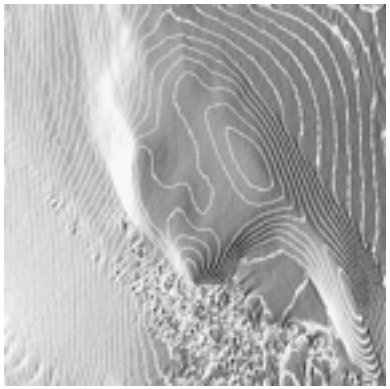
What about computer vision?

What about computer vision?

Focus/defocus

What about computer vision?

Focus/defocus

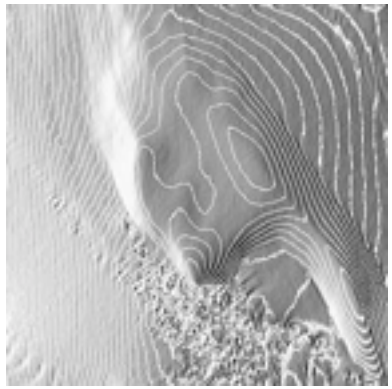


Shadow

What about computer vision?

Focus/defocus

Stereovision/multiple-view



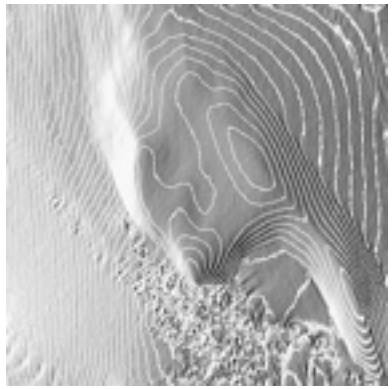
Shadow

What about computer vision?

