POLOTSK STATE UNIVERSITY

Intelligent Image Processing

Syllabus

Rykhard Bohush

2020-2021 Academic Year

PSU: Intelligent Image Processing
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MSc 1-40 81 01
Computer Science and Software Development Technologies

Course: Intelligent Image Processing

Faculty: ICT	Amount of student effort (hours): 210
Department: Computing Systems and Networks	Class contact time (hours): 96
Level: MSc, Year 1,2	Term period(s): Sem. 2,3 Sem.2 (hours): 60 Sem.3 (hours): 36
Language of instruction: English	Course status: Mandatory core
Course leader: Rykhard Bohush	Entry requirements: None
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Learning goals and learning outcomes

Objectives:

- *to introduce principles of image and video description for intelligent processing in computer systems;*
- *to equip students with knowledge and skills for application two-dimensional discrete transformations;*
- *to introduce principles and practices of methods for improving the quality of images in spatial and frequency areas;*

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- *to help students learn methods for object detection, analysis and recognition in images and video;*

- *to equip students with knowledge and skills for application convolution neural networks;*
- *to help students understand principles of video sequences processing methods and algorithms for object detection and tracking;*
- *to equip students with knowledge and skills for using open computer vision libraries;*
- *to apply image processing knowledge and skills to practical matters from different professional practices;*
- *to collaborate in teams and do project-based tasks for image and video processing.*

Learning outcomes

Upon successful completion of the course, students will be able to:

- *explain how digital images and video sequences are represented in a computer;*
- *know how go from the mathematical description of image processing techniques to code;*
- *apply knowledge of computing and mathematics appropriate to intelligent image processing;*
- *analyse a problem and identifies the computing requirements appropriate for its solution;*
- *design, implement and evaluate a computer-based system, process, component or program to meet desired needs;*
- *apply mathematical foundations, algorithmic principles and computer science theory to the modelling and design of computer-based systems;*
- *analyse a wide range of problems and provide solutions related to the design of image processing systems through suitable algorithms, structures, diagrams, and other appropriate methods;*
- *use the documentation for, and make use of OpenCV library and Deep Learning Frameworks;*
- *write a program which implements image and video processing algorithms for practical tasks;*
- *work as a member of a small group working on some programming tasks for intelligent image processing;*
- *self-evaluate their projects and assess the others' contributions and the overall process of tasks intelligent image and video processing.*

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Course methodology

For successful study, the material in this course uses classical teaching methods and didactic approaches.

- *Lectures*

Lectures are delivered according to the published plan and on the basis of the materials that are available to the students.

- *Laboratory Work*

Laboratory exercises are completed according to the published plan and based on the instructions available to students. Laboratory work involves software implementation of various methods for image processing and analysis.

- *Consultations*

Oral or on-line consultations are available on student request via the Google Classroom platform.

- *Other Forms of Group Work and Self Study*

Optionally students will work on team projects during the semester. At the end of the semester, the team prepares a report about the project and presents the project to the other students and the teaching staff with a following discussion.

The summative assessment is composed of a mid-term exam and a final exam that are graded together with the other student activities. Students who do not pass through formative assessments can still take the both exams.

Students work collectively on case studies as a way to integrate their insights. Students are responsible for the planning themselves and need to meet up in between the tutorials to work on the case study.

Compulsory requirements:

Oral presentation. Students will work on selected topics to present and discuss these topics with other students and course leader in the classroom.

Study one topic and present it at one of the lectures or implement an advanced algorithm and report on it. E-learning materials will be available for this course: files with lectures in PDF format and possibly with audio material as well as student presentations. These E-lectures materials will be available on the VLE platform (Google Classroom), which will also be used for discussions between the students as well as between the students and the teacher.

- *Exams*

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Course Policies and Academic Honesty

Students are required to attend classes. In case classes are missed, students should present work, which has been done during classes. Students are required to do work at classes and online using the Google Classroom and Microsoft Teams resources.

Students submit laboratory work covered with a sheet containing their name, course title, number and title of the laboratory work. All completed laboratory works are to be uploaded on the Google Classroom platform. Students are expected to keep a duplicate copy of their work on their PC or in the Cloud. Students are to accompany their assignments with: a brief report to explain their findings; description of their algorithms and solutions of the tasks; a list of their test programs; code of their programs.

Each student is expected to abide by the academic honesty policy. Any work submitted by a student in this course will be the student's own work. Students are encouraged to study together and discuss information and concepts covered in the lectures. However, the permitted cooperation should never presuppose one student's possession of a copy of all or part of the work done by someone else.

Course Outline

Semester 2

PART 1 – IMAGE PROCESSING AND ANALYSIS

Image Representation

Reading and recording images. Discretization and quantization. Description and presentation of binary, grayscale and colour images.

Two-dimensional discrete transforms

Fourier, Hadamard, cosine, sine, Haar

Wavelets

One-dimensional wavelet transforms. Fast wavelet transforms. Two-dimensional wavelet transforms. Wavelet packets.

Image Enhancement Techniques

Gradational transformations. Histogram modifications. Spatial filtering. Filtering in frequency domain.

Binary Image Morphological Processing

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Binary image processing: erosion and dilatation; opening and closing. Highlighting the boundaries. Hole filling. Isolation of connected components. Thinning.

Gray -Scale Image Morphological Processing

Features of erosion and dilatation operations. Building transformations of opening and closing. Basic algorithms for grayscale morphology.

Colour image processing

The basics of colour theory. Colour models. Colour conversions. Smoothing and sharpening. Segmentation of colour images.

Segmentation of points and contour lines

Detection of isolated dots and lines. Difference models. Methods for detecting contour differences. Linking contours and finding boundaries.

Segmentation by thresholding

Global Threshold Processing. Optimal method global threshold conversion. Multiple Threshold Processing. Variable Threshold Processing.

Region based segmentation

Growing region. Separation and merging of region.

Segmentation by morphological watersheds. Segmentation Algorithm.

Image representation and description

Chain codes. Fourier descriptors. Moments. Signatures Border descriptors.

Area descriptors. Using the main components to describe.

PART 2 – OBJECT DETECTION AND RECOGNITION

Object Detection

Detection using keywords. Features of colour and texture similarity. Similarity features of object shape and their location on the image.

Pattern Recognition Methods

The main tasks of pattern recognition. Recognition errors. Recognition by a set of measurements. Structural recognition methods. Matrix of inaccuracies. Decision tree. Bayesian decision making method. The concept of clustering methods.

Neural networks

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Model of an artificial neuron. Classification of neural networks. Activation functions. Hopfield Neural Network. Multilayer perceptron.

Deep Learning Methods for Intelligent Image Processing

The general structure of the convolutional layer. Input and output data of the convolutional network. Error back propagation method for convolutional neural networks. Determining the number of trained parameters. Estimating the amount of memory needed to store a network.

CNN architectures

Features and model of the convolutional neural network SNS LeNet 5. The architecture of AlexNet and its differences. ResNet, YOLO CNN family

Semester 3

PART 3 - VIDEO SEQUENCES PROCESSING

Motion Estimation is one of the most effective ways to utilize time redundancy in video frames, and this part discusses various fundamental ways to do this - optical flow, block-based methods, Bayesian methods and CNN approaches. Each of ways are related mathematical tools which is popular and useful for students to learn for their research.

Computer Vision and Deep Learning Libraries

Purpose and main features of OpenCV. Build and install the OpenCV library. Using the library in Microsoft Visual Studio. Build and install the dlib library. Deep learning image processing algorithms in dlib. TensorFlow, PyTorch, Keras.

Computer Vision Libraries for video processing

Key components: capture, play and save video. Deep Learning methods in OpenCV and dlib

Background subtraction

Approaches using time difference methods. Building on the basis of background subtraction methods (MOG, MOG2, ViBe). Pyramid representation of frames. Optical flow methods.

Moving objects segmentation and classification

Segmentation of objects in video sequences. Postprocessing. Use of classification metrics and temporal consistency. Methods based on the analysis of movement.

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Object tracking algorithms

Detection of singular points. Tracking points. Track region containing the image. Tracking methods that consider a set of parameters. Template methods of optical flow.

Deep learning video processing

Deep learning video processing algorithms. Using OpenCV, dlib, TensorFlow, PyTorch, Keras for practical tasks.

Assessment Strategies:

The final grade will be based on individual grades received on assignments, group projects and participation. Point values for assignments are based on the level of effort and knowledge required to complete each.

The course grade is determined as following

Participation in discussions 20 %

Laboratory work -30 %

Mid-term exam 20 %

Final exam - 30 %

Total 100%

Readings, materials, and resources

- Periodicals from International Journals and Conferences: http://computeroptics.smr.ru/eng/index.html, https://inf.grid.by/jour, http://mgv.wzim.sggw.pl/, https://www.pleiades.online/ru/journal/patrec/, https://iapr.org/conferences/ at al.
- Gonzalez, Rafael C., and Richard E. Woods. Digital image processing, 4th Edition, 2018,
- Computer Vision: Algorithms and Applications - http://szeliski.org/Book/
- OPENCV –https://opencv.org
- DLIB - http://dlib.net
- PYTORCH - https://pytorch.org/
- KERAS - https://keras.io

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