CIMET Course catalogue

Semester 1

Semester 2

CIMET Photonics and Optics Fundamentals

Course name: Photonics and Optics Fundamentals **Course code:** CIMET POF
Course level: Master **ECTS Credits:** 5.00

Course instructors: Javier Romero (University of Granada), Youcef Ouerdane & Nathalie Destouches Castagna & Ivar Farup (University of Saint-Etienne and University of Gvovik) and Kai Peiponen (University of Joensuu).

Education period (Dates): 1st semester 2008 **Language of instruction:** English

Expected prior-knowledge: undergraduate course of Physics (waves and electromagnetism), undergraduate course of mathematics (algebra and calculus).

Aim and learning outcomes:

This course develops an understanding of the fundamentals of Optics and Photonics focused on light models (geometrical, electromagnetic, quantum), propagation of light (rays), classical interaction of light with matter (reflection, refraction, absorption, scattering, chromatic dispersion), classical interaction of light with light (interferences, diffraction), paraxial theory of imaging systems and quality of imaging systems (aberrations, resolving power).

On completion of this course the students will be able to:

- know basic optical phenomena involved in the generation of color of objects from a physical point of view.
- understand the fundamentals and the basic tools which explain these phenomena.
- use the basic techniques involved in the geometrical theory of imaging systems.
- have a clear idea of the influence of aberrations and diffraction in the quality of images.

Topics to be taught (may be modified):

- Introduction: Overview of light models: geometrical, electromagnetic and quantum. Basic concepts: refraction index, ray and optical length. Light propagation: rays in homogenous and heterogeneous media. Reflection and refraction laws.
- Fundamentals of Electromagnetic Optics: Electromagnetic waves characteristics. Electromagnetic spectrum. Plane and spherical waves. Intensity. Coherence.
- Polarization: Unpolarized, partially polarized and polarized lights. Types of polarized light: linear, circular and elliptical. Reflection and refraction: Fresnel formulas. Polarization and reflection: Brewster angle. Birefringence. Polarizers. Half- and quarter-wave plates. Liquid crystals.
- Classical interaction of light with matter: Absorption. Chromatic dispersion. Scattering. Polarization in the Atmosphere.
- Interferences and diffraction: Double-slit Young's experiment. Multiple-wave interferences. Disfraction phenomena. Huygens-Fresnel Principle. Fresnel and Fraunhofer diffraction. Fraunhofer diffraction through different apertures: rectangular and circular apertures. Diffraction gratings.
- Imaging systems: Paraxial Optics. Principal planes and points. Focal planes and points. Spherical refractive surface. Mirrors. Prisms. Thin lenses. Thick lenses. Basic optical instruments: the human eye and the photographic camera.
- Quality of imaging systems: Third-order aberrations. Chromatic aberrations. Difraction-limited systems: resolving power.
- Quantum Optics: Photons. Matter quantization. Basic processes between energy levels: absorption, spontaneous emission and stimulated emission.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support:

Literature and study materials:

Reference book:
"Fundamentals of Photonics" B.E.A. Saleh and M.C. Teich. Wiley, 1991.

Additional books:
"Optics" E. Hetch. Addisson Wesley 2000.
"Introduction to Color Imaging Science" H-S Lee. Cambridge 2005.

Additional information:

Javier Romero
University of Granada
E-mail: jromero@ugr.es
Office hours**:** Monday to Thursday 9 to 17hrs, or by appointment.

Youcef Ouerdane & Nathalie Destouches-Castagna
University of Saint-Etienne
E-mail: ouerdane@univ-st-etienne.fr; nathalie.destouches@univ-st-etienne.fr
Office hours: By appointment

Ivar Farup
University of Gvovik
E-mail: ivar.farup@hig.no
Office hours: By appointment

Kai Peiponen
University of Joensuu
E-mail: kai.peiponen@joensuu.fi
Office hours: By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Color Science

Course name: Color Science
Course code: CIMET CS
Course level: Master
ECTS Credits: 5.00

Course instructors: Javier Romero and Rafael Huertas (University of Granada), Damien Muselet and Katemake Pichayada (University of Saint-Étienne), Amirshahi Seyed Hossein (University of Gjovik), Timo Jaaskelainen (University of Joensuu)

Education period (Dates): 1st semester
Language of instruction: English

Expected prior-knowledge: -

Aim and learning outcomes: -

To supply fundamentals and basic knowledge of Colorimetry and practical information on color measurements.

Learning outcomes:

- Training on color attributes, color measurements and color specification systems.
- Knowing the relationships between colorimetric values and color attributes and color vision mechanisms.
- Practical calculation of colorimetric values: color coordinates, whitness index, color rendering index and degree of metamerism.

Topics to be taught (may be modified):

- Light, Vision, Photometry: Light, Mechanism of the Human Eye, Adaptation and Responsivity of the Human Eye, Spectral Responsivity and the Standard Photmetric Observer, Definition of Photometric Quantities, Photometric Units, Calculation and Measurement of Photometric Quantities, Relations between photometric quantities
- Color Vision and Color Specification Systems: Mechnism of Color Vision, Chemestry of Color Vision, Color Specification and Terminology, Munsell Color System, Color System Using Additive Color Mixing
- Measurement and Calculation of Colorimetric Values, Direct Measurement of Tristimulus Values, Spectral Colorimetry, Geometrical Conditions for Measurement, Calculation of Colorimetric Values, Colorimetric Values in CIELAB and CIELUV Uniform Color Spaces
- Evolution of CIE Standard Colorimetric System, Additive Mixing, Substractive Mixing, Maximum Value of Luminous Efficacy and Optimal Colors, Chromatic Adaptation Process, Von Kries, Predictive Equation for Chromatic Adaptation, CIE Predictive Equations for Chromatic Adaptation, Color Vision Models, Color Appearance Models, Analysis of Metamerism
- Application of CIE Standard Colorimetric System, Evaluation of the Color Rendering Properties of Light Sources, Evaluation of the Spectral Distribution of Daylight Simulators, Evaluation of Whiteness, Evaluation of Degree of Metamerism for Change of Illuminant, Evaluation of Degree of Metamerism for Change of Observer, Designing Spectral Distributions of Illuminants, Computer Color Matching

Practical Laboratory Sessions (Some of these practical laboratory sessions will be held at Granada or at Saint Etienne following devices available).

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

Reference book:
“Colorimetry. Fundamentals and Applications" by Ohta and Robertson

Additional books:
Wyszecki and Stiles book
"Principles of Color Technology" by Billmeyer, Saltzman and Berns

Additional information:

Javier Romero
(University of Granada)
E-mail: jromero@ugr.es
Office hours**:** Monday to Thursday 9 to 17hrs, or by appointment.

Rafael Huertas
E-mail: rhuertas@ugr.es
Office hours: Monday to Thursday 9 to 17hrs, or by appointment.

Damien Muselet
E-mail: Damien.Muselet@univ-st-etienne.fr
Office hours: Monday to Thursday 9 to 17hrs, or by appointment.

Katemake Pichayada
E-mail: pichayada.k@chula.ac.th
Office hours: Monday to Thursday 9 to 17hrs, or by appointment.

Seyed Hossein Amirshahi
E-mail: hamirsha@aut.ac.ir
Office hours: Monday to Thursday 9 to 17hrs, or by appointment.

Timo Jaaskelainen
E-mail: timo.jaaskelainen@joensuu.fi
Office hours: Monday to Thursday 9 to 17hrs, or by appointment.

