International ICT Doctorate School

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University of Modena and Reggio Emilia, Italy
• 3 years program

• 3 curricula:
  • "Computer Engineering and Science"
  • "Electronics and Telecommunications";
  • "Industrial applications of ICT".

• Phd Students should acquire **180 ECTS**
  • **130 ECTS** for research training activities; (45,45,40 publications and research)
  • **30 ECTS** for educational activities; (first 2 years)
  • **20 ECTS** for the preparation of the PhD thesis.

English is the official language. All courses are taught in English!
Concerning the **research training** for each PhD student, a key role is played by the guidance action carried out by **his/her academic tutor and eventually his/her co-tutor**.

Said training should aim to involve PhD students in:

- **large-scale projects**, promoted by national and international collaborations, and in research contracts with **institutions or industries**. In this context, the opportunity to carry out
- **short training periods** (summer jobs) or
- **long-term** (internship) in companies operating in the various districts present on our territory or in national or international research centers is particularly important.
Educational activities

The educational activities are organized and coordinated by the PhD School Council and take place mainly in the Engineering Department "Enzo Ferrari" (DIEF) or in other departments of the University.

By educational activities we mean:

- seminars, tutorials (offered, for example, at international conferences), distance learning courses, certifications and courses organized by companies, courses offered within the framework of a master's degree or a PhD course. Two main kind of educational activities are considered:

  - **Educational activities with evaluation** - This kind includes the activities listed above for which the doctoral student is responsible for the final evaluation of the learning with relative evaluation. Each year, at least one of such educational activities is established by PhD Academic Council and approved in advance by the PhD Teaching Commission.

  - **Educational activities without evaluation** - This kind includes the activities listed above for which a final verification test is not carried out by the PhD student; however, a certificate of participation is required to acquire the corresponding CFDs.
2019 Research Topics: Computer Engineering and Science

**Big Data and Analytics:**
- Pay-as-you go Big Data Integration Tutor: Domenico Beneventano [Cotutors: Sonia Bergamaschi, Felix Naumann –University of Postdam]
- Action Recognition to estimate Activities of Daily Living (ADL) of elderly people Tutor: Sonia Bergamaschi
- Big data analytics and prediction techniques for healthy aging Tutor: Federica Mandreoli [Cotutors: Riccardo Martoglia]
- Traffic Modelling and Simulation for Smart Mobility Tutor: Laura Po

**Machine Learning theory and applications**
Continual learning techniques applied to lifelong systems Tutor: Simone Calderara
Machine Learning techniques for Databases Tutor: Francesco Guerra [Cotutors: Matteo Interlandi (Microsoft)]
Generative models and and deep learning for fintech Tutor: Simone Calderara [Cotutors: Daniele Grassi Axyon AI]
Artificial Conversational Entity (Chatbot) Tutor: Sonia Bergamaschi-[Cotutors: ing. Andrea Prandini, prof. Roberto Zicari,Carl Goethe University, Frankfurt]

**Autonomous systems, Agents and Middleware**
- Autonomic computing for collective self-adaptive systems Tutor: Giacomo Cabri
- Multi-level organization of complex systems Marco Villani
- Adaptive Middleware for the Internet of Things Tutor: Letizia Leonardi[Cotutors: Giacomo Cabri, Prof. Franco Zambonelli (DISMI)]

**Cybersecurity:**
- Innovation and applications of blockchain technologies Tutor: Michele Colajanni
- Protection and valorization of industrial data Tutor: Michele Colajanni-

**AI and Deep Learning for Computer Vision and Visual Understanding:**
- Artificial Intelligence for Cultural Heritage Tutor: Rita Cucchiara
- Design and development of the European Computer Vision Library Tutor: Costantino Grana
- Computer Vision and Artificial Intelligence for Collaborative Robotic Environments Roberto Vezzani
- Multimedia Data Learning: Big Multimedia Data Processing, Understanding, Retrieval by Learning Tutor: Rita Cucchiara Grant by RER
Control theory and Robotics:

