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Project-based learning in the Embedded Systems Masters

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https://drive.google.com/file/d/1QiKcXIfDN3EIbbCwVciCPGpc-V6dUC5o/view?usp=drive_web

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Brief Introduction to the speaker

- Teaching experience in Software Engineering (>20 years)
- Research interests:
  - Digital Twins
  - Applied AI
  - System Verification
  - Reliability of cyber-physical systems
- International Experience (>10 years):
  - Coordinator of the Erasmus CBHE projects
  - Coordinator Erasmus KA 171
  - Participation in DAAD projects
- Publications
  - More than 150 publications.
  - Scopus h-index – 9
  - Researcher Id h-index – 7
  - Author Profiles
    - SCOPUS authorId=56007319800
    - ResearcherID V-1838-2017
    - ORCID orcid.org/0000-0003-1429-5180

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Plan

- Context: FH Dortmund international projects with Ukraine
- Project Based Learning approach for “Applied Embedded Systems” course

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FH Dortmund international projects with Ukraine

EUROPIM

Education ⌄ Projects Events

ViMaCs: Virtual Master Cooperation Data Science

Project-ID: 57513461 (Phase 1), 57602060 (Phase 2)

The project creates the necessary conditions for the Ukrainian partners for digital and virtual teaching and learning infrastructure in the area of data science, which is very important for digital transformation. In relation to the funding objectives of the call for proposals, ViMaCs contributes to establishing the model of the virtual cross-border Master School as a cooperation and internationalization instrument in Ukraine.

The core of the project is the development and implementation of a digital teaching and learning offer in the field of the versatile and highly up-to-date "Data Science" by developing an innovative and inherently digitized structure of a Master School.

WORK4CE

Co-funded by the Erasmus+ Programme of the European Union

About the project Scope, goals and outcomes Project partners Working space
Consortium events and meetings News WORK4CE digital portal

WELCOME TO WORK4CE:

Cross-domain competences for healthy and safe work in the 21st century

Project Reference: 619034-EPP-1-2020-1-UA-EPPKA2-CBHE-JP

Work4CE addresses the need for educational resources in order to prepare for the future workplace (work 4.0). Interdisciplinary curricula and modules are developed and new forms of (virtual) university-enterprise collaboration are deployed to improve the practical value of the curricula and the employability of the graduates. With the implementation of the successful co-production

fessional associations new, job-related developed.

dustry in the partner countries and rmation of working environments, to strategy), to transform into a sustainable ealth and environmental protection.

Contact

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News & Events

Erasmus+ WORK4CE Pilot Training in WUNU

November 20, 2024 | News

As part of pilot training under the Erasmus+ KA2: Capacity Building in Higher Education "Cross-domain

More →

UA4PIM

DAAD

Federal Ministry of Education and Research

About the project Scope, goals and outcomes Project partners
Working space News Digital Portal

Welcome to UA4PIM:

Project and Innovation Management for Ukraine

Project Reference: 57808575

For over 15 years, Dortmund University of Applied Sciences and Arts has worked closely with three Ukrainian universities – **National University "Zaporizhzhia Polytechnic" (NUZP), Kyiv National University of Construction and Architecture (KNUCA)**, and **West Ukrainian National University (WUNU) in Ternopil**. Within the framework of the German-Ukrainian Higher Education Network (DUHN), this long-standing collaboration is to be secured, expanded, and developed into a University Alliance (UA) focusing on project management, digitalisation, innovation, and sustainability.

Through the DAAD-funded project, the University Alliance for Project and Innovation Management (UA4PIM) will be established and directly integrated into the **European Partnership for Project and**

