SILVIA LIBERATA ULLO, GEMINE VIVONE,
GÜLŞEN TAŞKIN, RONNY HÄNSCH, AND UJJWAL VERMA

Computer Vision for Earth Observation: The Second GRSS Image Analysis and Data Fusion School

Over the last decades, the importance of Earth observation (EO) data has steadily increased. Today, it plays a pivotal role not only in scientific research but also in monitoring, analyzing, and modeling natural and anthropogenic processes in the atmosphere and on the surface of the Earth, including its oceans, forests, ice and snow fields, and urban areas. It is also connected to the United Nations Sustainable Development Goals, where 34 indicators across 29 targets and 11 goals can be informed with EO data, and more and more companies leverage EO data, e.g., for insurance in regions prone to natural disasters or smart farming.

OVERVIEW OF THE SECOND IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY IMAGE ANALYSIS AND DATA FUSION SCHOOL

GOALS OF THE IMAGE ANALYSIS AND DATA FUSION SCHOOL ON COMPUTER VISION FOR EO

Nowadays, the quality and quantity of EO imagery calls for fully automatic methods that are able to efficiently and robustly analyze globally distributed samples. Computer vision (CV) methods—shown to be very successful in other areas, such as semantic or geometric interpretation of close-range imagery—promise to fulfill exactly this need by leveraging data-driven machine learning-based frameworks that model the complex relationship between spectral–spatial (and sometimes temporal) input and the target variable. The goal of this second IEEE Geoscience and Remote Sensing Society (GRSS) Image Analysis and Data Fusion (IADF) School on CV for EO (CV4EO) was to provide a general overview of the multitude of different aspects of how CV is used in EO applications together with deep insights into modern methods to automatically process and analyze remote sensing images (Figure 1).

ORGANIZATION OF THE SECOND GRSS IADF SCHOOL

ORGANIZING COMMITTEE

The school was organized by the IADF Technical Committee (TC) of the GRSS. The organizing committee consists of the following members:

- Silvia L. Ullo, University of Sannio, Benevento, Italy
- Gemine Vivone, National Research Council, Tito Scalo, Italy
- Gülşen Taşkın, Istanbul Technical University, Turkey

FIGURE 1. Logo of the GRSS IADF School on Computer Vision for Earth Observation.

Digital Object Identifier 10.1109/MGRS.2023.3341949
Date of current version: 1 March 2024

- Ronny Hänsch, German Aerospace Center, Weßling, Germany
- Ujjwal Verma, Manipal Institute of Technology Bengaluru, India
- Dalton Lunga, Oak Ridge National Laboratory, TN, United States
- Claudio Persello, University of Twente, The Netherlands.

PROGRAM

At the University of Sannio, in Benevento (Italy), we had the privilege of hosting an excellent school program that covered a wide range of topics, including sophisticated image processing methods, artificial intelligence (AI) applications in EO, and remote sensing. This multiday event combined experience, ideas, and real-world applications with a clear focus on EO. At the link in [1], it is possible to find the IADF School website with all of the information and also the version of the previous year. It provided participants with an enhanced and broad educational experience, emphasizing collaborative learning, where they gained practical skills through interactive sessions in addition to theoretical information. This strategy made sure that everyone in attendance had a stronger understanding of EO and its applications, which greatly improved their learning results.

DAY 1: A DIVE INTO DEEP LEARNING AND AI

The IADF School program commenced on 13 September with an opening ceremony by the organizers, which set the tone for an array of engaging and educational sessions (Figure 2). Leading the first day of the program, Prof. Michael Mommert from the University of St. Gallen, Switzerland led an insightful two-part series on "Label-Efficient Deep Learning in Remote Sensing." These sessions emphasized the value of methods for employing sparsely labeled data in remote sensing, a topic essential to Earth sciences and environmental monitoring. This included multitask learning, transfer learning, and self-supervised learning. It also covered handling diverse data, establishing single-multimodality, developing a supervised learning pipeline, and innovative use of data fusion to augment sparse labels.

