MAIA | Erasmus Mundus Joint Master

MAIA
Course Catalogue

2027 – 2029

Universitat de Girona | Université Bourgogne Europe | Università degli Studi di Cassino e del Lazio Meridionale

Course catalogue

Semester 1:

- M11: Medical Imaging Physics & Acquisition
- M12: Mathematics for Medical Artificial Intelligence
- M13: Introduction to Robotics for Medical AI
- M14: Digital Image Processing for Medical Applications
- M15: Programming for Medical Imaging
- M16: Scientific and Critical Thinking in Medical Research

Semester 2:

- M21: Machine Learning for Medical Data
- M22: Deep Learning for Medical Imaging
- M23: Robotics for Medical Applications
- M24: Medical Image Segmentation and Analysis
- M25: Regulation, Ethics and Trustworthy AI in Healthcare
- M26: Innovation, Translation and Teamwork in Medical AI

Semester 3:

- M31: Advanced Methods in Medical Imaging and AI
- M32: Multimodal and Longitudinal Medical Imaging Analysis
- M33: Self-Supervised and Foundation Models in Medical Imaging
- M34: Image-Guided Medical Interventions
- M35: Evaluation and Validation of Medical AI Systems
- M36: Regulatory and Professional Context in Medical AI

Semester 4:

- M41: MSc Project
- M42: Scientific Writing and Publishing
- M43: Secure Deployment of Medical AI Systems
- M44: Career Development and PhD Preparation

Semester 1

Université Bourgogne Europe

Medical Imaging Physics and Acquisition

6 ECTS

Learning Outcomes

- Explain the physical principles underlying the main medical imaging modalities.
- Describe image formation and acquisition processes in MRI, CT, PET, and ultrasound.
- Relate acquisition parameters and physical factors to image quality and image characteristics.
- Assess image quality and identify factors that may affect the reliability of medical imaging data.

Topics / Contents

- Physical principles of medical imaging
- Image formation and acquisition
- Magnetic resonance imaging (MRI)
- Computed tomography (CT)
- Positron emission tomography (PET)
- Ultrasound imaging
- Image quality and quality assessment

Mathematics for Medical Artificial Intelligence

6 ECTS

Learning Outcomes

- Apply probability and statistical concepts to medical artificial intelligence problems.
- Formulate and analyse optimisation problems arising in machine learning and medical imaging.
- Apply regularisation techniques to improve model robustness and generalisation.
- Use information-theoretic concepts relevant to medical data analysis and AI.

Topics / Contents

- Probability and statistics
- Optimisation methods
- Regularisation
- Information theory
- Mathematical foundations of machine learning and medical AI

Introduction to Robotics for Medical AI

6 ECTS

Learning Outcomes

- Describe fundamental concepts and components of robotic systems for medical applications.
- Represent spatial relationships using coordinate systems and rigid transformations.
- Apply basic homographies and geometric transformations to robotic perception problems.
- Explain sensor models and their role in perception for medical robotic systems.

Topics / Contents

- Fundamentals of robotics for medical AI
- Coordinate systems
- Rigid transformations
- Homographies
- Sensor models
- Robot perception

Digital Image Processing for Medical Applications

5 ECTS

Learning Outcomes

- Apply fundamental image processing techniques to medical images.
- Select appropriate filtering and enhancement methods for specific imaging problems.
- Apply classical methods for image segmentation, registration, and feature extraction.
- Assess the effect of image processing operations on subsequent analysis.

Topics / Contents

- Image filtering
- Image enhancement
- Image segmentation
- Image registration
- Feature extraction
- Classical medical image processing

Programming for Medical Imaging

5 ECTS

Learning Outcomes

- Develop Python programs for medical imaging and AI applications.
- Use scientific computing libraries to manipulate, analyse, and visualise medical imaging data.
- Implement reproducible computational workflows for medical image analysis.
- Apply sound programming practices to research and applied medical imaging problems.

