Transilvania University of Brașov
INTERDISCIPLINARY DOCTORAL SCHOOL

ADMISSION TO DOCTORAL STUDIES **Session September 2026**

Field of doctoral studies: Informatics

Doctoral supervisor: Assoc. Prof. Alexandra Băicoianu

TOPICS FOR THE ADMISSION TO DOCTORAL STUDIES

TOPIC 1: Towards Reliable and Explainable Earth Observation: Quality Assessment, Multi-Sensor Fusion, and Intelligent Analysis of Remote Sensing Data
Contents / Main aspects to be considered The fusion of heterogeneous remote sensing data into compact, classification-ready datasets without compromising information content or interpretability. - Robust multi-sensor data fusion for heterogeneous Earth Observation data - Optimizing information content vs. dimensionality in fused datasets - Ensuring interpretability and explainability in operational fusion pipelines - Quality assessment and uncertainty quantification in fused outputs - Intelligent analysis and applications with fused data
Recommended bibliography: 1. Luca R. I. et al. *Spectral image data aggregation for multisource data augmentation*, European Journal of Remote Sensing, 10.1080/22797254.2025.2492295, http://dx.doi.org/10.1080/22797254.2025.2492295 (2024) 2. Ahmed, M.T. et al. *A systematic review of explainable artificial intelligence for spectroscopic agricultural quality assessment*, Computers and Electronics in Agriculture 235, https://doi.org/10.1016/j.compag.2025.110354 (2025) 3. Yokoya, N. et al. *Hyperspectral and Multispectral Data Fusion: A comparative review of the recent literature*, IEEE Geoscience and Remote Sensing Magazine 5.2, 10.1109/MGRS. 2016.2637824 (2017) 4. Pai, D.G. et al. *Explainable AI in agriculture: Review of applications, methodologies, and future directions,* Engineering Research Express 7.3 (2025) 5. Hu, Xing, et al. *A Comprehensive Review of Diffusion Models in Smart Agriculture: Progress, Applications, and Challenges*, arXiv:2507.18376 (2025). 6. Jung, C. et al. *Fusionnet: Multispectral Fusion of RGB and NIR Images Using Two Stage Convolutional Neural Networks*, IEEE Access, 10.1109/ACCESS.2020.2968559 (2020)
Prerequisites / Remarks: Necessary prerequisites: - Knowledge in remote sensing principles, image processing, and geospatial data

analysis.

- Proficiency in machine learning and deep learning techniques, particularly for image analysis and fusion.
- Familiarity with various remote sensing data types (e.g., optical, SAR, lidar) and their respective characteristics and limitations.

Remark:

Practical implementation of this research will depend on adequate computational resources to efficiently process large geospatial datasets and train sophisticated fusion models.

☒ **Scientific Doctorate**

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TOPIC 2: Advancing Earth Observation through Foundation Models and Agentic Systems

Contents / Main aspects to be considered

Creating and assessing a variety of VLM/LLM-based technologies for remote sensing-derived applications, including multispectral imagery and multi-sensor derived data in order to enable specialized pipelines for a variety of tasks, including data quality assessment, classification reliability, feature importance analysis.

- VLM/LLM potential in understanding/analyzing and assessing remote sensing multi-sensor derived data
- Enabling specialized and intelligent pipelines for diverse Earth Observation applications
- Agentic AI integration in Earth Observation analysis
- Addressing explainability, trustworthiness, and ethical considerations in Foundation Model-driven Earth Observation

Recommended bibliography:

1. Soni, S. et al. *Earthdial: Turning multi-sensory earth observations to interactive dialogues*, https://arxiv.org/abs/2412.15190 (2024)
2. Marimo, C.T. et al. *Beyond the Visible: Multispectral Vision-Language Learning for Earth Observation,* Machine Learning and Knowledge Discovery in Databases. Research Track. ECML PKDD. Lecture Notes in Computer Science, Springer, Cham. https://doi.org/10.1007/978-3-032-06106-5_21 (2025)
3. Si D. et al. *SPEX: A Vision–Language Model for Land Cover Extraction on Spectral Remote Sensing Images*, IEEE Transactions on Geoscience and Remote Sensing, vol. 64, pp. 1-16, 5403416, 10.1109/TGRS.2026.3670308 (2026)
4. Cai, M. et al. *Earth-OneVision: Extending Remote Sensing Multimodal Large Language Models to More Sensor Modalities and Tasks,* https://arxiv.org/abs/2606.10819 (2026).

Prerequisites / Remarks:

Necessary prerequisites:

- Advanced knowledge in machine learning, deep learning, and natural language processing, with a focus on foundation models (VLMs, LLMs).
- Familiarity with the architectural principles and training paradigms of large-scale pre-trained models.
- Strong programming skills and experience with relevant AI/ML frameworks.
- Understanding of remote sensing data types, processing workflows, and common Earth Observation applications.