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Image Processing and Analysis

Course name: Image Processing and Analysis
Course code: CIMET IPA
Course level: Master
ECTS Credits: 5.00

Course instructors: Hubert Konik (University of Saint- Etienne), José Antonio Diaz Navas (University of Granada), Faouzi Alaya Cheikh (University of Gjovik), Alexander Kolesnikov (University of Joensuu)

Education period (Dates): 1st semester
Language of instruction: English

Expected prior-knowledge: scientific graduate level. Matlab/C++ basic knowledge

Aim and learning outcomes:

This course is a graduate-level introductory course to the fundamentals of digital image processing and analysis. It emphasizes general principles of image processing, rather than specific applications. We expect to cover topics such as digital image definition, basic transformations, sampling and quantization, point operations, linear image filtering, transforms and histogram processing, spatial, frequency and nonlinear filtering, image segmentation, texture analysis, color representations and spaces, image restoration, simple feature extraction and recognition tasks.

Programming assignments will use MATLAB and the MATLAB Image Processing Toolbox, though the use of other computer languages and/or software packages will be accepted.
Additional seminars will be organized to introduce specific tools or applications to enlarge the covering of image processing and analysis (compression, reconstruction, wavelets and multiresolutions approaches, ...).

Topics to be taught (may be modified):

- Introduction and overview of image processing; Image formation & sensing; sampling & quantization; pixel connectivity; digital images format
- Arithmetic/logic operations; 1-1 image processing; gray level transformations
- Histogram processing; equalization, thresholding, gray level transformation
- Spatial filtering; smoothing; sharpening; Laplacian; gradient and other derivative filters
- Filtering in the frequency domain; lowpass filters; highpass and other filters; Fourier transform
- Image restoration; noise reduction using spatial filters; adaptive filtering; noise reduction using frequency domain techniques; image degradation; inverse filters
- Point, line and edge detectors; operators
- Image segmentation; region growing; region splitting and merging; region adjacency graph
- Color images; color spaces; color space transformations; pseudocolor transformations; Color image transformations and color image processing
- Image analysis; texture analysis; features extraction; shape descriptors
- Pattern recognition; template matching; correlation; graph matching; objects recognition

Practical Laboratory Sessions:
Matlab/C++ laboratory topics in order to implement and master basic issues explained in the lectures.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: final exam (50%), homework (25%), presentations/seminars (25%)

External/internal examiner: --

Examination support:

Literature and study materials:

<u>Reference book</u>:

Digital Image Processing, 3rd Edition (DIP/3e), by Rafael C. Gonzalez and Richard E. Woods, Prentice Hall (2008)

Additional textbook:
Color Image Processing: Methods and Applications (Image Processing), by Rastislav Lukac & Kostantinos N. Plataniotis, CRC (2006)

The Image Processing Handbook, Fifth Edition (Image Processing Handbook), by John C. Russ, CRC (2006)

Image Processing: Analysis and Machine Vision by Sonka, V and Hlavac and R.Boyle, 3rd edition, Thomson (2008)

Additional information:

Hubert Konik
University of Saint- Etienne
E-mail: hubert.konik@univ-st-etienne.fr
Office hours**:** By appointment

José Antonio Diaz Navas
University of Granada
E-mail: jadiaz@ugr.es
Office hours**:** By appointment

Faouzi Alaya Cheikh
University of Gjovik
E-mail: faouzi@hig.no
Office hours**:** By appointment

Alexander Kolesnikov
University of Joensuu
E-mail: koles@cs.joensuu.fi
Webpage: http://www.cs.joensuu.fi/pages/koles/image/
Office hours**:** By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Data Analysis and Statistics

Course name: Data Analysis and Statistics
Course code: CIMET DASta
Course level: Master
ECTS Credits: 5.00

Course instructors: Jussi Parkkinen (University of Joensuu and University of Saint- Etienne), Andres Gonzales and Pedro Garcia (University of Granada), Katrin Franke (Gjovik University College)

Education period (Dates): 1st semester
Language of instruction: English

Prerequisite(s): BSc level basics in statistics and mathematics, Image analysis and processing course (1st semester)

Expected prior-knowledge: Understanding of basic statistics like probability density function, variance, etc. Basic analysis and matrix algebra. Digital image Processing with Mathlab (a student should be able to do some basic manipulations of images)

Aim and learning outcomes:
This course develops understanding of use of statistical analysis for multidimensional data. It also give fundamentals to understand data analysis from raw measurement values to higher level decision making in color and image context. The course develops basic understanding for difference between analysis with or without *a priori* data as well as ways to evaluate results. The methods will be learned in practical sessions, where they will be programmed and tested with real data.

The course is practice oriented, where students learn basics of data analysis useful in color, color image and spectral image analysis and processing. In lectures basics of methods are lectures and in practical session, their usage is practices. The aim is not to get deep theoretical understanding and derivation of methods.

On completion of this course the students will be able to:

- Understand principles how multidimensional statistical methods differ from one dimensional methods.
- Program some basic clustering and classification methods and test their validity.
- Program some basic Neural networks methods and test their validity.
- Extract features from raw, measured values of data to be analysed.
- Understand the distribution of information in statistical analysis and meaning in data representation.
- To apply basic statistical and data analysis methods to color and image data.

Topics to be taught (may be modified):

- Basics of multidimensional statistical analysis.
- Principal component analysis, non-negative matrix factorization.
- Data classification: Bayesian classifier, k-NN classifier, basics of neural networks.
- Data clustering: k-means clustering, Self-Organizing map.
- Spectrum estimation and reconstruction: PCA, polynomial, classification/clustering based method.
- Classification and clustering validity testing: leave-one-out, ground truth.

Practical Laboratory Sessions:

- Write spectral color and image data reading and writing routines by Matlab
- Produce PCA component images and reconstruct spectral images from PCA eigenimages
- Realize some classification methods by Matlab
- Realize some clustering methods by Matlab
- Realize some Neural networks and fuzzy-means methods by Matlab
- make simple tests of spectral image segmentation, spectral image categorization etc. using learned methods

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support:

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

Reference textbooks:

Sergios Theodoridis, Konstantinos Koutroumbas. “Pattern Recognition”, third edition. Academic Press.

Anany Levitin, "Introduction to the Design & Analysis of Algorithms", Addison Wesley, 2003.

Additional Textbook

R.O.Duda, P.E. Hart, and D.G. Storck: Pattern Classification. 2nd ed., Wiley, 2001.

Additional information:

Jussi Parkkinen
University of Joensuu and University of Saint- Etienne
E-mail: parkkine@cs.joensuu.fi
Office hours**:** By appointment

Andres Gonzales and Pedro Garcia
University of Granada
E-mail: andresgc@ugr.es; pagarcia@ugr.es
Office hours**:** By appointment

Katrin Franke
Gjovik University College
E-mail: kyfranke@ieee.org
Office hours**:** By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Design and Analysis of Algorithms

Course name: Design and Analysis of Algorithms (Joensuu) **Course code:** CIMET DAA
Course level: Master **ECTS Credits:** 5.00

Course instructors: Alexander Kolesnikov (University of Joensuu), Colin de la Higuera and Franck Thollard (University of Granada), Ivar Farup (University of Gjovik), Jean-Christophe Janodet and Franck Thollard (University of Saint Etienne)

Education period (Dates): 1st semester **Language of instruction:** English

Prerequisite(s): Programming skills, data structures.

Expected prior-knowledge: Sufficient knowledge of Data structures and algorithms. Image analysis and processing course (1st semester).