Focus/defocus

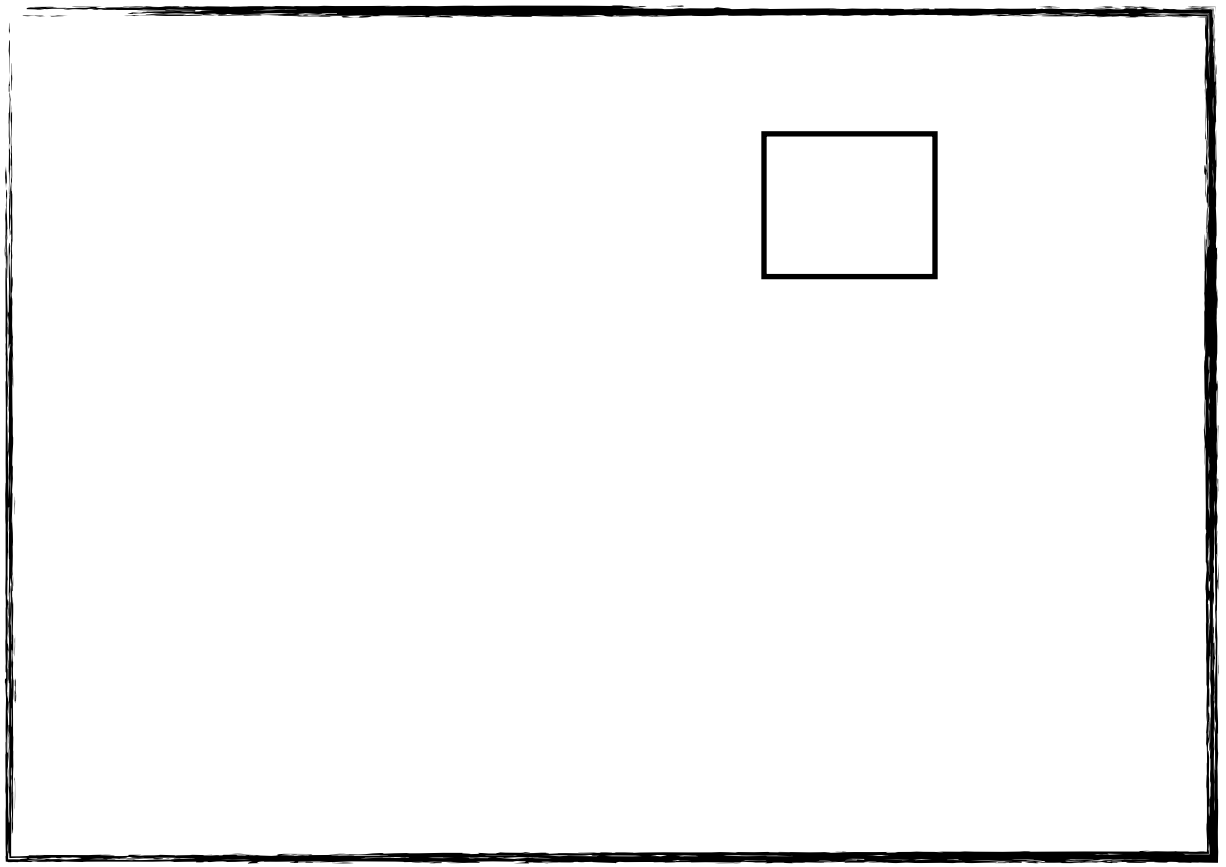
Stereovision/multiple-view

Structured light

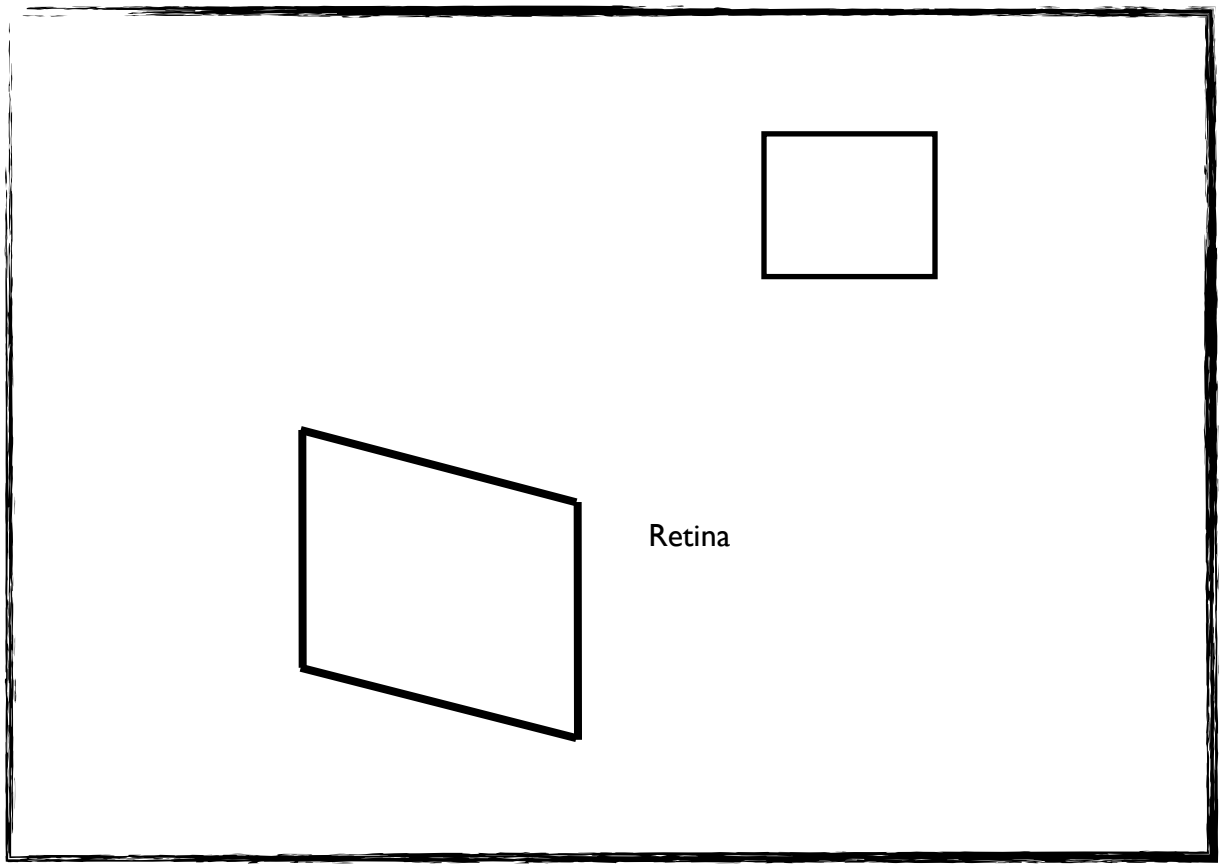


Shadow

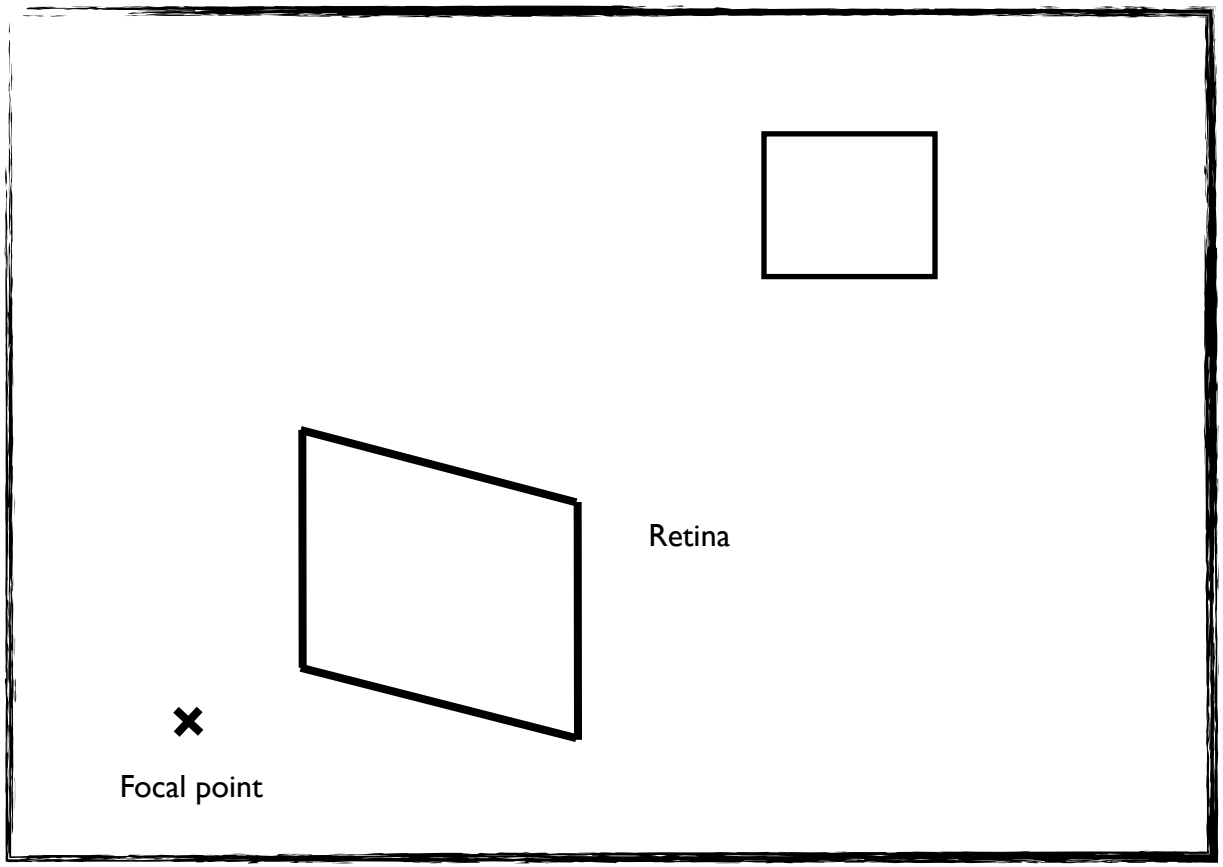
Pinhole model



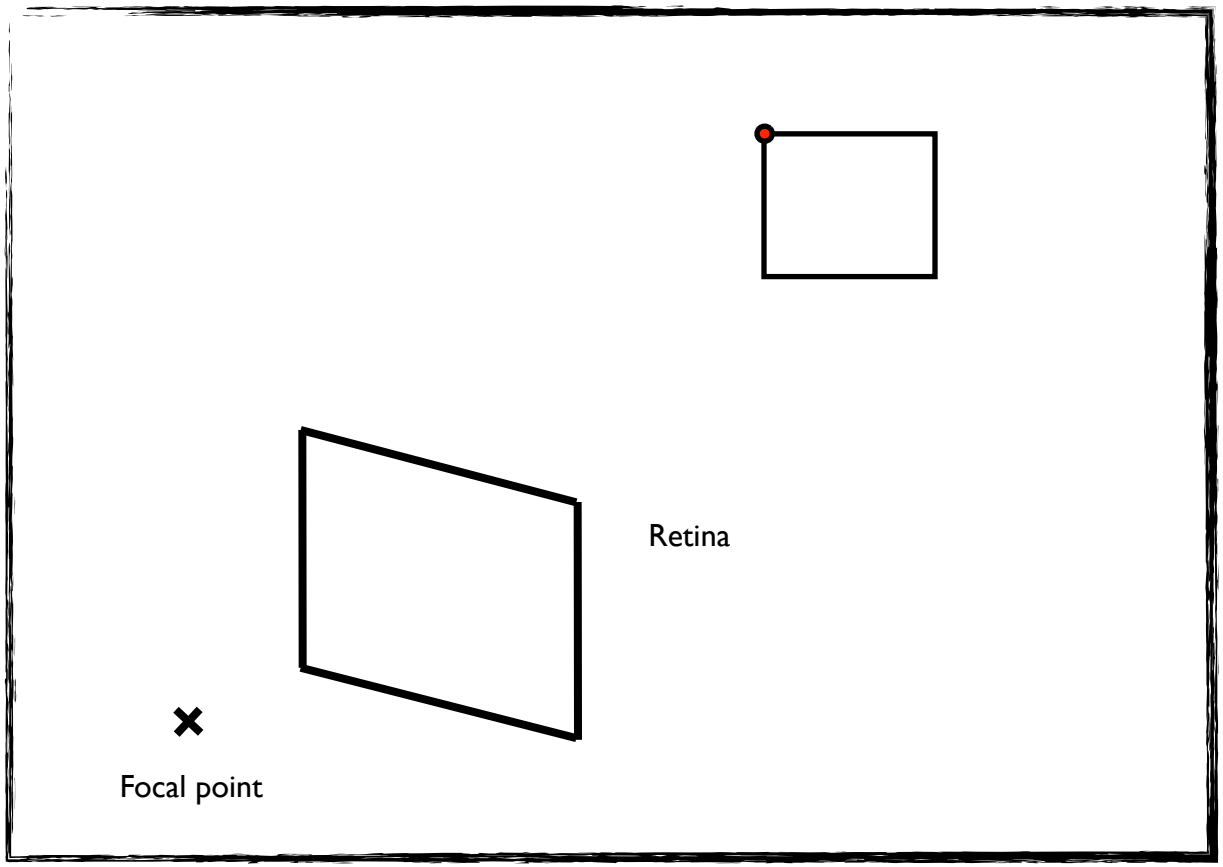
Pinhole model



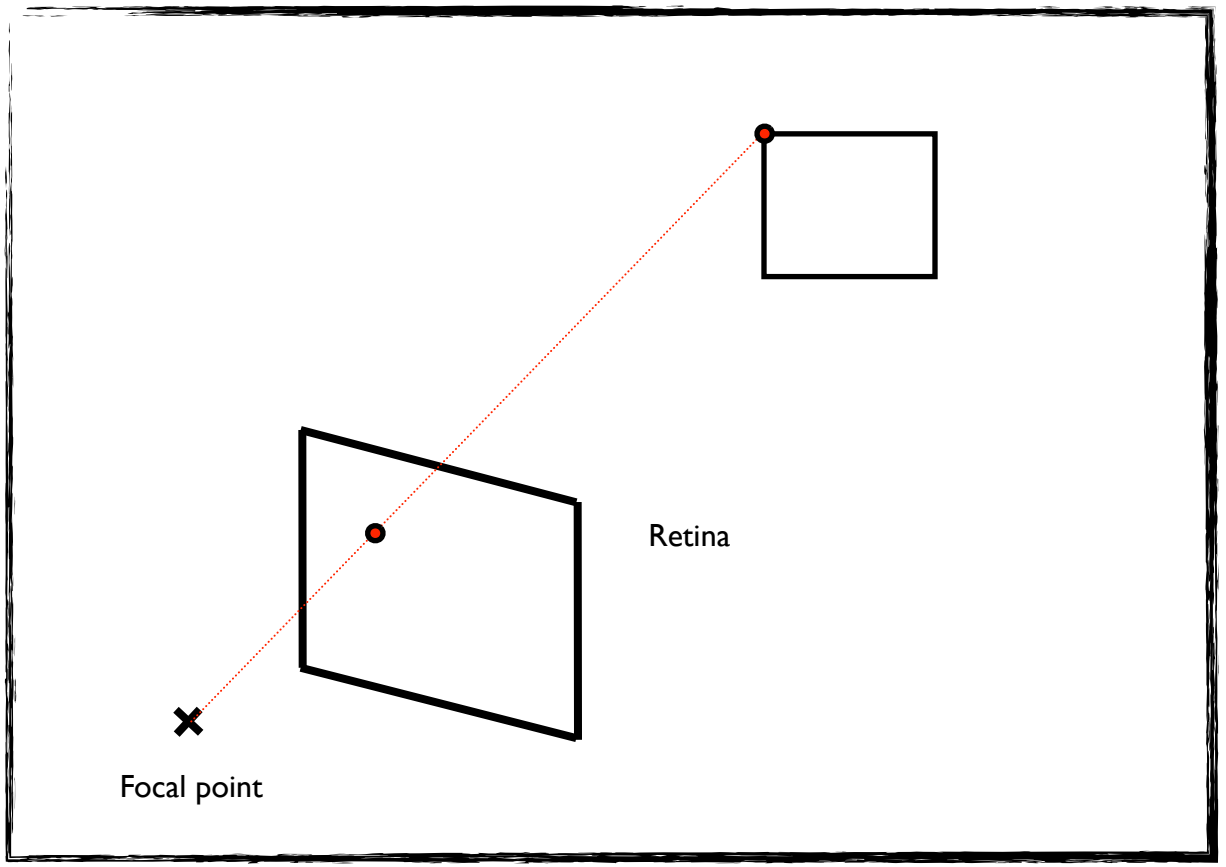
Pinhole model



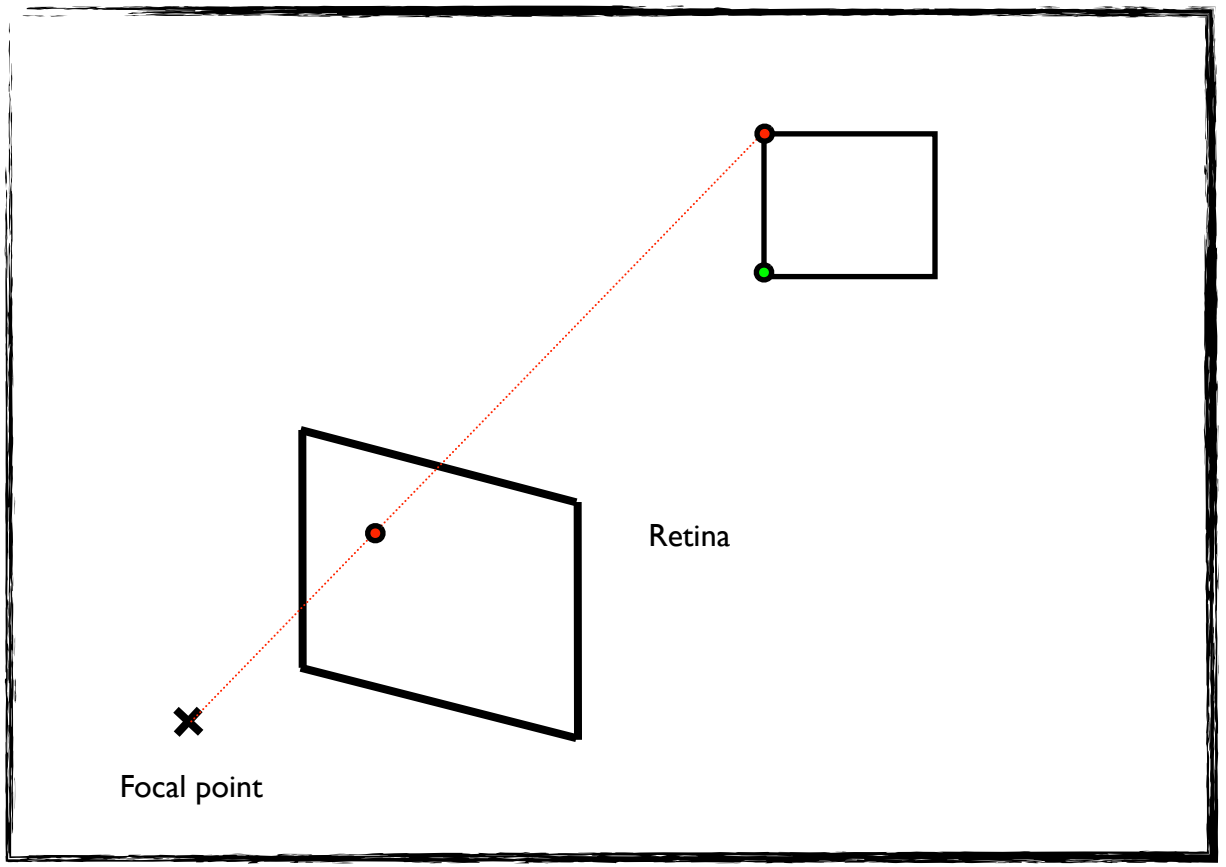
Pinhole model



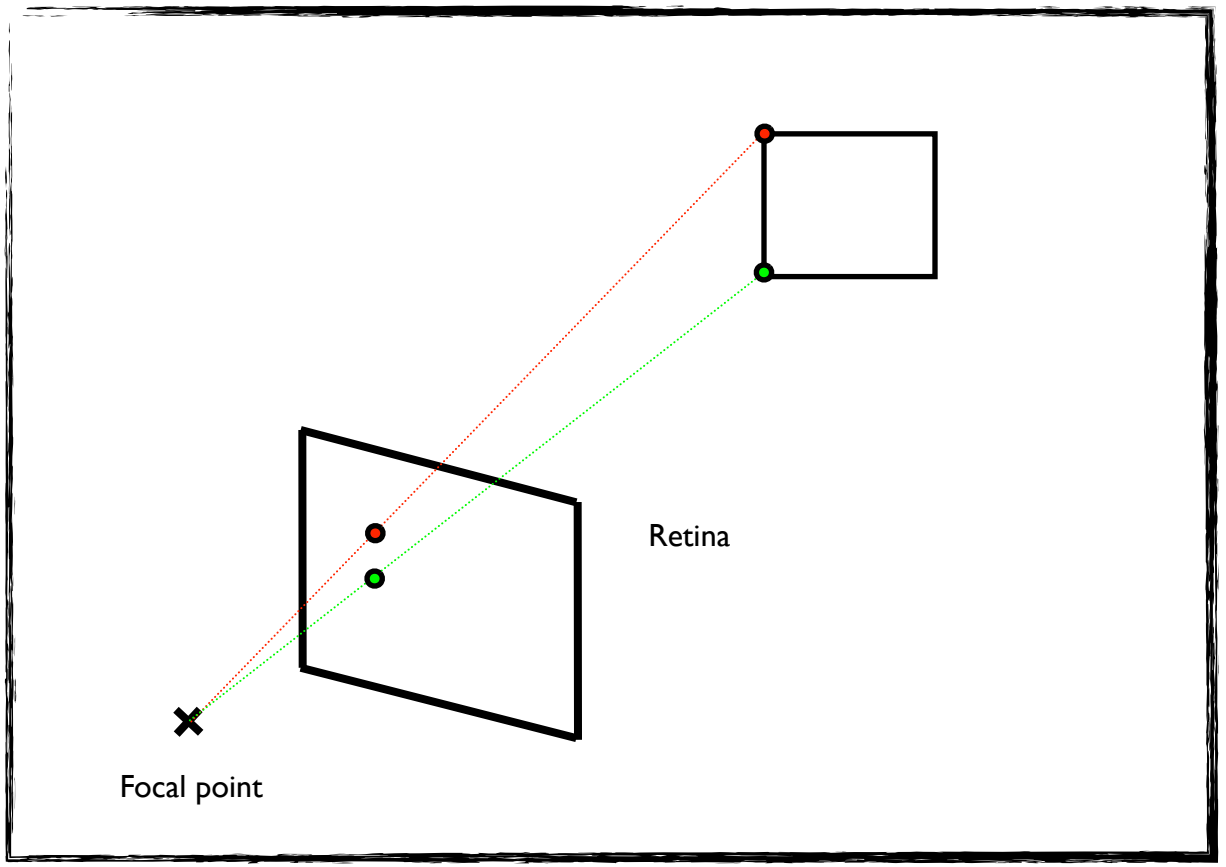
Pinhole model



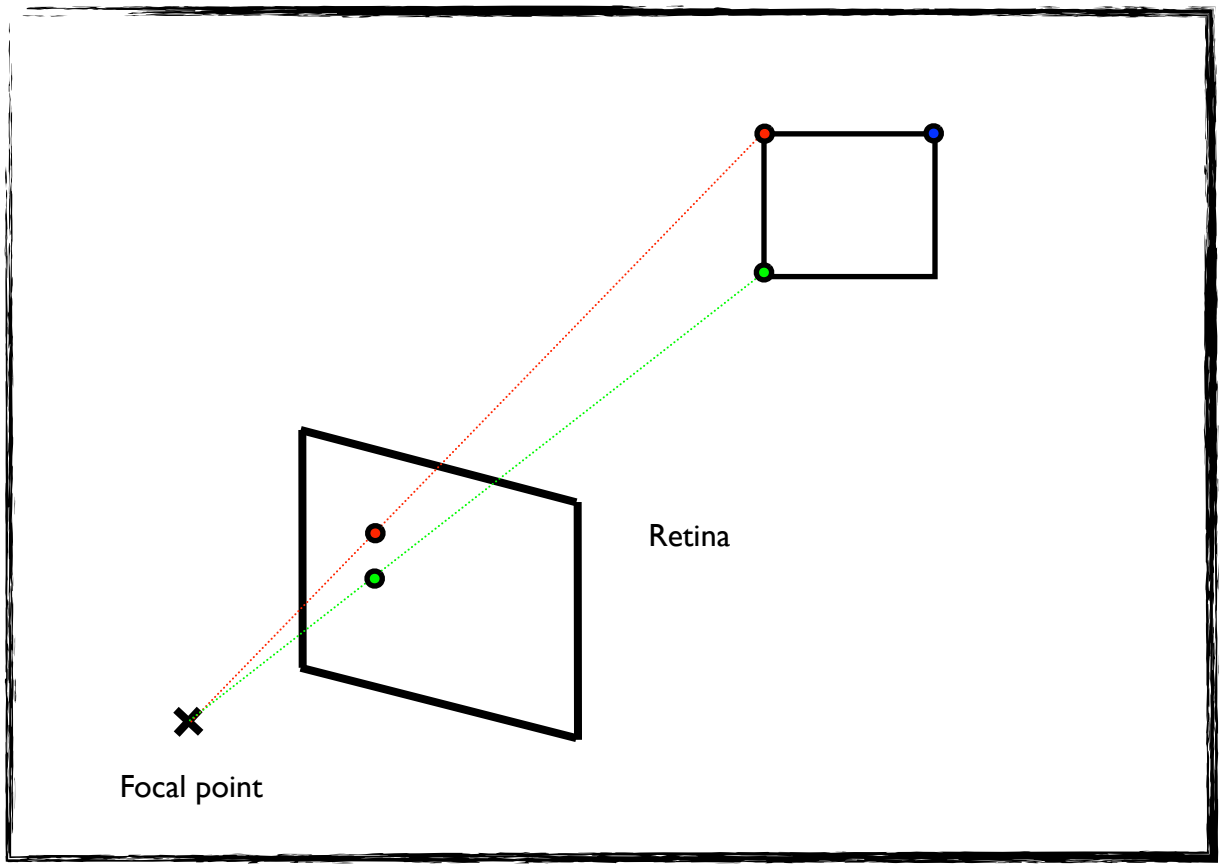
Pinhole model



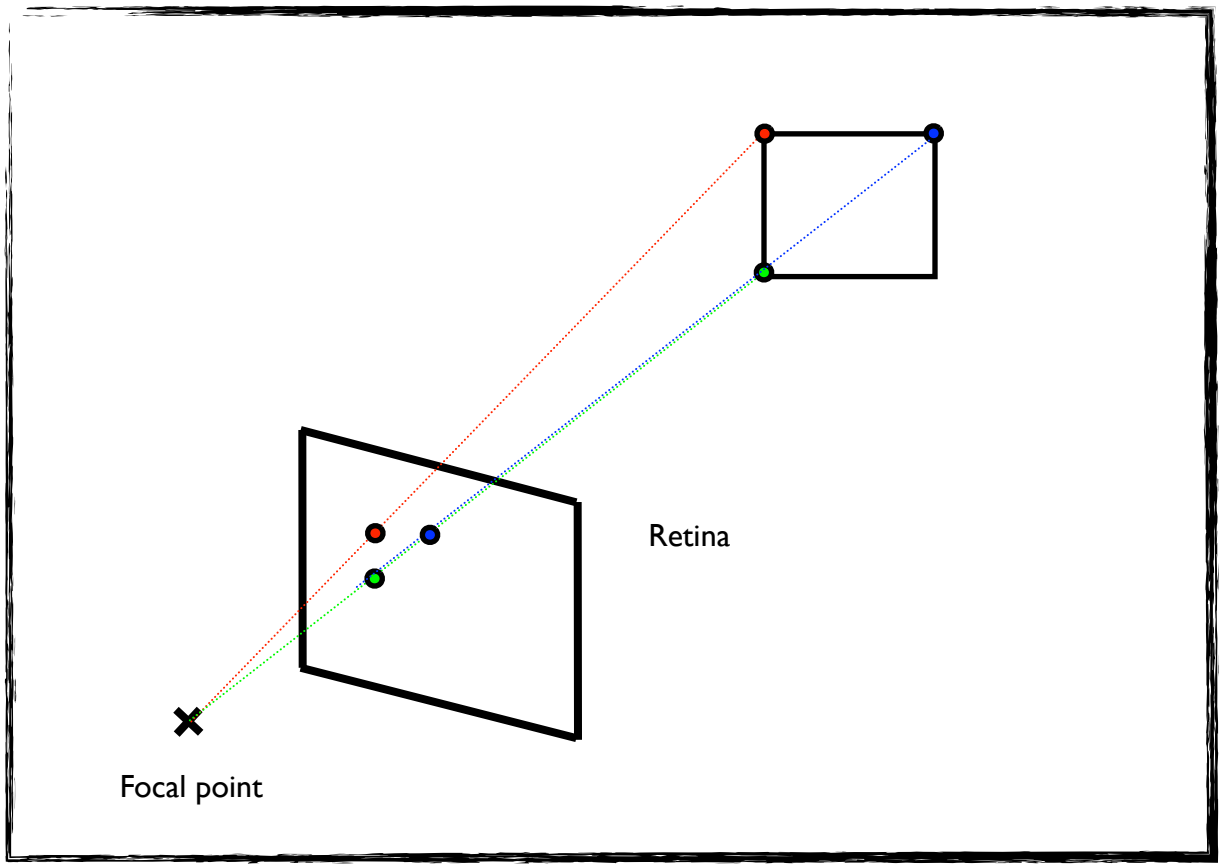
Pinhole model



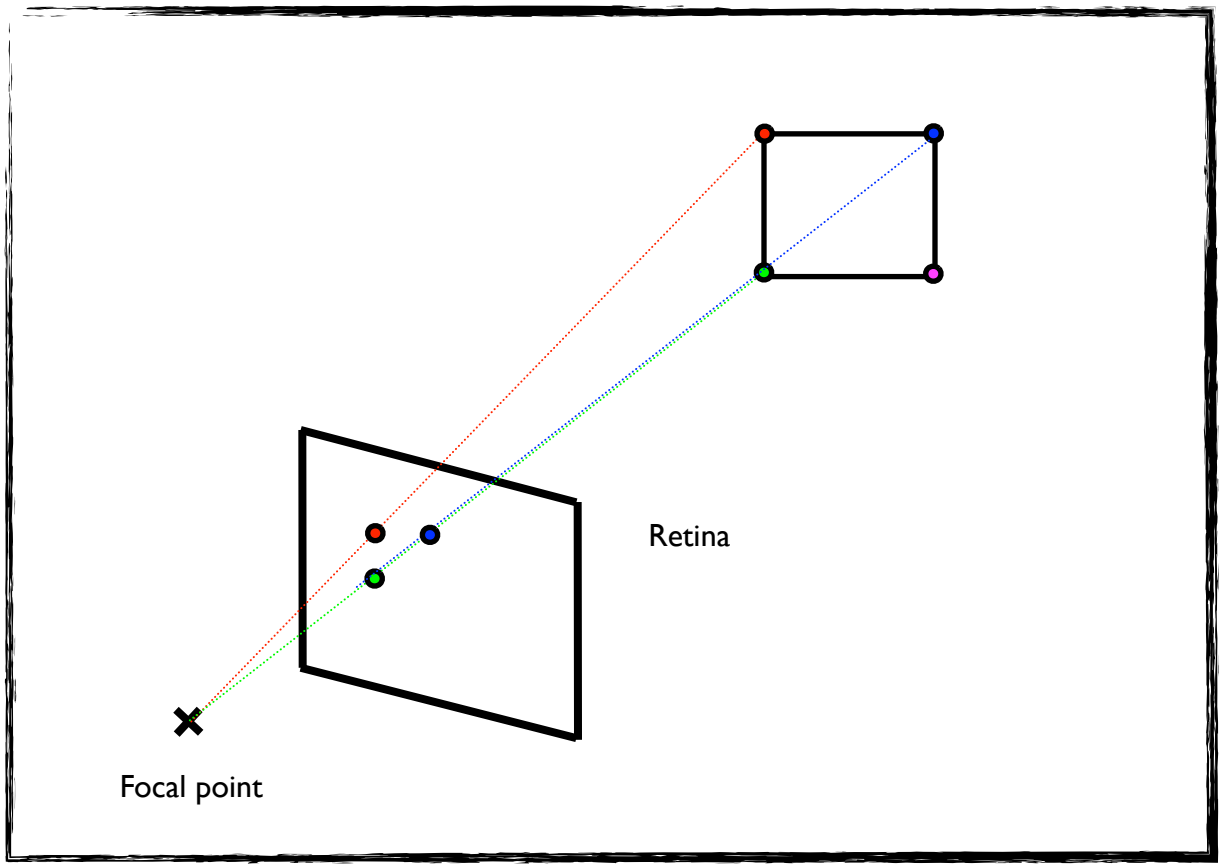
Pinhole model



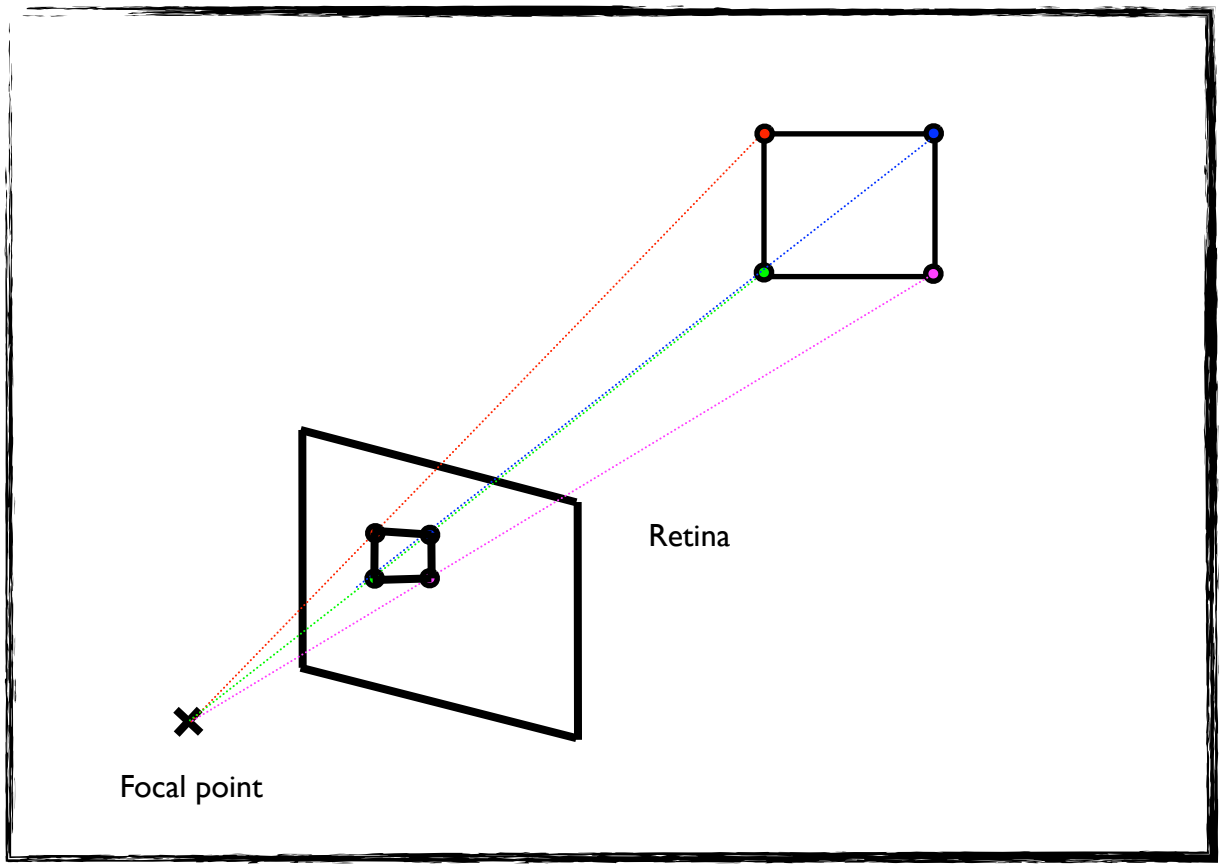
Pinhole model



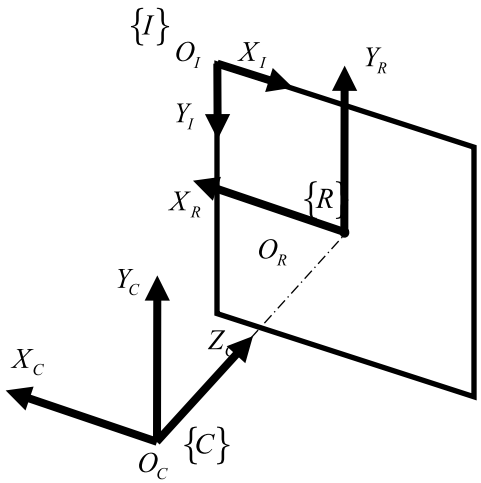
Pinhole model



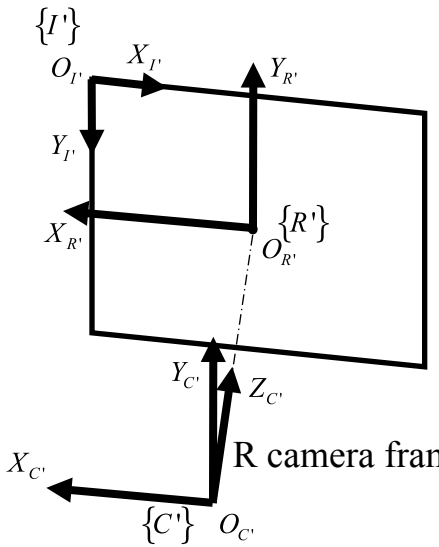
Pinhole model



Stereovision principle

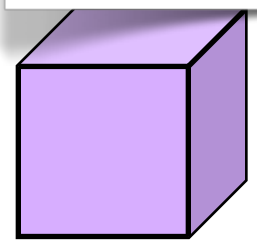


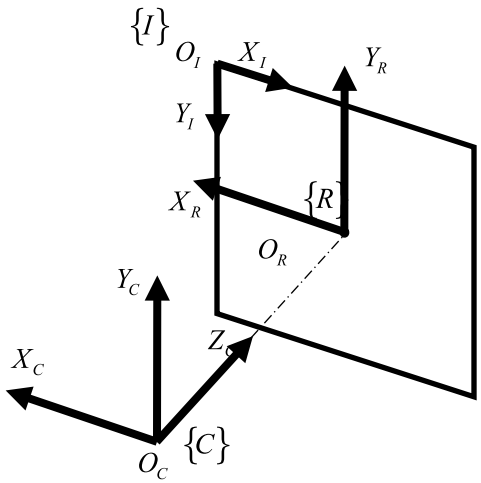
L camera frame



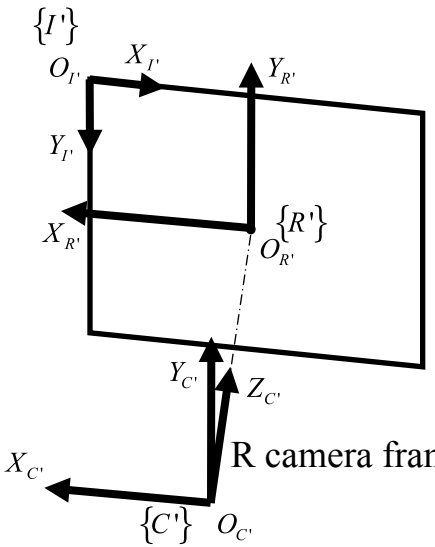
R camera frame

Stereovision principle



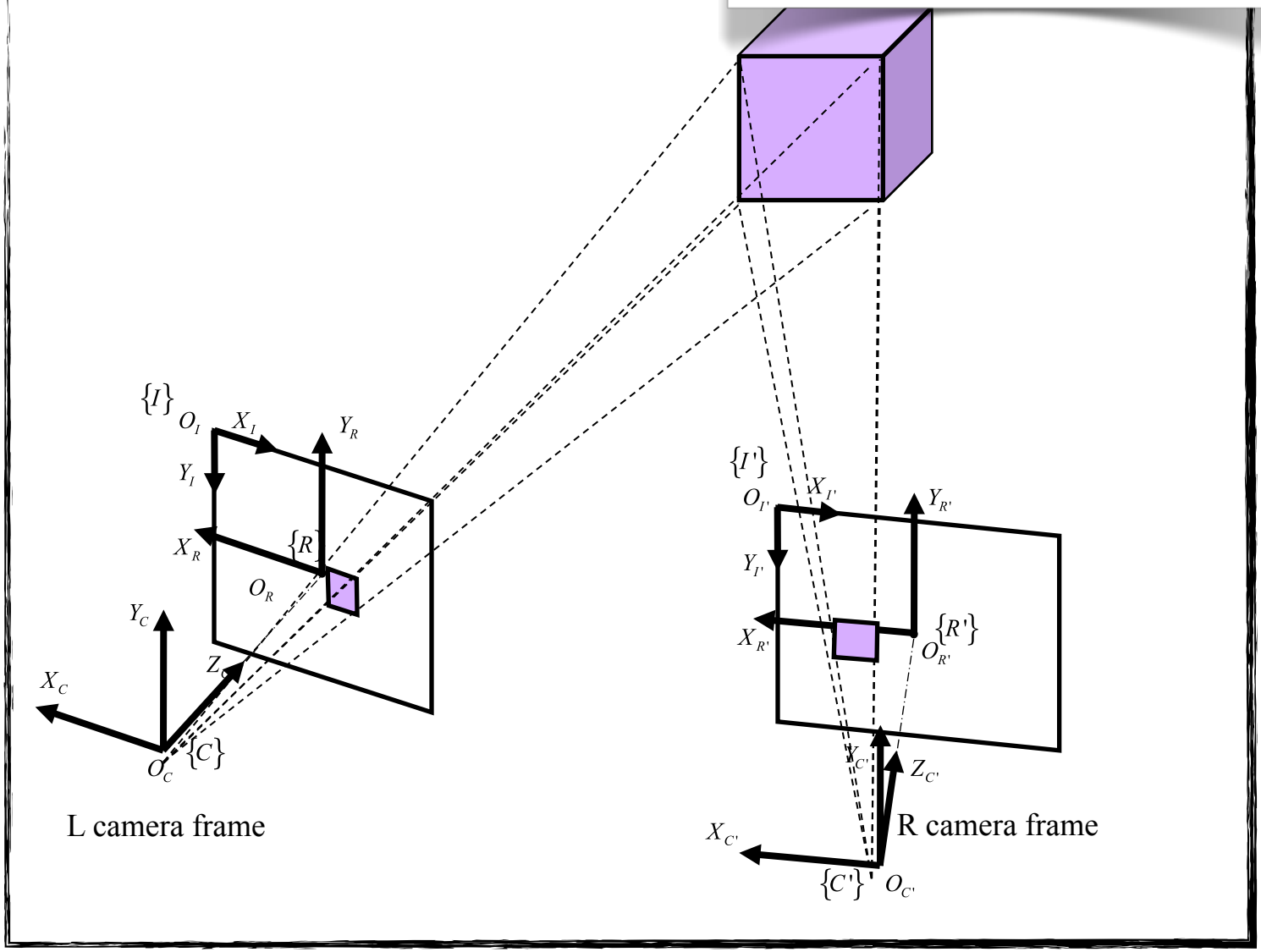


L camera frame



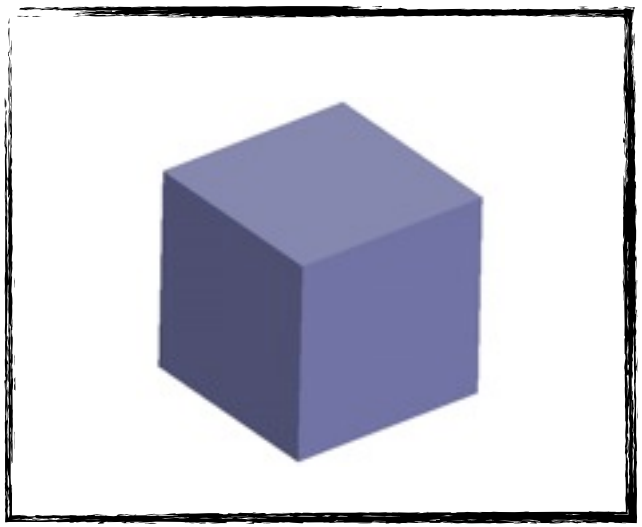
R camera frame

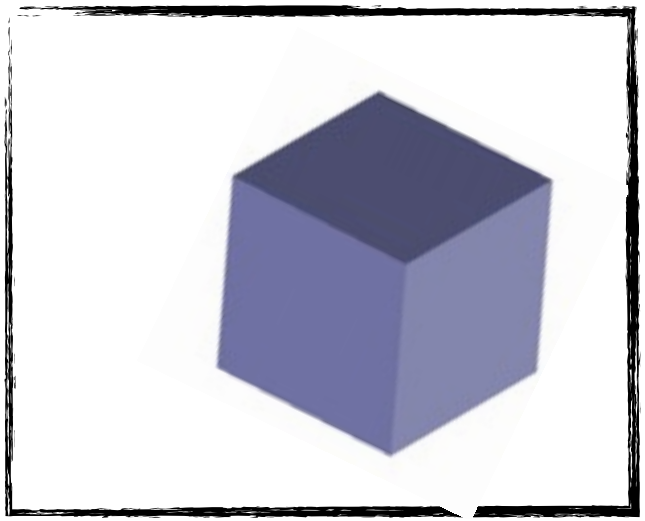
Stereovision principle



Feature matching

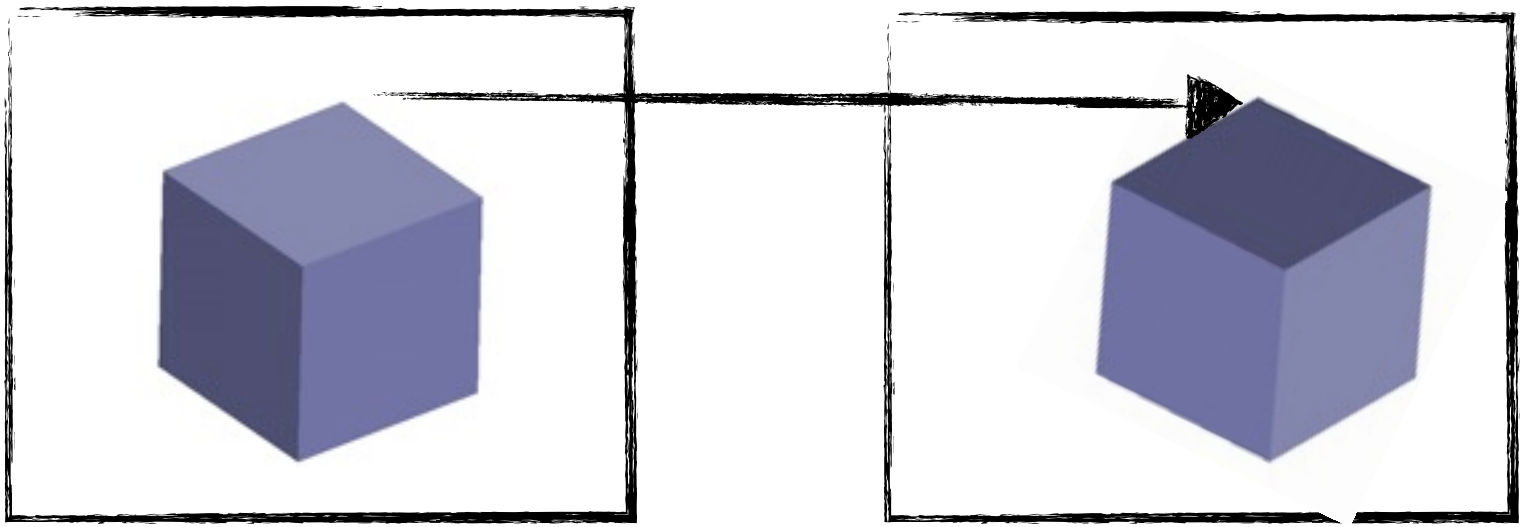
Objective: associating two points from two images corresponding to the same physical (3D) point.





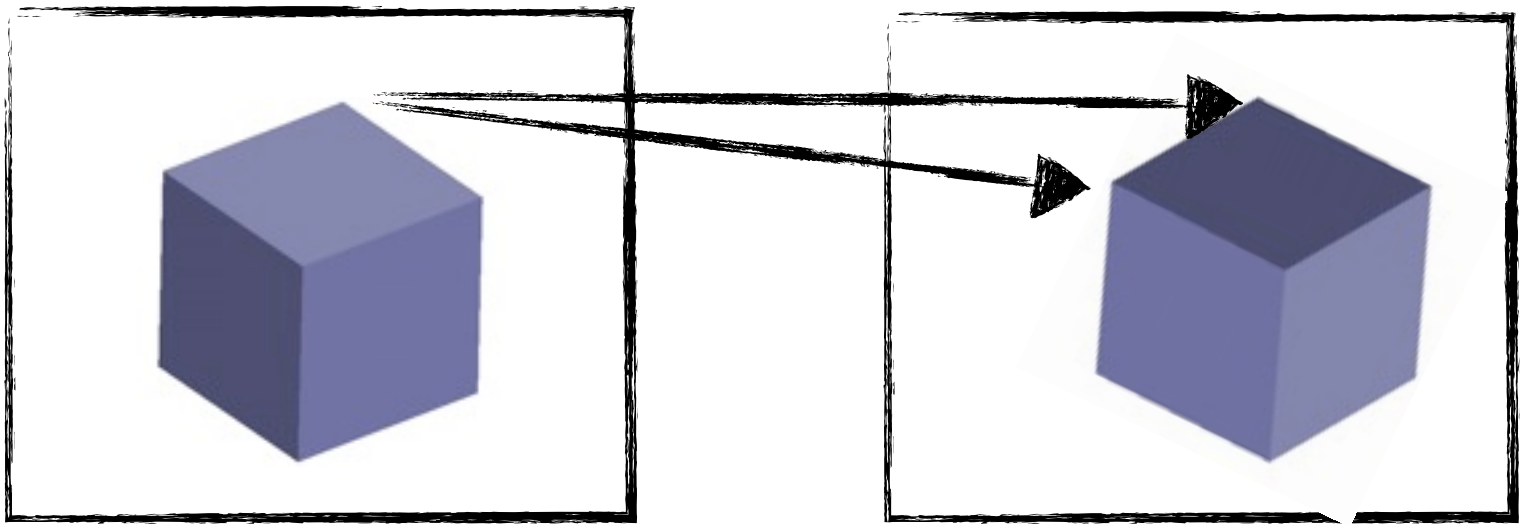
Feature matching

Objective: associating two points from two images corresponding to the same physical (3D) point.