• Shared control for robotic systems: from pre-planned tasks to autonomous execution Tutor: Luigi Biagiotti [Cotutors: Laura Giarrè]
• Multi sensors Localization and navigation for self-driving application Tutor: Laura Giarrè
• Repetitive control for electromechanical systems Tutor: Roberto Zanasi [Cotutors: Luigi Biagiotti]

Telecommunications:

• Vehicular Connectivity in 5G and Beyond Tutor: Maria Luisa Merani
• Multiple-input multiple-output radars for automotive applications Tutor: Giorgio Matteo Vitetta

Electromagnetism and Photonic:

• Hollow core optical fibers for industrial applications Tutor: Luca Vincetti
• Photonic Technologies for real time monitoring of product quality in manufacturing and agri-food industry - Tutor: Luca Vincetti Grant by RER

Electronics (Micro, Intelligent Sensing, Edge Devices):

• Analysis of pulmonary sounds for the diagnosis of interstitial lung diseases Tutor: Fabrizio Pancaldi
• Innovative Devices and Circuits for Edge Computing Tutor: Francesco Maria Puglisi
• Optoelectronic methods and instrumentation for vision research Tutor: Luigi Rovati [Cotutors: Rafat Ansari (NASA Glenn Research Center in Cleveland)]
• Characterization of Wide-Band-Gap Semiconductor Power Devices Tutor: Alessandro Chini
Research Institution:

CO-tutorship:
Institut Polytechnique de Grenoble, Università Bordeaux I, Università Paul Sabatier, Università Bordeaux I, Univ Paris-Sud

Agreements:
Institute of Telecommunications, Vienna University of Technology, University of Zaragoza, Erik Jonsson School of Engineering and Computer Science (University of Texas at Dallas), University of California in Los Angeles (UCLA), Computer Science Department, University of Manchester, School of Electrical and Electronic Engineering, University of Amsterdam, Computer Science Department, University of Sunderland, Faculty of Applied Sciences

Companies:
Panasonic, NVIDIA, Amazon, Facebook, Ferrari, Maserati, Tetrapak, Alstom, Axyon Fintech, Farm for Trade (AI for agrifood and EO), QUIX, SYSTEM spa, DataRiver
Research Activities Showcase
Computer Engineering and Science and Robotics
Current Members:

5 faculty

Sonia Bergamaschi
Dean of the ICT doctorate
(ACM distinguished researcher)

Domenico Beneventano

Maurizio Vincini

Francesco Guerra

Laura Po

– 1 research fellow

• Giovanni Simonini (IEEE best Computer Science phd thesis award 2017)

– 4 ICT PhD students

• Gagliardelli Luca (Emilia-Romagna phd scholarship on Big Data Integration & Analysis 3rd year)
• Giovanni Morrone (Speech Recognition phd at Doctorate School Industria 4.0 2nd year)
• Mario Alsini (Intelligent Chatbot - 1st year)
• Beatrice Nale (Intelligent Chatbot - upcoming)

Member of the Italian

CINI Big Data Lab

CINI Artificial Intelligence & Intelligent Systems

Founder of 1 spin-off (now innovative SME) to deploy the MOMIS Data Integration System www.datariver.it
Big Data Integration

The data scientist’s time [1]:

80% is spent for:  
• Data Integration  
  - Data Preparation  
  - Data Cleaning

Only 20% is spent for:  
• Actual Data Analysis

At DBgroup, we are developing automatic techniques to minimize the time that data scientists are spending preparing the data:

So they can focus more on what they want to do (and are paid for):

Integration, Analytics and Mining on Big Data

- Techniques for describing and analyzing the content of large datasets
  - M. Paganelli, P. Sottovia, A. Maccioni, M. Interlandi, F. Guerra: Understanding Data in the Blink of an Eye, CIKM 2019

- Big Data Integration:
  - F. Guerra, P. Sottovia, M. Paganelli, M. Vincini: Big Data Integration of Heterogeneous Data Sources: The Re-Search Alps Case Study. BigData Congress 2019: 106-110
  - P. Sottovia, M. Paganelli, F. Guerra, Y. Velegrakis: TuneR: Fine Tuning of Rule-based Entity Matcher, CIKM 2019