Aim and learning outcomes:

Specification of the concept of algorithm and analysis of its computational complexity. Design principles of algorithms and their application to computing problems. Topics include theory of NP-completeness, analysis techniques, and the main design principles such as divide-and-conquer, dynamic programming, branch-and-bound. Heap data structure and advanced binary search trees are also studied. Approximation, randomized and optimization techniques are considered for finding suboptimal solutions to NP-complete problems. These include local search, genetic algorithms and swarm intelligence.

On completion of this course the students will be able to: - Design algorithms for difficult problems. - Analyze and understand their complexity. - Being able to implement the algorithms in practice

Topics to be taught (may be modified):

- Introduction to complexity theory. Why is complexity an important topic? What are the elements that influence the fact that a program solves in an acceptable mount of time a problem? How complexity is computed: recurrences, asymptotics, Concrete complexity
- Greediness. Characterisation. Examples: minimum spanning trees, other graph algorithms
- Divide and conquer. Characterisation. Examples to be added. Many algorithms correspond to trees.
- Dynamic Programming 1 (due to the importance of this family of algorithms in image processing and pattern recognition, 2 lectures). Examples: HMM algorithms (Forward, Backward, Viterbi), edit distance algorithms, optimal allocation of constrained resource, optimal partition of data sequence, shortest path in graphs (Trellis and directed acylic graphs)
- Dynamic Programming 2
- Organising the data 1: once the best possible algorithm is found (?), what else can we do? We can aim to find an alternative representation of the data, in which case (but usually at a price) we can find new, faster algorithms. Examples : Huffman encoding, red/black trees, heaps, hashing
- Organising the data 2:
- Proving that a problem is intractable: NP-hard problems. NP completeness, NP-hardness. Reduction techniques. Classes P and NP, polynomial certificate, reductions
- Visiting different NP-complete problems. Giving different examples of reductions and therefore of NP-complete problems: Graphs (colouring, dominating set, clique), strings (longest common subsequence), arrays…
- Randomisation as a means to get results faster with a possible error. Monte Carlo and Las Vegas algorithms. Examples.
- Combinatorial optimisation: accepting not to find the best solution but hoping for a good one. Gradient descent, Tabu search, genetic algorithms, Ant colonies, ….

Practical Laboratory Sessions: Note that the idea is not to teach programming language. Each student should be allowed to use the programming language he/she prefers (provided the language can handle usual data structures. Examples can be C++, C, Java, CAML,… Typically the sessions could involve visiting several pattern recognition problems over different paradigms and compare the methods.

Teaching methods: Lectures, lab classes, seminars and homework exercises.

Form(s) of Assessment: Written exam (75%), practical work (25%)

External/internal examiner: --

Examination support:

Literature and study materials:

Reference book:
Jon Kleinberg and Eva Tardos , "Algorithm Design", Pearson International Edition, 2006.

Additional textbooks and lecture materials:

T. Cormen, C. Leiserson, and R. Rivest and C.Stein: *Introduction to Algorithms*, MIT Press, 2nd edition 2001.

Levitin: *The design and analysis of algorithm*, Addison Wesley, 2007.

P. Fränti, *Introduction to Combinatoric Optimization Techniques*, Lecture Notes, 2004

Additional information:

Colin de la Higuera and Franck Thollard
University of Saint Etienne at university of Granada
E-mail: cdlh@univ-st-etienne.fr and thollard@univ-st-etienne.fr
Webpage: http://labh-curien.univ-st-etienne.fr/~cdlh
Office hours**: 8-18**

Alexander Kolesnikov
University of Joensuu
E-mail: koles@cs.joensuu.fi
Webpage: http ://www.cs.joensuu.fi/pages/koles/daa/
Office hours**:** By appointment

Jean-Christophe Janodet and Franck Thollard
University of Saint Etienne
E-mail: Jean.Christophe.Janodet@univ-st-etienne.fr; franck.thollard@univ-st-etienne.fr
Webpage:
Office hours**:** By appointment

Ivar Farup
Gjovik University College
E-mail: ivar.farup@hig.no
Webpage:
Office hours**:** By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Language course: French for beginners

Course name: French for beginners
Course code: CIMET OCF
Course level: Optional course
ECTS Credits: 5.00
Course instructors:

Education period (Dates): 1st semester (01/09/2008- 10/10/2008)
Exam period: --
Language of instruction: French

Prerequisite(s): -none
Expected prior-knowledge: - a few basic words and phrases

Aim and learning outcomes: - To reach level A1 of the Common European Framework of Reference for Language Learning; understand basic instructions and take part in simple or factual conversations and be able to complete basic forms and write notes including times dates and places: to develop learning methodology for language study and learning.

Course outline: The course is organised in two parts: a semi-intensive week of 5 x 3 hour sessions of immersion in the language followed by 5 weekly sessions of 3 hours. Total 30h.

Practical Laboratory Sessions: Permanent access to the resource centre of the Centre International de Langue et Civilisation (CILEC).

Teaching methods: Learning will be organised around a communicative and functional course book suitable for A1 level students.

Form(s) of Assessment: Continual assessment via personal assignments and classroom participation and a 1 hour final test.

External/internal examiner: -Course teacher**-**

Examination support: None

Literature and study materials:

-Basic textbook: ***ICi,*** *Abry, Fort, Parpette,Stauder,Clé International, 2007*

-Additional books: ***ICI*** cahier d'exercices, French dictionary

Additional information:

Home page: http://cilec.univ-st-etienne.fr

CIMET Radiometry, sources and detectors

Course name: Radiometry, sources and detectors
Course level: Master

Course CIMET RSD
ECTS Credits: 5.00

Course instructors: Joaquin Campos Acosta (University of Granada-CSIC), and Jean Louis Meyzonnette (University of Saint- Etienne)

Education period (Dates): 2nd semester

Language of instruction: English

Prerequisite(s): Module "Photonics and Optics Fundamentals" (1st semester)

Expected prior-knowledge: Basic geometrical optics.

Aim and learning outcomes:
This course develops an understanding of the measurement of electromagnetic radiation in spectral regions from ultraviolet to infrared. The course covers principles of radiometric, photometric and spectrophotometric instrumentation, including the study of light sources and physical detectors.

On completion of this course the student will be able to:

- Understand (i.e. to describe, analyse and reason about) how to use the methodology in quantifying electromagnetic radiation, from ultraviolet to infrared.
- Correctly use radiometric and photometric quantities and units.
- Understand (i.e. to describe, analyse and reason about) how to characterize light sources with different emission spectra.
- Understand (i.e. to describe, analyse and reason about) how to characterize photodetectors with different properties and responsivities.
- Demonstrate the use of mathematical tools to solve problems in radiometry and photometry.

Topics to be taught (may be modified):

- Fundamentals of radiometry: Radiometric quantities and important laws.
- Photometric quantities: Photometry versus radiometry, radiometric and photometric quantities.
- Sources: Thermal sources (blackbody and incandescent lamps), gas discharge, luminescent, laser, solid state (light emitting diodes).
- Secondary light sources. Transmission, reflection, absorption.
- Photodetectors: Important features and types (thermal, photoemissive, photoconductive and photovoltaic detectors).
- Electronics reviews: detector electronics, detector interfacing.
- Noise in detection. Performance limits.
- Matrix detectors.
- Design and calibration of a radiometric system. Measurement uncertainty.
- Radiometric, spectroradiometric and photometric instruments.
- Radiometric measurements of satellite observation and remote sensing.
- Radiometry of laser and coherent sources.

Practical Laboratory Sessions:

- Verification of photometry laws.
- Design and built a radiance meter.
- Photodetector calibration.
- Source calibration.