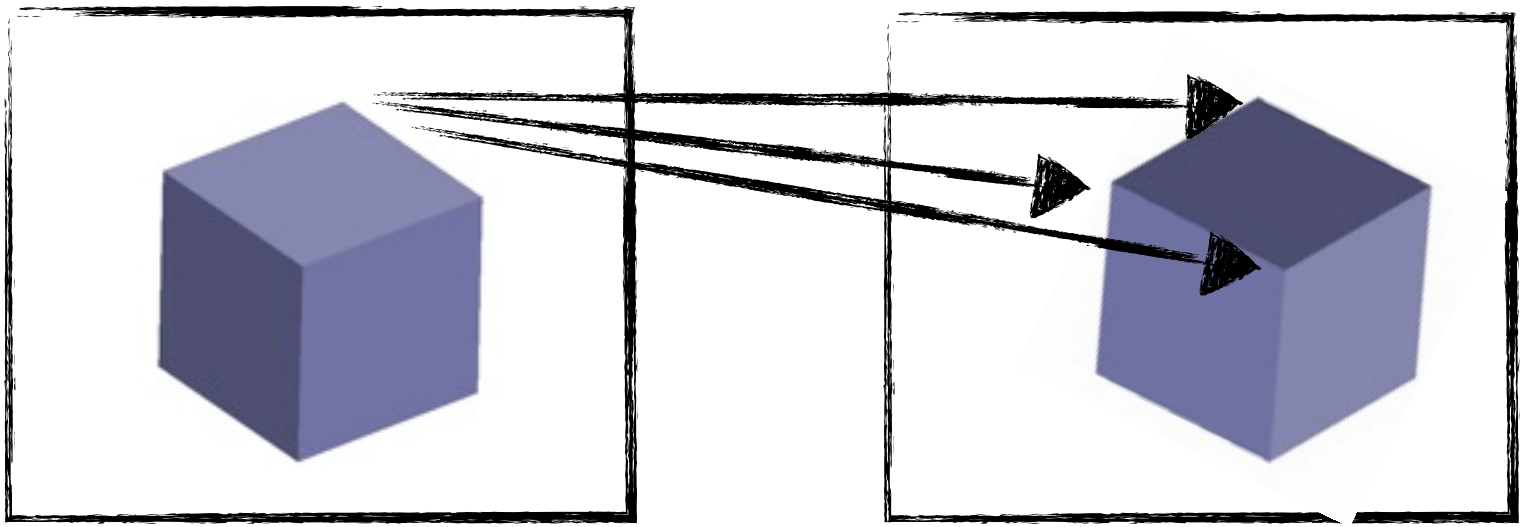
Feature matching

Objective: associating two points from two images corresponding to the same physical (3D) point.



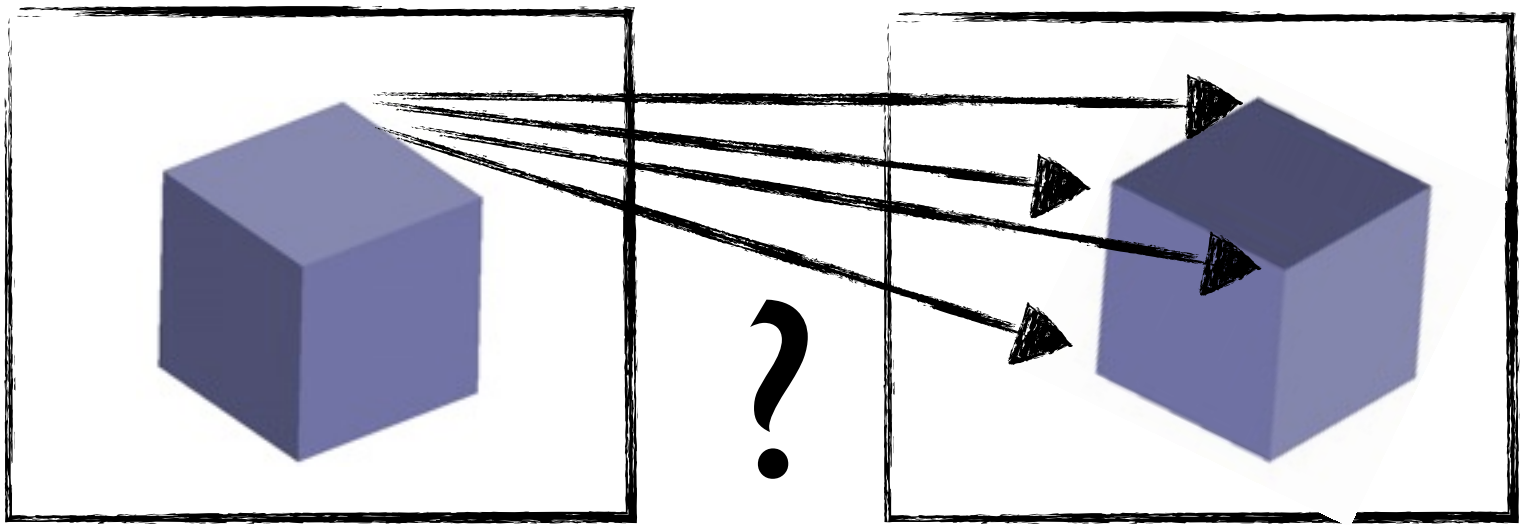
Feature matching

Objective: associating two points from two images corresponding to the same physical (3D) point.

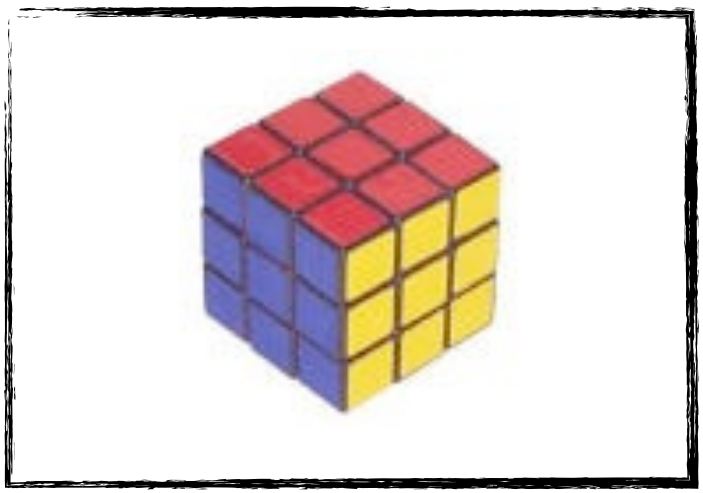


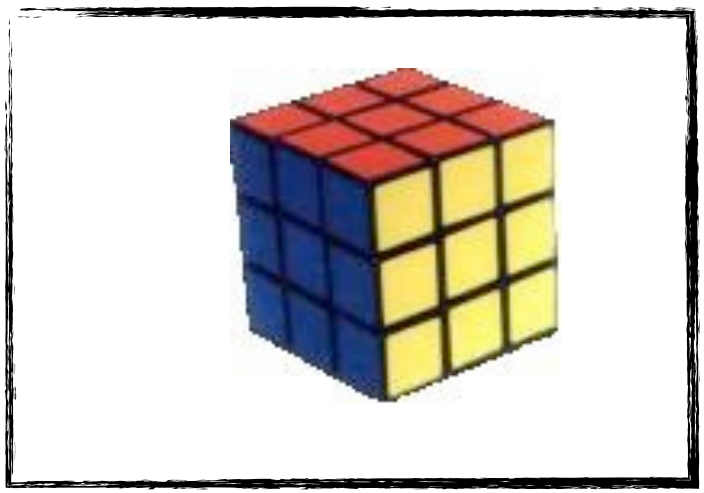
Feature matching

Objective: associating two points from two images corresponding to the same physical (3D) point.



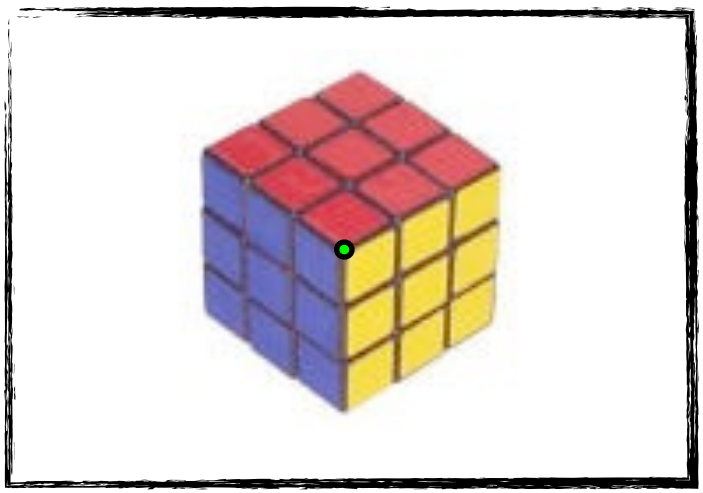
Matching is facilitated by the use of visual clues, such as the colour....

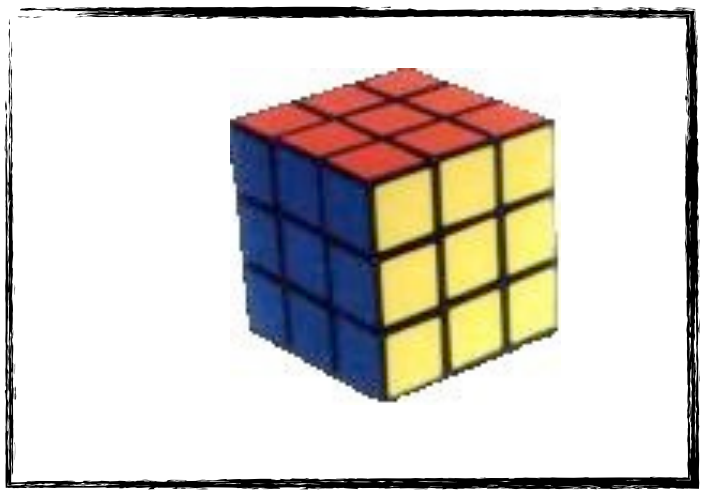




Feature matching

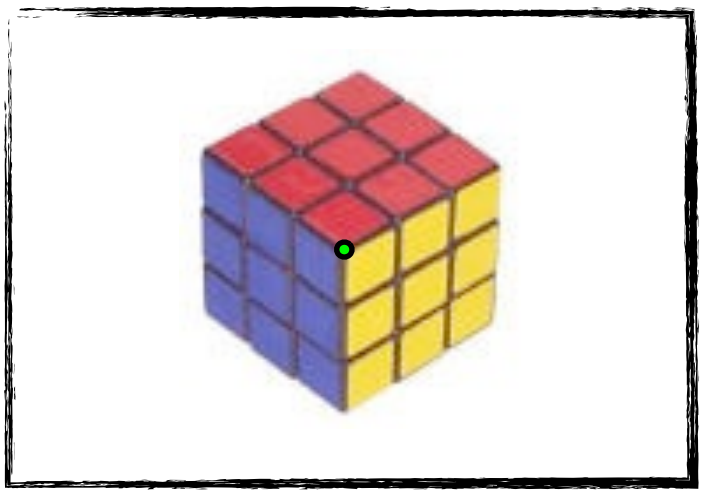
Matching is facilitated by the use of visual clues, such as the colour....

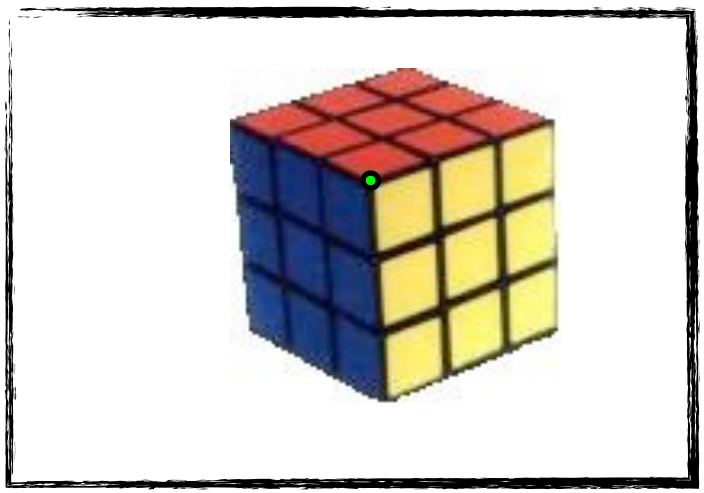




Feature matching

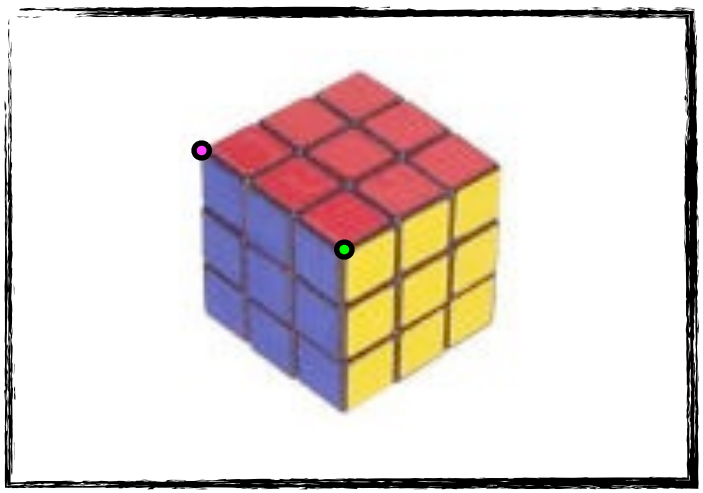
Matching is facilitated by the use of visual clues, such as the colour....

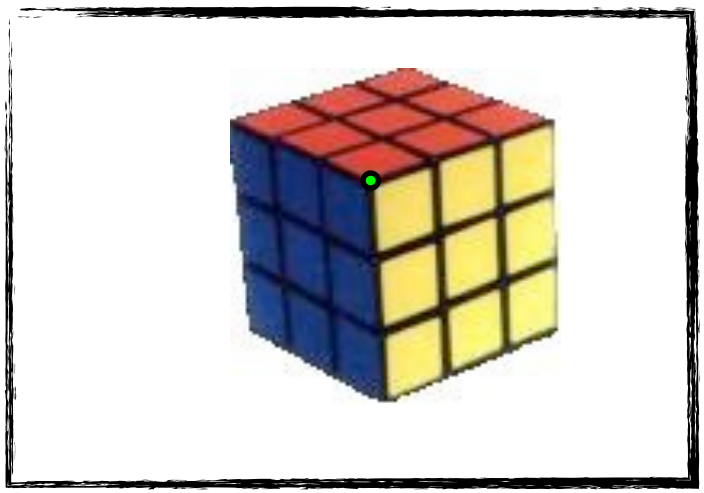




Feature matching

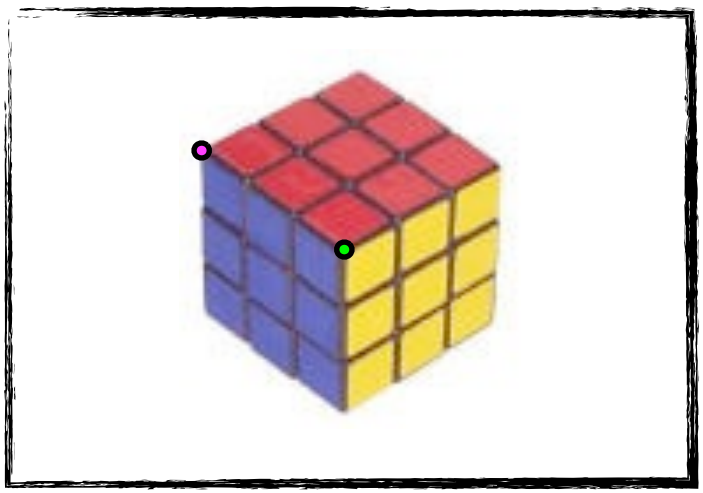
Matching is facilitated by the use of visual clues, such as the colour....

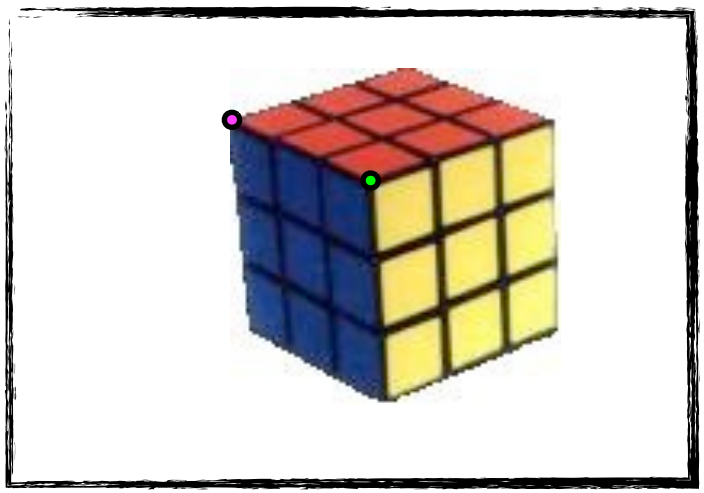




Feature matching

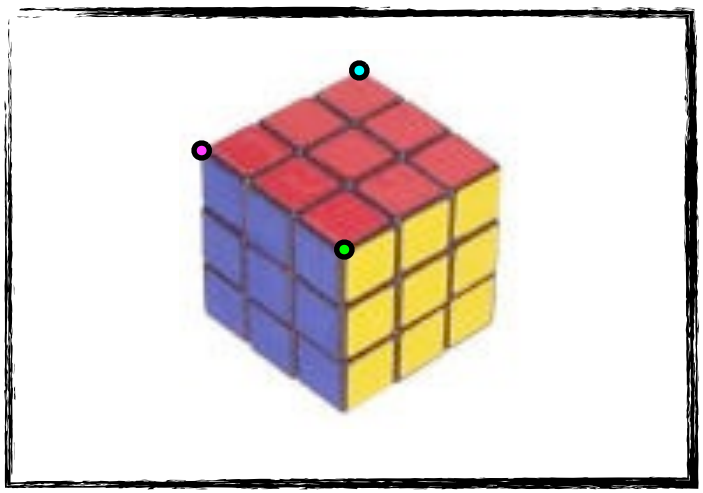
Matching is facilitated by the use of visual clues, such as the colour....

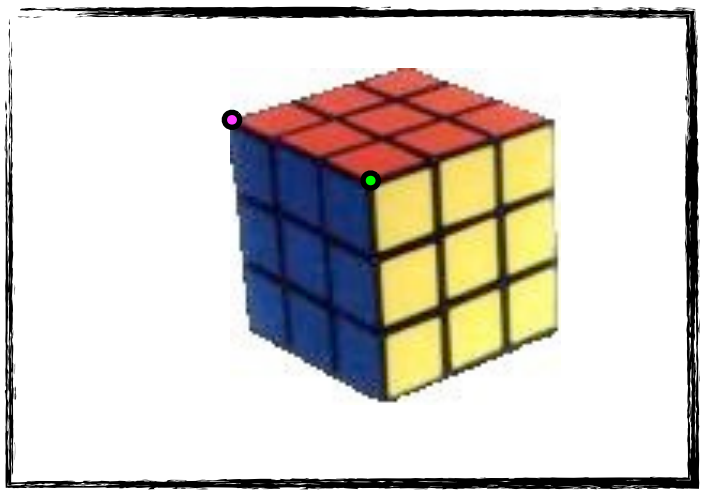




Feature matching

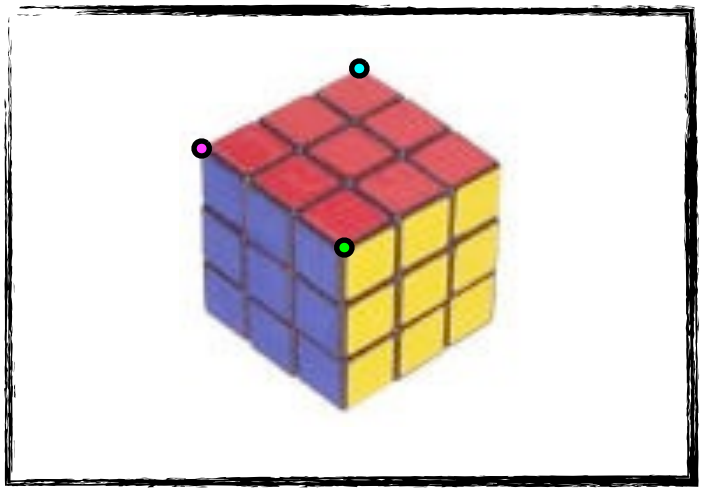
Matching is facilitated by the use of visual clues, such as the colour....

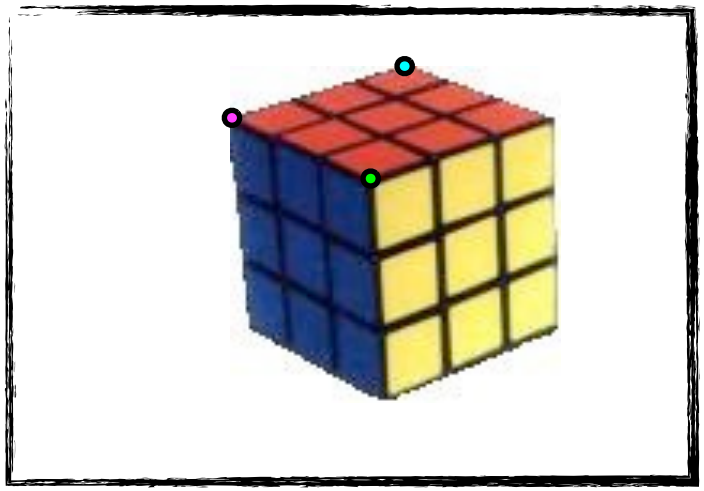




Feature matching

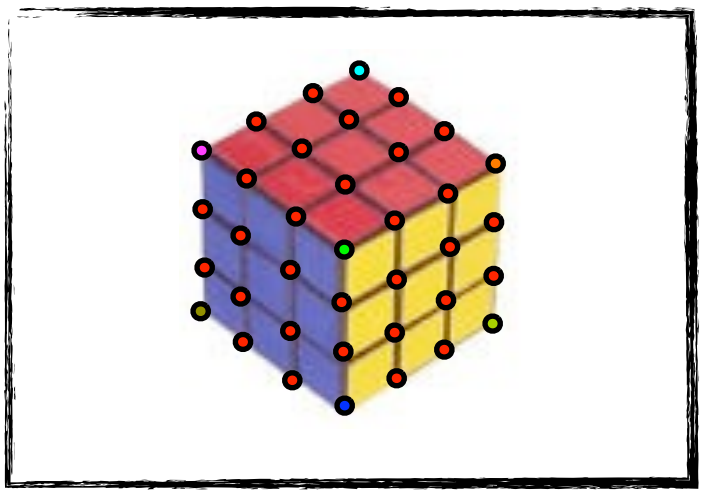
Matching is facilitated by the use of visual clues, such as the colour....

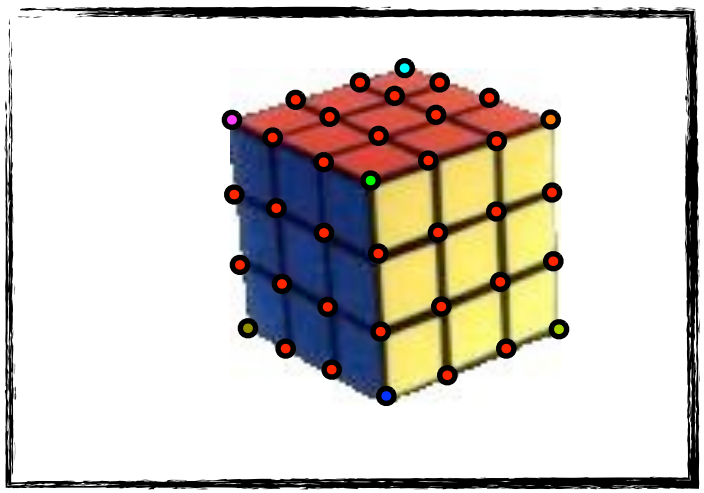




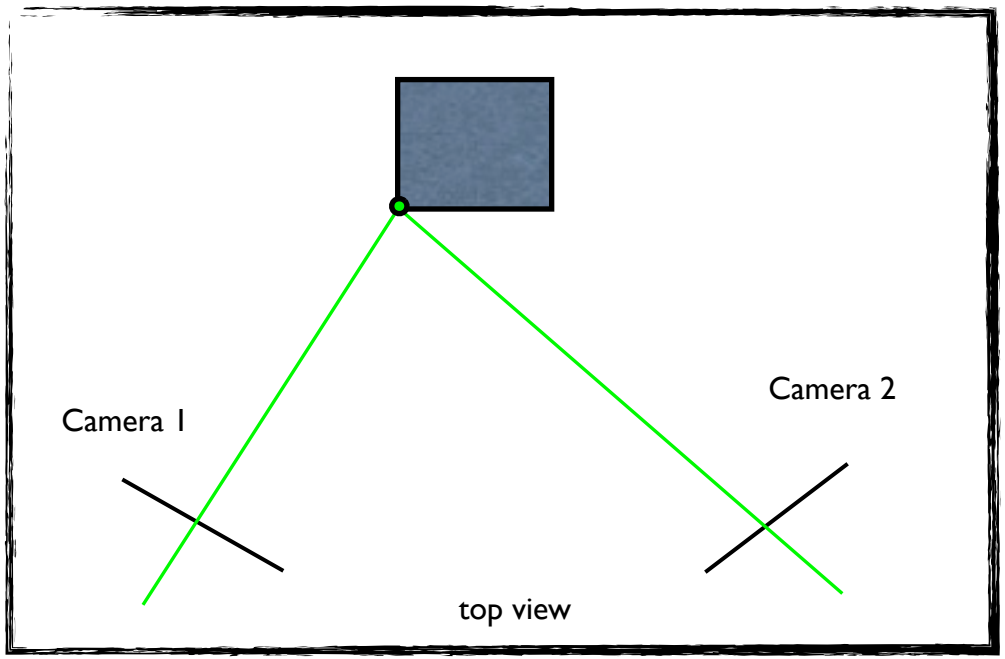
Feature matching

Matching is facilitated by the use of visual clues, such as the colour....

