



# Master in Computer Vision *Barcelona*

Module: 3D Vision

Project: 3D recovery of urban scenes

Session 2

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# Session 2

**Goal:** compute the homography that relates to images

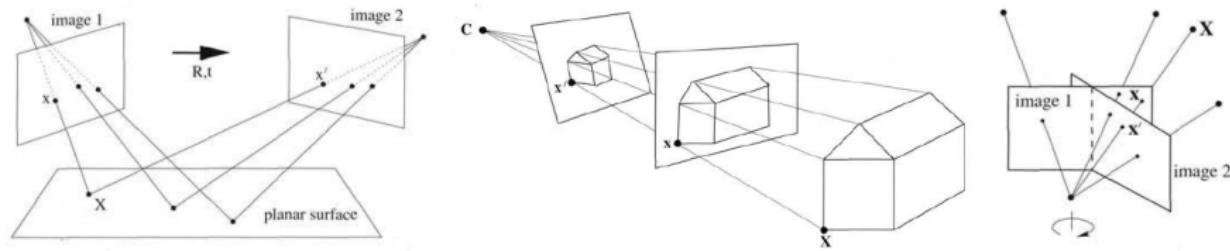
## Algorithms:

- Robust normalized DLT algorithm (algebraic method).
- Gold-Standard algorithm (geometric method).
- Camera calibration using a planar pattern.

## Applications:

- Image mosaics (panoramas).
- Camera calibration.
- Augmented reality.
- Logo detection in an image.
- Logo insertion in an image.

# Homographies



A homography relates two images:

- of the same plane in the 3D scene;
- taken with a camera rotating about its centre;
- taken with the same static camera varying its focal length;
- the whole scene is far away from the camera.

# Image mosaics



# Image mosaics

## Setting the canvas



# Gold-Standard algorithm

**Geometric algorithm:** It minimizes the reprojection error

$$\min_{\hat{H}, \hat{x}_i, \hat{x}'_i} \sum_i d([x_i], [\hat{x}_i])^2 + d([x'_i], [\hat{x}'_i])^2 \text{ s. t. } \hat{x}'_i = \hat{H}\hat{x}_i \forall i$$

where different matchings  $x_i \longleftrightarrow x'_i$  are the available data,  $[.]$  is the projection operator to Euclidean coordinates.

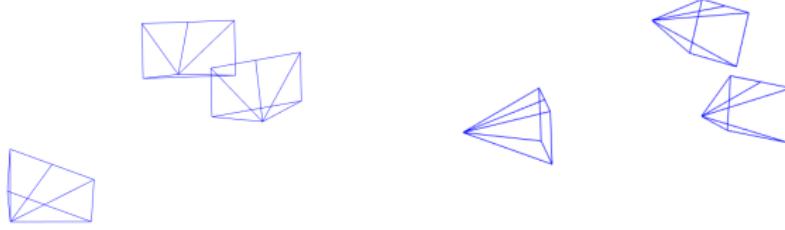
The above problem simplifies to the non-constrained minimization problem:

$$\min_{\hat{H}, \hat{x}_i} \sum_i d([x_i], [\hat{x}_i])^2 + d([x'_i], [\hat{H}\hat{x}_i])^2$$

# Camera calibration with a planar pattern



# Camera calibration with a planar pattern



# Augmented reality



# Logo insertion

Manually selecting the four corners in the target image



# Logo detection

Fully automatic



# Logo replacement

Fully automatic



# Session 2

## Mandatory tasks:

- Function that estimates the homography with the normalized DLT algorithm given  $n \geq 4$  image correspondences.
- Complete the RANSAC function.
- Compute an image mosaic with four different sets of data; compare and comment the results (why it works or it does not work in the different cases).
- Estimation of the homography with the Gold-Standard algorithm.
- Complete the code on camera calibration using a planar pattern and answer (in the report) the questions raised in the file lab2.ipynb.

## Optional tasks:

- Augmented reality (understand the code).
- Detect a logo in an image.
- Replace a logo in an image.

# Session 2

**Language:** PYTHON

## To Do:

- Complete the code in lab2.ipynb as indicated in the same file
- Write the function 'DLT\_homography' (DLT algorithm)
- Complete the function 'Inliers' in 'Ransac\_DLT\_homography'
- Prepare the input variables and function to call the 'least\_squares' function (Gold-Standard algorithm)
- Complete the code on camera calibration
- (Detect a logo in an image using the DLT algorithm)
- (Replace a logo in an image using the DLT algorithm)

# Evaluation

To deliver **before 8 am, December 31, 2025**, a zip file with:

- **Code deliverable:**

- Completed lab2.ipynb file with all cells already executed.
- Make sure to **include file utils.py**
- Additional images you have used

- **Short document (max. 8 pages):**

- Results
- Problems and comments
- Conclusions

# Evaluation

## Grading:

- Report: **2 points**
- DLT function: **2 points**
- RANSAC: **1 points**
- 4 mosaics: **1.5 point**
- Gold-Standard algorithm: **2.5 points**
- Calibration: **1 point**
- Optional augmented reality: **+ 0.25 points**
- Optional detect logo in an image: **+ 0.5 points**
- Optional replace logo in an image: **+ 0.25 points**

# HAPPY NEW YEAR

