

# STUDY GUIDE

## *Deploying Deep Learning using a microcontroller*

Organised by

Poznan University of Technology [PUT]

1. IDENTIFYING DATA.		
· Course Name.	Deploying Deep Learning using a microcontroller	
· Coordinating University.	Poznan University of Technology	
· Partner Universities Involved.	Not applicable	
· Course Field(s).	Electrical Engineering	
· Related Study Programme.	Electronics and Electrical Engineering, Laboratory of Power Electronics and Microprocessor Technology	
· ISCED Code.	07 – Engineering, manufacturing and construction	
· SDG.	Goal 4: Quality education, Goal 09: Industry, innovation and infrastructure	
· Study Level.	Bachelor (B), Master (M)	
· EUNICE Key Competencies	[Indicate the Key Competencies offered by the course.]	
	<ul style="list-style-type: none"> <li>• Green – strongly</li> <li>• Orange - moderately</li> <li>• Red – partially</li> <li>• Blank cell - not at all</li> </ul>	
	Problem solving	Green
	Teamworking	Red
	Communication	Orange
	Self-management	Orange
	Cognitive flexibility	Orange
	Digital competence	Green
	Technical competence	Green

	Global intercultural competence	Red
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· Number of ECTS credits allocated.	1
· Mode of Delivery.	Online live + Self-study
· Language of Instruction.	English
· Course Dates.	03.04.2027 – 24.04.2027
· Precise Schedule of the Lectures.	Lectures will take place every <b>Saturday</b> , starting on 3 April, and will last approximately four hours each. 03.04.27 – 4h 10.04.27 – 4h 17.04.27 – 4h 24.04.27 – 4h
· Key Words.	Microprocessor, NVIDIA Jetson, Edge AI, Electronics, Smart Vision System, ML models, Python, Linux
· Catchy Phrase.	The course aims to familiarise students with the techniques of programming microprocessors with ML models.

· Prerequisites and co-requisites.	English B2 or higher level  - The student starting this course should have basic knowledge of the basics of programming, telecommunications and mathematics. He should also have the ability to obtain information from the indicated sources and be ready to cooperate as part of the team. Knowledge in the field of digital electronics and the ability to design numerical algorithms and programming microprocessor systems at the level of first-cycle studies.
· Number of EUNICE students that can attend the Course.	30
· Number of EUNICE students that can attend the course per institution	5
· Course inscription procedure(s).	Application through the EUNICE website

## 2. CONTACT DETAILS.

· Department.	Faculty of Automatic Control, Robotics And Electrical Engineering
· Name of Lecturer.	mgr inż. Amadeusz Gąsiorek, PUT
· E-mail.	Amadeusz.Gasiorek@put.poznan.pl
· Other Lecturers.	-

## 3. COURSE CONTENT.

During the course, different models for deep learning will be presented. These will allow students to handle different models of their own learned neural network and have the opportunity to support already prepared and learned networks. Students can take full advantage of detecting different things depicted in real-time images (e.g. distinguishing between animals and people). With the neural network, we can use it for our own purposes, e.g. detecting a person as e.g. a house owner, etc. The next step is real-time detection of people and other elements in the video or camcorder footage. In addition, a method will be presented on how to easily export our own learned network for use in off-the-shelf devices such as the NVIDIA Jetson microcontroller. The final stage of the course aims to show that the models that have been written in the course can be easily and effectively used in microcontrollers for research or your own projects.

### System Setup:

- Setting up Jetson with JetPack
- Running the Docker Container
- Building the Project from Source

### Inference

#### Image Classification

- Using the ImageNet Program on Jetson
- Coding Your Own Image Recognition Program (Python)
- Coding Your Own Image Recognition Program (C++)
- Running the Live Camera Recognition Demo
- Multi-Label Classification for Image Tagging

#### Object Detection

- Detecting Objects from Images
- Running the Live Camera Detection Demo
- Coding Your Own Object Detection Program
- Using TAO Detection Models
- Object Tracking on Video

#### Semantic Segmentation

- Segmenting Images from the Command Line

- Running the Live Camera Segmentation Demo

#### Advanced Architectures

- Pose Estimation
- Action Recognition
- Background Removal
- Monocular Depth

#### Training

##### Transfer Learning with PyTorch

##### Classification/Recognition (ResNet-18)

- Re-training on the Cat/Dog Dataset
- Re-training on the PlantCLEF Dataset
- Collecting your own Classification Datasets

##### Object Detection (SSD-Mobilenet)

- Re-training SSD-Mobilenet
- Collecting your own Detection Datasets

## 4. LEARNING OUTCOMES.

### Knowledge:

1. Has knowledge of development trends, new achievements and dilemmas of modern engineering.

### Skills:

1. Can obtain information from literature, databases and other sources, make their interpretation, evaluation, critical analysis and synthesis, as well as draw conclusions and formulate and exhaustively justify opinions.
2. Can formulate and test hypotheses related to engineering and simple research problems, develop detailed documentation of the results of the experiment, design tasks, interpret the obtained results and draw conclusions.