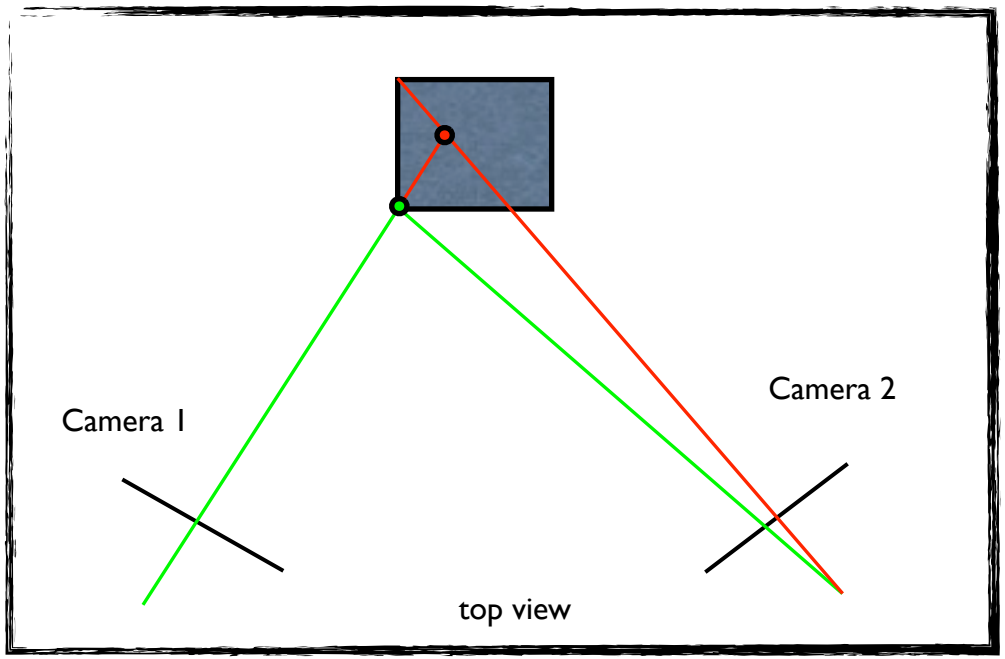




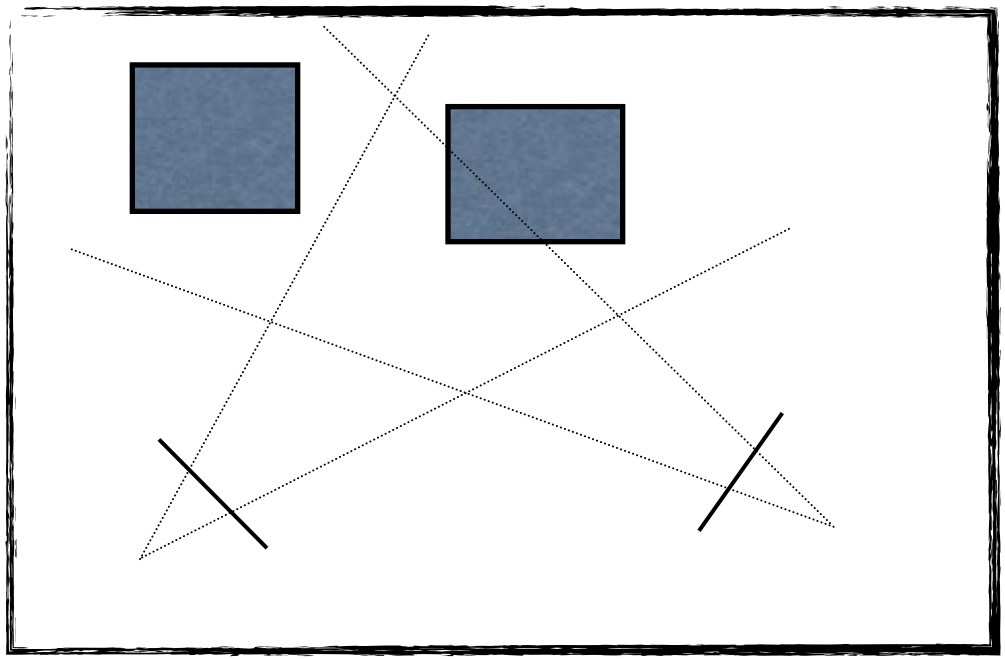
Bad matching leads to bad reconstruction...



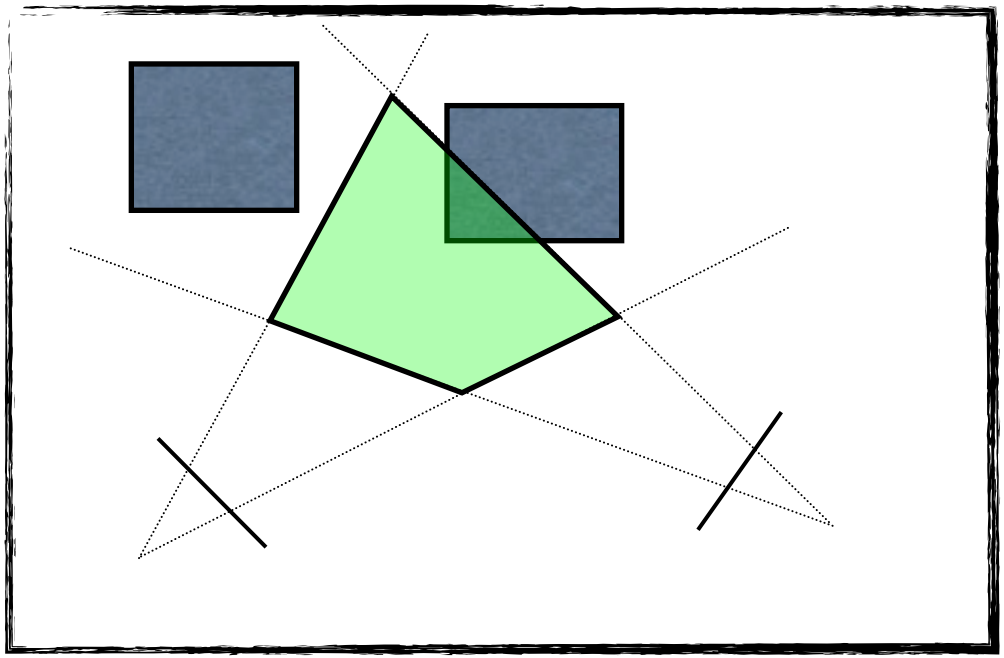
Bad matching leads to bad reconstruction...



A tricky problem because of **occlusions**, contraction, homogeneous area...

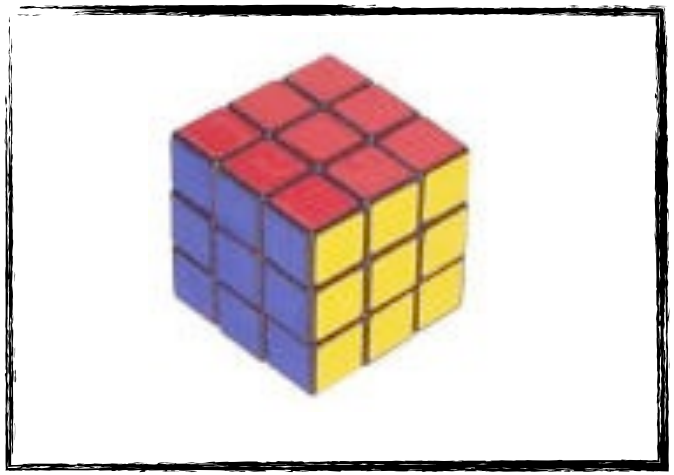


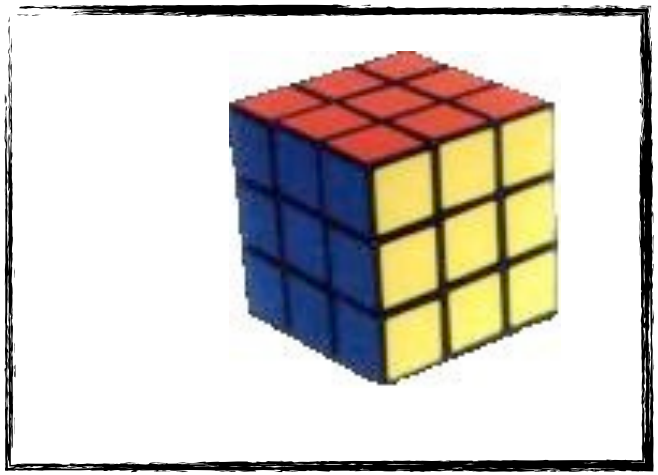
A tricky problem because of **occlusions**, contraction, homogeneous area...



Feature matching

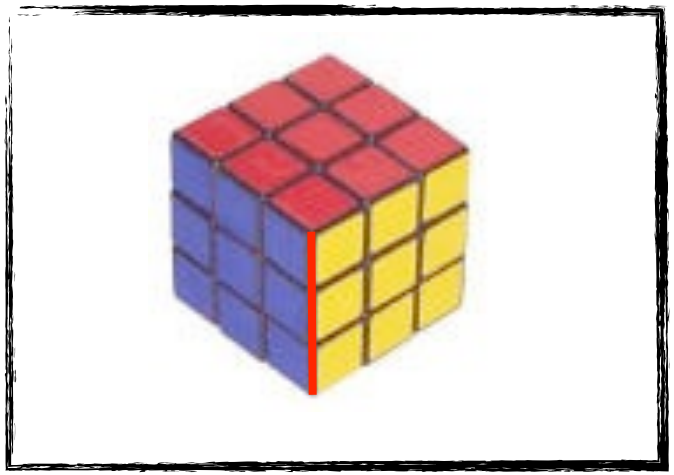
A tricky problem because of occlusions, **contraction**, homogeneous area...

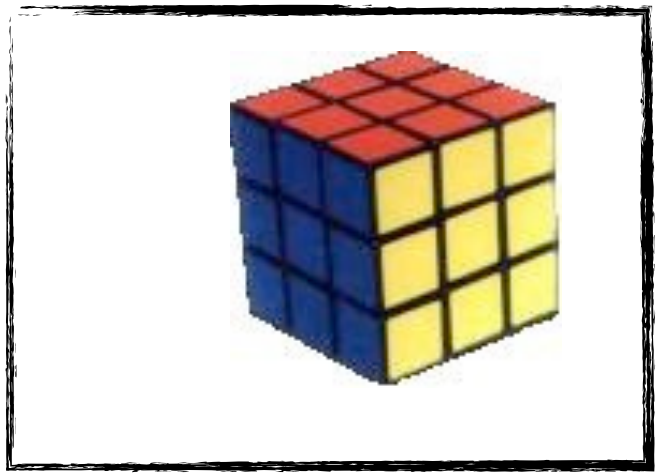




Feature matching

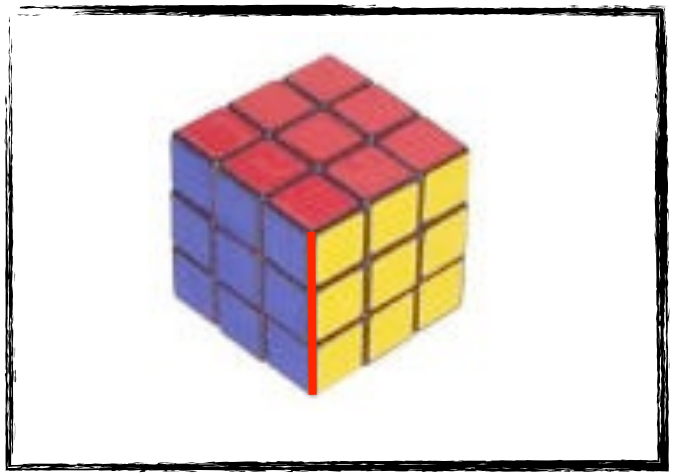
A tricky problem because of occlusions, **contraction**, homogeneous area...

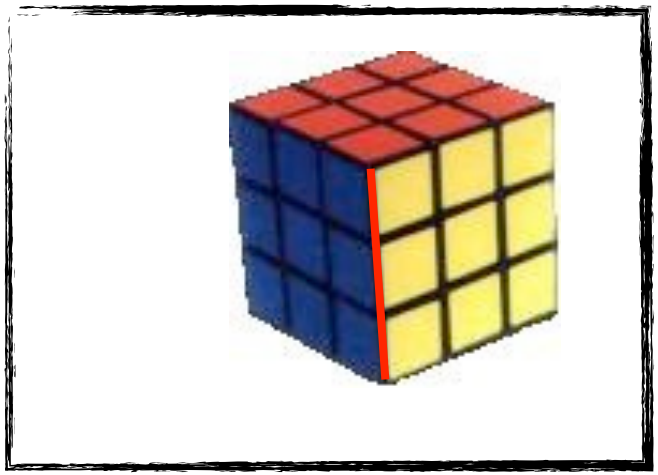




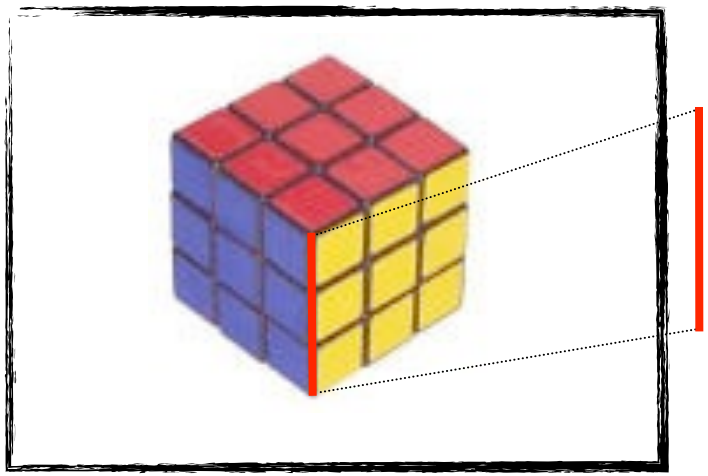
Feature matching

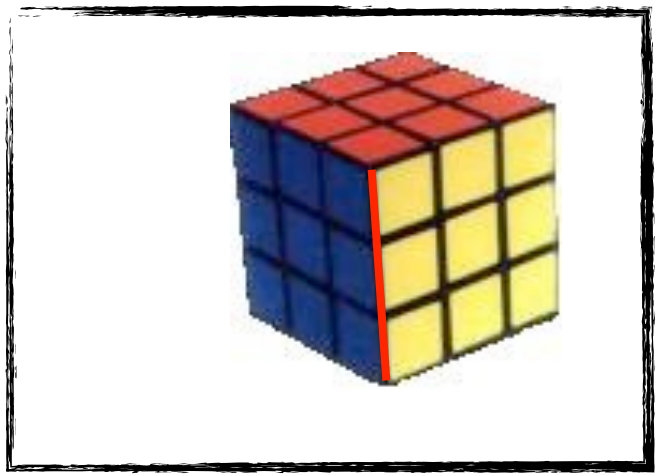
A tricky problem because of occlusions, **contraction**, homogeneous area...





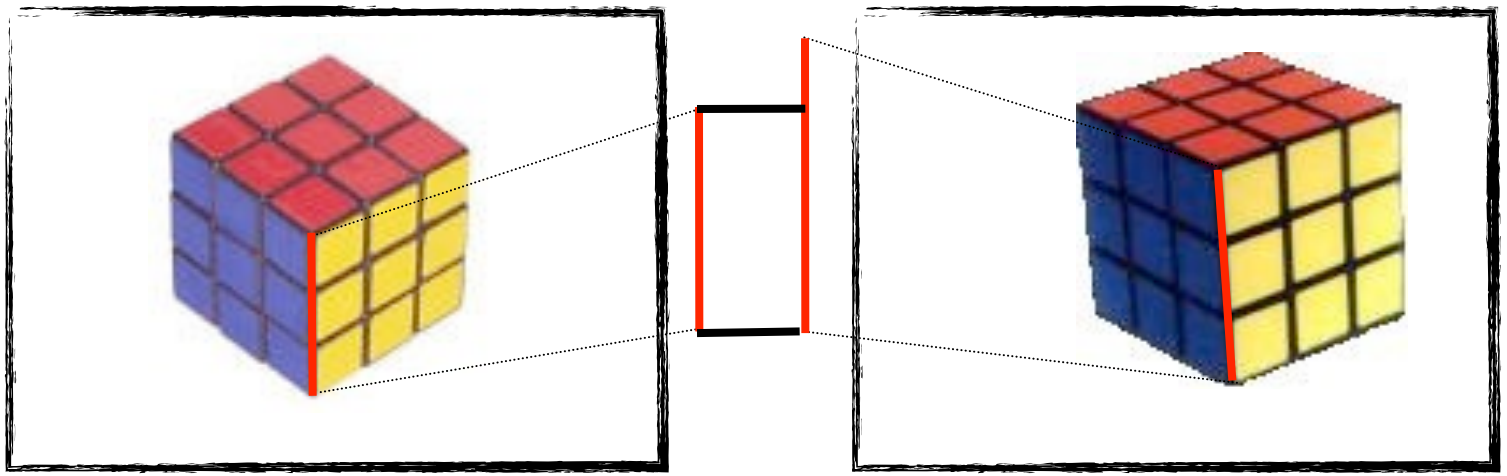
A tricky problem because of occlusions, **contraction**, homogeneous area...





Feature matching

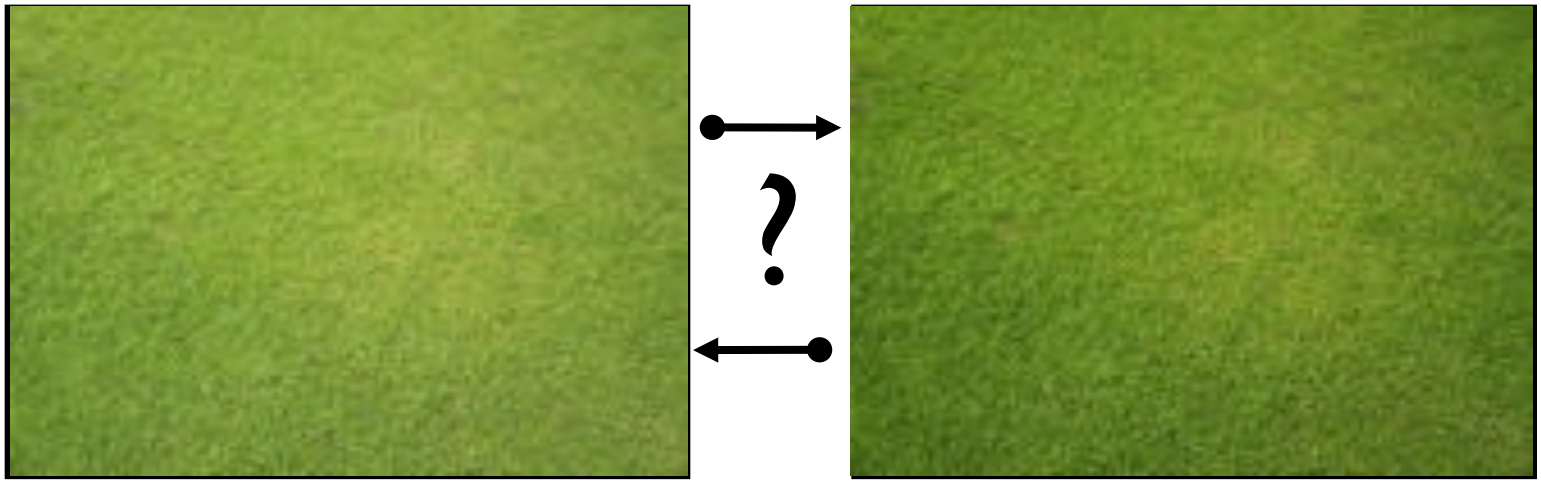
A tricky problem because of occlusions, **contraction**, homogeneous area...



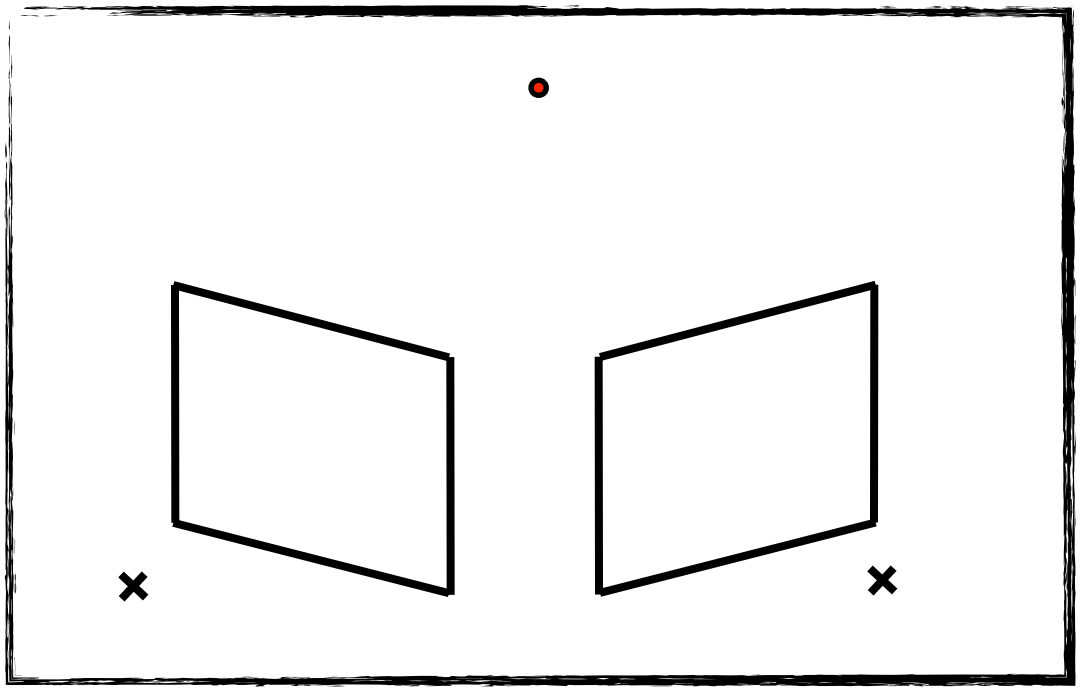
A tricky problem because of occlusions, contraction,
homogeneous area...

Feature matching

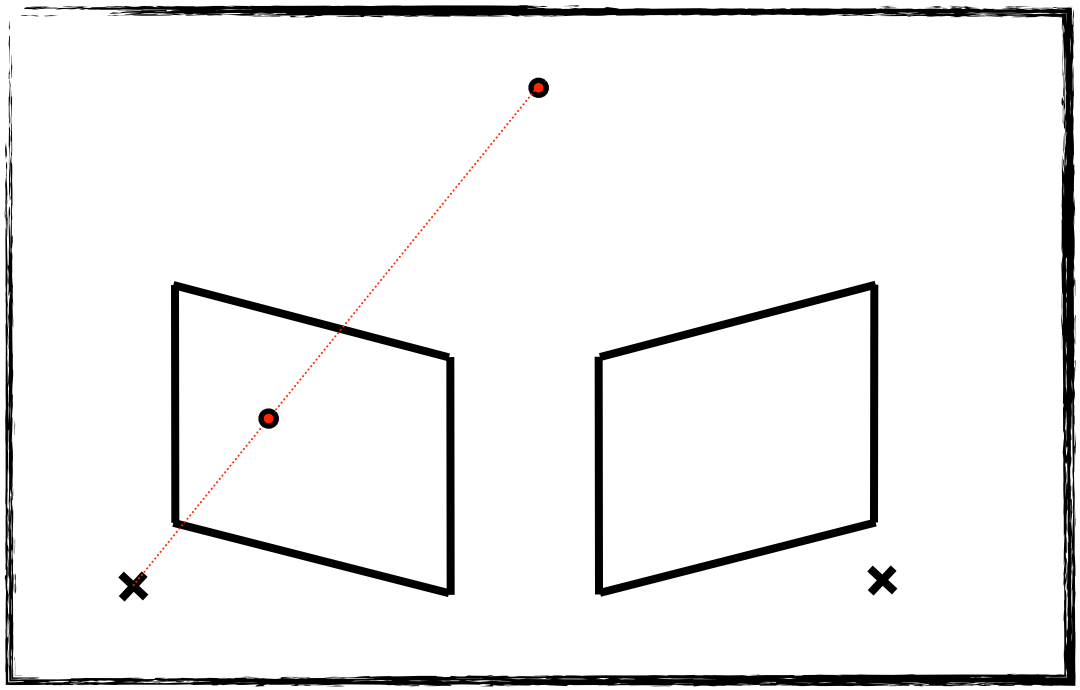
A tricky problem because of occlusions, contraction,
homogeneous area...



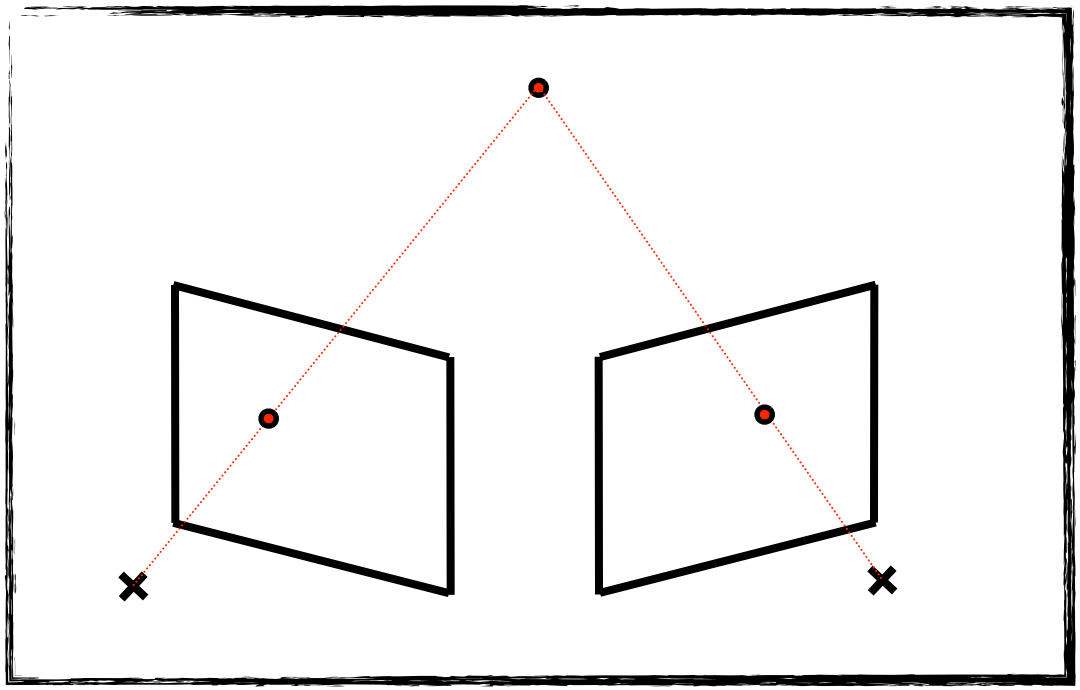
A physical constraint that eases the correspondence problem:
the **epipolar geometry**!



