



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Computer and Robot Vision (blended)

2324-2-F1801Q149

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#### Aims

The objective of the course is to give both theoretical foundations and practical abilities about the processing of data generated by cameras and range sensors, in order to understand the observed scene; in particular its geometry.

#### Contents

The course presents an introduction to the perception of the observed scene, focusing on its geometry (image formation, stereoscopy, analysis of image sequences, bayesian filtering, and perception for mobile autonomous robotics).

#### Detailed program

##### 1. Image formation

- image formation - geometry: geometric models of projection, model-based vision (hint), the need for optics, thin lenses, blur circles and depth of view, external and intrinsic projection parameters, FOV (Field Of View), calibration of the projection parameters
- image formation - technological issues: solid state sensors (CCD, CMOS), quantum efficiency, smearing / blooming, motion blur, vignetting, etc, 3D cameras, night visors, colour cameras (3-sensors, Bayer pattern, stacked sensors)

##### 2. Stereoscopy

- terminology, pixel-level and feature-based approaches
- example of pixel level stereo-matching algorithm: correlation-based stereo-matching, and usage of multi-resolution
- feature-based stereo-matching algorithms, hints about feature detection and description
- epipolar geometry

### 3. Analysis of image sequences

- the different problems, according to the scene and the observer motion
- image and scene motion field
- brightness constancy equation and the aperture problem
- differential methods and estimation of the optical flow with an LSE approach
- feature-based approaches
- data association and missing information problems: effects of outliers, breakdown level, Least Median of Squares, RANSAC

### 4. Bayesian filtering

- dynamical systems and Bayesian filtering
- Kalman filter (KF), extended Kalman filter (EKF), and usage of mixtures of gaussians
- unscented Kalman Filter (UKF)
- non-parametric filters: hints on histogram filter, particle filter (PF)

### 5. Perception for mobile autonomous robotics

- Review of kinematics of different mobile bases, Velocity Motion Model and Odometry Motion Model
- short review of sensors for range sensing and measurement model of laser scanners
- localization problem, EKF-based and PF-based approaches
- SLAM PF-based (FASTSLAM) and EKF-based
- Visual SLAM with inverse depth

## Prerequisites

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## Teaching form

Teaching is expected to take place in italian. Nevertheless, classes and practicals will be given in english should one of the following conditions become true:

- at least one foreign student prefers to use english;
- students ask to have classes and practicals given in english.

The teaching activities will include:

- classes: pre-recorded classes;
- periodic interactive meetings about the topics covered via the pre-recorded classes;
- laboratory events (practice, no programming);
- interactive meetings about laboratory programming activities (in matlab).

## **Textbook and teaching resource**

### Textbooks

- A. Fusiello, "Visione Computazionale: tecniche di ricostruzione tridimensionale", Franco Angeli, 2013
- E. Trucco, A. Verri, "Introductory techniques for 3D Computer Vision", Prentice Hall, 1998
- S. Thrun, W. Burgard, D. Fox, "Probabilistic Robotics", Mit press, 2005

### Other learning material

- Short videos (audio and tablet screen used as blackboard, taken from the videos of classes from previous years) for each subtopic
- Extra material, available on the elearning platform

## **Semester**

### First semester

## **Assessment method**

After the end of the course, an in person meeting with each student will take place, during which all assignments will be evaluated, and the final score will be determined.

The final mark will be the weighted average of:

- overall mark obtained in 2 written exams about theory (first: image formation and stereoscopy, second image sequences and perception for mobile robotics), weight = 0.4
- marks on 2 short matlab programs developed during the laboratory activity about Bayesian filtering, weight 0.6.

## **Office hours**

Send email to arrange an appointment

## **Sustainable Development Goals**

SUSTAINABLE CITIES AND COMMUNITIES

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