Teaching methods: Lectures, lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%).

External/internal examiner: --

Examination support: None

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

Reference book:
Wolf, W. L., “Introduction to Radiometry”, Ed. By SPIE-The International Society for Optical Engineering (Bellingham, 1998).

Additional books:
Grum F. and Becherer J., "Radiometry", vol. 1 of “Optical Radiation Measurements”, Ed. By Academic Press, 1979.
Boyd R. W., "Radiometry and the detection of optical radiation”, Ed. By John Wiley & Sons, 1983.
Parr A. C., Datla R. U. and Gardner J. L., editors, “Optical Radiometry”, Elsevier Academic Press, 2005.

Additional information:

Joaquin Campos
E-mail: joaquin.campos@ifa.cetef.csic.es.
Web page: www.ifa.csic.es.
Office hours: By appointment.

Jean Louis Meyzonnette
University of Saint- Etienne
E-mail: ?
Web page:
Office hours: By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Devices and Instrumentation

Course name: Device and Instrumentation
Course code: CIMET DI
Course level: Master
ECTS Credits: 5.00

Course instructors: Manuel Rubiño (University of Granada), Antonio Pozo (University of Granada) and Jean Louis Meyzonnette (University of Saint- Etienne)

Education period (Dates): 2nd semester
Language of instruction: English

Prerequisite(s): Module "Photonics and Optics Fundamentals" (1st semester)

Expected prior-knowledge: Fundamentals of Optics and colour vision

Aim and learning outcomes:
This course develops an understanding of emission and detection of the radiant energy. The course covers the study of photometric and colorimetric instrumentation, including the study of measurement methods and systems for the characterization of light sources, materials, displays and imaging systems.
On completion of this course the student will be able to understand (i.e. to describe, analyse and reason about)

- How the radiant energy is emitted and detected.
- How to design a measurement system using different light sources, optical components and physical detectors.
- How to characterize light sources, materials, displays and imaging systems.

Topics to be taught (may be modified):

- Fundamentals of Radiometry and Photometry. Radiometric and photometric quantities and laws.
- Fundamentals of Colorimetry. Colour terminology, standards and calculations.
- Light sources. Spectral properties and laboratory sources.
- Photodetectors. Applications in photometric and colorimetric instrumentation.
- Colour printing and scanners.
- Displays.
- Scientific electronic cameras.
- Digital still cameras and video cameras.

Lab classes:

- Spectroradiometric measurements of light sources.
- Spectrophotometric evaluation of materials.
- Colorimetric characterization of displays.
- MTF evaluation of array detectors.
- Optical-quality evaluation of multispectral imaging systems in terms of the MTF.
- Optical characterization of scanners in terms of the MTF.

Teaching methods: Lectures, lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%).

External/internal examiner: --

Examination support:

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

Reference book:

- Hunt, R.W.G., "The Reproduction of Colour ", 6th Ed. John Wiley & Sons, 2004.

Additional books:

- Bass, M., "Handbook of Optics, Vol. 1 Fundamentals, Techniques and Design", 2nd Ed. Optical Society of America, 1995.
- Berns, R.S., "Billmeyer and Saltman's Principles of Color Technology", 3rd Ed. John Wiley & Sons, 2000.
- Chirigov, V. G., "Liquid Crystal Devices. Physics and Applications", Artech House, 1999.
- Holst, G. C., "Electro-Optical Imaging System Performance", 4th Ed. JCD Publishing and SPIE Optical Engineering Press, 2006.
- Holst, G. C., Lomheim, T. S., "CMOS/CCD Sensors and Camera Systems", JCD Publishing and SPIE Press, 2007.
- Keller, P.A., "Electronic Display Measurement: Concepts, Techniques and Instrumentation", John Wiley & Sons, 1997.
- McDonald, L. W., Luo M. R. (Eds.), "Colour Imaging. Vision and Technology", John Wiley & Sons, 1999.
- Sproson, W. N., "Colour Science in Television and Display Systems", Ed. Adam Hilger, 1983.
- Wolfe, W.L., "Introduction to Radiometry", Ed. SPIE – The International Society for Optical Engineering, 1998.
- Wyszecki, G., Stiles, W.S., "Color Science: Concepts and Methods, Quantitative Data and Formulae", 2nd Ed. John Wiley & Sons, 2000.
- Yadid-Pecht, O., Etienne-Cummings, R. (Eds.), "CMOS Imagers: From Phototransduction to Image Processing", Kluwer Academic Publishers, 2004.

Additional information:

Manuel Rubiño
E-mail: mrlopez@ugr.es
Web page: www.ugr.es/~mrlopez
Office hours: By appointment

Antonio Pozo
E-mail: ampmolin@ugr.es
Web page:
Office hours: By appointment

Alain Trouillet
E-mail: alain.trouillet@univ-st-etienne.fr
Web page:
Office hours: By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Optical Imaging and Processing

Course name: Optical Imaging and Processing
Course code: CIMET OIP
Course level: Master
ECTS Credits: 5.00

Course instructors: Juan Luis Nieves (University of Granada), Corinne Fournier and Joelle Surrel (University of Saint- Etienne)

Education period (Dates): 2nd semester
Language of instruction: English

Prerequisite(s): Module "Photonics and Optics Fundamentals" (1st semester)

Expected prior-knowledge: Image formation fundamentals and diffraction phenomenon, Fourier analysis and linear systems.

Aim and learning outcomes:
This course develops an understanding of the fundamentals of diffraction limited and aberrated limited imaging systems. The course covers advanced topics in diffraction, Fourier Optics and optical image processing. Different architectures for optical-based image manipulation will be given, including optical correlation, wavefront coding, recording and manipulation, spatial filtering techniques, optical pattern detection, recognition and extraction, and optical correlators used in inspection industry. This course provides also an opportunity to engage with practical and theoretical aspects of optical and digital holography.

On completion of this course the students will be able to:

- Understand how diffraction and aberrations influence optical image quality.
- Analyze how an optical image can be encoded, manipulated and processed using optical-based techniques, with emphasis on coherent image formation.
- Make appropriate use of Fourier techniques in optical image processing.

Topics to be taught (may be modified):

- Overview of optical imaging: domains of image science. Electromagnetic waves and rays.
- Basics of signal processing. Fourier analysis in two dimensions. Linear systems. Two-dimensional sampling theory: the Whittaker-Shannon theorem.
- Diffraction. The Rayleigh-Sommerfeld formulation of diffraction. Fresnel and Fraunhofer approximations. Fundamentals of wave scattering.
- Diffraction-limited imaging. Image formation with coherent and incoherent illumination. Analysis of optical resolution.
- Frequency analysis of optical imaging systems. Frequency response for diffraction-limited optical systems: coherent and incoherent imaging. Optical transfer function (OTF), modulation transfer function (MTF) and phase transfer function (PTF): characterisation and measures.
- Aberrated imaging systems. Generalized pupil function. Apodization. Image quality in aberrated systems.
- Fundamental of wavefront modulation. Spatial light modulators. Diffractive optical elements.
- Spatial filtering. The VanderLugt filter. The Joint Transform Correlator. Optical pattern recognition architectures: the Matched Filter. Image processing tools for pattern recognition.
- Optical image restoration. Optical Transfer Function for image motion and vibration. Effects of atmospheric blur and target acquisition.
- Optical holography. Recording of digital holograms. Numerical reconstruction of digital holograms. "Inverse problem": approach to process holograms. Applications.