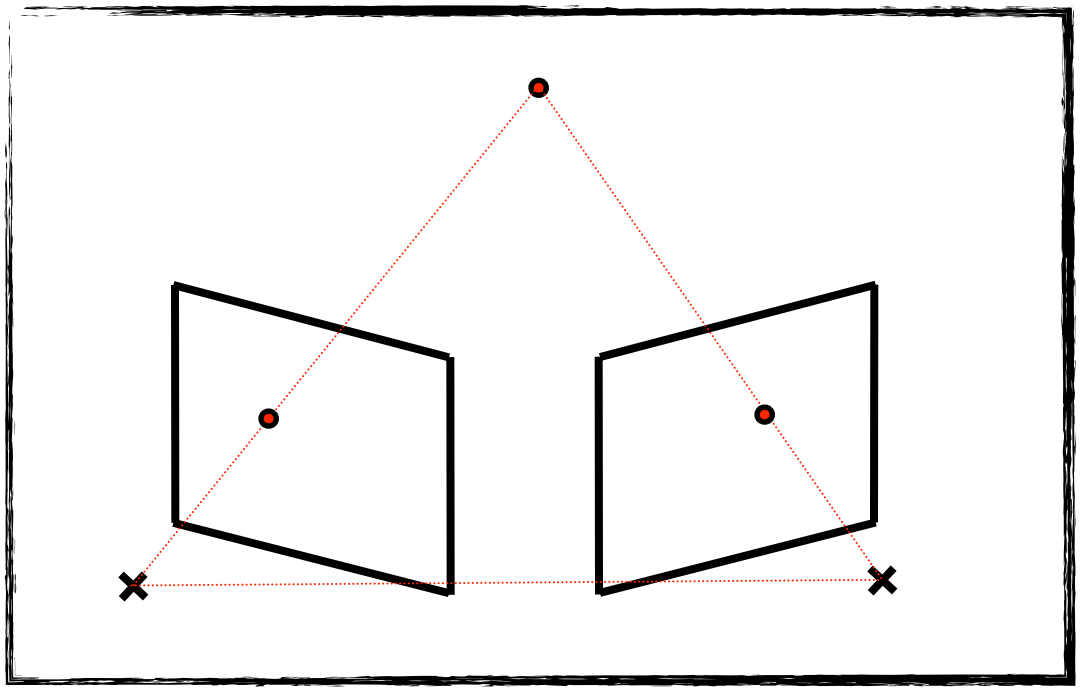
A physical constraint that eases the correspondence problem:
the **epipolar geometry**!



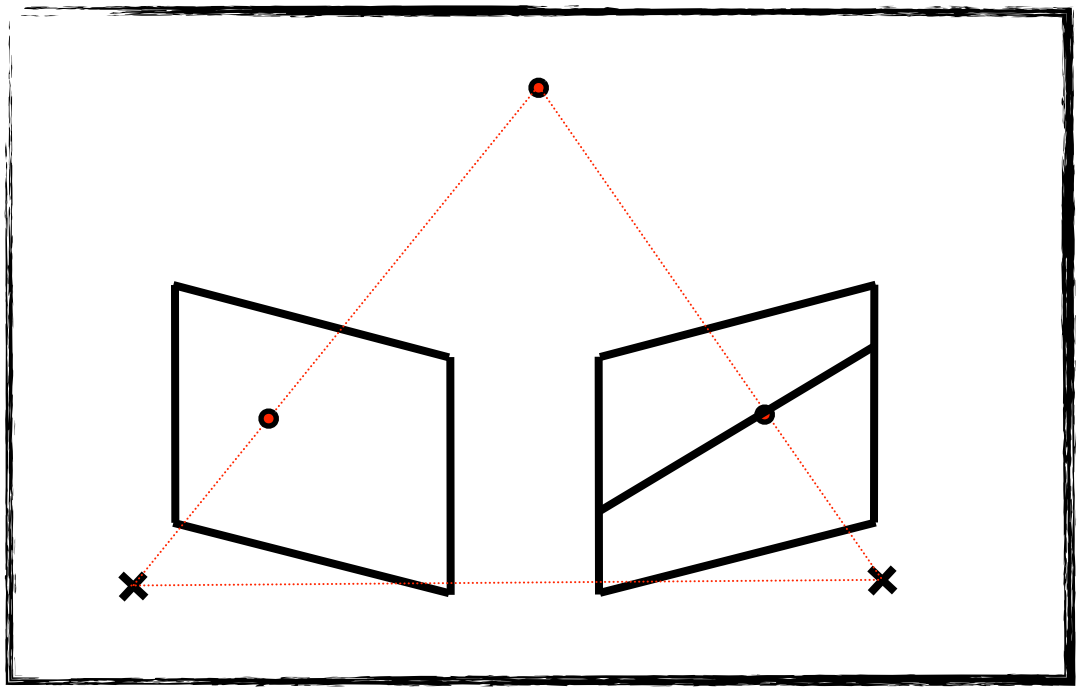
A physical constraint that eases the correspondence problem:
the **epipolar geometry**!



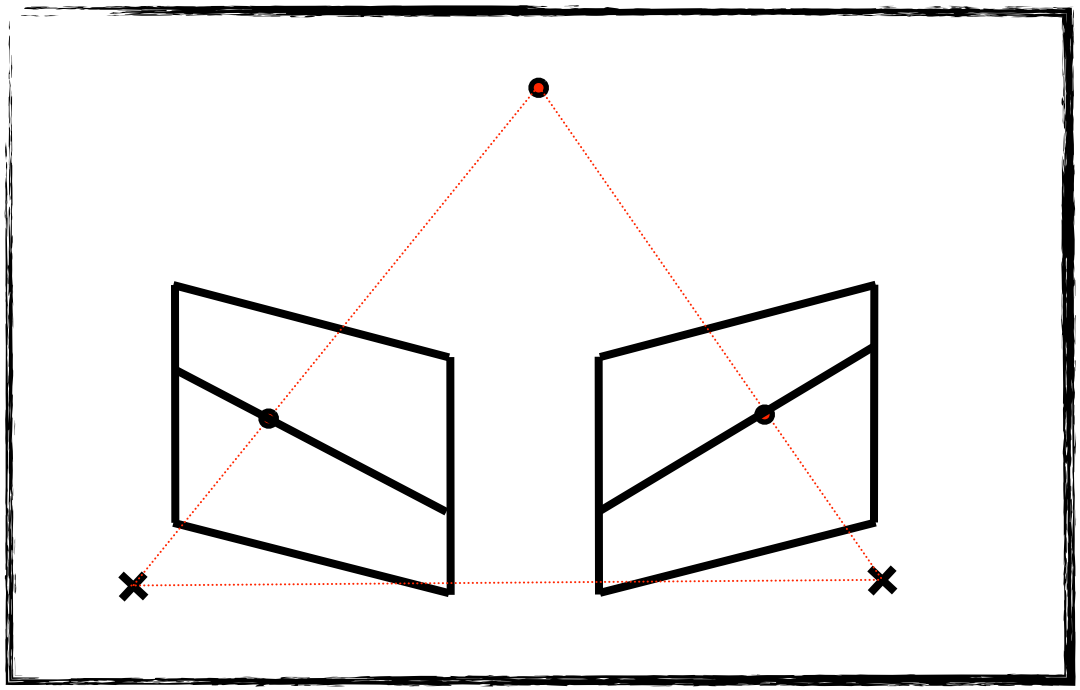
A physical constraint that eases the correspondence problem:
the **epipolar geometry**!



A physical constraint that eases the correspondence problem:
the **epipolar geometry**!

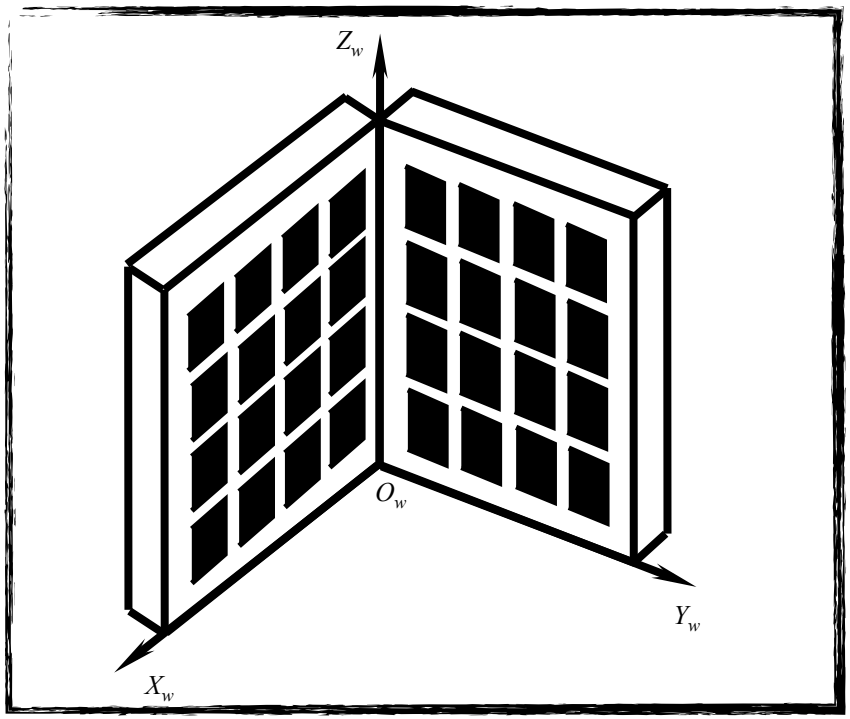


A physical constraint that eases the correspondence problem:
the **epipolar geometry**!

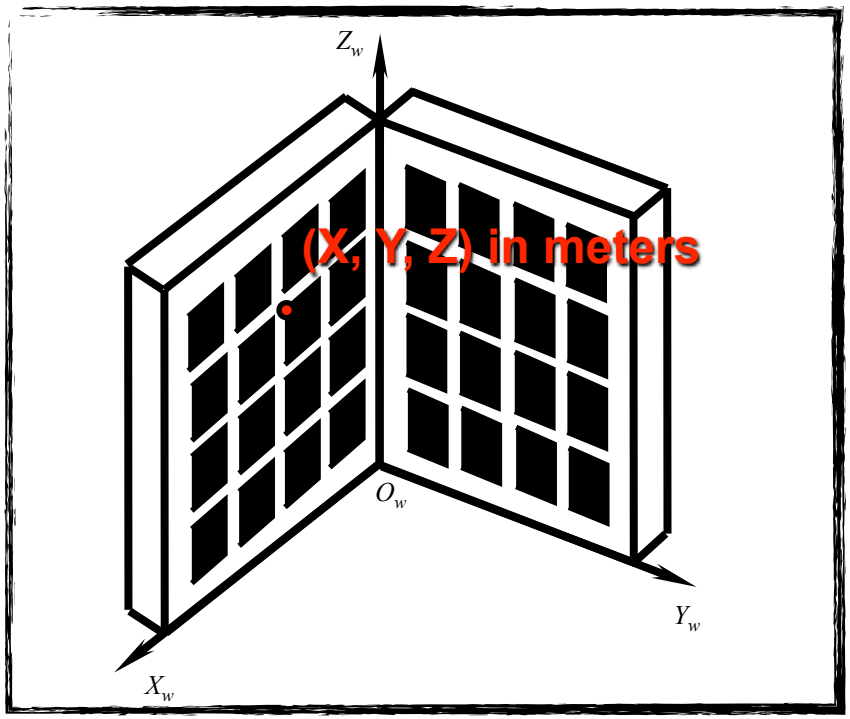


Calibration

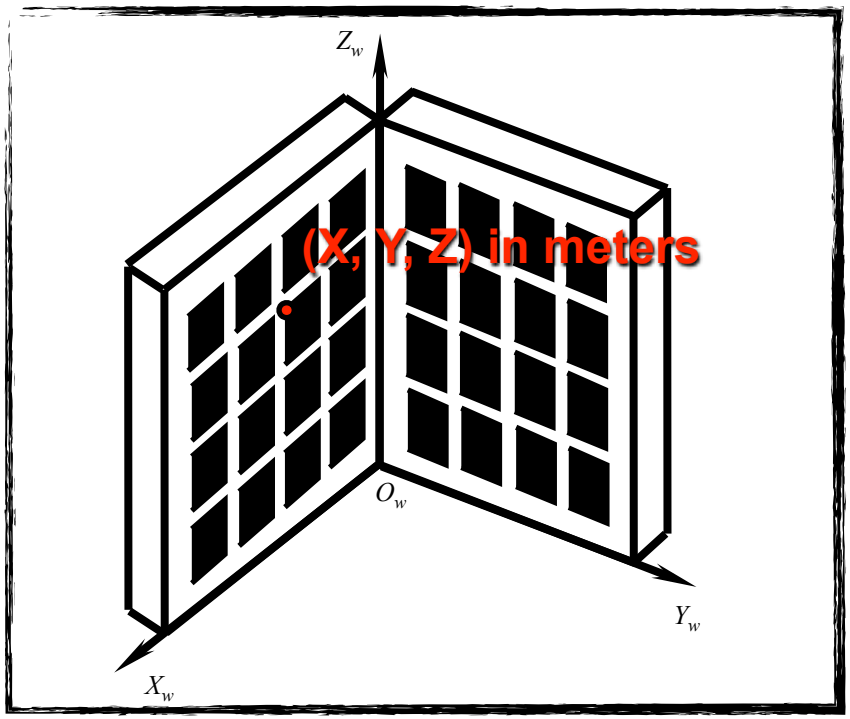
Calibrating is estimating the transformation to pass from 3D (m) to 2D (px)

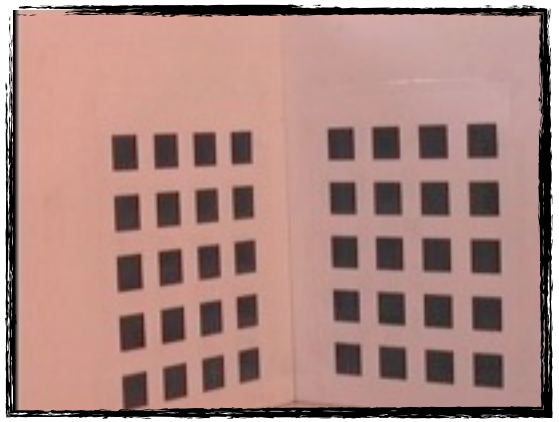


Calibrating is estimating the transformation to pass from 3D (m) to 2D (px)

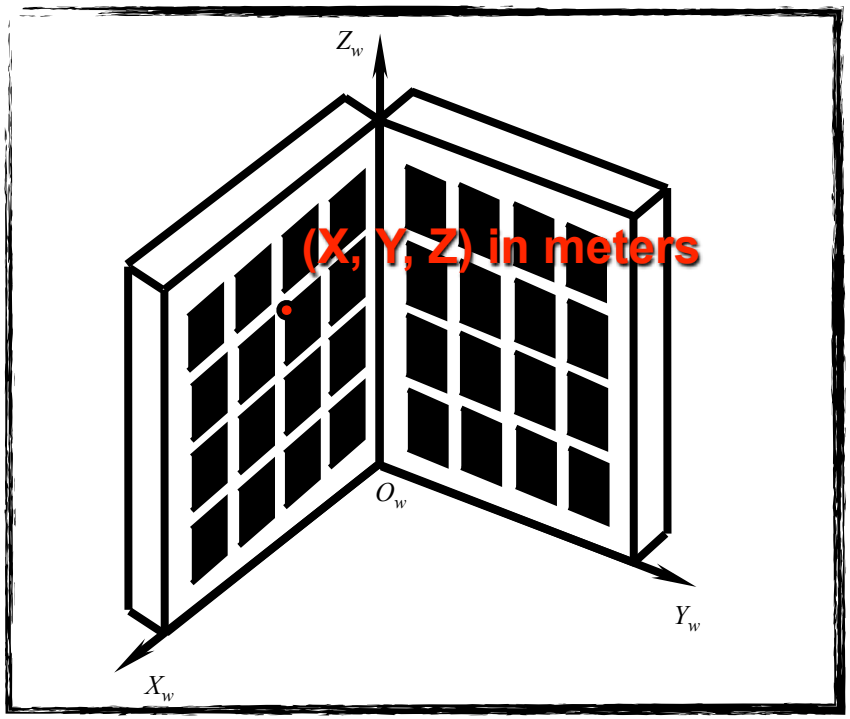


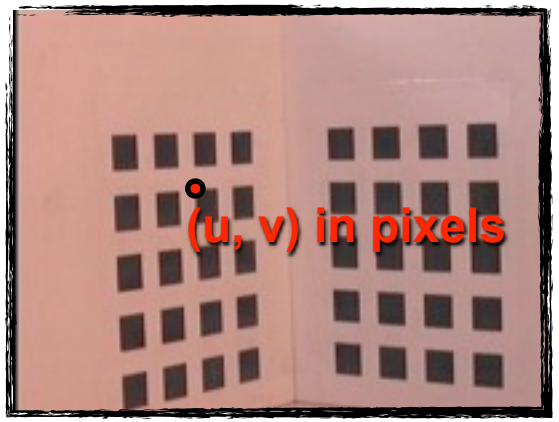
Calibrating is estimating the transformation to pass from 3D (m) to 2D (px)



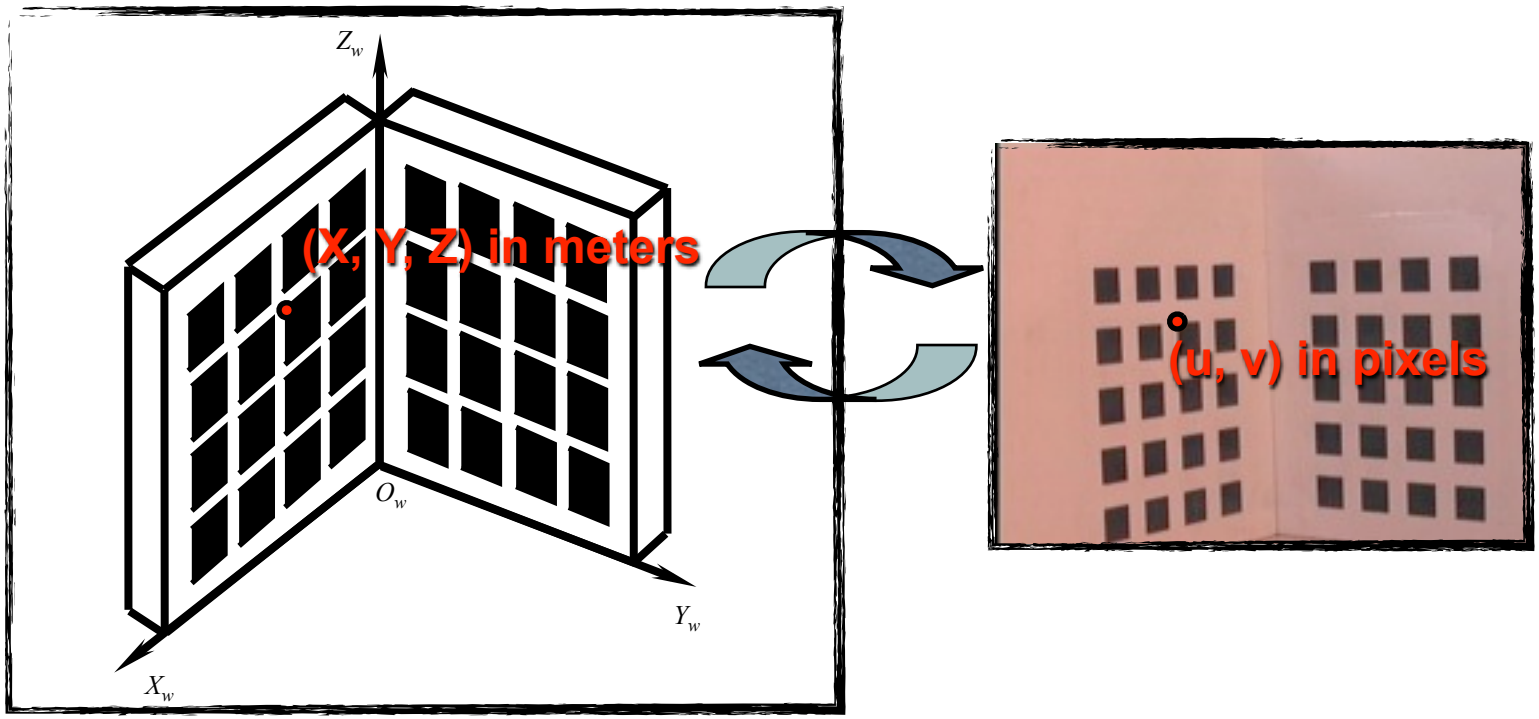


Calibrating is estimating the transformation to pass from 3D (m) to 2D (px)





Calibrating is estimating the transformation to pass from 3D (m) to 2D (px)



Calibration

$$\begin{bmatrix} u \\ v \\ s \end{bmatrix} = \begin{bmatrix} \alpha_u & 0 & u_0 & 0 \\ 0 & \alpha_v & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_x \\ r_{21} & r_{22} & r_{23} & t_y \\ r_{31} & r_{32} & r_{33} & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Calibration

$$\begin{bmatrix} u \\ v \\ s \end{bmatrix} = \begin{bmatrix} \alpha_u & 0 & u_0 & 0 \\ 0 & \alpha_v & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_x \\ r_{21} & r_{22} & r_{23} & t_y \\ r_{31} & r_{32} & r_{33} & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Image point (pixels)

Calibration

$$\begin{bmatrix} u \\ v \\ s \end{bmatrix} = \begin{bmatrix} \alpha_u & 0 & u_0 & 0 \\ 0 & \alpha_v & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_x \\ r_{21} & r_{22} & r_{23} & t_y \\ r_{31} & r_{32} & r_{33} & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Image point (pixels)

3D points (meters)

Calibration

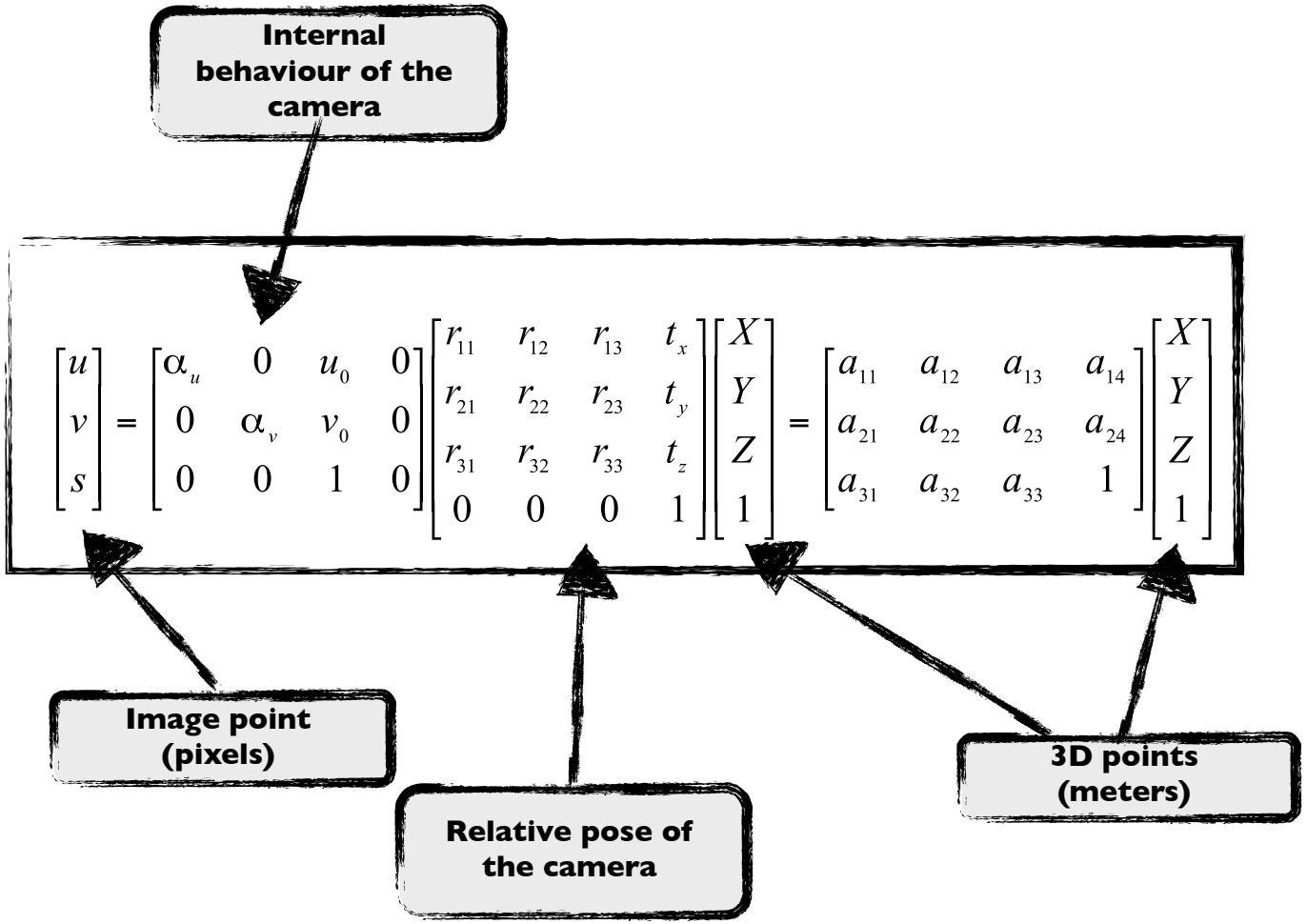
$$\begin{bmatrix} u \\ v \\ s \end{bmatrix} = \begin{bmatrix} \alpha_u & 0 & u_0 & 0 \\ 0 & \alpha_v & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_x \\ r_{21} & r_{22} & r_{23} & t_y \\ r_{31} & r_{32} & r_{33} & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Image point (pixels)

Relative pose of the camera

3D points (meters)

Calibration



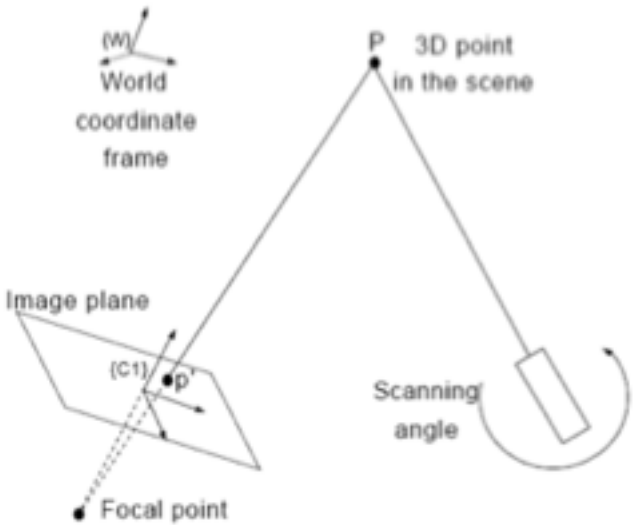
Performances

Table 2
Accuracy of 2D coordinate measurement

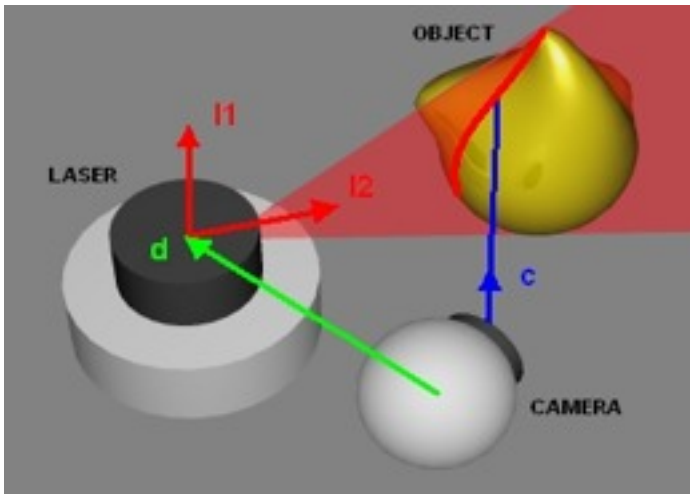
	2D distorted image (pix.)			2D undistorted image (pix.)		
	Mean	σ	Max	Mean	σ	Max
Hall	0.2676	0.1979	1.2701	0.2676	0.1979	1.2701
Faugeras	0.2689	0.1997	1.2377	0.2689	0.1997	1.2377
Faugeras NR without distortion	0.2770	0.2046	1.3692	0.2770	0.2046	1.3692
Faugeras NR with distortion	0.0840	0.0458	0.2603	0.0834	0.0454	0.2561
Tsai	0.1836	0.1022	0.6082	0.1824	0.1011	0.6011
Tsai optimized	0.0838	0.0457	0.2426	0.0832	0.0453	0.2386
Tsai with principal point of Tsai optimized	0.0879	0.0466	0.2277	0.0872	0.0463	0.2268
Tsai optimized with principal point of Tsai optimized	0.0836	0.0457	0.2500	0.0830	0.0454	0.2459
Weng	0.0845	0.0455	0.2680	0.0843	0.0443	0.2584

Référence : J. Salvi, X. Armangué, J. Batlle, "A comparative review of camera calibrating methods with accuray evaluation", *Pattern Recognition*, 35, pp. 1617-1635, 2002.

