Image Processing and Computer Vision

Co-funded by the European Union

VISION FOR MULTIPLE OR MOVING CAMERAS

1. SYLLABUS INFORMATION

1.1. Course title
Vision for Multiple or Moving Cameras

1.2. University
Universidad Autónoma de Madrid

1.3. Semester
2nd semester

2. COURSE DETAILS

2.1. Course nature
Compulsory

2.2. ECTS Credit allotment
6

2.3. Recommendations
This course requires previous knowledge in several aspects: advanced linear/matrix algebra, image processing at an introductory level, and programming and image handling with MatLab.

2.4. Faculty data
Escuela Politécnica Superior

3. COMPETENCES AND LEARNING OUTCOMES

3.1. Course objectives
The aim of this course is to help the student understand the fundamentals behind collaborative multi-camera video analysis, which is nowadays the main practical way to confront many challenging computer vision scenarios.

3.2. Course contents
UNIT I: The Projected Reality

Introduction to projection
- Projection models
- Projection relationships
- Projective Geometry: motivation

Fundamentals of Projective Geometry
- Synthetic vs Algebraic Geometry
- Elements and definitions
- Basic transforms

Calibration of a single camera
- The projection matrix
- Computation of the internal parameters
- Calibration based on 3D points measurement
- Calibration based on single view homographies
- Correction of the lens distortion

Two-view geometry
- The parallax effect
- Epipolar geometry
- Rectification and disparity maps
- Binocular reconstruction

UNIT II: Detection, description and matching of reference points
Pyramids and scale-space theory
Scale
- Early approaches on scale representation.
- Scale-space theory
- Non-linear scale-space
- Multi-resolution vs Multi-scale

Point-of-interest Detectors
- Scale-space detectors
- Handcrafted detectors
- Learned detectors

Point-of-interest Descriptors and Matching
- Generic description and matching process
- Handcrafted descriptors
- Descriptors matching
- Learned descriptors

UNIT III: Calibration of camera networks
Introduction. Two-view geometry ++
- Two-view geometry wrap-up
- Computation of the Fundamental Matrix
- Scene reconstruction
- Autocalibration: properties of autocalibration objects

Three-view geometry
- The trifocal tensor
- Line-point incidence relationships in three views
- Tensor notation and operations
- Three-view projective calibration
- Point/Line transfer using the trifocal tensor
- Estimation methods for the trifocal tensor

Autocalibration
- Algebraic approach

- Geometric interpretation of Autocalibration. the Absolute Conic
- The Absolute Dual Quadric (ADQ)
- The ADQ method
- The Absolute Line Quadric (ALQ)
- The ALQ method
- Other autocalibration methods

N-view geometry
- Multi-view geometry
- N - view reconstruction: Practical reconstruction pipeline
- Resectioning
- Bundle Adjustment

3.3. Course bibliography

R. Hartley and A. Zisserman, Multiple View Geometry in Computer Vision, Cambridge University Press 2003

Olivier Faugeras and Q.T. Luong, "The Geometry of Multiple Images", MIT Press 2001

Lindeberg, Tony. Scale-space theory in computer vision. Vol. 256. Springer Science & Business Media, 2013.

4. TEACHING-AND-LEARNING METHODOLOGIES AND STUDENT WORKLOAD

4.1. Contact hours
By mutual agreement between teacher and student.

4.2. List of training activities
The course involves lectures, lab assignments (including implementation and documentation), and evaluation activities, according to the following distribution:

Activity		Hours	%	Hours	%
Presential	Lecture sessions	24	16	60	40
	Practical programming sessions	24	16		
	Tests and exams	12	8		
Non-presential	Weekly study of lectures	24	16	90	60
	Practical work (programming and reporting)	56	37,3		
	Preparation of tests and exams	10	6,7		
TOTAL WORKLOAD: 25 hours x 6 ECTS		**150**	100	100	

5. EVALUATION PROCEDURES AND WEIGHT OF COMPONENTS IN THE FINAL GRADE

5.1. Regular assessment
The grading range is from 0.0 to 10.0. The maximum grade is 10.0 and each of the parts (labs and exam) will be also graded with the same grading range. In order to pass the course, it is necessary to have a pass grade (equal or greater than 5.0) in the overall evaluation, as well as a pass grade (equal or greater

than 4.0) in the two individual parts (Theory, TH and Practice, PR). The individual grades for the TH and PR parts, if passed, are kept for the resitting exam.
For the regular assessment, theory and practice will consider according to the following rule:

Final Mark = 50%TH + 50%PR

H is the grade obtained from the evaluation of the lectures. As lectures are grouped into three academic units, the TH mark is obtained as follows:

TH = 33%TH1 + 33%TH2 +33%TH3

where TH1, TH2, and TH3 are the marks of the three test-like evaluation exams corresponding to each academic unit. This rule will only be applied if THi >= 4.0; otherwise, the applied rule will be:
TH = min (TH1, TH2, TH3)

In case TH<5.0, if THi>=5, the corresponding academic unit is considered passed and there is no need to repeat the exam in future evaluation exams.

PR is the grade obtained from the evaluation assignment.

5.2. List of evaluation activities

Evaluatory activity	%
Lectures evaluation TH1	16,6%
Lectures evaluation TH2	16,6%
Lectures evaluation TH3	16,6%
Lab evaluation assignment	50%