The afternoon's program focused on "Explainable AI for Earth Observation," which was given by Prof. Ribana Roscher of the German Research Center Jülich's Bio and Geosciences and University of Bonn. Her lectures included a thorough exploration of how to improve the transparency and understandability of AI algorithms used in EO. With a hands-on part, the session focused on "Exploring Wilderness Using Explainable Machine Learning in Satellite Imagery," a specific application in EO. This hands-on part was designed to demonstrate the theories and approaches covered, giving participants a firsthand look at using explainable AI techniques in a real-world scenario. The day concluded with an exciting workshop on the ancient city of Benevento, blending historical insights.

DAY 2: EXPLORING SYNTHETIC APERTURE RADAR IMAGES AND URBAN CHANGE DETECTION

On the following day, Prof. Paolo Gamba from the University of Pavia, Italy, presented "Fusion of Heterogeneous Sensors for Change Detection in Urban Areas." This was particularly relevant for understanding urban development and environmental changes. Later, Prof. Florence Tupin and Dr. Emanuele Dalsasso from the Laboratory Treatment and Communication of Information, Telecom Paris, France, shared their expertise on "Deep Learning-Based Processing of SAR Images." They discussed the various applications of synthetic aperture radar (SAR) imaging in space missions and provided a detailed overview of SAR image statistics and modeling. The session focused on deep learning strategies for SAR speckle reduction, which involved demonstrating sophisticated methods to improve image quality. Additionally, a hands-on session was conducted, providing practical experience in applying these techniques.

The day ended with a poster session featuring the research works of participants, followed by a gala dinner where Nafiseh Kakhani, Nikita Basargin, and Davide Andreatta were recognized for their outstanding poster presentations. During the gala dinner, three travel grants were also assigned to Anindita Dasgupta, Omid Ghozatlou, and Daniela Andrea Quintero Garcia (Figure 3). We would like to thank our sponsors who made this possible: the European Space Agency in the person of Simonetta Cheli, the company cosine in the person of Marco Esposito, and the company intelligentia in the person of Davide De Pasquale.

DAY 3: VISION LANGUAGE MODELS AND A PANEL DISCUSSION

The last day of the program was led by Prof. Devis Tuia from the École Polytechnique Fédérale de Lausanne (EPFL), Switzerland. The topic of the session was "Vision Language Models in Remote Sensing." The session provided insights into how advanced vision and language processing models could be used in remote sensing, thereby offering a glimpse into the future of AI in this field. The program concluded with a panel session where participants had the opportunity to discuss and share their insights.

SPEAKERS

The second edition of the GRSS IADF School invited a diverse group of experts from different countries. This list includes:

- Prof. Paolo Gamba, a professor at the University of Pavia, Italy
- Prof. Devis Tuia, a professor of the EPFL, Switzerland
- Prof. Florance Tupin, a professor of image and signal processing with the Laboratory Treatment and Communication of Information, Telecom Paris, France, and her collaborator Dr. Emanuele Dalsasso who helped her in the practical activities

- Prof. Ribana Roscher, a professor of data science for crop systems at the University of Bonn, Germany
- Prof. Michael Mommert, a professor of computer vision at the School of Computer Science, University of St. Gallen, Switzerland.

DISTRIBUTED MATERIAL

Through lectures, hands-on exercises, and demonstrations, participants gained a deep understanding of key topics in CV4EO, including machine learning in remote sensing, explainable AI for the Earth science, big geo-data, multisource

FIGURE 2. The 2023 IADF School's Speakers: (a) Devis Tuia, (b) Michael Mommert, (c) Florence Tupin, (d) Emanuele Dalsasso, (e) Paolo Gamba, and (f) Ribana Roscher.