Topics / Contents

- Python programming
- Scientific Python libraries
- Medical image I/O and manipulation
- Data analysis and visualisation
- Reproducible computational workflows
- Programming practices

Scientific and Critical Thinking in Medical Research

2 ECTS

Learning Outcomes

- Critically analyse scientific literature in medical technology and medical imaging.
- Assess methodological strengths, limitations, and evidence presented in research articles.
- Formulate and communicate evidence-based scientific arguments.
- Discuss scientific findings clearly in an academic and interdisciplinary context.

Topics / Contents

- Critical reading of scientific literature
- Methodological analysis
- Evidence assessment
- Scientific argumentation
- Discussion and presentation of research findings

Semester 2

Università degli Studi di Cassino e del Lazio Meridionale

Machine Learning for Medical Data

6 ECTS

Learning Outcomes

- Apply classical machine learning methods to medical datasets.
- Select appropriate regression and classification approaches for medical problems.
- Use ensemble methods and model selection techniques to develop robust predictive models.
- Evaluate machine learning models using appropriate performance measures.

Topics / Contents

- Regression
- Classification
- Ensemble methods
- Model selection
- Model evaluation
- Machine learning for medical datasets

Deep Learning for Medical Imaging

6 ECTS

Learning Outcomes

- Explain the principles underlying deep learning methods for medical imaging.
- Design and train deep learning models for medical image analysis tasks.
- Apply deep learning architectures to image detection and related medical imaging problems.
- Apply deep learning approaches to medical image registration and assess their performance.

Topics / Contents

- Deep learning architectures
- Training and optimisation
- Medical image analysis
- Object detection
- Deep learning for image registration
- Model evaluation

Robotics for Medical Applications

6 ECTS

Learning Outcomes

- Analyse model-based and data-driven approaches for robotic systems in healthcare.
- Apply visual servoing techniques to medical robotic applications.
- Explain principles of human–robot interaction in clinical environments.
- Integrate automatic control and machine learning for reliable and adaptive medical robots.
- Assess safety requirements for robotic systems operating in clinical settings.

Topics / Contents

- Model-based and data-driven robotics
- Visual servoing
- Human–robot interaction
- Safety-critical control
- Automatic control and machine learning
- Adaptive medical robots

Medical Image Segmentation and Analysis

5 ECTS

Learning Outcomes

- Apply classical and learning-based methods for medical image segmentation.
- Select appropriate segmentation approaches for different medical imaging problems.
- Estimate and interpret uncertainty in medical image segmentation.
- Evaluate segmentation results using appropriate quantitative measures.
- Relate segmentation performance to clinical relevance and downstream applications.

Topics / Contents

- Classical segmentation
- Learning-based segmentation
- Segmentation uncertainty
- Segmentation evaluation
- Clinical relevance of segmentation outputs

Regulation, Ethics and Trustworthy AI in Healthcare

5 ECTS

Learning Outcomes

- Explain the main regulatory and ethical requirements governing AI in healthcare.
- Analyse the implications of the EU AI Act, Medical Device Regulation, and relevant FDA pathways.
- Apply principles of explainability, fairness, accountability, and risk management to medical AI.
- Identify data protection and compliance requirements relevant to AI-based medical technologies.

Topics / Contents

- EU AI Act
- Medical Device Regulation (MDR)
- FDA regulatory pathways
- Explainability and interpretability
- Fairness and bias
- Accountability
- Risk management
- Trustworthy AI

Innovation, Translation and Teamwork in Medical AI

2 ECTS

Learning Outcomes

- Explain key stages of innovation and technology transfer in medical AI.
- Identify translational pathways from research results to healthcare applications.
- Work effectively in multidisciplinary teams to address medical AI challenges.
- Communicate and pitch medical AI solutions to different stakeholders.