Funded by

DAAD
Deutscher Akademischer Austauschdienst
German Academic Exchange Service

Federal Ministry of Education and Research

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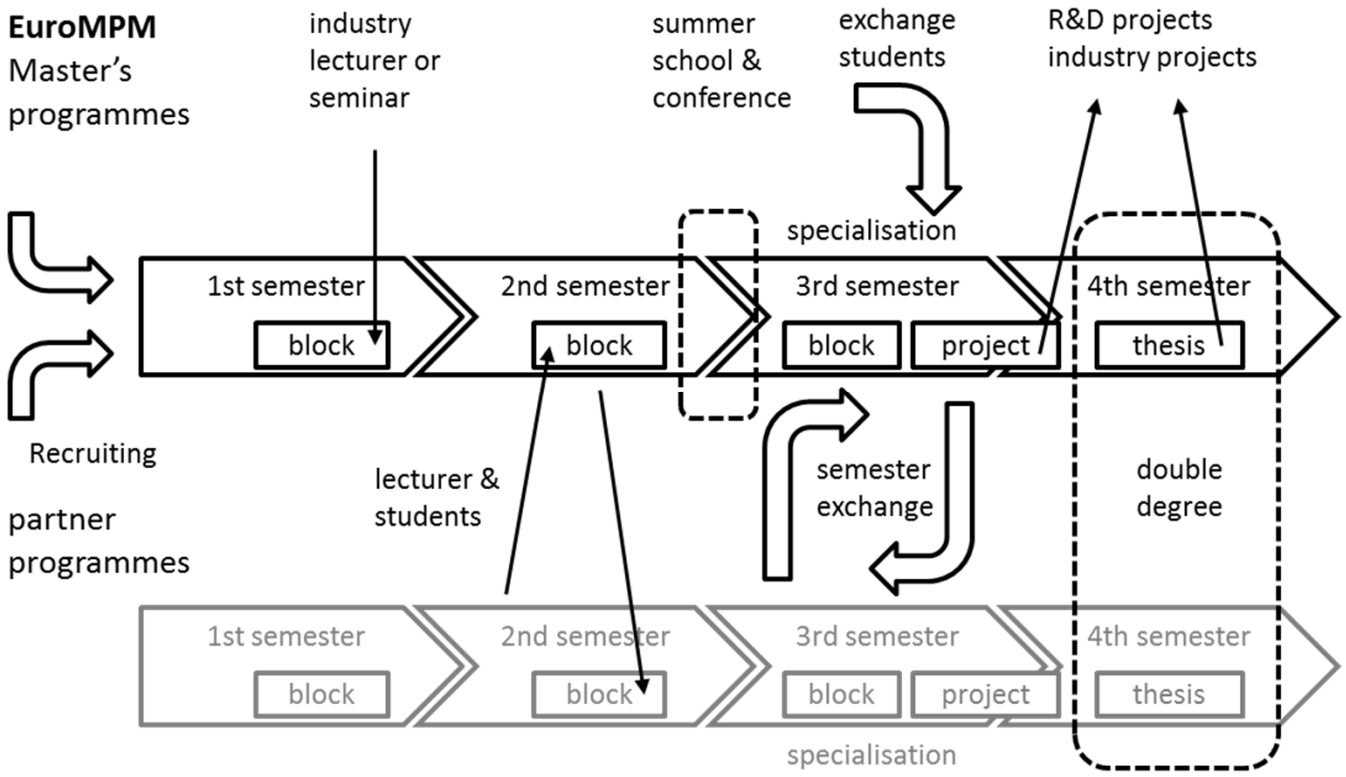
Virtual Master School



How to integrate in one course:

- students with different background
- students with different English language level
- students located in different countries?

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Project Based Learning

Pilot teaching: use case FH Dortmund

Block week in FH Dortmund

Pitch of the concept

Processing E-learning material

Uploading solution to the DEE

Co-funded by the Erasmus+ Programme of the European Union

Erasmus+ KA2, CBHE „WORK4CE" project
619034-EPP-1-2020-1-UA-EPPKA2-CBHE-JP

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Embedded Systems Engineering - ESE

EUROPIM

Education Projects News Events About EuroPIM Search

ACADEMIC DEGREE
Master of Engineering (M.Eng.) issued by FH Dortmund

LOCATION
Dortmund, Germany

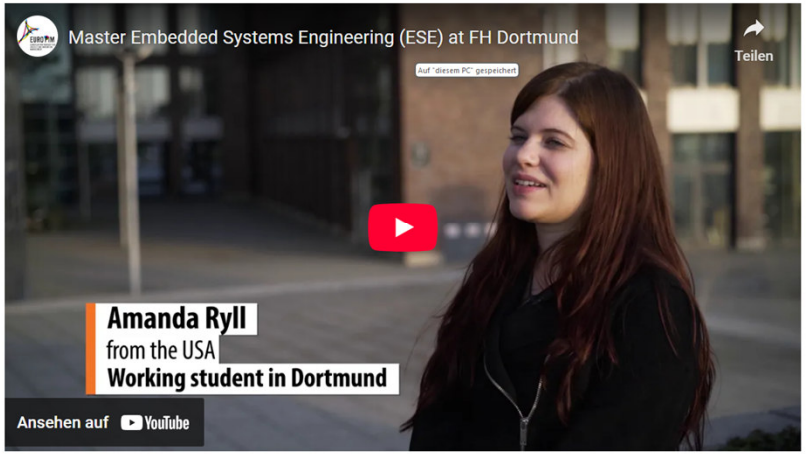
STANDARD PROGRAMME DURATION
4 Semesters, starts in Winter

LANGUAGE OF INSTRUCTION
English

ADMISSION
Unrestricted with pre-check

APPLICATION PERIOD FOR NON-EU CITIZEN
From 1 April to 15 June (Application process)

APPLICATION PERIOD FOR EU



Embedded Systems Engineering - ESE
From university to high-tech industry.