Join the GRSS IADF TC

You can contact the IADF TC chairs at iadf_chairs@grss-ieee.org. If you are interested in joining the IADF TC, please fill in the form on our website: https://www.grss-ieee.org/technical-committees/image-analysis-and-data-fusion. Members receive information regarding research and applications on image analysis and data fusion topics, and updates on the annual Data Fusion Contest and all other activities of the IADF TC. Membership in the IADF TC is free! Also, you can join the LinkedIn IEEE GRSS Data Fusion Discussion Forum at the link in [7] and Twitter channel (@Grssladf).

image analysis, data fusion, SAR image analysis, and deep interpretable remote sensing. Material has been distributed by some of the speakers and made available on their personal pages:

- from Ribana Roscher, "Explainable Machine Learning" [2]
- from Florence Tupin and Emanuele Dalsasso, "SAR Processing Repository" [3]
- from Michael Mommert, "Efficient Learning Repository" on his GitHub page [4]
- from Paolo Gamba, Fusion of Heterogeneous Sensors for Change Detection in Urban Areas" [5].

The lectures were recorded and made available online on the IEEE Learning Network (ILN) [6]. This was the first GRSS school available on the ILN.

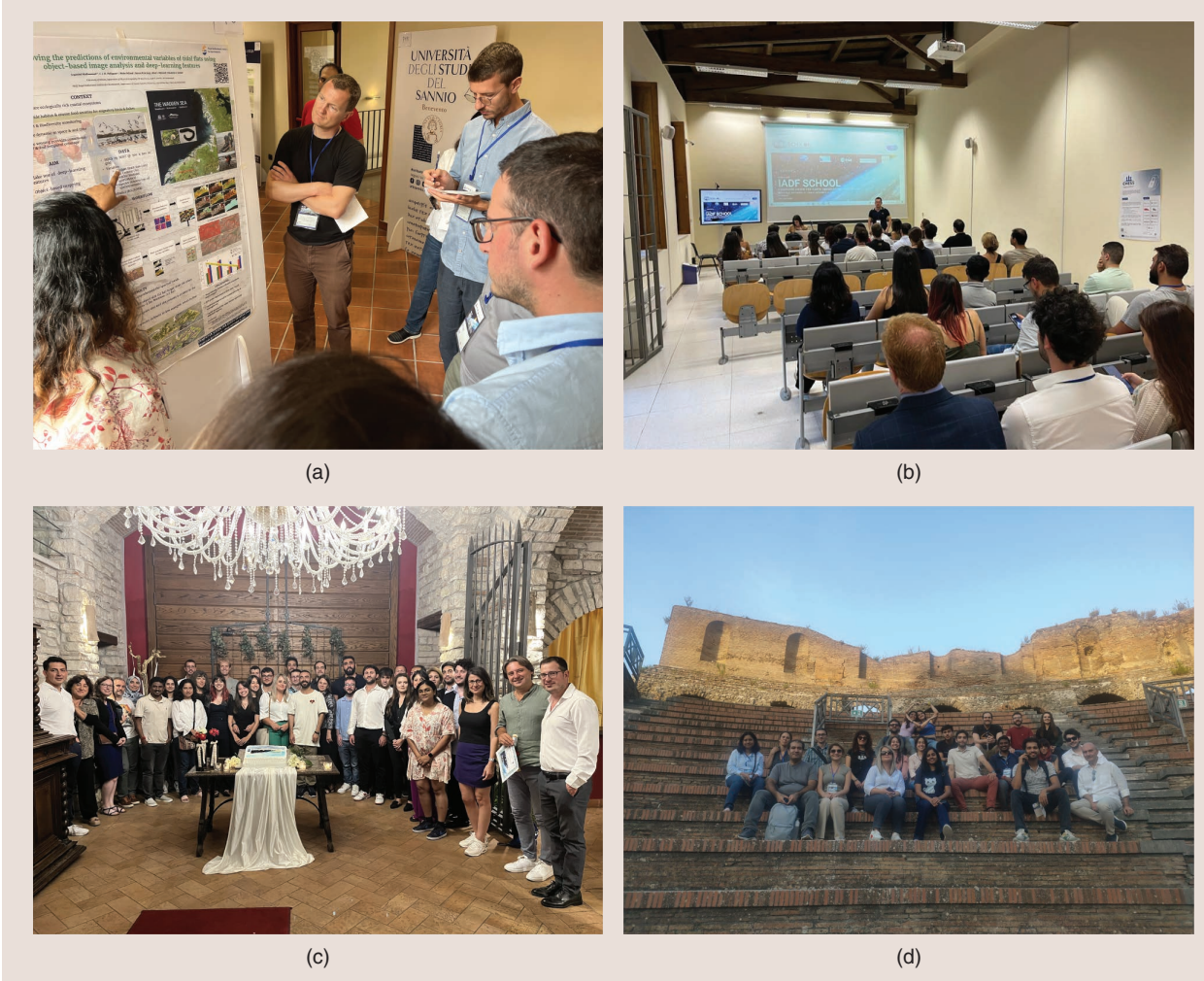
GRSS IADF SCHOOL: FIND OUT THE NEXT EDITION!