Practical Laboratory Sessions:

- Simulating diffraction using MATLAB.
- Visualization of diffraction patterns using an optical processor.
- Optical Fourier filtering: practical implementation of a 4f-Fourier processor.
- Digital Fourier filtering: simulations with MATLAB.
- Measure of the modulation transfer function (MTF) of an imaging system.
- Making a transmission hologram.
- Making a reflection hologram.
- Recording of a digital hologram and numerical reconstruction.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support:

Literature and study materials: Handouts of the material covered in the lectures will be distributed.
Reference book:

Goodman, J.W., "Introduction to Fourier Optics", 2nd Ed. McGraw-Hill (New York, 1996).

Additional books:

VanderLugt, A., "Optical Signal Processing", Ed. John Wiley & Sons, 1992.
Hariharan, P. "Optical holography. Principles, Techniques and Applications", Cambridge Studies in Modern Optics, Cambridge University Press, New York, 1996.
T. M. Kreis, Handbook of Holographic Interferometry, Optical and Digital Methods. Berlin: Wiley-VCH, 2005.

Additional information:

Juan Luis Nieves
University of Granada
E-mail: jnieves@ugr.es
Web page:
Office hours: By appointment

Corinne Fournier
University of Saint- Etienne
E-mail: corinne.fournier@univ-st-etienne.fr
Web page:
Office hours: By appointment

Joelle Surrel
University of Saint- Etienne
E-mail: joelle.surrel@univ-st-etienne.fr
Web page:
Office hours: By appointment

Isabelle Verrier
University of Saint-Etienne
Email: verrier@univ-st-etienne.fr
Practical sessions only

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Advanced Colorimetry

Course name: Advanced Colorimetry
Course code: CIMET AC
Course level: Master
ECTS Credits: 5.00

Course instructors: Manuel Melgosa and Rafael Huertas (University of Granada), Alain Trémeau (University of Saint-Etienne)

Education period (Dates): 2nd semester
Language of instruction: English

Prerequisite(s): Module "Color Science" (1st semester), Module "Human Vision and Computer Vision" (2nd semester)

Expected prior-knowledge:

Aim and learning outcomes:

To supply an introduction color difference models and color appearance models, their evolution and present development. Also, basic knowledge on color reproduction methods and perceptual and physical evaluation of color images.

On completion of this course the students will be able to:

- Describe the color difference models.
- Describe the perceptual attributes of colour and the different systems for the representation of colour
- Demonstrate the use of colour measurement instruments and the interpretation of colour measurement data
- Demonstrate the computation of uniform colour space coordinates from reflectance measurements
- Describe the requirements for consistent colour reproduction across different media.
- Practical implementation of measurements of the appearance.
- Skills on methods of evaluation of the quality of color images.
- Basic methods of color reproduction on the industry.

Topics to be taught (may be modified):

- Weighted color difference equations. Color tolerance experiments. CIE94 and CIEDE2000 color-difference formulas.
- Effects of viewing conditions. Achromatic adaptation models. The structure of chromatic adaptation (CAT) models.
- The appearance attributes of colored materials viewed against a neutral grey background. The appearance attributes of colored areas within images. The influence of surrounding and background color on the appearance of a central color element.
- The structure of color appearance models: CIECAM97's, CIECAM02. CAM implementation. CAM testing.
- S-CIELAB color-difference formulae. Image appearance models: iCAM
- Visual appearance(color + gloss, translucency and texture)
- Visual color matching. Instrumental color matching. Image color matching. Introduction to psychophysical methods of assessing of the perceived quality of images.
- Management of the transfer of color information between image capture devices and image production devices. Device characterization, Gamut mapping algorithms, Device calibration. Concepts of device dependent and device independent methods of color specification.
- Image quality Measurements. Rendering HDR Images
- Whiteness Measurements. Industrial Colorimetry.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support:

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

<u>Reference book</u>:

M.D. Fairchild, Color Appearance Models, Second Edition, Wiley-IS&T Series in Imaging Science and Technology, Chichester, UK (2005).

R. S. Berns, Billmeyer and Saltzman, Principles of Color Technology, 3rd ed., John Wiley & Sons, New York, (2000).

W.D. Wright, 50 years of the 1931 CIE standard observer for colorimetry, AIC Color 81, Paper A3 (1981).

G. Wyszecki, Current developments in colorimetry, AIC Colour 73, 21-51 (1973).

<u>Additional books:</u>

Digital color management: Encoding Solutions, E. Giogianni & T. Madden, Addison Wesley, (1992).

Colour Engineering, Achieving device independent colour, P. Green & L. MacDonald, John Wiley and Sons Ltd, (2002).

The reproduction of colour, R.W.G. Hunt, Foutain Press, (1995).

Colour physics for industry, R. McDonald, Society of Dyers & Colourists, (1997).

Additional information:

Manuel Melgosa
University of Granada
E-mail: mmelgosa@ugr.es
Web page:
Office hours:

Rafael Huertas
University of Granada
E-mail: rhuertas@ugr.es
Web page:
Office hours:

Alain Trémeau
University of Saint- Etienne
E-mail: alain.tremeau@univ-st-etienne.fr
Web page:
Office hours: Monday to Thursday 9 to 17hrs, or by appointment.

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Human Vision and Computer Vision

Course name: Human Vision and Computer Vision
Course code: CIMET HVCV
Course level: Master
ECTS Credits: 5.00

Course instructors: Sérgio Nascimento & Juan Luis Nieves (University of Granada), Éric Dinet & Alain Trémeau (University of Saint-Étienne)
Education period (Dates): 2nd semester (Dates to be determined)
Exam period: --
Language of instruction: English

Prerequisite(s): Module "Color Science" (1st semester)
Expected prior-knowledge: Modules Photonics and Optics Fundamentals" (1st semester) and Radiometry, Sources and Detectors" (2nd semester)

Aim and learning outcomes:
The aim of the course is to provide a solid and integrated view of the visual processes with an emphasis on the physical aspects and on automatic processing of visual information. This more quantitative approach is complemented with notions of retinal and cortical organization and with the fundamentals on visual psychophysics. Although the course aims at a solid theoretical basis, practical issues and problem solving will be considered wherever appropriate and independent project development and research will be strongly encouraged.

On completion of this course the students will be able to:
- anatomically and functionally identify the main components of the human visual system.
- apply visual optical to describe the imaging process in the eye.
- identify the physical constraints imposed on the visual system and to relate them with the limitation on visual performance.
- identify and to describe the main psychophysical aspects of human vision and to describe the basic psychophysical techniques.
- describe and to apply basic image processing algorithms in the context of automatic vision problems

Topics to be taught (may be modified):

- Introduction to visual perception. Visual perception and the main components of the human visual system. The visual process: image formation, transduction, codification, retinal and cortical processing. Receptive fields, LGN and cortex processing. Basic numbers in human vision.
- Visual Optics. Optics of the eye, spherical and astigmatic ametropy, aberrations. Magnification. Accommodation. Contrast sensitivity.
- Photopic and scotopic vision. Photopic and scotopic vision: photopic, scotopic and mesopic vision. Spectral sensitivities and Purkinje Shift. Night myopia. Visual Fields, spatial and temporal summation. Perimetry.
- Colour perception. Fundamentals of colour perception: colour matching and the trichromacy, spectral sensitivities of photoreceptors. Hue cancellation and opponent colours. Colour constancy. Colour illusions. Acquired and inherited colour vision deficiencies.
- Spatial and temporal aspects of visual perception. Perception of objects and shapes. Perception of movement. Binocular vision and depth perception. Stereo acuity. Eye movements. Troxler phenomenon intensification.
- Image quality. Image quality and psychophysical methods of assessing of the perceived quality of images.
- Introduction to computer vision. Introduction to computer vision: what is computer vision? The Marr paradigm and scene reconstruction, Model-based vision. Other paradigms for image analysis: bottom-up, top-down, neural network, feedback. Pixels, lines, boundaries, regions, and object representations. "Low-level", "intermediate-level", and "high-level" vision.

