Photonics and Optics Fundamentals, 3312055, 4 ECTS, UEF semester 1

Learning outcomes

Student understands basic optical phenomena and experiments involved, and is able to utilize basic measurement techniques in realizing optical phenomena.

Content

Models for light, propagation of light, interaction of light with a medium, light polarization, interference, diffraction and image formation in paraxial optical systems.

Modes of study

Written exam and active participation to laboratory practices

Teaching methods

Lectures and exercises 28 h; laboratory practices 14 h.

Study materials

Handouts of the material covered in the lectures will be distributed. Books: Hecht. E.: Optics (2000).

Evaluation criteria

Scale 0-5 (0 = fail, 5 = excellent)

Prerequisites

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Design and Analysis of Algorithms, 3621511, 4 ECTS, UEF semester 1

Content

Principles of algorithm design, such as divide-and-conquer and dynamic programming. Asymptotic analysis of algorithms. Computational complexity, especially NP-completeness. Examples of data structures and algorithmic approaches to NP-complete problems.

Objectives

To learn methods for designing efficient algorithms and analyzing them; to become familiar with the fundamentals of computational complexity theory; to meet methods for dealing with computationally challenging problems.

Study materials

Lecture notes, based mainly on the books T.H. Cormen et al. “Introduction to Algorithms” 3rd Ed. (MIT Press, 2009) and S.S. Skiena “The Algorithm Design Manual” 2nd Ed. (Springer, 2008). Other material cited during the course.

Teaching Method

Lectures 34 h, exercises 16 h

Modes of study

By exam and active participation in the exercises.

Assessment
0 (Fail) - 5 (Excellent)

Prerequisites
Bachelor studies of Computer Science, including courses on basic data structures and algorithms, and on basic models of computation; basic university level mathematics studies, or well-mastered high school mathematics.

Robotics and XR, 4 ECTS, UEF semester 1

Learning outcomes
After the course, the student is able to build and program Arduino-based mobile robotics solutions that with basic sensors and actuators. The student understands and is able to implement robotics algorithms (such as navigation and planning algorithms) with Arduino programming language. The student understands possibilities of virtual and extended reality (VR, XR) environments in robotics applications and is able to implement a simple project in such environments.

Content
Social dimensions of robotics, fundamentals of robotics (structure of robots, sensors, actuators), programming Arduino robots and Robotics Operating System (ROS), basic VR/XR technologies and application in robotics, navigation and planning algorithms for mobile robots, course project work.

Modes of study
Course and project work, active participation

Teaching methods
Lectures 12 hours; guided exercises and practical work 28 hours; project work

Study materials
Morgan Quigley, Brian Gerkey, and William D. Smart. 2015. Programming Robots with ROS: A Practical Introduction to the Robot Operating System. O'Reilly Media, Inc.

Lecture handouts and other material

Evaluation criteria
Active participation to lectures and exercises, project work

Scale 0-5 (0 = fail, 5 = excellent)

Prerequisites
Introduction to computer science and Programming I-III (or equivalent set of courses covering procedural and object-oriented programming).

Physical Optics, 3312008, 4 ECTS, UEF semester 1

Learning outcomes

To understand the basics of electromagnetic optics and wave optics. To understand the concepts of polarization and coherence in wave optics. To understand connections between electromagnetic optics, wave optics, and geometrical optics.

Content

Maxwell's equations, electromagnetic field, polarization; interference, diffraction, coherence; basics of ray and beam optics; light at interfaces, thin films, and waveguides.

Modes of study

Written intermediate and final exams, Homework assignments.

Teaching methods

Lectures 24h and Exercises 12h.

Study materials

Handouts of the material covered in the lectures will be distributed.

Evaluation criteria

Scale 0 – 5 (Homeworks 20%, intermediate exam 30% and final exam 50%)

Prerequisites

Basics in optics and Photonics, e.g., courses Photonics and Optics Fundamentals

Eye tracking, 3621587, 5 ECTS, UEF semester 1

Learning outcomes

After the course, students will be able to set up and handle eye-tracking hardware equipment, set up a simple eye-tracking study and analyze the data independently. They will understand the principles of eye-tracking, on physiological, theoretical, software and hardware levels. They will also be able to understand the principles, benefits and challenges of gaze-based interaction. More information on http://cs.uef.fi/pages/bednarik/eyetracking.

Content

Eye and human visual system, visual attention, pupilometry, eye movements, eye tracking principles, eye-movement data analysis and visualization, eye-tracking as a usability evaluation

Modes of study

Course and project work, active participation

Teaching methods

Lectures and exercises

Study materials

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Van de Weijer, J. (2011). Eye tracking: A comprehensive guide to methods and measures. OUP Oxford. Handouts

Evaluation criteria
Scale 0-5 (0 = fail, 5 = excellent)

Prerequisites
Human Factors of Interactive Technology or equivalent

Mathematical methods for Photonics, 3312057, 4 ECTS, UEF semester 1

Learning outcomes
To master important mathematical methods in photonics.

Content
Basic calculus, vectors, complex numbers, differential equations, Fourier series, Fourier transform, special functions, matrices.

Modes of study
Lectures and demonstrations and an exam.

Teaching methods
Lectures 24h and Exercises 12h.

Study materials
G. J. Bur, Mathematical Methods for Optical Physics and Engineering, G. B. Arfken and H. J. Weber, Mathematical Methods for Physicists, 6th edition, K.-E. Peiponen, Mathematical Methods for Photonics.

Evaluation criteria
Scale 0 – 5

Prerequisites
Basic knowledge of mathematics.

Applications of Photonics, 3312073, 4 ECTS, UEF semester 1

Learning outcomes
To understand various applications of photonics from practical perspective. And product development of companies including the basics.

Content
Basics of photonics and how the can be applied for solving various tasks and problems in, e.g., industry, medicine and consumer applications. The most important applications today and in the future.

Modes of study
Lectures. Company visits. Seminar presentation.

Teaching methods
Lectures 24 h, company visit and seminar preparation and presentation 12h.

Study materials
Material presented and handed out in the lectures.

Evaluation criteria
pass / fail

Prerequisites
Basic optics courses.

Color Science, 3312062, 4 ECTS, UEF semester 1

Learning outcomes
The aim of the course is to supply basic knowledge of colorimetry and color measurements. After the course student understands how human color vision works, how spectral distribution of light is measured in different cases and how color values are defined in industry and science. In addition, student understands how desired color can be created by additive system, such as computer display, or subtractive system, such as printing.

Content
Human color vision, basics of photometry, radiometry and spectral measurements, color coordinate systems, additive and subtractive formation of color.

Modes of study
Lectures.

Teaching methods
Lectures and demonstrations 48h.

Study materials
Ohta, Robertson: Colorimetry: Fundamentals and Applications (2006).

Evaluation criteria
Scale 0-5

Prerequisites
-

Advanced Spectral Imaging, 4 ECTS, UEF semester 1

Learning outcomes
After the course, students will understand how spectral cameras are applied in science and research (medicine, industry, biology).

Students will be able to set up and handle several spectral cameras: Specim scanner based line spectral system (including visible range V10E camera and infrared range N25 camera), Specim IQ mobile handheld spectral camera, two Nuance spectral cameras based on liquid crystals filtering, Fluxdata seven-channel spectral real-time video camera.

Student will understand the principles of operation of spectral cameras, i.e. 3D spectral cube acquisition. They will learn how to setup cameras, lights and objects. They will also be able to understand spectral data formats (ENVI, TIFF) and learn how to handle this big data in Matlab and Python. Student may optionally learn basic principles of handling the spectral data: cropping, resizing, compressing and conversion. There is possibility of learning basic multivariate statistical analysis methods applying to spectral data.

Content
Spectral camera, spectral measurements, spectral data, 3D spectral cube, Matlab, Python, big data

Modes of study
Lectures, exercises, work in the laboratory, individual study and project work

Teaching methods
108 hours: Lectures 10h, practice in the lab 20h, independent work on the project 78h

Study materials
Lecture notes

Evaluation criteria
written assignments (programming tasks) / project work

Scale 0-5 (0 = fail, 5 = excellent)

Prerequisites
Color Science, Photonics and optics fundamentals, basic knowledge of Matlab and Python