Topics / Contents

- Innovation processes
- Technology transfer
- Translation of medical AI
- Multidisciplinary teamwork
- Project pitching
- Stakeholder communication

Semester 3

Universitat de Girona

Advanced Methods in Medical Imaging and AI

6 ECTS

Learning Outcomes

- Analyse state-of-the-art AI methods for medical imaging.
- Apply generative and diffusion models to advanced medical imaging problems.
- Critically compare emerging AI architectures and methodological approaches.
- Identify current research challenges and opportunities in medical imaging AI.

Topics / Contents

- State-of-the-art AI
- Generative models
- Diffusion models
- Emerging architectures
- Advanced medical imaging applications
- Current research challenges

Multimodal and Longitudinal Medical Imaging Analysis

6 ECTS

Learning Outcomes

- Integrate heterogeneous imaging and clinical data for medical analysis.
- Apply methods for multimodal medical data analysis.
- Analyse longitudinal medical imaging data and temporal patterns.
- Develop models for disease progression and temporal analysis.

Topics / Contents

- Multimodal medical data
- Integration of imaging and clinical variables
- Longitudinal studies
- Temporal analysis
- Disease progression modelling

Self-Supervised and Foundation Models in Medical Imaging

6 ECTS

Learning Outcomes

- Explain the principles of self-supervised learning and foundation models for medical imaging.
- Apply contrastive learning and masked autoencoder approaches to medical imaging.
- Adapt pretrained foundation models to medical imaging tasks.
- Evaluate transfer learning and adaptation strategies for medical imaging.
- Explore vision–language models and their applications in medical imaging.

Topics / Contents

- Self-supervised learning
- Contrastive learning
- Masked autoencoders
- Transfer learning
- Foundation models
- Model adaptation
- Vision–language models

Image-Guided Medical Interventions

5 ECTS

Learning Outcomes

- Analyse the role of AI in image-guided medical interventions.
- Apply methods for intraoperative imaging and video analysis.
- Apply registration techniques for pre- and intra-operative image alignment.
- Evaluate AI-based decision support approaches during medical interventions.

Topics / Contents

- Image-guided interventions
- Intraoperative imaging
- Video analysis
- Pre-operative registration
- Intra-operative registration
- AI-based decision support

Evaluation and Validation of Medical AI Systems

5 ECTS

Learning Outcomes

- Design evaluation strategies for medical AI systems.
- Apply external validation, reproducibility, and benchmarking methodologies.
- Critically assess reporting standards for medical AI research.
- Explain Software as a Medical Device concepts, including classification, lifecycle, and clinical evidence.
- Identify regulatory documentation requirements for medical AI systems.

Topics / Contents

- Evaluation methodologies
- External validation
- Reproducibility
- Benchmarking
- Reporting standards
- Software as a Medical Device (SaMD)
- Clinical evidence
- Regulatory documentation

Regulatory and Professional Context in Medical AI

2 ECTS

Learning Outcomes

- Analyse regulatory and professional challenges associated with deploying AI in healthcare.
- Apply regulatory and professional considerations to realistic medical AI scenarios.
- Evaluate decisions concerning the deployment and use of AI systems in clinical environments.

Topics / Contents

- Regulatory challenges
- Professional responsibilities
- Deployment of AI in healthcare
- Case-based discussions
- Decision-making scenarios

Semester 4

Master Thesis Host Institution

MSc Project

24 ECTS

Learning Outcomes

- Define and critically analyse a research or applied problem in medical image analysis and AI.
- Design and implement an appropriate methodological approach.
- Analyse data and evaluate experimental results using appropriate scientific methods.
- Demonstrate autonomy in conducting a substantial research or applied project.
- Communicate and defend project outcomes in written and oral form.

Topics / Contents

- Problem definition
- Literature review and research methodology
- Data analysis
- Methodological development
- Experimental validation
- Scientific writing
- Oral defence

Scientific Writing and Publishing

2 ECTS

Learning Outcomes

- Structure and write scientific manuscripts following accepted academic conventions.
- Select appropriate journals and conferences for scientific dissemination.
- Understand the peer-review process and respond effectively to reviewers.
- Prepare research outputs derived from the Master's thesis for publication.

