Course Title

Artificial Intelligence Techniques for Remote Sensing

Teacher(s)

Giuseppina Andresini
Annalisa Appice

Course Website (optional)

Code: To be defined

Course description (min 150, max 300 words)

The integration of artificial intelligence (AI) with remote sensing technologies has revolutionized the way we observe, analyze and interpret the Earth's surface and atmosphere. Remote sensing traditionally relies on satellite, airborne and ground-based sensors to collect large amounts of data in various wavelengths of the electromagnetic spectrum. These data provide valuable information on phenomena such as land cover changes, deforestation, agricultural dynamics and natural disasters [1]. With the increasing quality and volume of data from remote sensing platforms, there's a growing demand for effective tools to handle and extract valuable information from remote sensing datasets. AI algorithms play a crucial role in managing large volumes of observations, modeling, analysis, and environmental forecasting, and have proven effective for tasks such as data fusion, object detection, and semantic segmentation [2]. Although AI techniques enable researchers to observe and understand the earth more accurately, the vulnerability and uncertainty of AI models deserve further attention [3]. Challenges include the problem of imbalanced data that can affect prediction results, the need for explainability in model decisions, and the vulnerability of models to adversarial attacks [3]. Handling these challenge is a necessary step to advance towards a more symbiotic application of AI in remote sensing.
This course aims to provide a comprehensive understanding of how AI techniques can enhance remote sensing capabilities for various applications, including land cover change detection, disaster response (e.g., forest tree dieback caused by insect outbreaks or wildfires).
Specifically, the course will be organized into two main sections:
(1) An introduction to remote sensing and the type of remote sensing data.
(2) An overview of more advanced approaches using AI algorithms in the remote sensing, focusing on applications like forest disasters and land change detection.

The course is part of the training activities promoted by the SWIFTT Project funded by the European Union under Grant Agreement 101082732 and by the project FAIR, Future AI Research (PE00000013), Spoke 6 “Symbiotic AI”.

Course period
2025

SSD

ING-INF/05

Course References (optional)

[1] Y. Xu, T. Bai, W. Yu, S. Chang, P. M. Atkinson and P. Ghamisi, "AI Security for Geoscience and Remote Sensing: Challenges and future trends," in IEEE Geoscience and Remote Sensing Magazine, vol. 11, no. 2, pp. 60-85, June 2023, doi: 10.1109/MGRS.2023.3272825.

[2] Janga, B.; Asamani, G.P.; Sun, Z.; Cristea, N. A Review of Practical AI for Remote Sensing in Earth Sciences. Remote Sens. 2023, 15, 4112. https://doi.org/10.3390/rs15164112

[3] L. Zhang and L. Zhang, "Artificial Intelligence for Remote Sensing Data Analysis: A review of challenges and opportunities," in IEEE Geoscience and Remote Sensing Magazine, vol. 10, no. 2, pp. 270-294, June 2022, doi: 10.1109/MGRS.2022.3145854.

Credits and Hours

3 credits of lectures (by 8 hours) for a total of 24 hours.
8 hours of Introduction to Remote Sensing and Project SWIFTT (Prof. Annalisa Appice)
16 hours of overview of AI techinques for remote sensing in a Symbiotic AI perspective (Dr. Giuseppina Andresini)

Exam Modality
Two alternatives are available to the student to pass this exam:

1) Paper presentation. Students will illustrate the content of 2 papers suggested by the teachers by discussing novelties and issues and identifying possible relationships with their research projects. No groups are allowed.
2) Project. Students will implement and experimentally validate Ab AI technique for a remote sensing problem suggested by the teachers. Projects can be done in groups of 1-3 students, depending on the complexity of the technique.

Teacher(s) CV

Giuseppina Andresini is an Assistant Professor (non-tenure) at the Department of Computer Science, the University of Bari Aldo Moro. She graduated cum Laude in Computer Science from the University of Bari Aldo Moro, Italy, in April 2018, discussing a Laurea thesis on data mining. She was a Ph.D. Student in Computer Science (with a scholarship) from November

2, 2018 to November 1, 2021 with a research project on “Innovative machine learning techniques for cybersecurity”. She received a Ph.D. in Computer Science, University of Bari Aldo Moro, Italy, in March 2022. Her current research interests mainly concern deep learning, XAI and adversarial learning with applications in cybersecurity and remote sensing. On these topics, she has published several papers in international journals and international conferences. She has participated in the organization (as co-chair) of the tfour editions of Workshop on Machine Learning for Cybersecurity co-located with ECML PKDD 2021-2024. She held the module of Deep Learning Advanced (12 hours) for the course of Machine Learning Techniques and Applications of Master 2 DISS (Data Intelligence for Smart Systems) at Lyon 1 University (Lyon, France). She has co-tutored 20 theses in both Bachelor and Master degrees on topics cybersecurity, remote sensing, machine learning, adversarial learning and deep learning.