- Applications of computer vision. Image Processing Shape from X Shape from shading. Photometric stereo. Occluding contour detection. Motion Analysis. Motion detection and optical flow structure from motion. Object recognition model-based methods. Appearance-based methods. Invariants.

Practical Laboratory Sessions (Some of these practical laboratory sessions will be held at Granada or at Saint Etienne following devices available):
- Colour measurement and illumination. Colour measurement and colour perception.
- Colour mixing and colour perception. Colour emotion.
- Optical illusions.
- Image processing, image quality evaluation and imaging system design (with ISET : Image Systems Evaluation Tools)
- Demos of stereo vision and measurement of stereo acuity (needs CRS card and goggles, for acuity a basic system with three vertical bars)
- Demos of apparent movement (needs CRS card)
- Cambridge Colour Test (needs CRS card)
- Measurement of CSF (needs CRS card and metropsis software)
- Calibration of monitors (and printers?)
- Anomaloscope

Specialized seminars (University of Granada)**:**
- Sérgio Nascimento: Chromatic diversity perceived by the normal and colour deficient observer.
- Larry Maloney: Computational algorithms for colour constancy.
- Gavin Brelstaff: Mysterious aspects of color perception - beyond the trichromatic.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

Basic textbook:
Foundations of vision, Brian A. Wandell, Sinauer Associates, 1995.

Eye, brain, and vision, David A. Hubel, W. H. Freeman & Co, 1988.

Color appearance models, Mark D. Fairchild, Addison-Wesley, 2005.

Principles of color technology, Roy S. Berns, Wiley-Interscience, 2000.

Sensation and Perception. E. Bruce Goldstein. 6th edition Wadsworth Publishing. ISBN: 0534639917, 2002

The image processing handbook, Fifth edition, John C. Russ, CRC Press, 2006.

Additional books:

Vision science: photons to phenomenology, Stephen E. Palmer, The MIT Press, 1999.

Visual space perception, Maurice Hershenson, The MIT Press, 1999.

The reproduction of colour, Robert W. G. Hunt, Voyageur Press, 2004.

Introduction to Visual Optics. Alan H. Tunnacliffe. Association of British Dispensing Opticians. ISBN 0-900099-28-1, 1993.

Computer Vision and Applications: A Guide for Students and Practitioners. Bernd Jahne. Academic Press, 2000.

Additional information:

Alain Trémeau & Eric Dinet
E-mail: alain.tremeau@univ-st-etienne.fr and eric.dinet@univ-st-etienne.fr
Office hours: Monday to Thursday 9:30 to 17:30, or by appointment.

Sérgio Nascimento & Juan Luis Nieves
E-mail: mailto:smcn@fisica.uminho.pt & jnieves@ugr.es
Web page: http://online.uminho.pt/pessoas/smcn/ & www.ugr.es/~jnieves
Office hours: Monday 16-18 hrs / Wednesday 12-14 hrs / Thursday 9:30-11:30 hrs, or by appointment.

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Color in Industry

Course name: Color in Industry
Course code: CIMET CIND
Course level: Master
ECTS Credits: 5.00

Course instructor: Manuel Melgosa (University of Granada).

Education period (Dates): 2nd semester **Language of instruction:** English

Prerequisite(s): Module "Color Science" (1st semester)

Expected prior-knowledge: It is advisable to follow also the course "Advanced Colorimetry" (2nd Semester)

Aim and learning outcomes:

This course tries to supply an introduction to classical problems and hot topics arising in industrial colorimetry. On completion of this course the students will be able to understand and approach to some color problems in different industries.

Topics to be taught (may be modified):

- Introduction to industrial colorimetry.
- Color atlases in industry.
- Industrial color tolerances.
- Color assessment cabinets.
- Colorant formulation.
- Whiteness and tint.
- Color fastness.
- Color and gloss, translucency, or texture.
- Metallic and pearlescent colors.
- Color in soil science.
- Color in food science.
- Color in liquid samples: olive oils, wines, etc.
- Color in graphic arts.
- Colorimetry in the paper and textile industries.

Teaching methods: Lectures, seminars by invited experts, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials:

Basic textbook: to be done

Additional books: to be done

G. Wyszecki and W.S. Stiles, Color Science, 2nd Edition. Wiley Classics Library, 2000.

R. S. Berns, Billmeyer and Saltzman Principles of Color Technology, 3rd ed., John Wiley & Sons, New York, (2000).

J. Shanda. Colorimetry (Understanding the CIE System). Wiley, 2007.

R.D. Lozano. El Color y su medición (in Spanish language). Ed. Americalee, 1978.

The reproduction of colour, R.W.G. Hunt, 6th Ed. John Wiley & Sons Inc., 2004.

Colour physics for industry, R. McDonald, Society of Dyers & Colourists, (1997).

ASTM Standards on Color and Appearance Measurements, 5th Ed. American Society for Testing and Materials, 1996.

Additional information:

Manuel Melgosa
University of Granada
E-mail: mmelgosa@ugr.es
Web page:
Office hours: By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Remote Sensing and Image Processing

Course name: Remote Sensing and Image Processing
Course code: CIMET RSIP
Course level: Master
ECTS Credits: 5.00
Course instructors: Lucas Alados-Arboledas (University of Granada) and Francisco José Olmo (University of Granada)
Education period (Dates): 2nd semester (Dates to be determined)
Exam period: --
Language of instruction: English

Prerequisite(s): Module "Fundamentals" (1st semester)

Expected prior-knowledge: Optics and photonics fundamentals.

Aim and learning outcomes:
This course develops the fundamentals of remote sensing techniques. The course covers the basic principles of remote sensing, a revision of the electromagnetic radiation and its interaction with matter, some basics ideas about the atmosphere both as a transfer medium and as an observational object, advanced topics in surface and atmosphere remote sensing. Different platforms and sensors used in remote sensing will be presented including imaging systems. Pre-processing aspects of remotely sensed data will be addressed paying special attention to atmospheric and radiometric corrections.

On completion of this course the students will be able to:
•Understand the bases of the remote sensing process.
•Approach to the remote sensing procedures applied to the surface and atmosphere.
•Distinguish the different kind of sensors and platforms used in remote sensing.
•Understand the need of atmospheric correction of surface remote sensing data.
•Apply atmospheric correction to real remote sensing data.
•Extract geophysical variables from remote sensing data.

Topics to be taught (may be modified):

- Remote sensing: basic principles
- Electromagnetic radiation and its interaction with matter.
- Basics principles of atmospheric remote sensing and radiative transfer: atmosphere, radiative transfer.
- Remote sensing platforms and sensors: airborne and surface systems, optical, infrared and microwave sensors, imaging and non-imaging systems.
- Pre-processing of remotely sensed-data: geometric correction, atmospheric correction, calibration.
- Extraction of geophysical variables from remote sensing data.