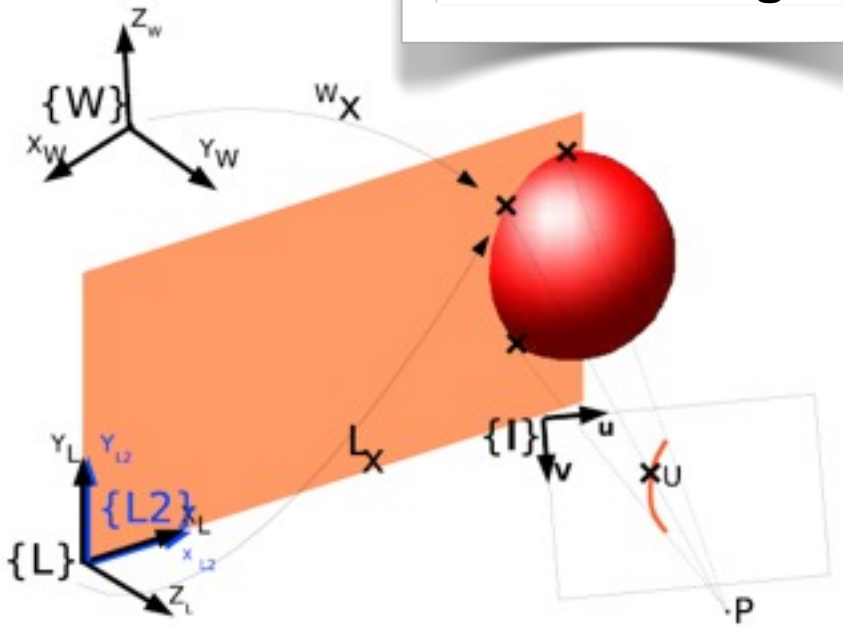
Structured light



One of the cameras is replaced by a laser source that projects either a dot, a line or a bi-dimensional pattern onto the object...



Structured light



$$\begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix} = {}^{W}T_{L} \cdot {}^{L}T_{L2} \cdot {}^{L2}H_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{L} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot$$

$$\cdot \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} t_{11} & t_{12} & t_{13} \\ t_{21} & t_{22} & t_{23} \\ t_{31} & t_{32} & t_{33} \\ t_{41} & t_{42} & t_{43} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

Structured light

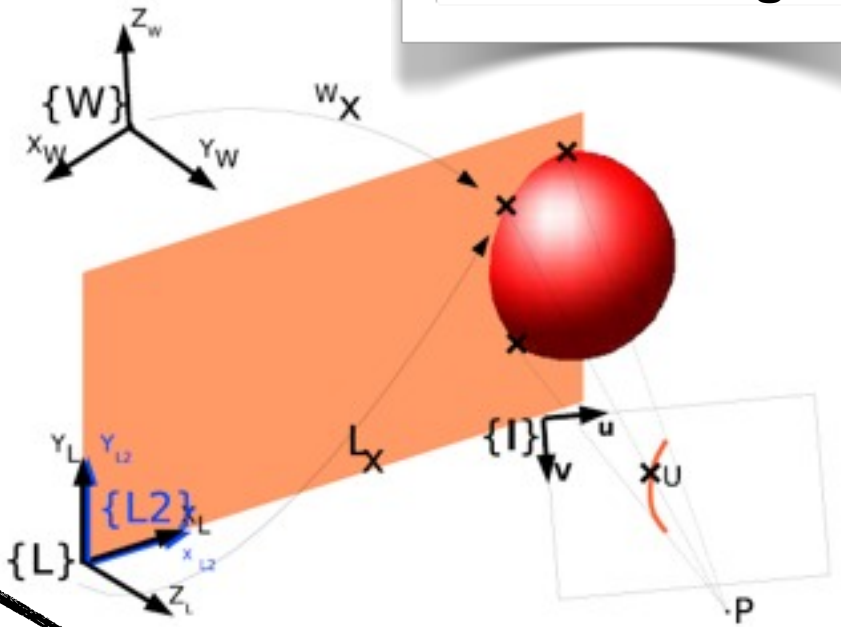


Image point (pixels)

$$\begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix} = {}^{W}T_{L} \cdot {}^{L}T_{L2} \cdot {}^{L2}H_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{L} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot$$

$$\cdot \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} t_{11} & t_{12} & t_{13} \\ t_{21} & t_{22} & t_{23} \\ t_{31} & t_{32} & t_{33} \\ t_{41} & t_{42} & t_{43} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

Structured light

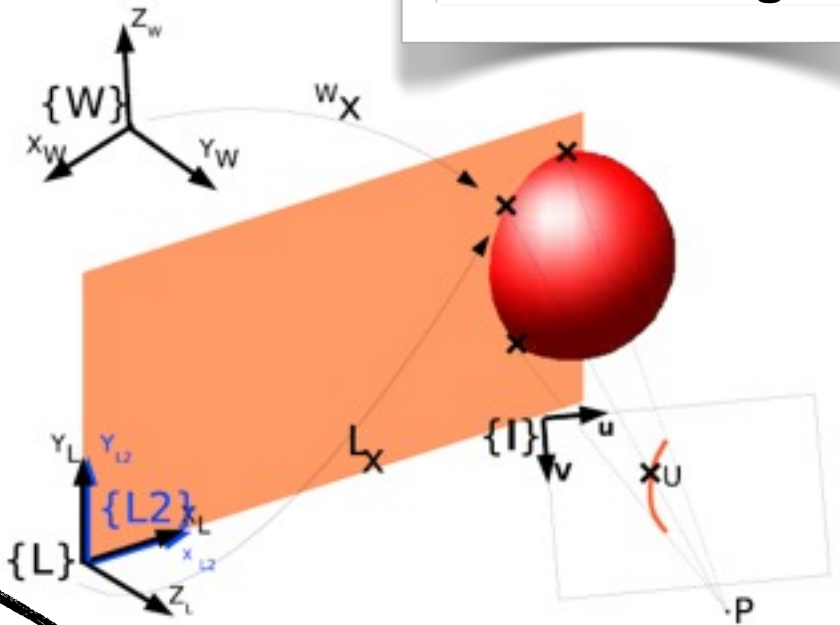


Image point (pixels)

3D point (meters)

$$\begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix} = {}^{W}T_{L} \cdot {}^{L}T_{L2} \cdot {}^{L2}H_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{L} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} t_{11} & t_{12} & t_{13} \\ t_{21} & t_{22} & t_{23} \\ t_{31} & t_{32} & t_{33} \\ t_{41} & t_{42} & t_{43} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

Structured light

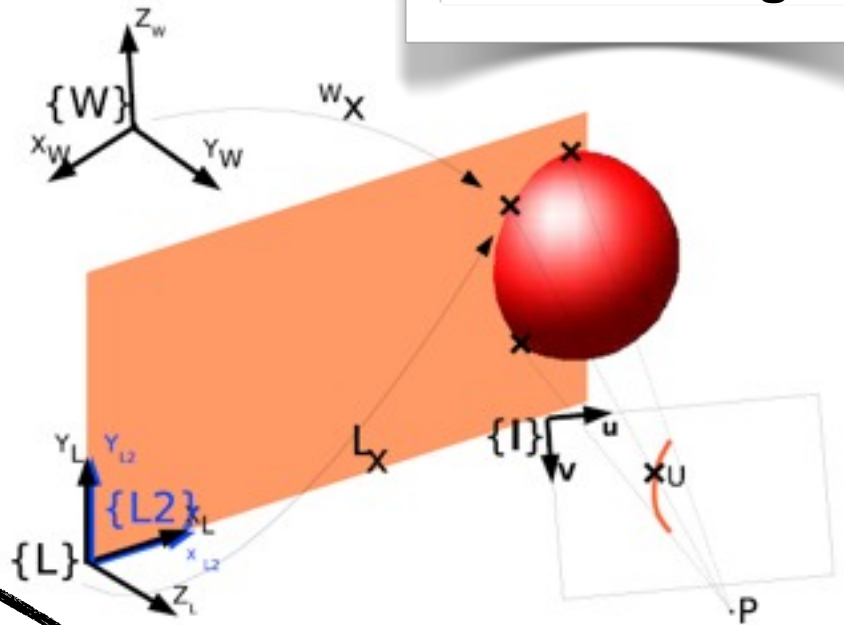


Image point (pixels)

3D point (meters)

Relative pose of the laser plane

$$\begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix} = {}^{W}T_{L} \cdot {}^{L}T_{L2} \cdot {}^{L2}H_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{L} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} t_{11} & t_{12} & t_{13} \\ t_{21} & t_{22} & t_{23} \\ t_{31} & t_{32} & t_{33} \\ t_{41} & t_{42} & t_{43} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

Structured light

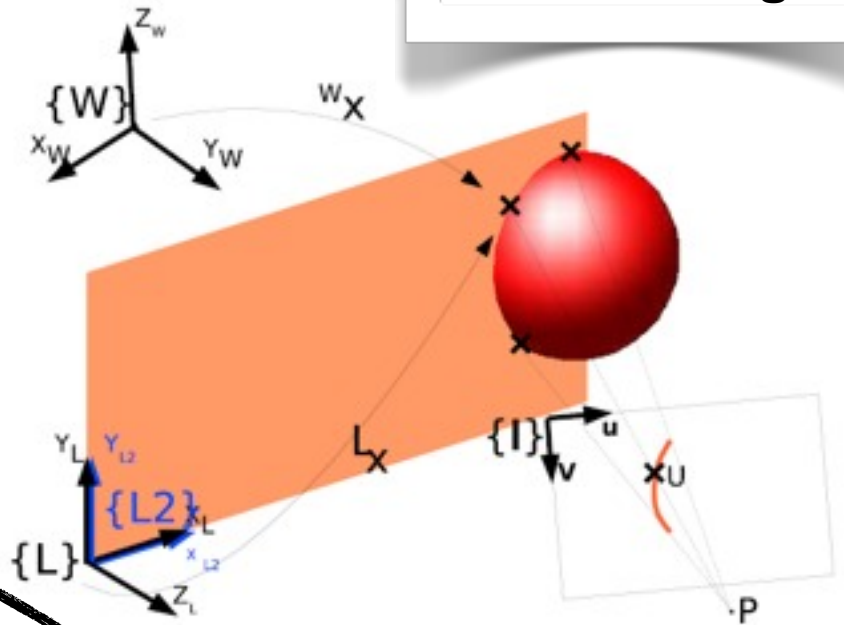


Image point (pixels)

3D point (meters)

Relative pose of the laser plane

2D/3D transformation

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = {}^{W}T_{L} \cdot {}^{L}T_{L2} \cdot {}^{L2}H_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{L} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} t_{11} & t_{12} & t_{13} \\ t_{21} & t_{22} & t_{23} \\ t_{31} & t_{32} & t_{33} \\ t_{41} & t_{42} & t_{43} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

Structured light

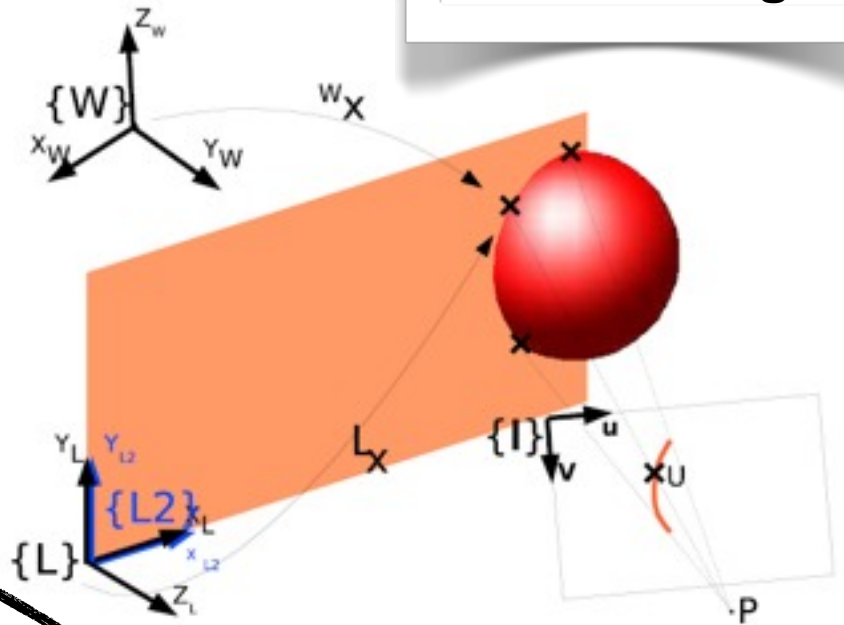


Image point (pixels)

3D point (meters)

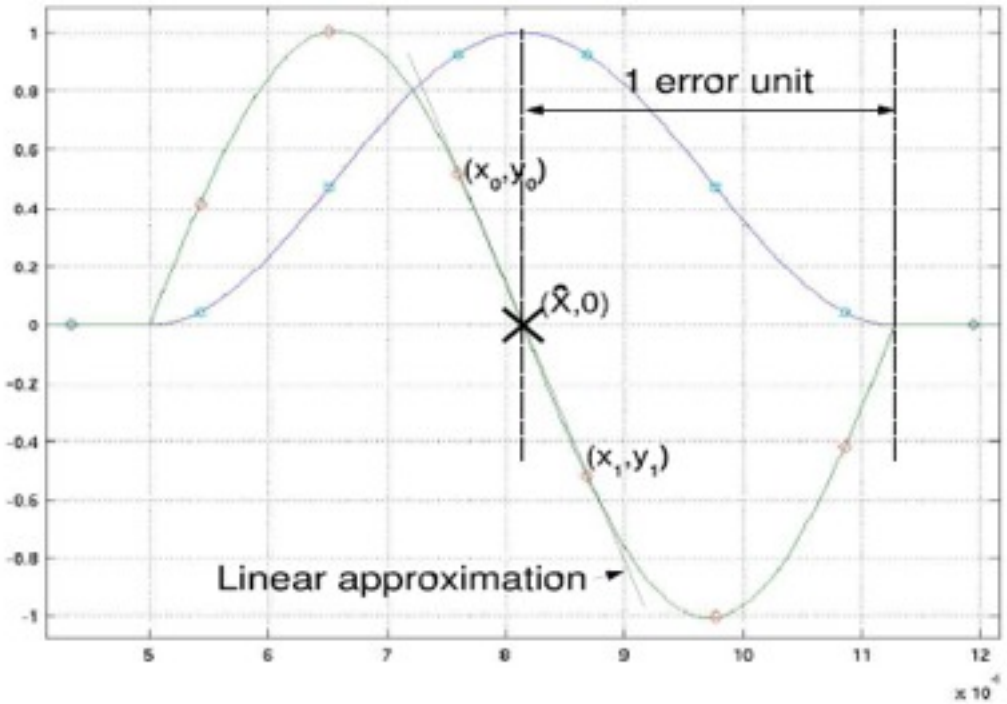
Relative pose of the laser plane

2D/3D transformation

Image plane/laser plane homography

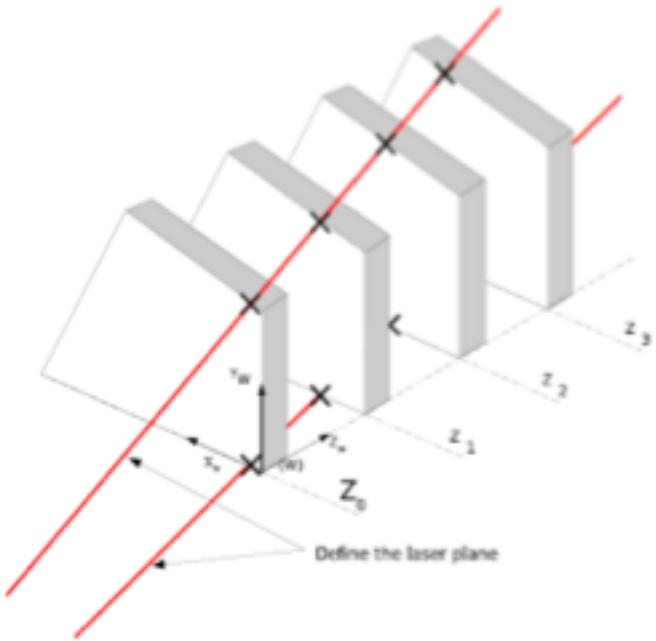
$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = {}^{W}T_{L} \cdot {}^{L}T_{L2} \cdot {}^{L2}H_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{L} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} t_{11} & t_{12} & t_{13} \\ t_{21} & t_{22} & t_{23} \\ t_{31} & t_{32} & t_{33} \\ t_{41} & t_{42} & t_{43} \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = {}^{W}T_{I} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

Peak detection



How to retrieve the coordinate of 3D points lighted by the laser (to establish the 3D/2D correspondence)?

One method: the complete quadrangle!



Référence : J. Forest, "New methods for triangulation-based shape acquisition using laser scanners", *Thèse de doctorat*, Université de Gérone, Espagne, mai 2004.

Performances

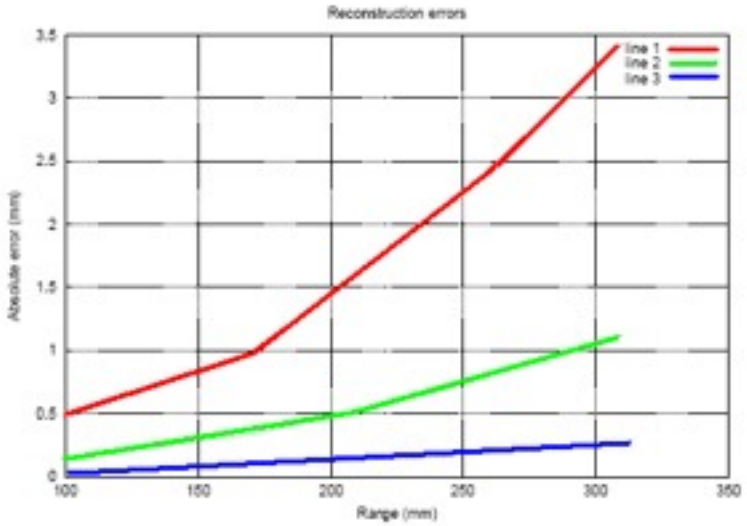
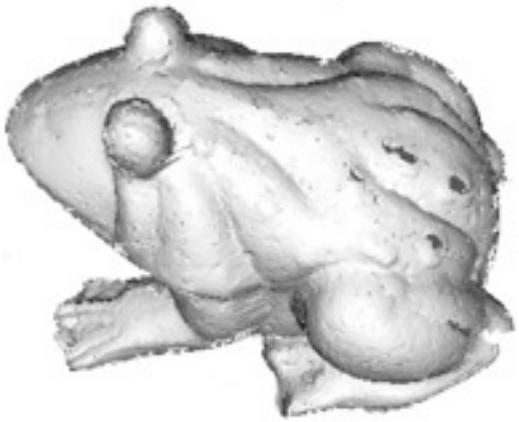


Table A.1: Performance of the Chen and Kak scanner.

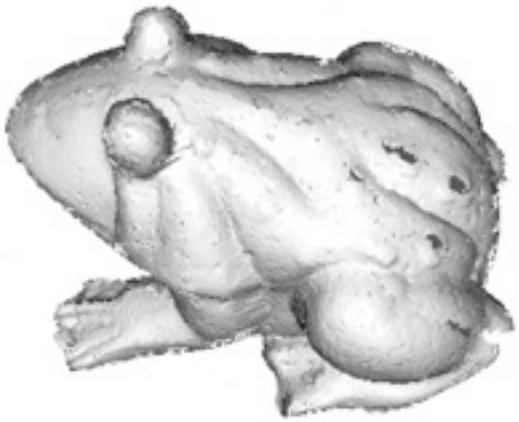
Range (mm)	100	170	240	310
Image error (pix.)	6,8916	7,0088	7,0505	7,0395
X error (mm)	0,144	0,3342	0,6703	1,1239
Y error (mm)	0,0573	0,0963	0,1594	0,2651
Z error (mm)	0,4535	0,9967	2,0569	3,4345