After the successful second edition of the GRSS IADF school, a third one will be announced soon. It will follow the same theme as the 2023 edition, i.e., CV4EO. It will be an in-person event and will take place for the second time at the University of Sannio, Benevento, Italy. We look forward to seeing you in Benevento! Please, stay tuned!

CONCLUSION

The school program provided a diverse range of opportunities for developing knowledge in geoscience and remote sensing. It also fostered a sense of community among students, professionals, and researchers. Looking back, we are inspired by the collaborative spirit, exchange of ideas, and topics discussed. We would like to thank GRSS and IADF for their support and all of the lecturers who gave freely

(continued on p. 204)



(a) (b) (c) (d)

FIGURE 3. Some of the 2023 IADF School's moments: (a) the Poster session; (b) the Welcome event; (c) the Gala Dinner; and (d) a moment of the city tour with some students.

CONCLUSION

HDCRS members were delighted to receive overwhelmingly positive feedback for the school. This encouragement strengthens our commitment, and we are looking forward to organizing the fourth edition. We plan to address new topics, seeking to promote the adoption of new technologies and tools related to efficient data processing. In addition to the core academic program, we are also planning a series of social activities to foster camaraderie and networking among participants. Registrations for the upcoming edition will commence in spring 2024. Furthermore, to provide diverse experiences and cater to a global audience, we are contemplating relocating future editions of the school to various other locations.

AUTHOR INFORMATION

Gabriele Cavallaro (g.cavallaro@fz-juelich.de) is with the Forschungszentrum Jülich, 52428 Jülich, Germany, and with the University of Iceland, 107 Reykjavik, Iceland. He is a Senior Member of IEEE.

Dora Blanco Heras (dora.blanco@usc.es) is with the Centro Singular de Investigación en Tecnoloxías Intelixentes, Universidade de Santiago de Compostela, 15782 Santiago de Compostela, Spain. She is a Senior Member of IEEE.

Manil Maskey (manil.maskey@nasa.gov) is with the National Aeronautics Space Administration, Huntsville, AL 35805 USA. He is a Senior Member of IEEE.

REFERENCES

[1] D. Tuia et al., "Artificial intelligence to advance Earth observation: A perspective," 2023, *arXiv:2305.08413*.

[2] G. Cavallaro et al., "High-performance and disruptive computing in remote sensing: HDCRS—A new working group of the GRSS earth science informatics technical committee," *IEEE Geosci. Remote Sens. Mag.*, vol. 10, no. 2, pp. 329–345, Jun. 2022, doi: 10.1109/MGRS.2022.3145478.