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Applied Embedded Systems

Knowledge

Knows standards and platforms for specific domain

Knows target systems

Has acquired overview of target domain

Skills

Can describe relevant characteristics and challenges of application domain

Can model mechatronic systems for the domain

Can apply methodology and state of the art tools on real use cases

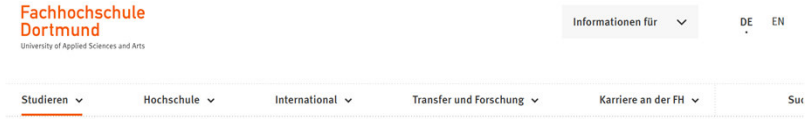
Can select tools and define tool chains and design flows

Competence - attitude

Can structure a real mechatronic systems design project

Can communicate and find solutions with domain experts

Understands issues from application domains and can integrate solutions into a holistic design



Module Handbook Master Embedded Systems Engineering

Number	MOD-E01
Title	Applied Embedded Systems
Language	English

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Applied Embedded Systems

- 6 Lab sessions to gain practical skills
- Capstone project – research component of the course

- Course success rate
  - 2023 80 %
  - 2024 75%

- Project topics examples:
  - Neural Networks on FPGA
  - FPGA-Based CNN Acceleration for Autonomous Driving
  - FPGA-based acceleration for CNN in Image classification
  - FPGA in IoT Edge Computing

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Task and student project outcome

The aim of the project to provide the literature research.

Outcome:

- students learn how to provide the literature research
- students understand the current state of fields of implementation of FPGA
- students have the systematic overview of possibilities of ML application on FPGA

Criteria	Ratings			
	Excellent 50-40 points	Good 40-30 points	Fair 30-25 points	Need improvement
Quality of the material	The topic is completly covered, content are according the requirement, in the research there were analysed from 5 to 6 high quality sources (IEEE, ACM, Springer).	The topic is generally covered, content aremostly according the requirement, in the research there were analysed from 3 to 4 high quality sources (IEEE, ACM, Springer) and Internet resources	The topic is generally covered, content are mostly according the requirement, in the research there were analysed from 1 to 2 high quality sources (IEEE, ACM, Springer) and Internet resources	Sources are only from the Internet, text is AI generated
Quality of presentation	Presentation contains all information with the usage of graphical and table views. There are some missed information in the slides: Some errors in spelling and grammar	Presentation contains all information with the usage of graphical and table views. There are some missed information in the slides: Some errors in spelling and grammar	Presentation contains a lot of unstructured text . There are some missed information in the slides. Fewer errors in spelling and grammar	Presentation contains a lot of unstructured text . Required information missed at the slides. A lot of errors in spelling and grammar

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Applied Embedded Systems

Presentation

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- Title
- Team presentation
- Research hypothesis and tasks
- Paper1: Task, Input data, output data, solution(methods and tools), results
- Paper2: Task, Input data, output data, solution(methods and tools), results
- Paper2: Task, Input data, output data, solution(methods and tools), results
- Summary
- List of referencies

AI Generated Reviews:

1. Non existing referencing
2. Incorrect description of the task
3. Absent analysis of the solutions

Conclusions

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COMPARISON OF FPGA IMPLEMENTATIONS OF NEURAL NETWORKS

Paper Title and Reference	Application Domain	Neural Network Type	FPGA Platform	Performance Metrics	Notable Findings
Paper 1: Fixed-point FPGA Implementation of ECG Classification Using Artificial Neural Networks	ECG Classification	ANN	Xilinx Zybo	1.856 µs classification time, 100% accuracy	Direct feed of preprocessed ECG signals, 8-bit fixed-point arithmetic, real-time capability
Paper 2: FPGA Implementation of a Convolutional Neural Network for Image Classification	Image Classification	CNN	PYNQ-Z1	78.20% accuracy (Fruits Classifier)	Fixed-point arithmetic, significant speed and resource efficiency improvements
Paper 3: Pattern Classification Using Quantized Neural Networks for FPGA-Based Low-Power IoT Devices	IoT Devices	QNNs, BNNs	Xilinx Zynq 7020	Competitive accuracy, reduced eur-	Emphasis on lightweight
Paper 4: FPGA Implementation of a Complex-Valued Neural Network for Polar-Represented Image Classification	Image Classification	CVNN	Not specified		
Paper 5: An Efficient FPGA-Based Convolutional Neural Network for Classification: Ad-MobileNet	Image Classification	Enhanced CNN (Ad-MobileNet)	Not specified		

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FPGA Implementation

- **Frameworks and Tools :**
  - High-Level Synthesis (HLS): Use HLS tools to write CNN models in high-level languages like C/C++ or OpenCL, which are then converted to HDL (Hardware Description Language)
  - **FINN**: Xilinx's framework for deploying quantized neural networks
  - Xilinx Vivado HLS: For Xilinx FPGAs
  - Intel FPGA SDK for OpenCL: For Intel FPGAs
- **Deep Learning Libraries:**
  - **hls4ml**: High-level synthesis library for machine learning

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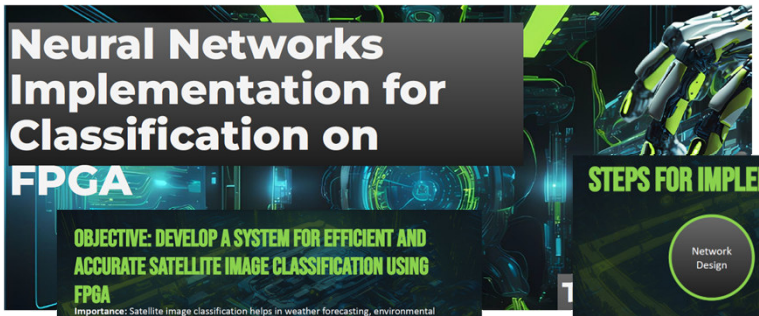
Overview of FPGA-based deep learning accelerators

FPGAs can be 40× more efficient than CPUs, 11.5× over GPUs
Techniques: parallelism, optimized memory, Roofline model
Challenges: complex programming, runtime re-config
Conclusion: High potential, but tool improvement needed

FPGA-Based CNN Acceleration for Autonomous Driving



OBJECTIVE: DEVELOP A SYSTEM FOR EFFICIENT AND ACCURATE SATELLITE IMAGE CLASSIFICATION USING FPGA

Importance: Satellite image classification helps in weather forecasting, environmental monitoring, and disaster management.

Challenges: High computational demands and power constraints of satellite systems.

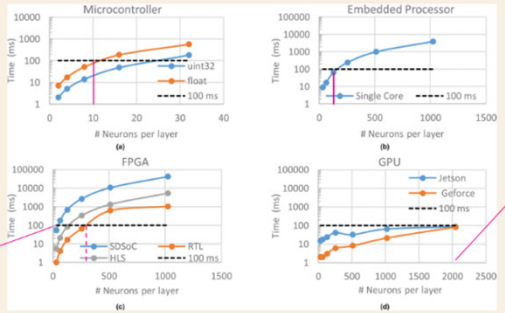
The paper discusses how to build a system that can quickly and efficiently classify satellite images into different categories (like identifying clouds or non-cloud areas) using FPGA.

CAPSTONE PROJECT

FPGA-BASED FOR EDGE COMPUTING APPLICATIONS

PAPER 3:
COMPUTING IN THE BLINK OF AN EYE: CURRENT POSSIBILITIES FOR EDGE COMPUTING AND HARDWARE-AGNOSTIC PROGRAMMING

Performance results for the studied platforms:



Pipelined implementation to reach parallelism between layers => achieves the highest performance

maximum performance and the best ratio of computation performance to power consumption

(a) microcontroller, (b) embedded processor
(c) FPGA RTL, HLS and SDSoC implementations, (d) Jetson TX2 and GForce GPUs.

[3] M. H. Ghasemi, O. Lucia and S. Lucia, "Computing in the Blink of an Eye: Current Possibilities for Edge Computing and Hardware-Agnostic Programming," in IEEE Access, vol. 8, pp. 41626-41636, 2020, doi: 10.1109/ACCESS.2020.2977087.

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Thank you
for your attention!!!!