- Data Mining techniques on Relational Databases
  - Continuous Deployment in R-DBMS (work in progress)

People: Sonia Bergamaschi, Francesco Guerra, Maurizio Vincini, Laura Po, Domenico Beneventano
Study Deep Learning techniques for:

• People tracking
• People detection 2D and 3D
• Human Behavior understanding
• Anomaly Detection
• Vehicles-human interaction
• Geometric view synthesis

Conferences and Journals:
CVPR, ICCV, TPAMI, TIP, TMM

Projects and Collaborations:
PRIN COSMOS and PREVUE, EU PRYSTINE, EU ARROWHEADTOOLS, Panasonic Beta LABS, NVIDIA

AlimageLab Group: Rita Cucchiara, Roberto Vezzani, Simone Calderara
http://aimagelab.ing.unimore.it
**Embodied AI**: Integration between Vision, Language and Action
- Automatic description of Images and Video
- Natural Language and multi-modal retrieval
- Vision and Language Navigation
- Navigation of embodied agents in unseen environments

Applications in Cultural Heritage and Digital Humanities

**Conferences and Journals:**
CVPR, ICCV, TPAMI, TIP, TMM

**Projects and Collaborations:**
- IDEHA, CULTMEDIA, AI4CH, AI4DH
- Facebook AI Research, NVIDIA, University of Haifa (Israel)

**AImageLab Group**: Rita Cucchiara, Massimiliano Corsini, Lorenzo Baraldi

http://aimagelab.ing.unimore.it
Deep Learning and Graph based analysis for:

• Satellite Images self-supervised feature extraction
• Inference of physical phenomena from EO
• Epidemic and vectors analysis using temporal EO

Projects and Collaborations:

AI4VECT Italian Ministry of Health, 
AIDEO European Spatial Agency

AlmageLab Group: Simone Calderara, Angelo Porrello
http://aimagelab.ing.unimore.it
Medical Imaging

Lesion diagnosis

- Actinic Keratosis
- Benign Keratoses
- Dermatofibroma
- Nevus
- Basal Cell Carcinoma
- Melanoma

Lesion boundary segmentation and attribute detection

- Third-place (out of 64 research groups) at the 2019 international ISIC challenge (lesion diagnosis)


- Intensity, patterns and locations of antibody deposits in immunofluorescence images from renal biopsies

AImageLab Group: Costantino Grana, Federico Bolelli
http://aimagelab.ing.unimore.it
**FIRST EU H2020 vF Interoperation suppoRting buSiness innovaTion**

The research aims at exploring the exploitation of software abstractions to manage the assets of manufacturing industries. An important aspect is the interoperability at both intra-factory and inter-factories levels, in order to support adaptation to uncertainty and enactment of dynamic supply chains.

**IoT – enabled Predictive Parking**

The project aims at developing an industrial-grade testbed for smart parking technologies. Bosch provides the physical sensors, while LGH and a2a groups provide LoraWAN connectivity and competences within the multi-utility sector. UNIMORE provides expertise in data management, visualization and predictive analysis.

People: Giacomo Cabri, Letizia Leonardi, Nicola Bicocchi
People: Marco Villani

Research Activities:

• Evolution of natural and artificial systems
• Criticality hypothesis
• Identification of the dynamical cores of complex systems
• Multi-level organization of (self-organizing) dynamically critical systems

Collaborations

• Institute for Systems Biology, Seattle
• European Organization for Nuclear Research (CERN)
• European Centre for Living Technology (Cà Foscari University, Venice)
Research directions and methodologies:

- Management of **cloud** and **multi-cloud** data centers
  - Energy consumption and cost optimization with SLA
  - Main tools: Game theory and simulation
- Deployment of **fog** infrastructures
  - Cost and Performance Optimization optimization
  - Theoretical models and heuristics (Genetic Algorithms)
- **Cooperation** strategies for fog nodes
  - Design of cooperation algorithms
  - Simulation of realistic (geographically distributed) scenarios

