COSI / Colour in Science & Industry /
Erasmus Mundus
Joint Master Degree

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COURSE MODULE ï FUNDAMENTALS OF SPECTRAL SCIENCE

COURSE CODE	COSI FSC
COURSE LEVEL	Master
ECTS CREDITS	5
COURSE INSTRUCTOR/S	Prof. Javier Hernández-Andrés and Prof. Eva M. Valero (UGR)
EDUCATION PERIOD	SEMESTER 2
EXPECTED PRIOR-KNOWLEDGE	Color Science, Photonics and Optics Fundalmentals, Image Processing and Analysis, Basics and Fundamentals with Matlab, Basics and Fundamentals on Statistics and Probability, Basic and Fundamentals on Mathematics for Data analysis, Signal and Image Processing. Basic skills in Matlab.
LANGUAGE OF INSTRUCTION	English

AIM

This course provides the basics and fundamental principles of spectral science, focusing on applied and technological applications in this quite new, hot and broad topic. The core of this course is the multispectral approach of color imaging, i.e., imaging systems that use more than three acquisition channels. The contents include image capture procedures, spectral characterization of image capture devices, estimation of spectral functions from conventional image capture systems, evaluation of the accuracy or performance of multispectral images, and a basic description of some of the most relevant applications of multispectral images. To develop their practical and analytical skills, students have to work on case studies, using MATLAB and specific software, as well as different spectral and multispectral systems and equipments.

TEACHING ACTIVITIES

This course is based on flip-teaching, exchanges and discussions between students and instructors, lectures and practical session activities, as well as homework.

COURSE OUTLINE

(topic 1) Why spectral imaging? Preliminary questions, motivation and justification.

(topic 2) Spectral imaging: what is a spectral image? Difference between spectral, multispectral, hyperspectral. How to get a spectral image? CCD, CMOS, LCTF, filters, multiplexed illumination, etc

(*topic 3*) Calibration of spectral imaging devices: spectral characterization of image acquisition systems, experimental determination of spectral response curves.

(*topic 4*) Spectral estimation algorithms: linear and non-linear models, PCA, ICA, NNMF, Neural Networks, POCS, Kernel, noise influence, training sets, ...

(*topic 5* Spectral analysis: detection, classification, recognition, discrimination, segmentation, retrieval, texture,...

(*topic 6*) Spectral visualization. Band selection

(*topic 7*) Spectral metrics. Spectral accuracy performance: theoretical and experimental evaluation

(*topic 8*) Applications and future: high-speed spectral imaging, spectral video imaging, spectral compression, UV and IR, fluorescence,...

PRACTICAL ACTIVITIES

Practical works (laboratory sessions and case studies) in order to implement concepts introduced in the lectures, to practice on real applications and to train students.
(Lab session 1) Spectral estimation with a linear non-regularized regression model. Application to a Multispectral Line Scan Camera with 12 channels.
(Lab session 2) Spectral recovery with orthogonal and non-orthogonal basis: PCA, ICA and NNMF methods.
(Lab session 3) Hyperspectral imaging with an LCTF: application to spectral reflectance measurement of effect coatings used in the car industry.
(Lab session 4). Hyperspectral imaging of outdoor scenes with a Bragg-grating based spectral camera.

LEARNING OUTCOMES[1]

Å *Knowledge* and *Comprehension* of the fundamentals, principles, applications, limits, relationships, of all concepts and topics covered by this course;
Å *Application, Analysis, Synthesis* and *Evaluation* skills of the main concepts and topics covered by this course;
ÅAbility to apply/implement concepts and principles introduced in the lectures on practical tasks and on industrial study cases;
ÅAbility to self-learn, to understand some problems and to suggest/find solutions to solve these problems.
On completion of this course the students will be able to:
ÅDemonstrate an understanding of basic multispectral color science.
ÅAnalyze, compare, implement algorithms for spectral estimation from camera responses.
ÅDescribe, analyze and reason about how multispectral acquisition devices work and how can they be optimized for a particular application.
ÅTo know the state of the art of spectral color science and some of its most relevant fields of application.

FORM/S OF ASSESSMENT

Written exam (25%), Practical works (50%), Acquired skills (25%)

ASSESSMENT CRITERION

Written exam and Practical works

Excellent - outstanding performance	A
Very Good - above the average standard but with some errors	B
Good - generally sound work with a number of notable errors	C
Satisfactory - fair but with significant shortcomings	D
Sufficient - performance meets the minimum criteria	E
Fail - some more work required before the credit can be awarded	FX
Fail - considerable further work is required	F

Detail of criteria used to assess acquired skills :
ÅActivities and questionnaires giving evidence of knowing (5%)
ÅActivities and questionnaires giving evidence of comprehension/understanding (5%)
ÅActivities and questionnaires giving evidence of analysis (5%)
ÅActivities and questionnaires giving evidence of synthesis (5%)
ÅActivities and questionnaires giving evidence of evaluation (5%)

Excellent	A
Very Good - above the average standard	B
Good - generally sound well	C
Satisfactory - but with significant shortcomings	D
Sufficient - performance meets the minimum criteria	E
Fail - some more work required	FX
Fail - considerable further work is required	F

The evaluation of informal learning outcomes will be based on questionnaires and laboratory notebook (self-evaluation, learning diary).

LITERATURE AND STUDY MATERIALS

Å J. Y. Hardeberg, ñAcquisition and reproduction of color images: colorimetric and multispectral approaches,ò (Dissertation.com, 2001). (Revised second edition of Ph.D. dissertation, Ecole Nationale Supérieure des Télécommunications, 1999)
Å Papers from international scientific journals

CONTACT DETAILS

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[1] The meaning of *keywords* in italic used to define Learning Outcomes are detailed in Annex.