Examples

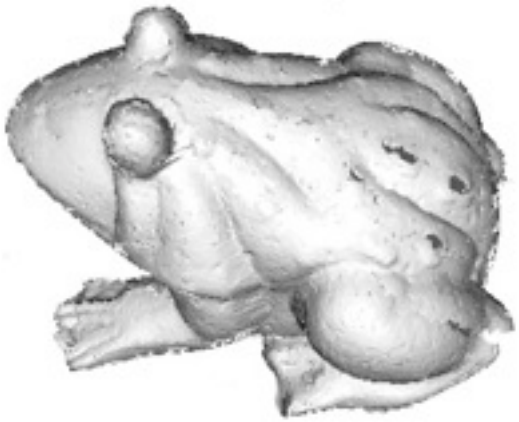


Examples

Camera + RGB filter

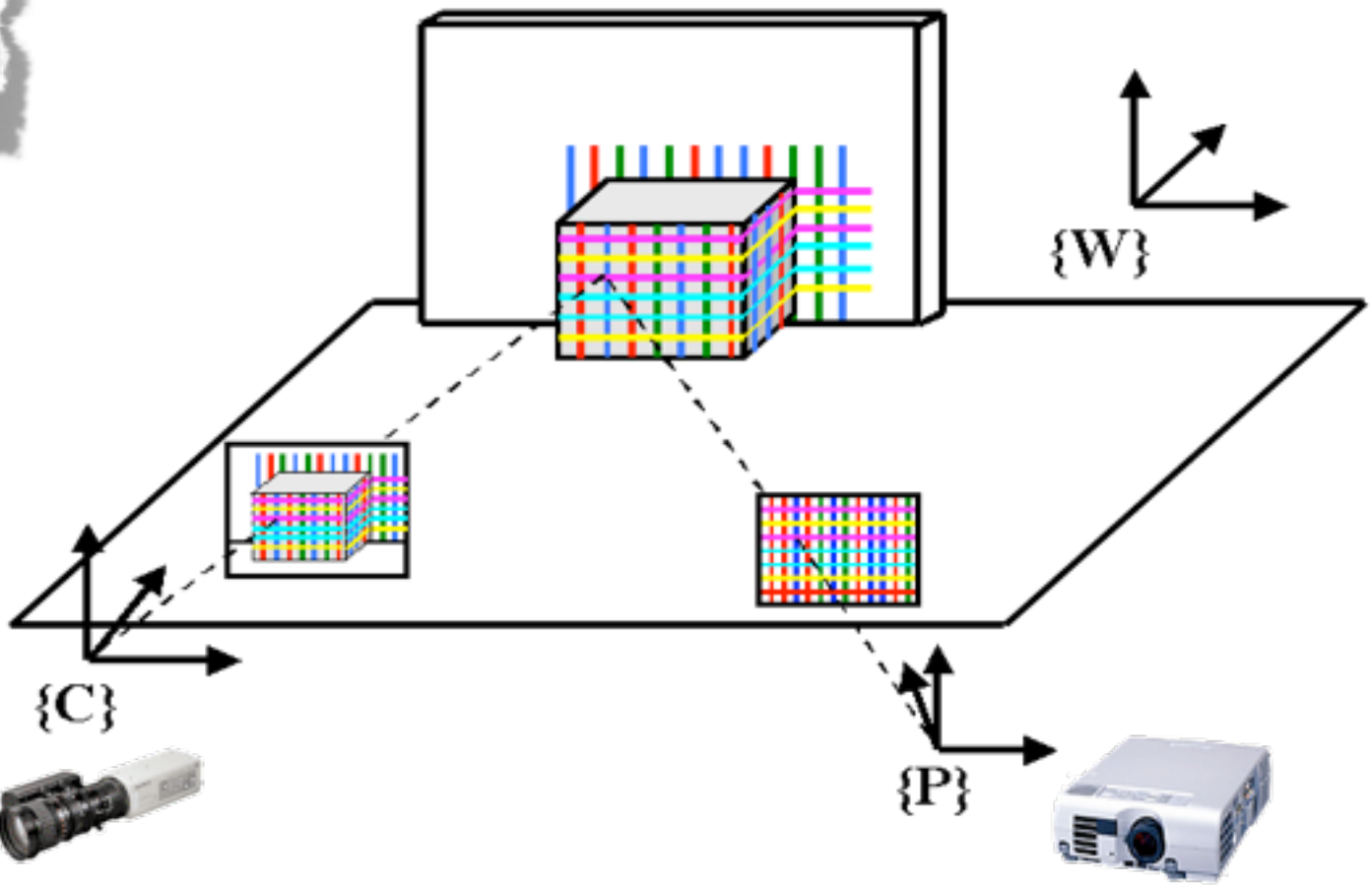


Examples

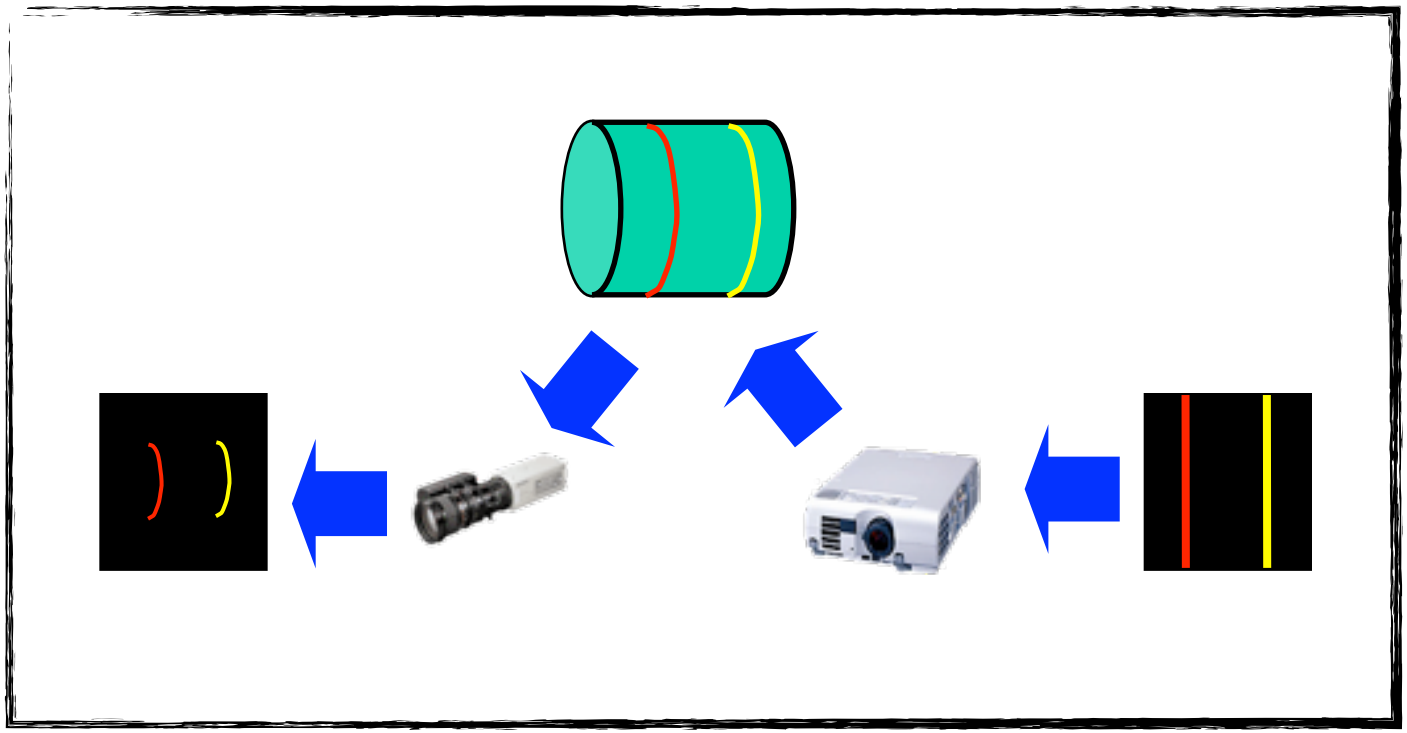


Examples

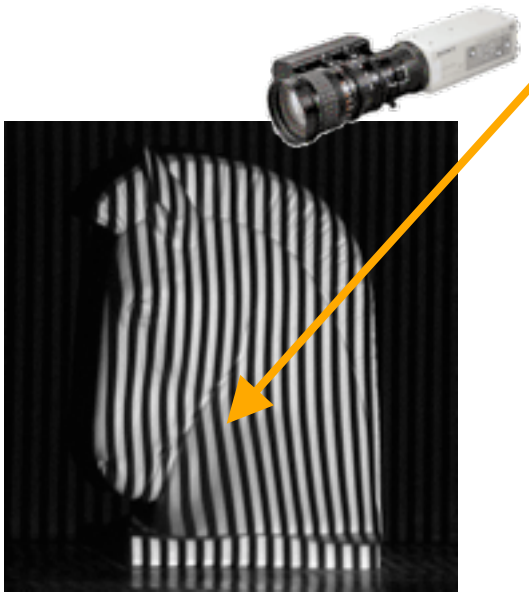
Projector-Camera

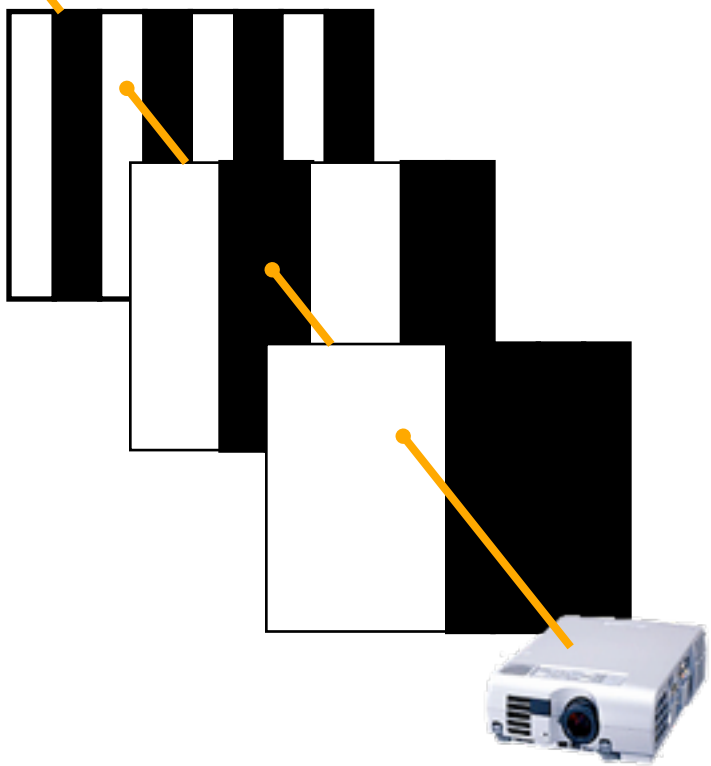


In order to ease the correspondence problem, the projected light can be coded...

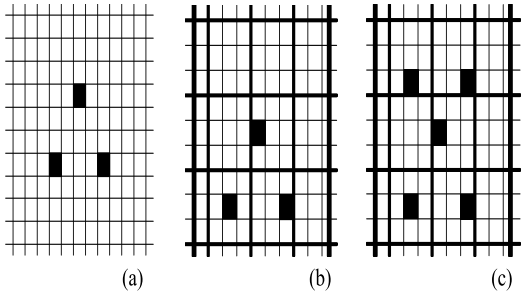


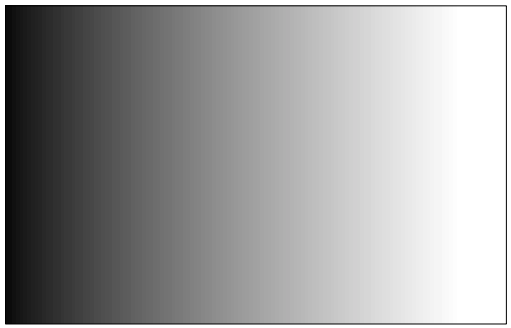
Example

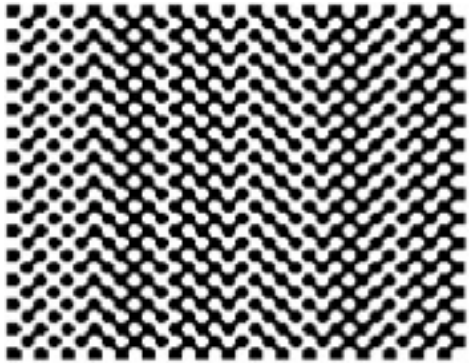


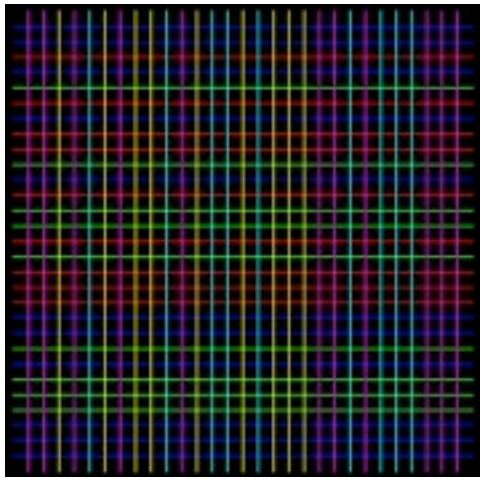


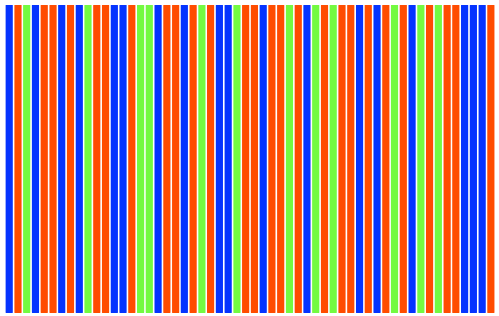
Pattern codification

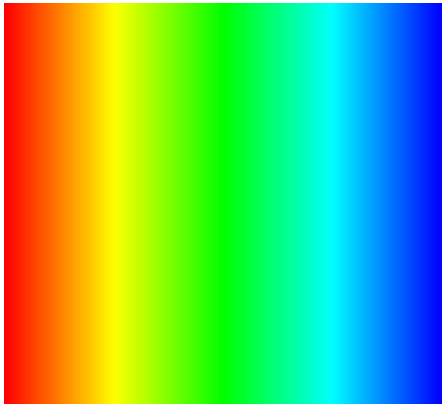


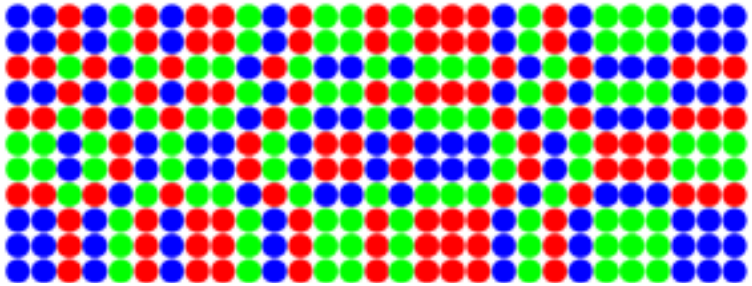




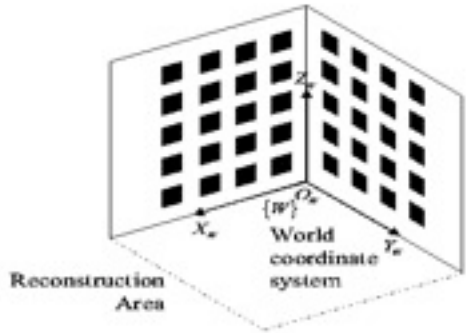


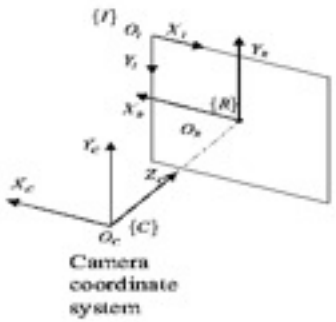


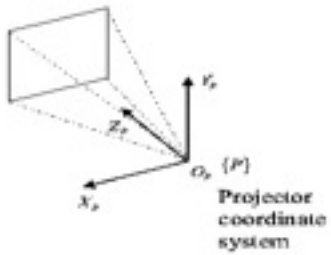




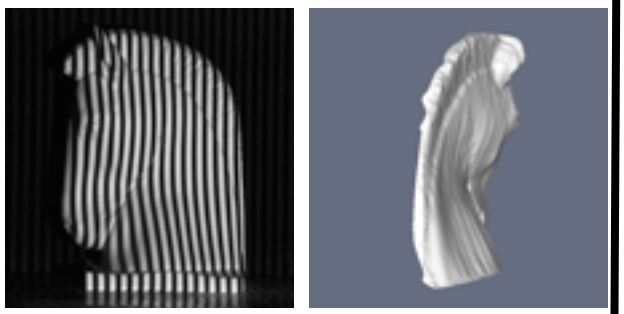
A projector can be seen as a camera acting in reverse!

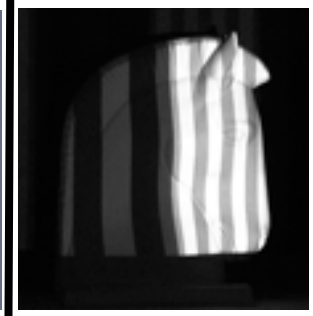


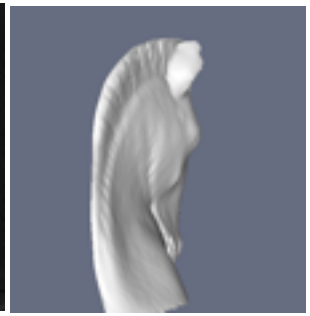
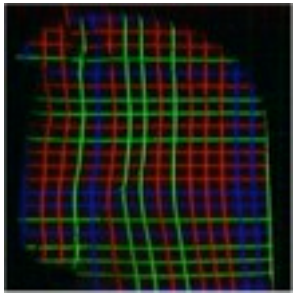


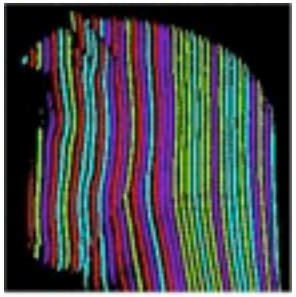
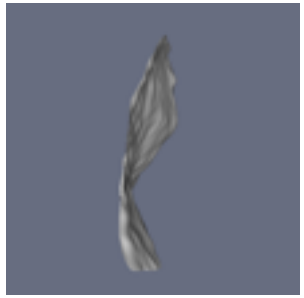
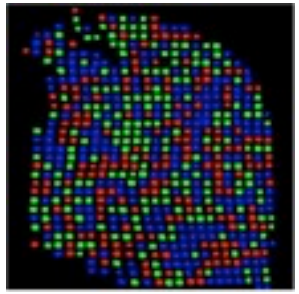
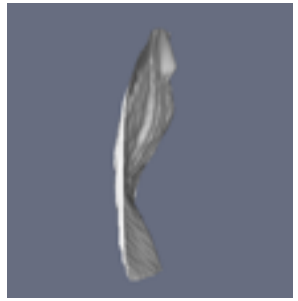
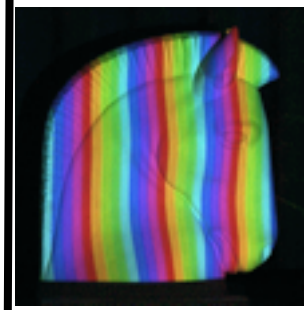
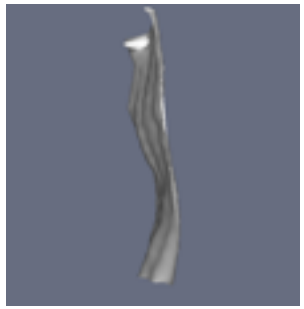


Examples

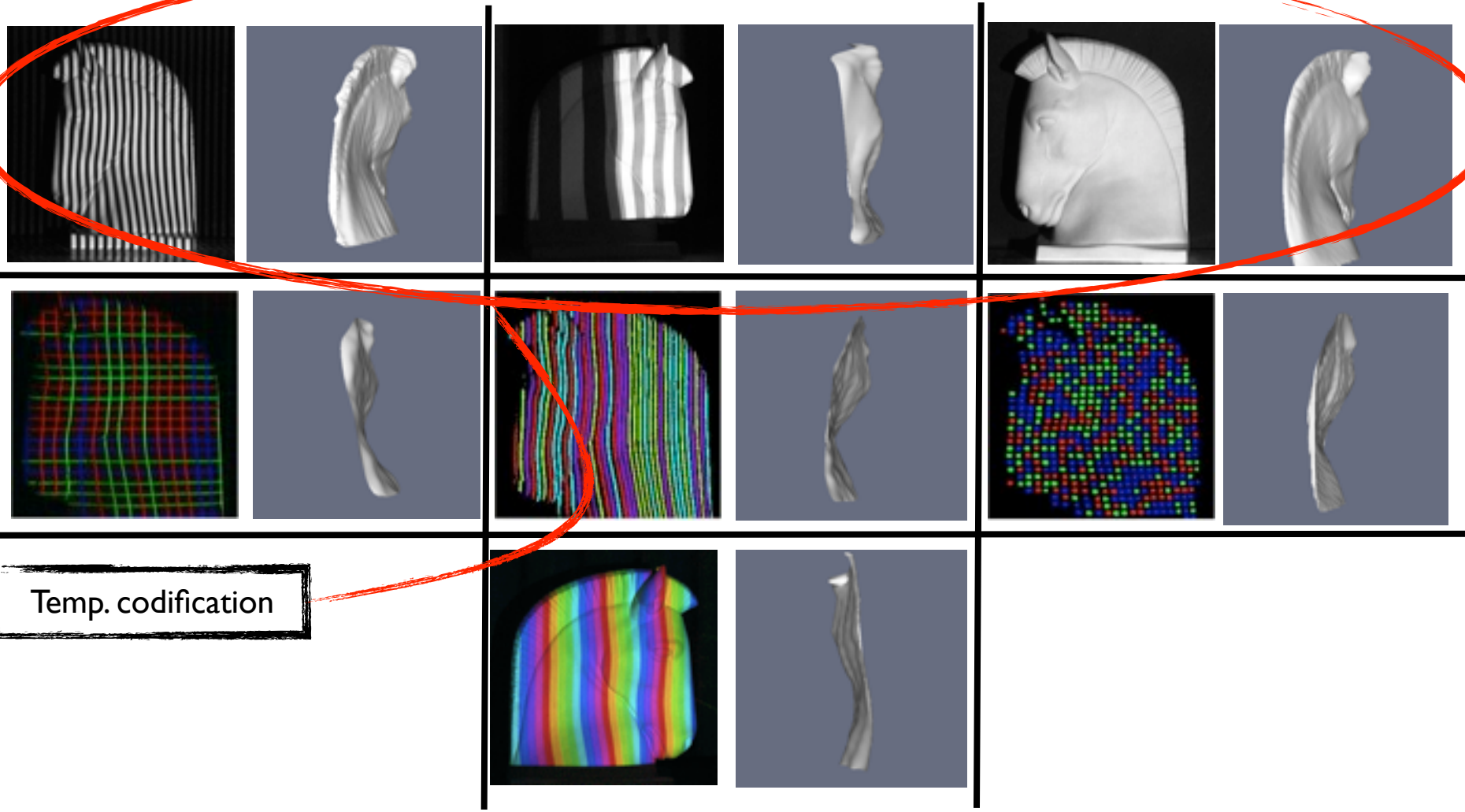




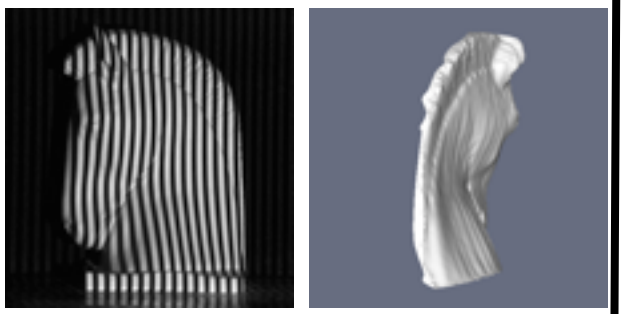







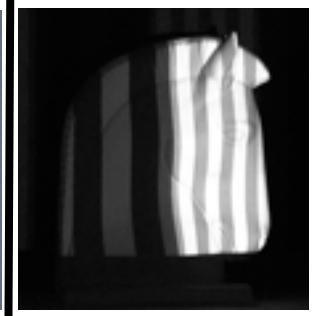
Examples

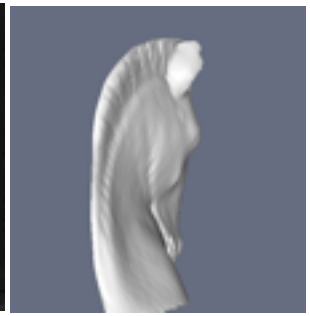
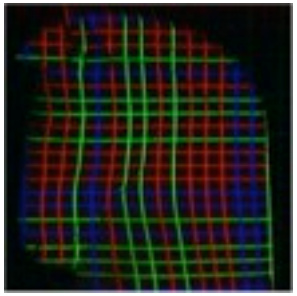


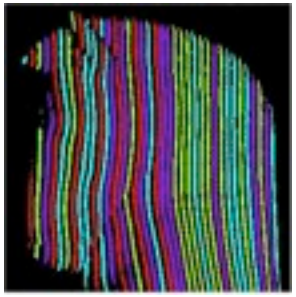
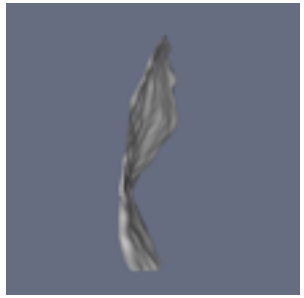
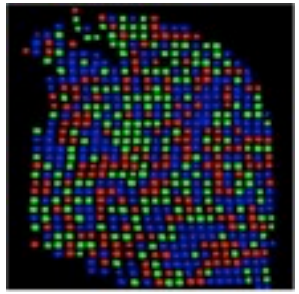
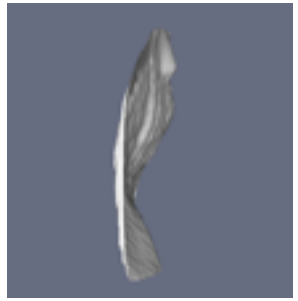
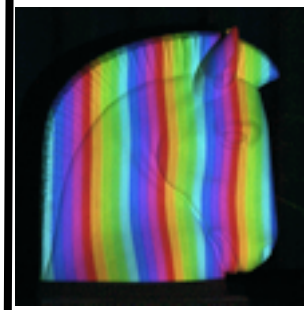
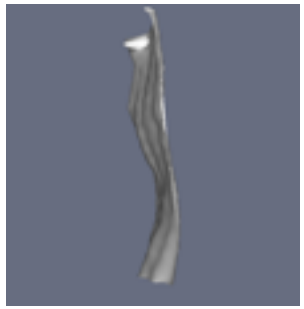
Temp. codification

Examples

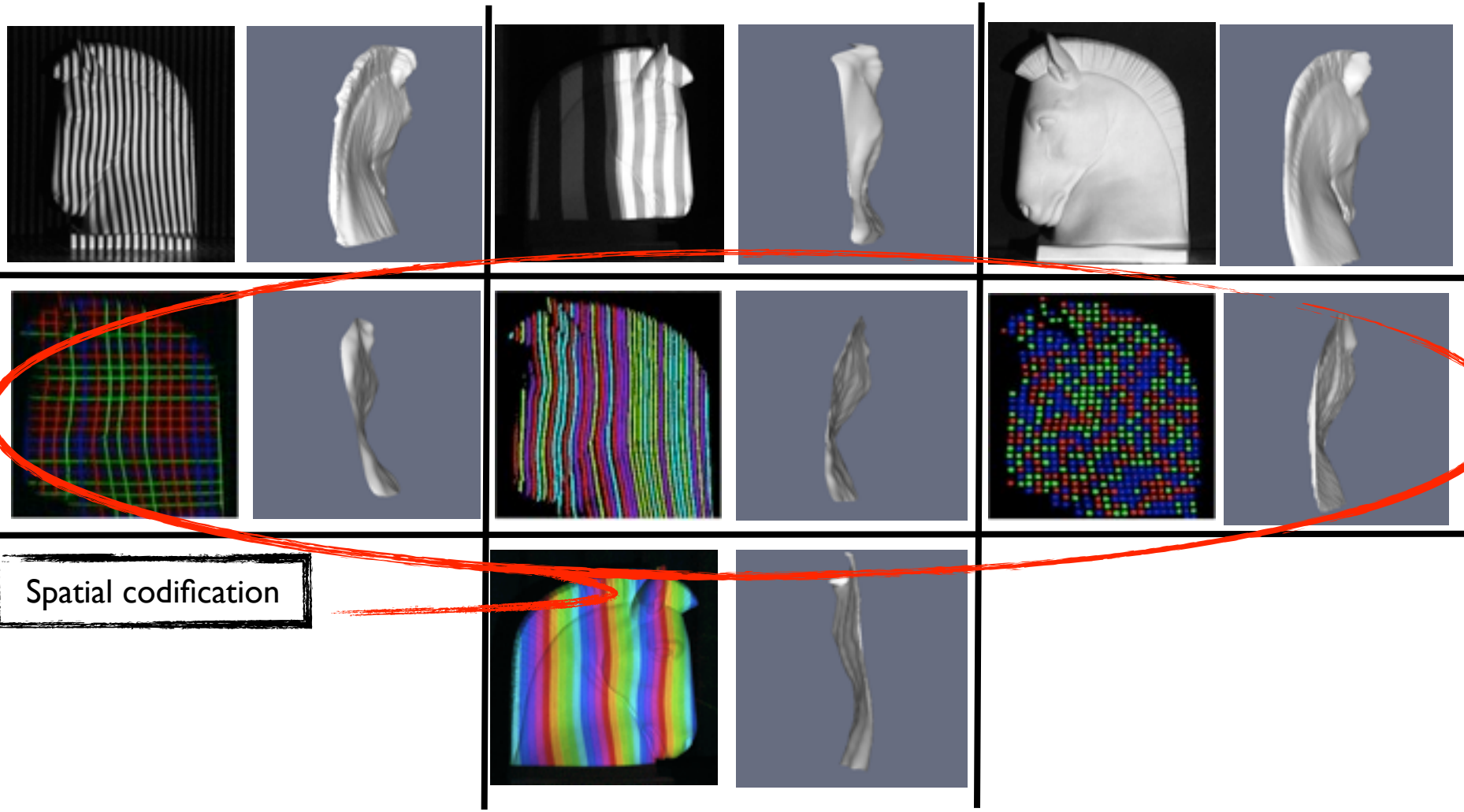




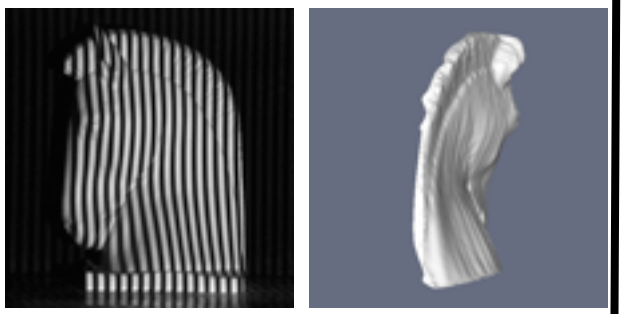







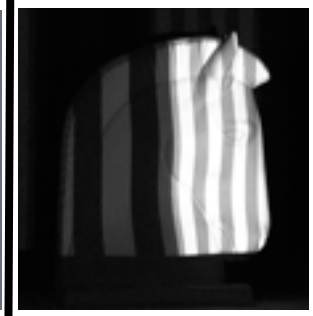
Examples

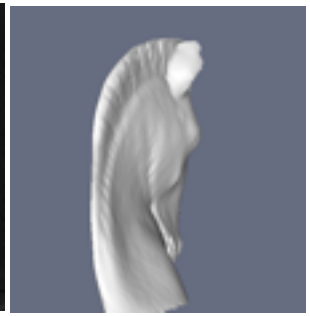
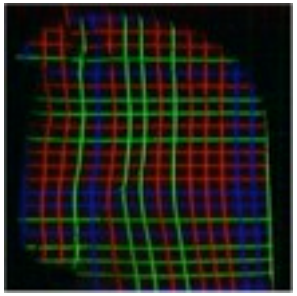