Topics / Contents

- Scientific writing
- Structure of research papers
- Journal and conference selection
- Peer review
- Responding to reviewers
- Publication of thesis-related research

Secure Deployment of Medical AI Systems

2 ECTS

Learning Outcomes

- Describe common architectures for deploying medical AI systems.
- Apply basic MLOps concepts to the deployment and maintenance of AI systems.
- Identify cybersecurity risks and apply basic threat-modelling principles.
- Address data protection and GDPR requirements in healthcare AI deployments.

Topics / Contents

- Cloud, edge, and mobile deployment
- MLOps fundamentals
- Cybersecurity risks
- Threat modelling
- Data protection
- GDPR in healthcare AI

Career Development and PhD Preparation

2 ECTS

Learning Outcomes

- Evaluate academic and industrial career pathways in medical AI.
- Align Master's thesis activities with longer-term academic or professional goals.
- Identify opportunities for doctoral studies, funding, innovation, and technology transfer.
- Communicate a coherent professional profile and career plan.

Topics / Contents

- Academic careers
- Industrial and MedTech careers
- PhD preparation
- Career planning
- Funding opportunities
- Innovation and technology transfer
- Professional profile

APPENDICES

MAIA Learning Outcomes

Upon successful completion of MAIA, graduates will be able to:

- LO1: Design, implement, and evaluate advanced medical image analysis and computer vision algorithms within clinically relevant workflows.
- LO2: Apply artificial intelligence and machine learning techniques to complex, high-dimensional medical imaging data, selecting appropriate models and methodologies.
- LO3: Integrate image acquisition, processing, and AI-driven modelling techniques into end-to-end diagnostic or therapeutic systems.
- LO4: Critically assess the performance, robustness, and limitations of medical image analysis systems, including validation and benchmarking in real-world clinical contexts.
- LO5: Develop software-based solutions using advanced programming practices suitable for research, clinical, and industrial deployment.
- LO6: Design and integration of perception, planning and learning components in image-guided and robotic medical systems operating in real clinical settings.
- LO7: Apply research methodologies, conduct critical literature reviews, and contribute to scientific and technological innovation in medical imaging.
- LO8: Address ethical, societal, and regulatory aspects of AI-based medical technologies, including data protection, bias mitigation, trustworthy AI principles, and compliance with European regulatory frameworks.
- LO9: Communicate complex technical concepts effectively to specialist and non-specialist audiences in academic, clinical, and industrial environments.
- LO10: Work effectively in international and interdisciplinary teams, demonstrating autonomy, responsibility, and professional judgement.

The learning outcomes are addressed through a balanced combination of:

- Lectures, designed to provide students with the fundamental concepts, state of the art, and mathematical foundations of medical image analysis and artificial intelligence, while fostering interaction, discussion, and critical reflection through direct exchange with academic staff.
- Seminars, consisting of expert-oriented presentations delivered by renowned researchers, clinicians, patient advocacy groups, and invited scholars, enabling students to explore advanced topics in medical image analysis, to become familiar with emerging methods and algorithms, and to understand the clinical, societal, and ethical impact of current research.
- Tutorial sessions, organised as guided exercise-based classes directly linked to lecture content, allowing students to solve theoretical and methodological problems with the support of academic staff and to consolidate conceptual understanding.
- Hands-on laboratory sessions, focused on the practical implementation of algorithms and sys-

tems using real medical imaging data, enabling students to translate theoretical knowledge into operational solutions and to develop programming and experimental skills.

