UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Adaptive Optics

2425-1-F1702Q010

Aims

It provides specialized training in advanced optical techniques to enhance the diagnosis and treatment of eye diseases. The course will cover the principles and applications of adaptive optics, focusing on how these technologies can improve the resolution and accuracy of ophthalmic imaging. Topics include wavefront sensing and correction, retinal imaging, and the integration of adaptive optics into clinical practice. The goal is to equip optometrists and specialists in vision science with the knowledge and skills to leverage adaptive optics for better patient outcomes.

Contents

• Basics of Physical Optics: the propagators (Fresnel, Fraunhofer, Angular spectrum)
• Examples in Fourier Optics: the holographic algorithm to generate visual stimuli
• Description of optical aberrations: first order Seidel aberrations
• Adaptive optics tools I: deformable mirrors.
• Adaptive optics tools II: spatial light modulators (the Gerchberg-Saxton algorithm)
• Corrections of optical aberrations and Zernike description.
• Applications of adaptive optics for vision testing: retina imaging (https://www.imagine-eyes.com/)
• Role of adaptive optics to study accommodation, how to assess the vision improvement.
• Learning about vision at the scale of single photoreceptors.

Detailed program

**introduction to Adaptive Optics. **
Description of optical aberrations: first order Seidel and second order aberrations with geometrical optics.

Analysis of the first order aberrations with the wave propagation.

** **Methods for the correction of the optical aberrations**:
• Adaptive optics tools I: deformable mirrors.
• Adaptive optics tools II: spatial light modulators (the Gerchberg-Saxton algorithm)
**
• **Methods to describe the optical aberrations** (with particular care to the Zernike description).
• Applications of adaptive optics for vision testing. Analysis of two main AO opthalmoscopes and their applications to retina imaging (https://www.imagine-eyes.com/)
• Role of adaptive optics to study accommodation, in particular: understanding accommodation, vision Improvement Assessment, applications in Clinical Practice.
• How to exploit high resolution imaging assisted by AO to diagnose vision defects at the scale of single photoreceptors.

Prerequisites

Algebra and geometry
introdcutory calcolus, derivatives and integrals
basics of Python or MatLab coding.

Teaching form

Lectures with proposition of problems in the classroom. Assignment of problems at home tha go to make an exam pre-evaluation.
Use of numerical simulatons and animations. Proposition of real world cases. Lectures, problem-solving, and simulations will be integrated.
Student Participation is encourage through the problem solving.
Summary:

- Number of in-person lesson hours: 28;
- Number of interactive remote hours: 14.

Textbook and teaching resource

Optical Imaging and Aberrrations, Virendra Mahajan, SPIE press, 1998.
Adaptive Optics for Vision Science: Principles, Practices, Design, and Applications.
Edited by Jason Porter, Hope M. Queener, Julianna E. Lin, Karen Thorn, And Abdul Awwal
Wiley Scientific, 2006.

Semester

second

Assessment method

THE FINAL ASSESSMENT CONSISTS OF FIVE STEPS:
1- Submission, at least three weeks before the date of the exam, of the revision of a scientific article (indicated by the lecturer and accoridng to an evaluation form provided by the lecturer)
2 - Submission, at least three weeks before the date of the exam, of a set of 3 problems left to the student as homework during the course.
3- Written questions (closed answers) on the course syllabus for an extensive verification of the preparation on the course syllabus.
4- Oral discussion on the revised scientific article to verify the ability to produce, collect, organize, analyze, and critically interpret scientific literature
5- Oral discussion of the solved problems to assess the ability of the student in problem solving.

Stesp 1 and 2 will be done before the date of the exam. Steps 3-5 will be done the day of the exam.
Steps 1 to 3, will give a WRITTEN SCORE expressed aout of thirty. the student can improve by up to 4 points the WRITTEN SCORE with steps 4 and 5.

STEP 1: it will be assessed with a single grade expressed out of thirty (the "article" grade), obtained by summing the following scores:
0 to 5 points: Does the student address clearly what is the general impact of th research addressed in the article?
0 to 5 points: does the student address clearly the methodology?
0 to 5 points: does the student address correctly the physical principles of the methodology?
0 to 5 points: Are the main results summarized clearly?
0 to 5 points: are the graphical result interpreted correctly and clearly?
0 to 5 points: Is the terminology used in the report in general correct?

STEP 2: for each of the three problems, the following aspects will be assessed with a single grade ("problems" grade) expressed out of thirty , obtained by summing the following scores:
0 to 6 points: does the student have understood correctly the text?
0 to 6 points: does the student have stated clearly what principles should be used?
0 to 6 points: does the student implements correctly the principles to obtain equations for the solution ?
0 to 6 points: is the numerical result correct?
0 to 6 points: does the student comment correctly the result obtained and, if needed, represent correctly them in graphical form?

Step 3: it will be assessed with a grade (the "test" grade) expressed out of thirty (the grade is equal to the number of correct answers, as the test consists of 30 questions).

The WRITTEN SCORE will be the average of the three previous grades, rounded to the nearest integer.

Steps 4 and 5 will count for an at most additional 4 points to be added to the WRITTEN SCORE and provide the FINAL SCORE

Office hours

through the webex page
https://unimib.webex.com/meet/giuseppe.chirico
Every Monday, 13.00-14.00.

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING