Real time 3D visualization, 6 ECTS, UJM semester 2

Learning outcomes

The first aim of this course is to understand the modern GPU architectures and capabilities. The second is to understand and apply the basic and advanced techniques of real-time 3D rendering in the context of XR. A focus will be placed on the web technologies (WebGL, WebVR and WebXR) that will be used to implement these techniques.

Content

- GPU architecture
- Introduction to WebGL, WebVR and WebXR
- Concept of the third dimension to create realistic 3D animations.
- Lighting and materials
- GPU programming with shaders
- Advanced 3D visualization techniques with Three.js (https://threejs.org/)

Modes of study

Course and project work, active participation and a 3 days development sprint.

Teaching methods

Lectures: 12 hours, Practical work (during the lectures): 24 hours, 3 days development sprint

Study materials

- The Graphics Codex, V2.15, by Morgan McGuire, 2011-2018
- The Book of Shaders - https://thebookofshaders.com
- Real-Time 3D Graphics with WebGL 2, Second Edition, by Farhad Ghayour and Diego Cantor, Packt Publishing, October 2018

Evaluation criteria

1 theoretical examination (1h30, 1/2), 1/2 project (3 days sprint included)

Prerequisites

Basic knowledge of HTML, Basic knowledge of JavaScript/Typescript

Real time processing of conventional and non-conventional images with GPUs, 6 ECTS, UJM semester 2

Learning outcomes

This course introduces basic and advanced techniques dedicated for General-Purpose processing on Graphics Processing Unit (GPGPU). It introduces the basic concepts of parallel programming and shows how to use the computing power of modern GPUs for conventional/non-conventional images processing in real time.

Content

Introduction to parallel programming; Introduction to General-purpose processing on graphics processing units (GPGPU): GPGPU with shaders, CUDA; Image processing with graphic shaders and compute shaders

(application with WebGL for web applications); CUDA based image processing (application with OpenCV for native applications)

Case of studies: Implementation of conventional color image/video processing methods, Implementation of non-conventional image processing methods

Modes of study
Course and project work, active participation

Teaching methods
Lectures: 12 hours, Practical work (during the lectures): 24 hours, 3 days development sprint

Study materials
Programming Massively Parallel Processors, Third Edition: A Hands-on Approach, by David B. Kirk and Wen-mei W. Hwu, December 2016

Hands-On GPU-Accelerated Computer Vision with OpenCV and CUDA: Effective techniques for processing complex image data in real time using GPUs, Bhaumik Vaidya, Packt Publishing, 2018

Evaluation criteria
1 theoretical examination (1h30, 1/2), 1/2 project (3 days sprint included)

Prerequisites
Real time 3D visualization

Complex computer rendering methods, 6 ECTS, UJM semester 2

Learning outcomes
The aim of this course is to propose complex visualization methods based on the combination of different technologies that have been developed in the different modules of this semester. It introduces techniques dedicated for data visualization, complex algorithms integration (image processing, deep learning inference, etc.) and real-time communication. The whole being implemented as part of Web applications integrating these technologies.

Content
Data Visualization: Data visualization basics, Introduction to D3.js (https://d3js.org/), Design and visualization

Complex algorithms and external libraries integration: C/C++ implementation with WebAssembly, OpenCV integration, TensorFlow integration

Real-Time Communications: WebRTC integration

Case of studies: Image/video processing in 3D environments, Spectral computation and visualization in 3D environments

Modes of study
Course and project work, active participation and a 5 days development sprint.

Teaching methods
Lectures: 12 hours, Practical work (during the lectures): 24 hours, 5 days development sprint

Study materials

The Visual Display of Quantitative Information - Edward Tufte - 1983

Information Visualization: Perception for Design: Second Edition - Colin Ware - 2004

A Tour Through the Visualization Zoo - Vadim Ogievetsky, Jeffrey Heer, Mike Bostock - 2010

D3.js - Data-Driven Documents - https://d3js.org/

Evaluation criteria

1 theoretical examination (1h30, 1/2), 1/2 project (5 days sprint included)

Prerequisites

Real time 3D visualization, Real time processing of conventional and non-conventional images with GPUs

Machine Learning: Fundamentals and Algorithms, 6 ECTS, UJM semester 2

Learning outcomes

This course introduces fundamental concepts in machine learning and presents some classical approaches and algorithms. The scikit-learn library is presented during the practical sessions. The course aims at providing fundamental basics for using machine learning techniques.

Keywords

Machine Learning, SVM, Decision Trees, Deep Learning, HMM

Content

Basics of Machine Learning (learning settings, risks and generalization, loss functions, etc.); K-Nearest neighbors; Decision trees and Random Forests; Support Vector Machines; Neural Networks and introduction to Deep Learning; Hidden Markov Models; Practical: Introduction to Scikit-learn

Modes of study

Course and project work, active participation

Teaching methods

Lectures (15h), tutorials (10h) and lab sessions (10h).

Study materials

Statistical Learning Theory, V. Vapnik, 1989

Machine Learning, Tom Mitchell, MacGraw Hill, 1997

An Introduction to Support Vector Machines and Other Kernel-based Learning Methods, Nello Cristianini, John Shawe-Taylor, Cambridge University Press 2010: I-XIII, 1-189

Pattern Recognition and Machine Learning, Christopher M. Bishop,Springer 2013

On-line Machine Learning courses: https://www.coursera.org/

Evaluation criteria

1 theoretical examination (2h, 2/3), 1/3 practical assignments.

Prerequisites

- Basics of python programming
- Basics in algebra and statistics

Deep learning and Computer Vision, 6 ECTS, UJM semester 2

Learning outcomes

The course aims at providing fundamental basics about usage of Deep Learning in Computer Vision. Students will make use of the theoretical knowledge they have learned in the course “Machine Learning: Fundamentals and Algorithms”, deepen and apply them to many problems in computer vision such as image classification, object recognition, object detection, object tracking, …

Content

Classical convolutional neural networks (CNN); Learning features (batch normalization, fine tuning, transfer learning, domain adaptation, self-supervised learning); Residual NN; Recurrent NN and Long short-term memory networks (LSTM); Auto-encoders and Generative adversarial Networks (GAN); Applications to image classification and object detection

Modes of study

Course and project work, active participation

Teaching methods

Lectures (10 hours), exercises (10 hours) and lab sessions (10 hours).

Study materials

Online materials about deep learning and computer vision. Detailed information will be given to the students at the beginning of the class.

Evaluation criteria

Several exams, assignments and project works during this course. The average of all will give the final grade.

Prerequisites

Course of Machine Learning: Fundamentals and Algorithms.