Practical Laboratory Sessions:

- Design of look up tables for atmospheric correction.
- Atmospheric correction of remote sensing images.
- Extraction of geophysical variables from remote sensing data.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

Basic textbook: to be done

Additional books: to be done

CAMPBELL, J.B., Introduction to remote sensing, The Guildford Press, New York, 1987.
CURRAN, P., Principles of remote sensing. Longman Scientific & Technical, New York, 1985.
ELACHI, C., Introduction to the physics and techniques of remote sensing. John Willey & Sons, New York, 1987.
LENOBLE, J., Atmospheric radiative transfer. A. Deepak Publishing, Virginia, 1993.
LIOU, K.N., An introduction to atmospheric radiation. Academic Press, New York, 2002.
MATHER, P.M., Computer processing of remotely-sensed images. An introduction. John Willey & Sons, Chichester, England, 1999.
SLATER, P.N., Remote sensing. Optics and optical systems. Addison-Wesley Publishing Company, Reading, Massachusetts, 1980.

Additional information:
Prof. Dr. Lucas Alados-Arboledas and Francisco José Olmo
E-mail: alados@ugr.es
Web page: atmosfera.ugr.es
Office hours: Monday 10-12 hrs / Wednesday 10-12 hrs / Friday 10:00-12:00 hrs, or by appointment.

Prof. Dr. Francisco José Olmo
E-mail: fjolmo@ugr.es
Web page: atmosfera.ugr.es
Office hours: Monday 9-12 hrs / Tuesday 9-12 hrs or by appointment.

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Fundamentals of Spectral Science

Course name: Fundamentals of Spectral Science
Course code: CIMET FSC
Course level: Master
ECTS Credits: 5.00

Course instructors: Javier Hernández-Andrés and Eva M. Valero (University of Granada)
Education period (Dates): 2nd semester (Dates to be determined)
Exam period: --
Language of instruction: English

Prerequisite(s): Module "Fundamentals" (1st semester)
Expected prior-knowledge: Matlab knowledge

Aim and learning outcomes:
The main aim of this course is to provide the basis of 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.

On completion of this course the students will be able to:
• Demonstrate an understanding of basic multispectral color science.
• Analyze, compare, develop and implement algorithms for spectral estimation from camera responses.
• Describe, analyze and reason about how multispectral acquisition devices work and how can they be optimized for a particular application.
• To know the state of the art of spectral color science and some of its most relevant fields of application.

Topics to be taught (may be modified):

- Overview of color imaging: light and surfaces, color vision, colorimetry, physics of image capture. Spectral measurements: theory and instruments.
- Spectral characterization of image acquisition systems: experimental determination of spectral response curves, influence of noise.
- Mathematical modelization of spectral functions: reflectances, illumination, color signals, etc. Linear and non-lineal models: principal and independent component analysis.
- Spectral estimation from camera responses: models, algorithms, a priori necessary information, selection of data sets, use of color filters, filter selection, quality evaluation of the spectral signals obtained, influence of noise.
- Spectral accuracy performance: theoretical and experimental evaluation.
- Experimental spectral image acquisition systems.
- Applications of spectral imaging.

Practical Laboratory Sessions:
Matlab laboratory topics in order to implement and master basic issues explained in the lectures.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials: Lessons outlines (presentations), description and guides for exercises' sessions. Handouts of the material covered in the lectures will be distributed.

Basic textbook:
Acquisition and Reproduction of color images: colorimetric and multispectral approaches. J.Y. Hardeberg, 2001 (Universal Publishers)?

Additional books:
Color image science: Exploiting Digital Media. MacDonald, Luo, 2002 (John Wiley and Sons)
http://books.google.es/books?id=lbexPr9lcjoC&dq=Multispectral+images+book&lr=&source=gbs_summary_s&cad=0

Spectral Imaging: Eighth International Symposium on Multispectral Color Science. Mitchell Rosen, Francisco H. Imai, Shoji Tominaga, 2006, SPIE. Este sería para algunas aplicaciones…

Remote sensing digital image analysis: an introduction. Richards, Xia,, 2006 (Springer).
http://books.google.es/books?id=4PB5vhPBdJ4C&dq=remote+sensing+digital+image+analysis+an+introduction&pg=PP1&ots=AdMv5QdNUS&sig=UsezCWV1efMkDU4MWuKUFrtIYUc&hl=es&prev=http://www.google.es/search?hl=es&q=Remote+Sensing+Digital+Image+Analysis:+An+Introduction&btnG=Buscar+con+Google&sa=X&oi=print&ct=title&cad=one-book-with-thumbnail

Additional information:
Javier Hernández-Andrés
E-mail: javierha@ugr.es
Web page: http://www.ugr.es/local/javierha
Office hours: By appointment

Eva M. Valero
E-mail: valerob@ugr.es
Web page: http://www.ugr.es/local/valerob
Office hours: By appointment

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Color in Art and Design

Course name: Color in Art and Design
Course code: CIMET CAD
Course level: Master
ECTS Credits: 5.00
Course instructors: Éric Dinet & Alain Trémeau (University of Saint-Étienne)

Education period (Dates): 2nd semester (Dates to be determined)
Exam period: --
Language of instruction: English

Prerequisite(s): --
Expected prior-knowledge: --

Aim and learning outcomes:
This course is designed to provide students with an introductory but in-depth orientation to interrelated fields of color in art and design of multi-cultural origins. Through exposure to the art and design elements of various cultures, students are encouraged to assess and interpret human values, attitudes, and social development and, in turn, to relate these to personal development.

This course provides coverage of most major fields of color in art and design with a focus on the interrelationships of each area. Western and Eastern perspectives are presented which promulgate the melding of cultures into a color language. Through the study of color, the students should gain a better understanding of the utilitarian and aesthetic effects of color on human social orders and communication.

Students are required to take a "hands-on" approach by extrapolating implications from color studies and media. Color forms the cornerstone of societies, affecting the way we eat, sleep, work and play. It is to the advantage of students from interdisciplinary areas to gain a thorough understanding of the complexities of color awareness and to relate that awareness to their environment.

Lectures and course outline:
1. Gray scale and values: from light to dark. Patterns and motifs. Illusionary volumes.
2. Color theory: the color wheel. Tint, shade and tone. Simultaneous contrast. Bezold effect. Gradation and texture. Transparency. Equiluminant colors.
3. Color meaning: patterns and motifs. Perspective and depth. Perceptual grouping.
4. Color history in art and science.
5. Color and culture: color symbolism. Color taboos. Color harmony. Visual arts.
6. Color for e-commerce: limitations of color capture and limitations of media. Color palette and color selection. Rendering. Color transfer.
7. Color in design: functional color. Color and emotions.

Practical Laboratory Sessions Practical laboratory sessions will be organized according to the available devices.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

-Basic textbooks:
- *Vision and Art – The biology of seeing*, Margaret Livingstone, Harry N. Abrams, 2002.

- *Colour – Art & Science*, Trevor Lamb and Janine Bourriau, Cambridge University Press, 1995.
- *Cognition and the Visual Arts*, Robert L. Solso, MIT Press, 1996.
- *The Art of Color*, Johannes Itten, Wiley, 1997.
- *Color and meaning: Art, Science and Symbolism*, John Gage, University of California Press, 2000.

-Additional books:

- *Color and Culture: Practice and Meaning from Antiquity to Abstraction*, John Gage, University of California Press, 1999.
- *Design basics*, David A. Lauer and Stephen Pentak, Wadsworth Publishing, 1999.
- *Colors: the story of dyes and pigments*, Guineau Delamare and Ber Francois, Harry N. Abrams, 2000.

Additional information:

Alain Trémeau & Éric Dinet
E-mail: alain.tremeau@univ-st-etienne.fr and eric.dinet@univ-st-etienne.fr
Office hours: Monday to Thursday 9:30 to 17:30, or by appointment.