Remark:

The exploration and development of VLM/LLM-based technologies and Agentic AI systems for Earth Observation will necessitate substantial computational infrastructure, capable of supporting large-scale experimentation, model fine-tuning, and the processing of vast multi-modal datasets.

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TOPIC 3: Intelligent Condition Monitoring and Fault Management through Agentic AI in Industrial and Software Systems

Contents / Main aspects to be considered

As industrial and software systems become increasingly intricate and connected, it's more important than ever to proactively monitor their health and manage potential issues autonomously. This topic explores the potential of Agentic AI to transform how we ensure reliability, efficiency, and safety, by intelligently detecting anomalies early, diagnosing problems with precision, and continuously optimizing performance.

- Agentic AI for proactive condition monitoring
- Advanced fault detection, diagnosis, and root cause analysis using foundation models
- Multi-Agent systems for collaborative fault management and optimization

Recommended bibliography:

1. Alonso-González, M. et al. *Designing an Agentic AI–Driven Framework for Decision-Making in Industrial Maintenance,* Multidisciplinary Social Networks Research, Communications in Computer and Information Science, Springer, Cham. https://doi.org/10.1007/978-3-032-09945-7_11 (2026)
2. Ogunmolu, A.M. et al. *Autonomous Artificial Intelligence Agents for Fault Detection and Self-Healing in Smart Manufacturing Systems*, Journal of Energy Research and Reviews, https://doi.org/10.9734/jenrr/2025/v17i8445 (2025)
3. Farahani, M.A. et al. *Hybrid agentic AI and multi-agent systems in smart manufacturing, Journal of Manufacturing Systems*, Volume 86, ISSN 0278-6125, https://doi.org/10.1016/j.jmsy.2026.04.002 (2026)

4. Courter, B. *Agentic Engineering: How AI Automata Will Participate in Engineering in 2025*, https://www.blakecourter.com/2025/01/20/agentic-engineering.html (2025)

Prerequisites / Remarks:

Necessary prerequisites:

- Strong background in industrial control systems and/or software engineering principles, coupled with a deep understanding of relevant fault modes and condition monitoring techniques.
- Advanced proficiency in machine learning, deep learning, and particularly in foundation models (LLMs, VLMs) and Agentic AI concepts.
- Familiarity with simulation tools and optimization techniques relevant to industrial or structural engineering (e.g., FEA, CAD integration).

Remark:

Implementing Agentic AI effectively will require robust computational resources, smart strategies for managing the vast amounts of data these systems rely on, and most importantly, access to high-quality, specific data alongside the expertise of engineers to correctly interpret and act upon the insights generated.

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TOPIC 4: Advanced Computational Models for Intelligent Behaviors

Contents / Main aspects to be considered

This topic explores advanced computational models, specifically Neural Cellular Automata (NCA), investigating their capacity to exhibit intelligent behaviors through pattern generation, texture synthesis, and/or predictive analytics.

- NCAs for spatio-temporal and sequential data processing
- Learning Continuous Dynamics and Robustness in NCAs
- The potential for NCAs to overfit the discrete spatio-temporal domain used during training, rather than learning true continuous dynamics.
- Texture Synthesis with NCAs
- Exploring continuity in NCA models - spatial, temporal, and resolution continuity of learned local rules
- Adaptive computation time / variable step-count NCA, letting the model learn how many update steps a pattern needs (evaluation and interpretability - exploring quantitative metrics for NCA assessment)

Recommended bibliography:

1. Pajouheshgar, E. et al. *Discovering Partial Differential Equations With Neural Cellular Automata,* Artif Life, https://doi.org/10.1162/ARTL.a.454 (2026)
2. Hartl, B. et al. *Neural cellular automata: Applications to biology and beyond classical*

AI, Physics of Life Reviews, https://doi.org/10.1016/j.plrev.2025.11.010 (2026)
3. Richardson A. et al. *Learning spatio-temporal patterns with Neural Cellular Automata* https://pmc.ncbi.nlm.nih.gov/articles/PMC11078362/ (2024)
4. Pajouheshgar E. et al. *DyNCA: Real-time Dynamic Texture Synthesis Using Neural Cellular Automata*, IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 10.1109/CVPR52729.2023.01987 (2023)
5. Pajouheshgar E. et al. *NoiseNCA: Noisy Seed Improves Spatio-Temporal Continuity of Neural Cellular Automata*, Artificial Life Conference Proceedings, Cambridge, MA 02142-1209, USA journals-info@ mit. edu: MIT Press (2024)

Prerequisites / Remarks:

Necessary prerequisites:

- Strong fundamentals in Neural Networks (NN) and Neural Cellular Automata (NCA)
- Proficiency in programming and AI/ML frameworks
- Solid mathematical and algorithmic background

Remark:

Access to robust computational infrastructure is essential for training and simulating complex NCA models.

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Doctoral supervisor,

Assoc. Prof. Alexandra Băicoianu

Coordinator of the field of doctoral studies,

Prof. Sabin Tăbîrcă