- Project-based learning, where students address complex, open-ended problems, integrating knowledge from multiple modules to design, implement, and evaluate complete medical image analysis solutions.
- Collaborative and interdisciplinary activities, promoting teamwork across diverse academic backgrounds and cultures, and fostering the ability to operate effectively in international, interdisciplinary, and professional environments.
- Individual and group assessments, designed to evaluate the achievement of learning outcomes through a variety of formats, including written examinations, technical reports, software deliverables, oral presentations, and research-oriented assignments.

.1 MAIA Competences

The achievement of the above learning outcomes leads to the acquisition of a coherent set of advanced core and transversal competences, which define the professional and academic profile of MAIA graduates at European level. MAIA graduates demonstrate competences in:

- End-to-end development and clinical deployment of medical image analysis systems, from data acquisition and curation to validated implementation in healthcare environments.
- Advanced application of artificial intelligence and machine learning techniques to medical imaging and image-guided intervention problems.
- Development and validation of image-guided and robot-assisted medical systems, integrating medical imaging, AI-driven perception, and safe physical interaction in clinical settings.
- Critical evaluation, validation and benchmarking of AI-based medical technologies in safety-critical contexts.
- Integration of ethical, societal and regulatory requirements into the design, development and deployment of medical AI systems.
- Research capacity, innovation skills and lifelong learning competences, enabling progression towards doctoral studies or advanced industrial and clinical roles.
- Professional communication, teamwork and leadership in international and interdisciplinary environments.

Through this jointly defined and outcome-driven framework, MAIA ensures that graduates achieve a consistent level of academic excellence and professional readiness, fully aligned with European standards for joint master programmes.

Assessment in MAIA

Assessment methods are selected to ensure constructive alignment between learning outcomes, teaching activities, and evaluation criteria. These include written examinations, project reports, software implementations, oral presentations, and research-oriented assignments.

- Written examinations and exercise resolution. Examinations may assess both theoretical knowledge and the ability to apply concepts to problems and exercises. They may be conducted at the end of a module, during the examination period, or as part of continuous assessment. In handwritten examinations, students are responsible for ensuring that their answers are sufficiently clear and legible to be assessed.
- Project reports and practical activities. Projects may require students to produce technical reports, written analyses, or other forms of documented coursework. Assessment may consider the quality and organisation of the work, the accuracy and clarity of the content, the appropriate use of sources, and compliance with any specified requirements such as structure or word limits. Projects may be carried out individually or in groups, with individual contributions taken into account where appropriate.
- Software implementations and laboratory assignments. Practical work may involve the development and implementation of software solutions, algorithms, or technical systems. Depending on the module, assessment may consider aspects such as correctness, functionality, design, documentation, and critical evaluation. Laboratory activities may also assess students' practical skills, participation, and ability to work effectively both individually and as part of a team.
- Oral presentations. Students may be required to present their work individually or in groups. Presentations are expected to communicate the main ideas and results clearly and concisely, using appropriate supporting material where relevant. Assessment may consider the organisation and clarity of the presentation, the quality of the delivery, the ability to explain and discuss the work, and effective management of the allocated time.
- Research-oriented activities may include literature reviews, critical analyses, research reports, and other assignments requiring students to investigate a topic independently and critically. Assessment may consider the formulation and analysis of the problem, the use and interpretation of relevant sources, the quality of the discussion, and the ability to draw well-supported conclusions. The Master's thesis is assessed through both the written thesis and its oral defence.

The table below shows the alignment between the programme learning outcomes and the assessment methods used across MAIA. The symbols P (Primary contribution) and C (Contributing) indicate the role of each assessment method in assessing the learning outcomes. P indicates that the learning outcome is a central objective of the assessment, while C indicates that it is addressed and reinforced as part of the assessment.

	Exams	Labs	Projects	Oral presentations	Research-oriented
LO1	C	P	P	C	P
LO2	C	P	P		P
LO3		C	P	C	P
LO4	C	C	P		P
LO5		P	P		P
LO6			C	C	P
LO7	C		C	P	C
LO8			C	P	P
LO9			P	C	C