[3] N. Wedi et al., "Destination earth: High-performance computing for weather and climate," *Comput. Sci. Eng.*, vol. 24, no. 6, pp. 29–37, Nov./Dec. 2022, doi: 10.1109/MCSE.2023.3260519.

[4] G. Giuffrida et al., "The Φ-Sat-1 Mission: The first on-board deep neural network demonstrator for satellite earth observation," *IEEE Trans. Geosci. Remote Sens.*, vol. 60, pp. 1–14, 2022, doi: 10.1109/TGRS.2021.3125567.

[5] H.-D. Guo, L. Zhang, and L.-W. Zhu, "Earth observation big data for climate change research," *Adv. Climate Change Res.*, vol. 6, no. 2, pp. 108–117, Jun. 2015, doi: 10.1016/j.accre.2015.09.007.

[6] "HDCRS summer school 2023," GRSS-IEEE, Piscataway, NJ, USA, 2023. [Online]. Available: https://www.grss-ieee.org/community/groups-initiatives/high-performance-and-disruptive-computing-in-remote-sensing-hdcrs/hdcrs-summer-school-2023/

GRS

TECHNICAL COMMITTEES *(continued from p. 198)*

their time and expertise. A survey among the participants conducted after the school clearly showed that the event received high attention and provided an exciting experience. All of the comments have been collected and will be used to improve the format of the next editions.

AUTHOR INFORMATION

Silvia Liberata Ullo (ullo@unisannio.it) is with the Department of Engineering, University of Sannio, 82100 Benevento, Italy. He is a Senior Member of IEEE.

Gemine Vivone (gemine.vivone@imaa.cnr.it) is with the National Research Council-Institute of Methodologies for Environmental Analysis, 85050 Tito Scalo, Italy, and the National Biodiversity Future Center, 90133 Palermo, Italy. He is a Senior Member of IEEE.

Gülşen Taşkın (gulsen.taskin@itu.edu.tr) is with the Institute of Disaster Management, Istanbul Technical University, 34469 Istanbul, Turkey. She is a Senior Member of IEEE.

Ronny Hänsch (ronny.haensch@dlr.de) is with the German Aerospace Center, 82234 Weßling, Germany. He is a Senior Member of IEEE.

Ujjwal Verma (ujjwal.verma@manipal.edu) is with the Manipal Institute of Technology Bengaluru, Manipal Academy of Higher Education, 576104 Udupi, India. He is a Senior Member of IEEE.

REFERENCES

[1] "2023 IEEE GRSS IADF school." IADF. Accesssed: Dec. 2023. [Online]. Available: https://iadf-school.org/

[2] R. Roscher. "Explainable machine learning." Sciebo. Accesssed: Dec. 2023. [Online]. Available: https://uni-bonn.sciebo.de/s/YA0zxAhu4LlBiOU

[3] F. Tupin and E. Dalsasso. "SAR processing repository." Télécom Paris. Accesssed: Dec. 2023. [Online]. Available: https://gitlab.telecom-paris.fr/ring/iadf-2023-sar-processing

[4] M. Mommert. "Efficient learning repository." GitHub. Accesssed: Dec. 2023. [Online]. Available: https://github.com/mommermi/iadfschool2023_efficientlearning

[5] P. Gamba. "Fusion of heterogeneous sensors for change detection in urban area." Google Drive. Accesssed: Dec. 2023. [Online]. Available: https://drive.google.com/file/d/1cjBrVN3FFos6gTmNaT9fav3Ej33hueL1/view?usp=sharing

[6] "2023 IEEE GRSS IADF school." ILN. Accesssed: Dec. 2023. [Online]. Available: https://iln.ieee.org/public/contentdetails.aspx?id=11ECA9BDA72640B89EFF4B28D970F4EC

[7] "LinkedIn IEEE GRSS data fusion discussion forum." LinkedIn. Accesssed: Dec. 2023. [Online]. Available: https://www.linkedin.com/groups/3678437/

GRS