### Social competences:

1. Recognises the importance of knowledge in solving cognitive and practical problems and understands that in technology, knowledge and skills quickly become obsolete and therefore require constant replenishment.

## 5. OBJECTIVES.

Getting to know the architecture and applications of digital signal processors and embedded systems. Acquiring the ability to design real-time digital signal processing algorithms and using camera detection and motion sensors. Acquisition of programming skills for digital signal processors and microcontrollers, NVIDIA Jetson - based on selected runtime environments.

## 6. COURSE ORGANISATION.

### UNITS

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|----|---|
| 1. | Hello, AI World Setup.                                  |
| 2. | Image Classification Inference.                         |
| 3. | Training Image Classification Models.                   |
| 4. | Object Detection Inference.                             |
| 5. | Training Object Detection Models                        |
| 6. | Semantic Segmentation and other Advanced Architectures. |

### LEARNING RESOURCES AND TOOLS.

GitHub, Anaconda Navigator, NVIDIA Jetson

### PLANNED LEARNING ACTIVITIES AND TEACHING METHODS.

Multimedia presentation, presentation illustrated with examples given on the blackboard and carrying out the tasks given by the teacher - practical exercises.

## 7. ASSESSMENT METHODS, CRITERIA AND PERIOD.

Design

1. Continuous assessment, rewarding the increase in the ability to use the learned rules and methods.
2. Assessment of knowledge and skills related to the implementation of the project.
3. Obtaining additional points for activity during classes, especially for:
  - proposing to discuss additional aspects of the issue,
  - the effectiveness of applying the acquired knowledge while solving a given problem,
  - the ability to cooperate as part of a team, practically carrying out a detailed task in the laboratory,
  - remarks related to the improvement of teaching materials.

### OBSERVATIONS.

Teacher-Led Observations

## 8. BIBLIOGRAPHY AND TEACHING MATERIALS.

Basic:

1. A. Dąbrowski, Przetwarzanie sygnałów przy użyciu procesorów sygnałowych, Wydawnictwo Politechniki Poznańskiej, Poznań, 2000.
2. R. G. Lyons, Wprowadzenie do cyfrowego przetwarzania sygnałów, Wyd. II, WKŁ, W-wa, 2010.

3. T.P. Zieliński, Cyfrowe przetwarzanie sygnałów. Od teorii do zastosowań, Wyd. II, WKŁ, W-wa, 2014.
  4. S. R. Ball, "Embedded Microprocessor Systems: Real World Design", Elsevier Science, 2002.
  5. Technical documentation of microcontrollers NVIDIA Jetson and their application notes and educational materials - available on the websites of NVIDIA and GitHub.
  6. Semantic Intelligent Computing and Applications, Walter de Gruyter GmbH, Berlin/Boston 2024
  7. Deep Learning Research and Applications, Walter de Gruyter GmbH, Berlin/Boston 2020
  8. Deep Learning for Cognitive Computing Systems Technological Advancements and Applications, Walter de Gruyter GmbH, Berlin/Boston 2023
  9. Artificial Intelligence Machine Learning, Convolutional Neural Networks and Large Language Models, Walter de Gruyter GmbH, Berlin/Boston 2024
  10. Magnus Ekman - Learning Deep Learning Theory and Practice of Neural Networks, Computer Vision, Natural Language Processing, and Transformers U (2021, Addison-Wesley Professional)
- Additional:**
1. Fitz M. P., Fundamentals of Communications Systems, 2007, McGraw-Hill
  2. Hsu Hwei P., Schaum's Outlines of Theory and Problems of Signals and Systems, 1995, McGraw-Hill
  3. W. Kester, The Data Conversion Handbook, Elsevier, 2005
  4. Artificial Intelligence for Signal Processing and Wireless Communication, Walter de Gruyter GmbH, Berlin/Boston 2022