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

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COURSE MODULE – FOURIER OPTICS

COURSE CODE	COSI FO
COURSE LEVEL	Master
ECTS CREDITS	5
COURSE INSTRUCTOR/S	Juan Luis Nieves Gómez & Javier Hernández Andrés (University of Granada)
EDUCATION PERIOD	SEMESTER 2
EXPECTED PRIOR-KNOWLEDGE	• Pre-requisite/s: Module "Photonics and Optics Fundamentals" (1st semester) • Image formation fundamentals and diffraction phenomenon, Fourier analysis and linear systems.
LANGUAGE OF INSTRUCTION	English

AIM

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.

COURSE OUTLINE

(topic 1) Diffraction. Fresnel and Fraunhofer approximations.

(topic 2) Diffraction-limited imaging. Image formation with coherent and incoherent illumination. Analysis of optical resolution.

(topic 3) 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.

(*topic 4)* Fundamental of wavefront modulation. Spatial light modulators. Diffractive optical elements.

(*topic 5*) Spatial filtering. The VanderLugt filter. The Joint Transform Correlator. Optical pattern recognition architectures: the Matched Filter. Image processing tools for pattern recognition.

(*topic 6)* Optical and digital holography. Introduction to classical holography. Recording of digital holograms. Numerical reconstruction of digital holograms. "Inverse problem": approach to process holograms. Applications.

PRACTICAL ACTIVITIES

• 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.
• Recording of a digital hologram and numerical reconstruction.

LEARNING OUTCOMES[1]

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.

FORM/S OF ASSESSMENT

Written exam (50%), Practical work (50%)

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

ASSESSMENT CRITERION

Written exam lab sessions and Homework/seminar presentations

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 :
• Activities and questionnaires giving evidence of knowing (5%)
• Activities and questionnaires giving evidence of comprehension/understanding (5%)
• Activities and questionnaires giving evidence of analysis (5%)
• Activities and questionnaires giving evidence of synthesis (5%)
• Activities and questionnaires giving evidence of evaluation (5%)

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.

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