Annalisa Appice is a Full Professor at the Department of Computer Science, University of Bari Aldo Moro, Italy. She received a Ph.D. in Computer Science in the University of Bari Aldo Moro. She was a visiting researcher at the University of Bristol (U.K.) and at the Jozef Stefan Institute (Slovenia). Her current research interests include data mining with spatio-temporal data, data streams and event logs with applications to remote sensing, process mining and cybersecurity. She has authored and co-authored more than 180 papers in international journals and conferences. She has been the Program co-Chair of the European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML-PKDD) 2015, International Symposium on Methodologies for Intelligent System (ISMIS) 2017, and Discovery Science (DS) 2020. f Machine Learning Journal (MACH), Data Mining and Knowledge Discovery Journal (DAMI), Engineering Applications of Artificial Intelligence Journal (EAAI) and Journal of Intelligent Information Systems (JIIS). She is responsible for the local research unit of the University of Bari Aldo Moro in the EU project SWIFTT.

Teacher(s) Main Publications

Giuseppina Andresini and Annalisa Appice

1. **G. Andresini**, **A. Appice**, D. Malerba, **Silvia: An explainable framework to map bark beetle infestation in sentinel-2 images**, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (2023) 10050–10066 Q1 in Computers in Earth Sciences (Scimago-2022). doi:10.1109/JSTARS.2023.3312521.

2. **G. Andresini**, **A. Appice**, D. Ienco, D. Malerba, **Seneca: Change detection in optical imagery using siamese networks with active-transfer learning**, Expert Systems with Applications 214 (2023) 119123, Q1 in Artificial Intelligence (Scimago-2022). doi: 10.1016/j.eswa.2022.119123.

3. **G. Andresini**, **A. Appice**, D. Iaia, D. Malerba, N. Taggio, A. Aiello, **Leveraging autoencoders in change vector analysis of optical satellite images**, Journal of Intelligent Information Systems 58 (2022) 433–452, Q2 in Artificial Intelligence (Scimago-2022). doi:10.1007/s10844-021-00670-9.

4. **G. Andresini**, **A. Appice**, Malerba, **Leveraging sentinel-2 time series for bark beetle-induced forest dieback inventory,** Association for Computing Machinery, Inc, 2024, pp. 875–882, proceedings of 39th Annual ACM Symposium on Applied Computing, SAC 2024, Technical Track on Machine Learning and Its Applications, doi: 10.1145/3605098.363590

5. **G. Andresini**, **A. Appice**, D. Dell'Olio, D. Malerba, **Siamese networks with transfer learning for change detection in sentinel-2 images**, in: In: Bandini, S., Gasparini, F., Mascardi, V., Palmonari, M., Vizzari, G. (eds) AixIA 2021 – Advances in Artificial Intelligence. AIxIA 2021. Lecture Notes in Computer Science(), vol 13196. Springer, Cham, 2021.

6. M. Al-Essa, **G. Andresini, A. Appice**, D. Malerba, **Panacea: A neural model ensemble for cyber-threat detection**, Machine Learning (2023) 1–14 Q1 in Artificial Intelligence (Scimago-2022). doi:10.1007/s10994-023-06470-2

7. **G. Andresini**, **A. Appice**, F. Caforio, D. Malerba, G. Vessio, Roulette: A neural attention multi-output model for explainable network intrusion detection, Expert Systems with Applications 201 (2022) 117144, Q1 in Artificial Intelligence (Scimago-2022). doi:https://doi.org/10.1016/j.eswa.2022.117144

8. **Andresini G.**, **Appice A,** De Rose L., Malerba D., **GAN augmentation to deal with imbalance in imaging-based intrusion detection**, *Future Generation Computer Systems, Elsevier*, Volume 123, 2021, Pages 108-127 ISSN 0167-739X, Q1 in Computer Networks and Communications, Software (Scimago-2021) DOI: 10.1016/j.future.2021.04.017

9. **Andresini G.**, **Appice A.,** Malerba D., **Autoencoder-based deep metric learning for network intrusion detection**, *Information Sciences, Elsevier*, Volume 569, 2021, Pages 706-727, Q1 in Artificial Intelligence (Scimago-2021) DOI: 10.1016/j.ins.2021.05.016

10. **Andresini G.**, **Appice A.,** Malerba D., **Nearest cluster-based intrusion detection through convolutional neural networks**, *Knowledge-Based Systems, Elsevier,* Volume 216, 2021,106798, Q1 in Artificial Intelligence (Scimago-2021), DOI: 10.1016/j.knosys.2021.106798