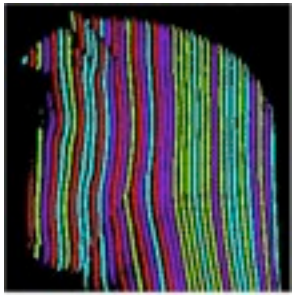
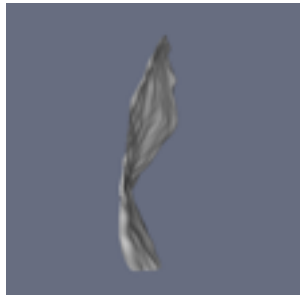
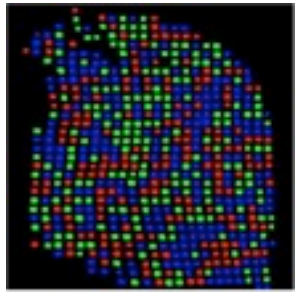
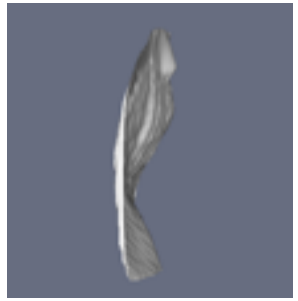
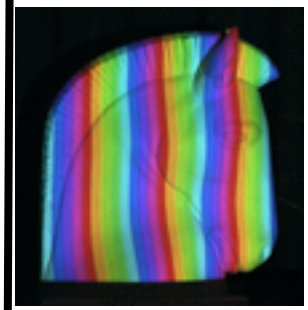
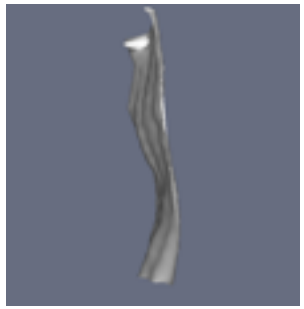
Spatial codification

Examples

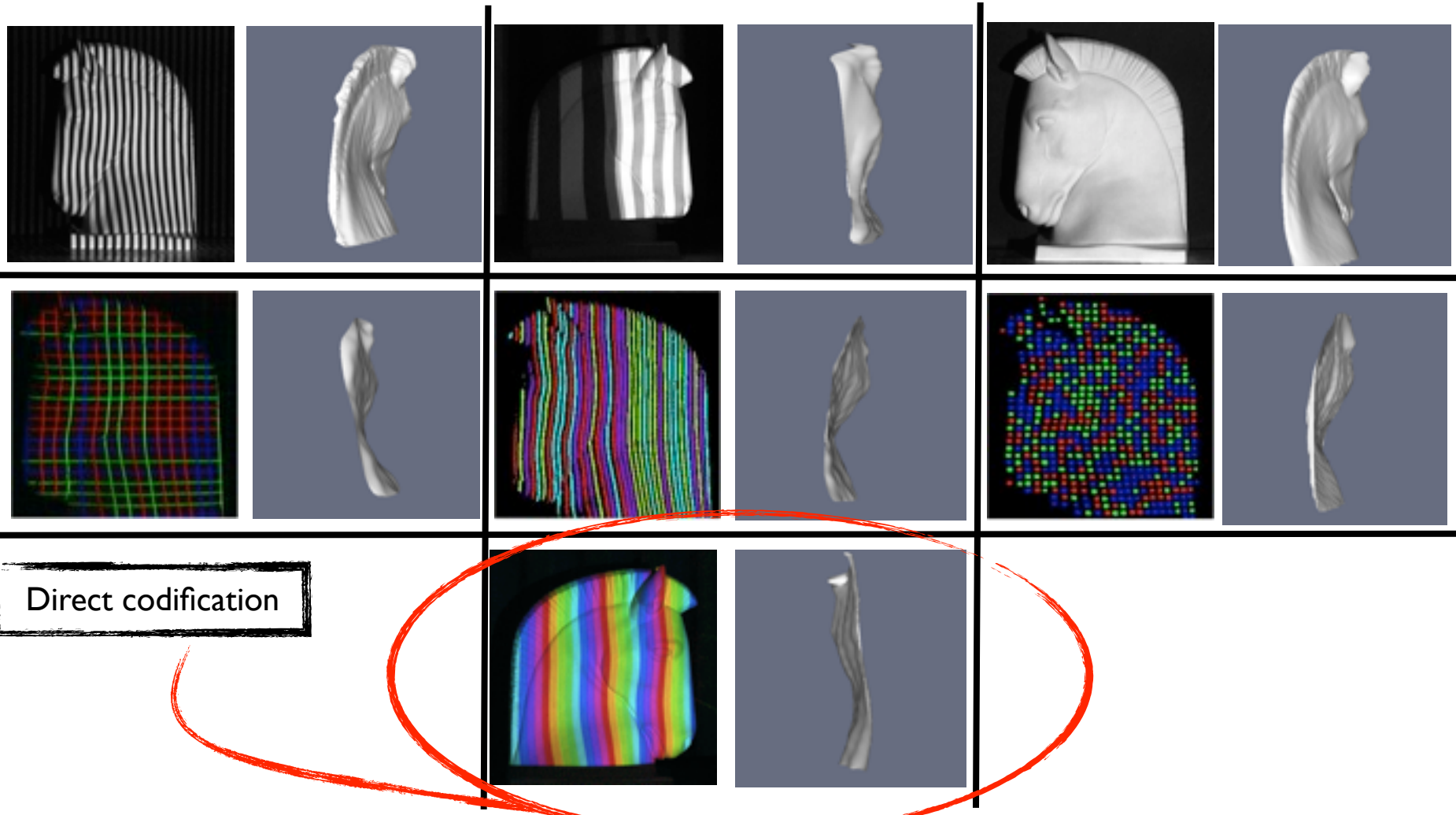




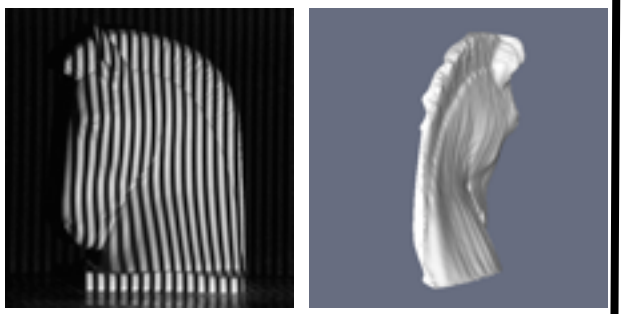




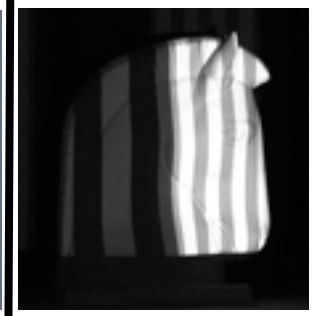







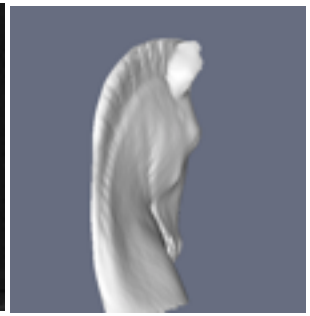
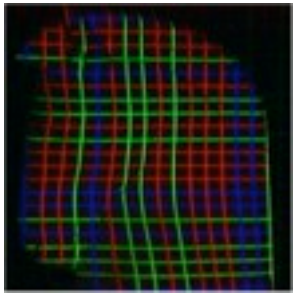
Examples

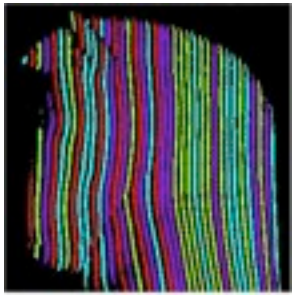
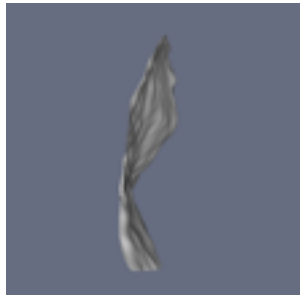
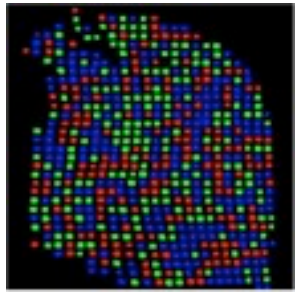
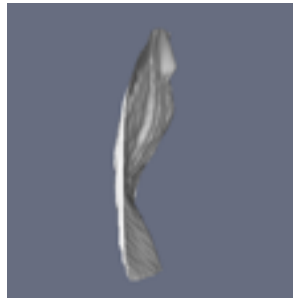
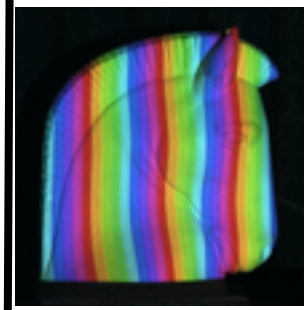
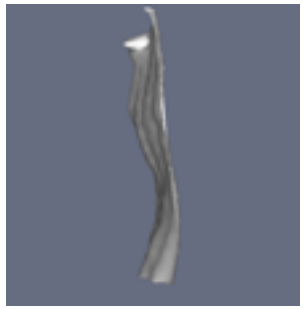


Examples



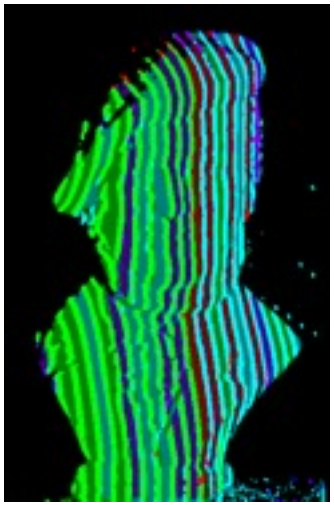


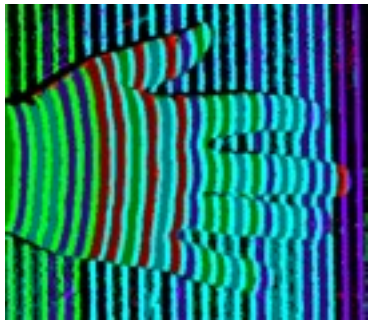




Examples



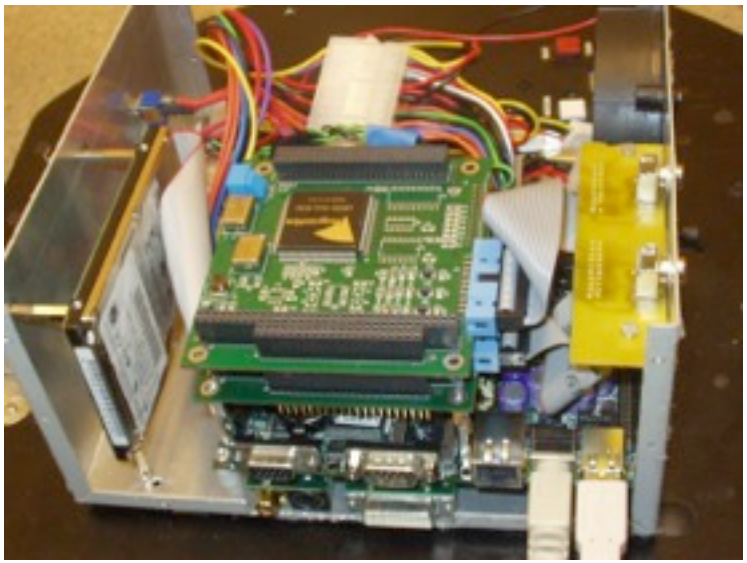


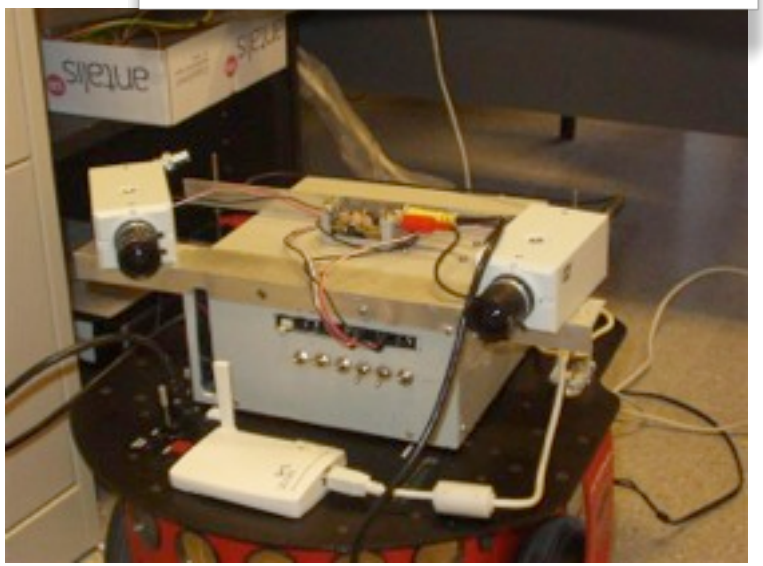

Stereo and robotics

Pioneer 2

Stereo and robotics



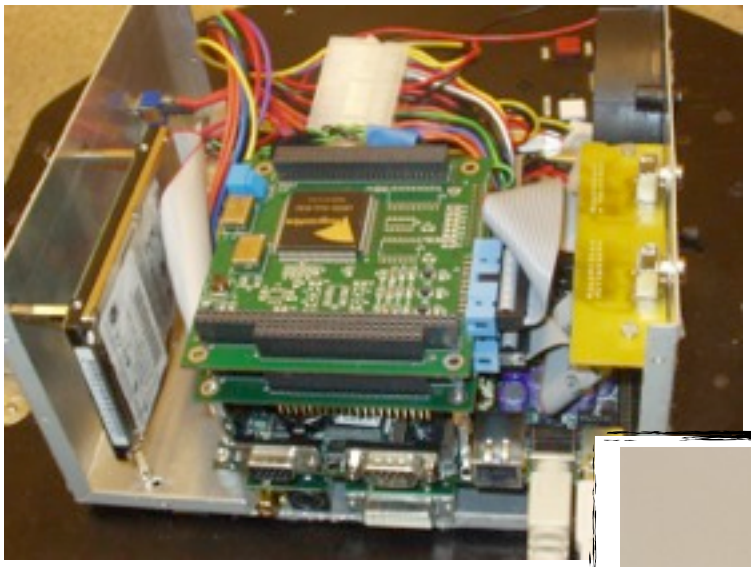
vue interne

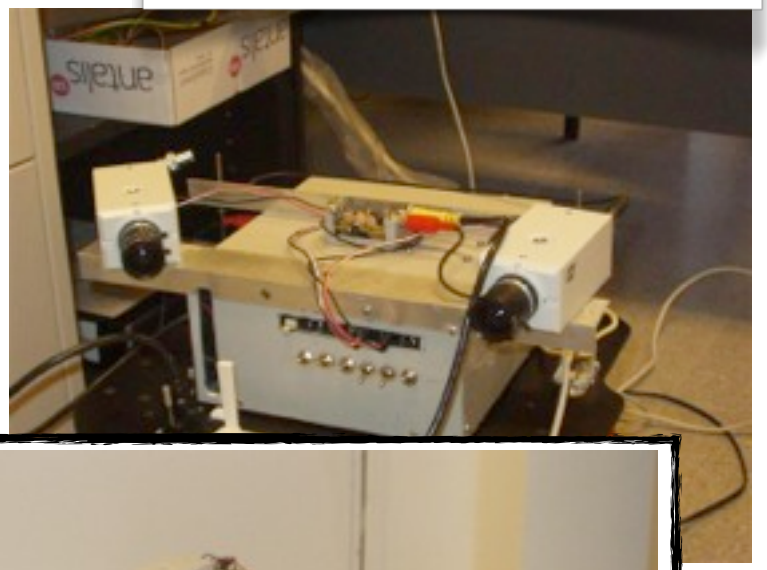


vue externe

Pioneer 2

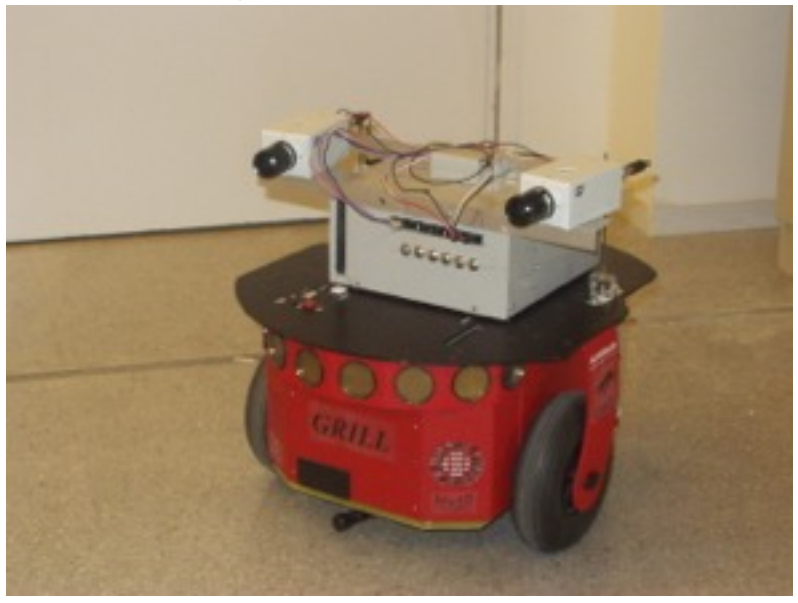
Stereo and robotics





vue interne

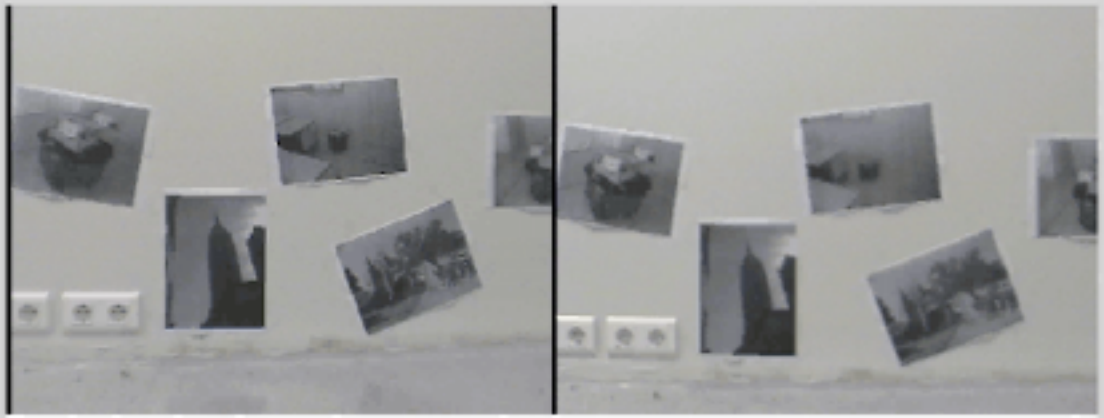
Pioneer 2



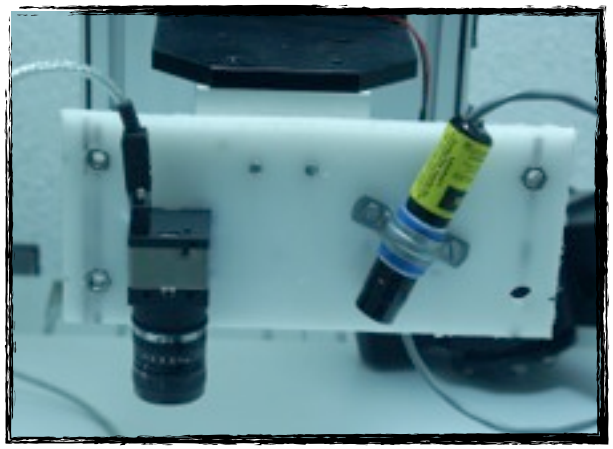
GRILL, le robot mobile

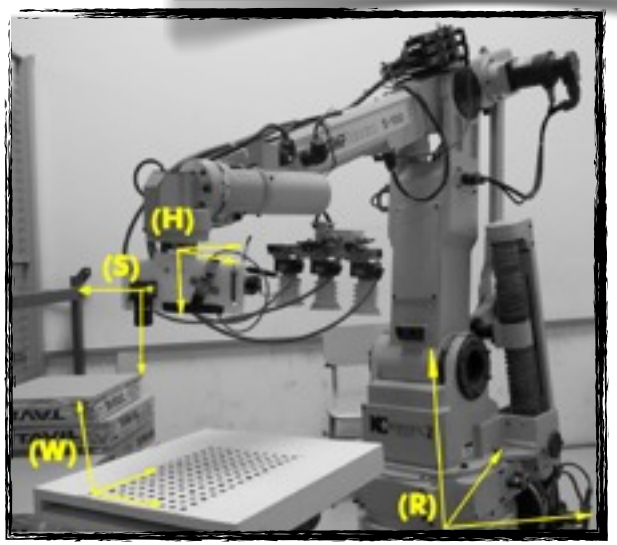
Stereo and robotics

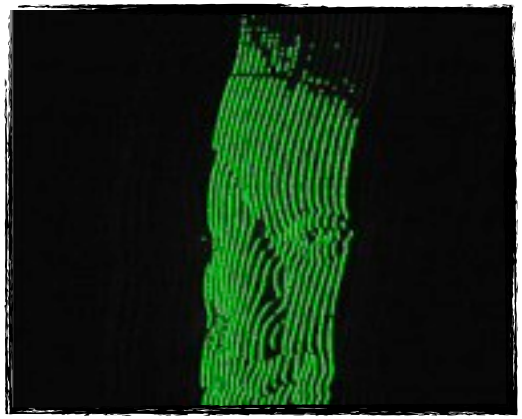
Input Stereo Image



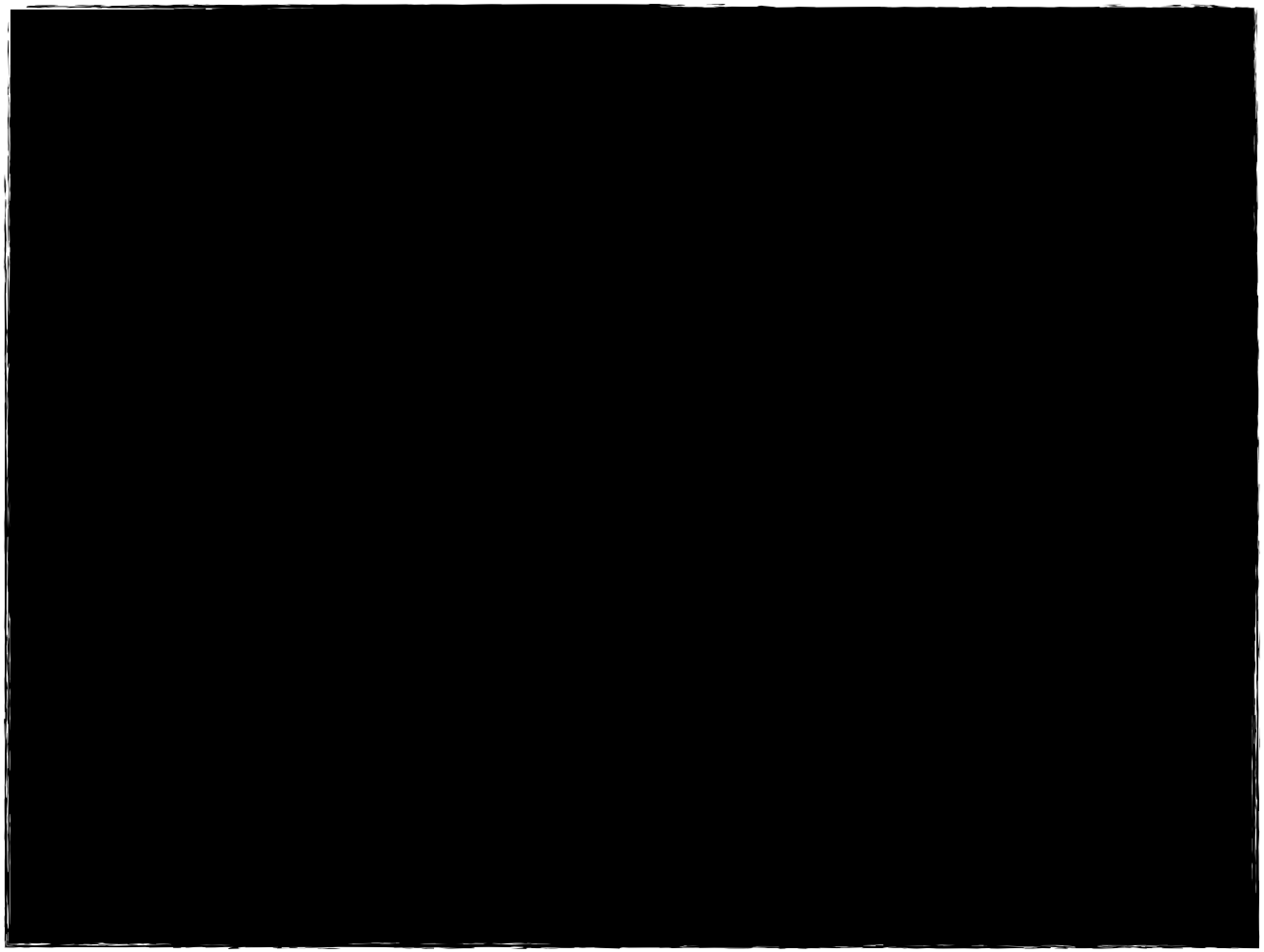
Structured light







Structured light



Conclusions

Stereovision

- Sparse reconstruction (in general)
- Correspondence problem
- Applications to SfM/SLAM for mobile robotics

Laser-Camera

- High density, high resolution, high accuracy
- Mechanical scanning
- Intrusive sensor
- Applications to 3D modeling and measurements

Projector-Camera

- In between...
- Kinect...