Collaborations with other universities:
- Prof. Danilo Ardagna, Polytechnic University of Milan
- Prof. L. Chiaraviglio, University of Rome “Tor Vergata”
- Prof. R. Beraldi, University of Rome “La Sapienza”

Some results:
People: L. Giarré, R. Zanasi, L. Biagiotti, P. Falcone, D. Tebaldi

Research activity:
- Modeling and control of electro-mechanical systems
- Planning and control of Robots and autonomous systems
- Collaborative Robotics
- Filtering and data fusion in Localization and Navigation systems
- Model Predictive Control and Multi step Identification in Automotive Applications
- Learning in mixed human-machine environments
- Networked control for constrained systems
- Social Innovations (ICT for intellectual disabilities and Assistive Technologies for Blind)

Industrial Partner: CNH, Ericsson, Toyota, Volvo, IMA, Sacmi, Coesia

Collaborations: NTNU (S. Gros, L. Jaccheri), Chalmers University (Sweden), JKU (Austria), NTU(Taiwan)

Italy: Polimi, IMT Lucca, UNIPA
Logic-in-Memory and Brain-Inspired Computing Architectures

• Logic-in-Memory Circuits
  Exploring emerging non-volatile memories (e.g., RRAM, PCM, FeRAM) to realize next-generation ultra-low power edge computing architectures. Exploit experiments and simulations to develop innovative solutions by implementing original device/circuit co-design strategies.

• Brain-Inspired Computing
  Development of new brain-inspired computing paradigms beyond Boolean logic for high-performance low-power AI systems. Exploit the properties of new non-volatile memories to implement synaptic behavior and learning possibilities directly on chip.

• Partners
  SUNY @ Albany (NY) – Applied Materials – ETH Zurich – NamLab – IBM – Soochow University – …

• Venues: Flagship IEEE conferences (ESSDERC, IRPS, IIRW, IEDM)

• Projects: BeFerroSynaptic (H2020)

People: Paolo Pavan, Francesco Maria Puglisi
Electronics and Telecommunications
5G Vehicular and Public Safety Communications

UNIMORE Networking Lab

**V2X Communications**
- Focus on safety-related applications
- Analysis of application-level performance
- Field tests!

Partners: ALSTOM SA
Applications: connected and autonomous vehicles

**Public Safety Networks**
- 4G and 5G Networks in the aftermath of a disaster
- Earthquake Early Warning Systems

Applications: natural and man-made disasters

**Network Softwarization**
- Software-Defined Networking
- Network Function Virtualization
- Field tests!

Applications: data centers and network management

**Green communications**
- Reducing energy consumption in 5G networks
- Energy savings in SDN appliances

Applications: 5G network architectures and SDN

netlab.unimore.it
Detection and Estimation Techniques for MIMO Radars

Deterministic Algorithms for MIMO FMCW and SFCW Radars

- Range and DOA estimation techniques
- Test on commercial radar devices
- Operating frequency: 5-77 GHz

Automotive applications

- Velocity estimation based on the Doppler effect
- Two- and three-dimensional imaging
- Exploitation of hardware for parallel computing

Partners: CNH Industrial
Collaboration: KULeuven

Machine Learning and Deep Learning algorithms

- Training based on data acquired from commercial radars
- Application to gesture recognition through micro-Doppler signature

Cognitive radar

- Filtering methods for target tracking
- Interference and clutter mitigation
- Multi-radar coexistence

www.sigcomm.unimore.it

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Human iris hyperspectral imaging

Optical sensors for blood analysis

Ophthalmic instrumentation

Microfluidics and bioprinting

Nanoscale capacitance imaging of analytes

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- Coordinator for Computer Engineering and Science curriculum: Prof. Domenico Beneventano
- Coordinator for Electronics and Telecommunications curriculum: Prof. Giorgio Matteo Vitetta
- Coordinator for Industrial applications of ICT curriculum: Prof. Simone Calderara

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