UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Computer and Robot Vision

2627-2-F1802Q116

Aims

The course aims to provide theoretical and practical skills related to the processing of data generated by cameras and range sensors, to analyze the observed scene by extracting information about its geometry.

Knowledge and Understanding
Understand the theoretical foundations of visual perception, image geometry, stereoscopy, and Bayesian filtering.

Applying Knowledge and Understanding
Process and practically handle data from visual and range sensors for vision and robotics applications.

Judgment and decision-making
Critically evaluate sensor data quality and choose the most appropriate algorithms for scene reconstruction.

Communication Skills
Present and document visual analysis results and models with technical rigor and appropriate terminology.

Learning Skills
Develop the methodological autonomy required to keep pace with technological advancements in computer and robot vision.

Contents

The course presents an introduction to the perception of the observed scene and recostruction of 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 and considerations.

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
- the point clouds registration and its usage in a variety of robot vision problems
- localization problem, EFK-based and PF-based approaches
- SLAM PF-based (FASTSLAM) and EKF-based
- Visual SLAM with inverse depth

Prerequisites

- Basic knowledge of geometry, linear algebra, and programming.

Teaching form

The scheduled activities are: 40 hours of lessons in dispensing mode and/or in interactive mode, 12 hours of laboratory in interactive mode.

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;
- activities with preparation of talks by students on some parts of the course that will be discussed in the classroom and commented by the professors.

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
- Videos, reports and other documents publicly available and produced by experts of the field.

Semester

II° Year, I° Semester

Assessment method

The exam will consist of:

- A written test divided into two parts (the first part around mid-November, the second at the end of the course). In each exam session, it will be possible to take the full written test.
- Two homework assignments given during the course.
- An oral exam, which primarily consists of a discussion of the homework and the written test (and, optionally, further questions on topics covered in the course, if requested by the student).
- Up to 3 bonus points may be awarded through the voluntary submission of a project that covers one of the lab activities carried out during class.

Office hours

Send email to arrange an appointment

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES