| | | | | | |
|---|---|---|---|---|---|
| Name of the course | Polish | Zaawansowane cyfrowe przetwarzanie obrazów | | | |
| | English | Advanced Digital Image Processing | | | |
| Type of the course | Specialized course | | | | |
| Course coordinator | Prof. Nieniewski, Ph.D, D.Sc., EE | Course teacher | Mariusz Nieniewski, Ph.D, D.Sc., EE | | |
| Implementing unit | ZIiNO | Scientific discipline / disciplines | Computer science/Informatics | | |
| Level of education | doctoral studies | Semester | Summer semester | | |
| Language of the course | English or Polish | | | | |
| Type of assessment | assessment of activity during class, lab reports | Number of hours in a semester | 60 | ECTS credits | 4 |

| Type of classes | | Lecture | Auditory classes | Project classes | Laboratory | Seminar |
|---|---|---|---|---|---|---|
| Number of hours | in a week | 2 | | | 2 | |
| | in a semester | 30 | | | 30 | |

## COURSE OFFERED IN THE DOCTORAL SCHOOL OF IPPT PAN

| 1. Prerequisites |
|---|
| Digital Image Processing course |

| 2. Course objectives |
|---|
| The aim of the course is to teach students to process images in the frequency domain (also called transform domain). The textbooks references for this course indicate the use of Matlab. In fact Matlab is not a necessity for this course since the same functionality can be obtained by using Octave or Python, which are available in public domain. The lectures provide theoretical background at the introductory level. The main flavor of the course is lab experiments with image processing. These experiments are conducted mainly in Octave and Fiji (imageJ), which is another freely available software. Possible software conversions from one programming language to another are implemented via AI so the student obtains a more general overlook of the area of digital image processing and can choose the best software option in a particular case. |

### 3. Course content (separate for each type of classes)

**Lecture**

**Main topics:**

1. theoretical principles of lowpass and highpass filtering in the frequency domain – ideal filters, Butterworth filters, and Gaussian filters
2. theoretical principles of bandpass and bandreject filtering in the frequency domain – ideal filters, Butterworth filters, and Gaussian filters
3. theoretical principles of noise modelling in images
4. theoretical principles of image restoration in simpler cases of degradation
5. comparison of filtering in image domain and frequency domain
6. transformations between color spaces and their uses

7. miniprojects in the area of digital image processing

**Laboratory**

**Main topics:**

1. lowpass and highpass filtering in the frequency in the Matlab/Octave environment – ideal filters, Butterworth filters, and Gaussian filters
2. bandpass and bandreject filtering in the Matlab/Octave environment – ideal filters, Butterworth filters, and Gaussian filters
3. noise modelling in the Matlab/Octave environment
4. image filters for improving image quality in frequency domain
5. comparison of filtering in image domain and frequency domain
6. transformations between color spaces and their uses
7. carrying out complete miniprojects in frequency domain using built-in Matlab/Octave functions of the IPT (Image Processing Toolbox), user defined functions delivered in the textbook Gonzalez, Digital Image Processing Using Matlab, as well as student defined functions, possibly generated with the use of AI.

4. Learning outcomes

| Number of the learning outcome | Learning outcomes description | Reference to the learning outcomes according to the 8th level of PRK | Learning outcomes verification methods* |
|---|---|---|---|
| **Knowledge** | | | |
| **Knowledge acquired from lecture** | | | |
| 1 | The graduate acquires knowledge of theoretical principles of lowpass and highpass filtering in the frequency domain – ideal filters, Butterworth filters, and Gaussian filters. | P8S_WG | assessment of activity during classes and assessment of lab reports |
| 2 | The graduate acquires knowledge of theoretical principles of bandpass and bandreject filtering in the frequency domain – ideal filters, Butterworth filters, and Gaussian filters. | P8S_WG | assessment of activity during classes and assessment of lab reports |
| 3 | The graduate acquires knowledge of theoretical principles of noise modelling in images. | P8S_WG | assessment of activity during classes and assessment of lab reports |

| | | | |
|---|---|---|---|
| 4 | The graduate acquires knowledge of theoretical principles of image restoration in simpler cases of degradation. | P8S_WG | assessment of activity during classes and assessment of lab reports |
| 5 | The graduate acquires knowledge of how to compare results of filtering in image domain and frequency domain. | P8S_WG | assessment of activity during classes and assessment of lab reports |
| 6 | The graduate acquires knowledge of transformations between color spaces and their uses. | | assessment of activity during classes and assessment of lab reports |
| 7 | The graduate acquires knowledge how to carry out complete miniprojects in frequency domain using built-in Matlab/Octave functions of the IPT (Image Processing Toolbox), user defined functions delivered in the textbook Gonzalez, Digital Image Processing Using Matlab, as well as student defined functions, possibly generated with the use of AI. | | assessment of activity during classes and assessment of lab reports |
| **Knowledge acquired from laboratory** | | | |
| 1 | The graduate acquires knowledge of lowpass- and highpass filtering in the frequency in the Matlab/Octave environment – ideal filters, Butterworth filters, and Gaussian filters. | P8S_WK | assessment of activity during classes and assessment of lab reports |
| 2 | The graduate acquires knowledge of bandpass-, and bandreject filtering in the frequency domain in the Matlab/Octave environment – ideal filters, Butterworth filters,, and Gaussian filters. | P8S_WK | assessment of activity during classes and assessment of lab reports |
| 3 | The graduate acquires knowledge of noise modelling in the Matlab/Octave environment. | P8S_WK | assessment of activity during classes and assessment of lab reports |
| 4 | The graduate acquires knowledge of image filters for improving image quality in frequency domain. | P8S_WK | assessment of activity during classes and assessment of lab reports |
| 5 | The graduate acquires knowledge of how to compare filtering in image domain and frequency domain in the Matlab/Octave environment. | P8S_WK | assessment of activity during classes and assessment of lab reports |
| 6 | The graduate acquires knowledge of transformations between color spaces and their uses in the Matlab/Octave environment. | P8S_WK | assessment of activity during classes and assessment of lab reports |
| 7 | The graduate acquires knowledge carrying out complete miniprojects in frequency domain using built-in Matlab/Octave functions of the IPT (Image Processing Toolbox), user defined functions delivered in the textbook Gonzalez, Digital Image Processing Using Matlab, as well | P8S_WK | assessment of activity during classes and assessment of lab reports |

| | | | |
|---|---|---|---|
| | as student defined functions, possibly generated with the use of AI. | | |
| **Skills** | | | |
| 1 | The graduate is able to solve problems of image filtering with images coming from industrial, scientific, and biomedical environments using methods available when filtering in image domain. | PBS_UW | assessment of activity during classes and assessment of lab reports |
| 2 | The graduate is able to solve problems of image filtering and image quality improving in image domain. | P8S_UW | assessment of activity during classes and assessment of lab reports |
| 3 | The graduate is ready to apply the acquired knowledge of the theory of image filtering in the field of his/her scientific research. | P8S_UW | assessment of activity during classes and assessment of lab reports |
| 4 | The graduate is able to transfer the acquired knowledge of the theory of image filtering to the industrial and other environments and disseminate the results of his/her research. | P8S_UW | assessment of activity during classes and assessment of lab reports |
| **Social competences** | | | |
| 1 | The graduate is ready to think and act in a creative and entrepreneurial way. | P8S_KO | assessment of activity during classes and assessment of lab reports |
| 2 | The graduate is ready to critically evaluate the achievements of the represented scientific discipline, including his/her own contribution to the development of this discipline. | P8S_KK | assessment of activity during classes and assessment of lab reports |

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

## 5. Assessment criteria

Activity in the lab, presentation of the lab reports

## 6. Literature


Primary references:

[1] **R.C. Gonzalez, R. E. Woods,** Digital Image Processing, 3rd ed.

[2] **R.C. Gonzalez, R.E. Woods, S. L. Eddins,** Digital Image Processing Using Matlab, 3rd ed.

[3] **Princeton_Fourier_da8827c90-6617-4bc6-b840-2bea0618d480.pdf**

[4] **Osgood_book-fall-07.pdf**

Secondary references:

[1] **Butz_Fourier_Transformation_For_Pedestrians.pdf**

[2] **K.F. Riley, M.P. Hobson, S.J. Bence,** Mathematical Methods for Physics and Engineering, 3rd ed. 2006, Cambridge University Press

[3] **R. Szeliski,** Computer Vision, Algorithms and Applications, 2011, Springer

| 7. PhD student's workload necessary to achieve the learning outcomes** | | |
|---|---|---|
| No | Description | |
| 1 | Hours of scheduled instruction given by the lecturer in the classroom | **60** |
| 2 | Hours of consultations with the lecturer, tests, etc. | **15** |
| 3 | Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework | **30** |
| | **Total number of hours** | **105** |
| | **ECTS credits** | **4** |

** 1 ECTS = 25–30 hours of the PhD students work (2 ECTS ≈ 60 hours; 4 ECTS ≈ 110 hours, etc.)