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Lighting and Image Capture

Course name: Lighting and image capture
Course level: Master

Course code: CIMET LIC
ECTS Credits: 5.00

Course instructors: Éric Dinet (University of Saint-Étienne)

Education period (Dates): 2nd semester

Language of instruction: English

Prerequisite(s): Module "Photonics and optics fundamentals" (1st semester)
Expected prior-knowledge:

Aim and learning outcomes:
This course aims to provide a general education including light sources, lighting fundamentals, lighting techniques in machine vision and fundamentals of solid-state imaging, with a focus on the repercussion of digital image capture on image processing stages. Industrial applications illustrate the theoretical concepts and demonstrate the great importance of lighting and image capture in machine vision systems.

On completion of this course the students will be able to:

- understand the fundamentals of light.
- identify and to describe the different light sources available for machine vision.
- identify and to classify the different techniques of lighting suitable for machine vision.
- understand how image sensors work.
- identify general characteristics of machine vision cameras and color cameras.

Topics to be taught (may be modified):

- Light fundamentals: brief review of radiometry and photometry. Luminous efficiency. Colour temperature. Colour rendering index.
- Light sources: incandescent light bulbs. High-intensity discharge lamps. Xenon arc lamps. Flash lamps. Fluorescent lamps. Inductive lighting. LED and OLED. Laser.
- Lighting fundamentals: photometric curves. CIE illuminants and standard sources. Types of reflection and transmission. Filtering. Polarization. Lighting geometry.
- Lighting in machine vision: common lighting techniques. Structured lighting. Colour lighting. Lighting products dedicated to machine vision. Examples of applications.
- Fundamentals of solid-state imaging: photon sensing. Photoelectric effect. Photodiode and MOS capacitor.
- Charge-Coupled Device (CCD): linear and array architectures. Charge transfer. Progressive scan. Time-delay and integration. CCD performance.
- CMOS sensor: linear and array architectures. Design variants. CMOS performance.
- Machine vision cameras: general characteristics. Sampling, resolution and MTF. Transfer function. Sensitivity. Dynamic range and quantization. Electronic shutter. CCD cameras versus CMOS cameras.
- Colour cameras: linear and array architectures. Bayer mask. RGBE filter. Dichroic beam splitter prism. Foveon X3 sensor. Multispectral devices.

Practical Laboratory Sessions:

- Digital camera simulation.
- Lighting techniques and lighting problems in machine vision.
- Feasibility studies.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials: Handouts of the material covered in the lectures will be distributed.

Basic textbooks:

Light: science and magic: an Introduction to photographic lighting, Fil Hunter, Steven Biver and Paul Fuqua, Focal Press, 2007.

Handbook of machine vision, Alexander Hornberg, Wiley-VCH, 2006.

CCD arrays, cameras, and displays, Gerald C. Holst, SPIE Optical Engineering Press, 1996.

Additional books:

Light and light sources: High-Intensity Discharge lamps, Peter Flesh, Springer, 2006.

Solid-state imaging with Charge-Coupled Devices, Albert J.P. Theuwissen, Kluwer Academic Publishers, 1996.

Additional information:

Éric Dinet
E-mail: eric.dinet@univ-st-etienne.fr
Office hours: Monday to Thursday 9:30 to 17:30, or by appointment.

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Compression and transmission in media systems

Course name: Compression and transmission in media systems
Course code: CIMET CTMS
Course level: Master
ECTS Credits: 5.00
Course instructors: Damien Muselet (University of Saint-Étienne)
Education period (Dates): 2nd semester
Exam period: --
Language of instruction: English

Prerequisite(s): --
Expected prior-knowledge: --

Aim and learning outcomes:

To supply fundamentals and basic knowledge of image compression and transmission.
Learning outcomes :
- still image compression,
- video compression,
- video transmission.

Topics to be taught (may be modified):

- Fundamentals
  - introduction to compression
  - quantization
  - differential coding
  - transform coding
  - variable length coding
  - Run length and dictionnary coding

- Still image compression
  - JPEG
  - Wavelet transform
  - Non standard image coding

- Motion estimation and compression
  - motion analysis and compensation
  - Block matching
  - PEL recursive technique
  - Optical flow
  - 2D motion estimation

- Video compression
  - digital video coding
  - video standards of MPEG- 1/2
  - applications of MPEG- 1/2
  - video standard of MPEG-4
  - video standards of H.261 and H.263

- Compressed video transmission
  - buffer constraints
  - video synchronisation
  - decoding and presentation
  - video buffer management
  - video transcoder

- transport packet scheduling and multiplexing

Teaching methods: Lectures, lab classes and homework exercises.

Form(s) of Assessment: Written exam (75%), exercises (25%)

External/internal examiner: --

Examination support: None

Literature and study materials: of the material covered in the lectures will be distributed.

Basic textbook:

“Image and Video Compression for multimedia Engineering (2nd edition – 2008)" by Yun Q Shi and Huifang Sun

Additional books:

"Transporting Compressed Digital Video" by Xuemin Chen

Additional information:

Damien Muselet
University of Saint-Etienne - France
E-mail: Damien.Muselet@univ-st-etienne.fr
Office hours: Monday to Thursday 9 to 17hrs, or by appointment.

Home page: *http://www.master-erasmusmundus-color.eu/*

CIMET Pattern Recognition

Course name: Pattern Recognition
Course level: Master

Course code: CIMET IPA
ECTS Credits: 3.00

Course instructors: Marc Sebban (University of Saint- Etienne), Marc Bernard (University of Saint- Etienne)

Education period (Dates): 2nd semester

Language of instruction: English

Expected prior-knowledge: sufficient knowledge in statistics

Aim and learning outcomes:

This course presents a survey of the main pattern recognition and machine learning algorithms. It aims to cover different approaches in **supervised learning** from numerical data (bayesian model, k nearest neighbors, geometrical methods, induction trees) and structured data (Hidden Markov models, deterministic automata), and in **unsupervised learning** (data clustering).

Topics to be taught (may be modified):

- Introduction to pattern recognition and machine learning; statistical learning theory; empirical and generalization errors; model quality estimates.
- Bayesian model.
- K-Nearest Neighbors (algorithm, theoretical properties, solution to overfitting, speed-up).
- Geometrical models (Minimum spanning tree, Gabriel graph, Delaunay triangulation).
- Induction trees (ID3, C4.5)
- String-based models:
    - Hidden Markov models (Forward, backward and Viterbi algorithms, Expectation-Maximization algorithm),
    - Deterministic automata (KTSSI, RPNI algorithms).
    - Probabilistic automata
- Distances between numerical vectors, strings and trees; learning stochastic string edit distance.
- Data Clustering (hierarchical and non hierarchical clustering).

Practical Laboratory Sessions:
Use of Weka[1] to compare the different learning algorithms on a set of benchmarks.

Teaching methods: Lectures and lab classes.

Form(s) of Assessment: written exam (75%), practical work (25%)

External/internal examiner: --

Examination support: None

Literature and study materials:

<u>Basic textbook: ??</u>?

<u>Additional book:</u>

- Machine Learning, Tom Mitchell, McGraw Hill, 1997.
- Classification and Regression Trees, by Leo Breiman, Jerome Friedman, Charles J. Stone, R.A. Olshen, Chapman et al. 1998

[1] http://www.cs.waikato.ac.nz/ml/weka/

Additional information:

Marc Sebban
University of Saint- Etienne
E-mail:
Web page:
Office hours:

Marc Bernard
University of Saint- Etienne
E-mail:
Web page:
Office hours:

Home page: *http://www.master-erasmusmundus-color.eu/*