

LECTURE 1: WORK AND ACTIVITIES OF THE GRSS ESI HDCRS WORKING GROUP

End-to-End Machine Learning with High Performance and Cloud Computing - Tutorial IGARSS 2022 – 17 July, 2022

PROF. DR.-ING. GABRIELE CAVALLARO (WWW.GABRIELE-CAVALLARO.COM)
HEAD OF SIMULATION AND DATA LAB "AI AND ML FOR REMOTE SENSING", JÜLICH SUPERCOMPUTING CENTRE
ADJUNCT ASSOCIATE PROFESSOR, SCHOOL OF ENGINEERING AND NATURAL SCIENCES, UNIVERSITY OF ICELAND

BIG DATA EARTH OBSERVATION

Information about the physical, chemical, and biological systems of the planet Earth



A market in constant expansion

Upstream

Space
Infrastructure

Manufacturing of satellites,
ground systems, launchers,
ground operations

Midstream

Data Sales

Data acquisition Data
processing Data
archiving Data
distribution and delivery

Downstream

Value-adding
services Data

Processing, adaptation to
users' need, integration with
data from other sources

Digital Transformation Monitor, Big Data in Earth Observation, EASME/COSME/2017:
<https://ati.ec.europa.eu/sites/default/files/2020-06/Big%20Data%20in%20Earth%20Observation%20%28v1%29.pdf>

EO IS BEYOND BIG DATA

Volume, Variety, Veracity, ... Velocity and ...

High Dimensional



Data reflect complex relationships between natural and social phenomena

High Complexity

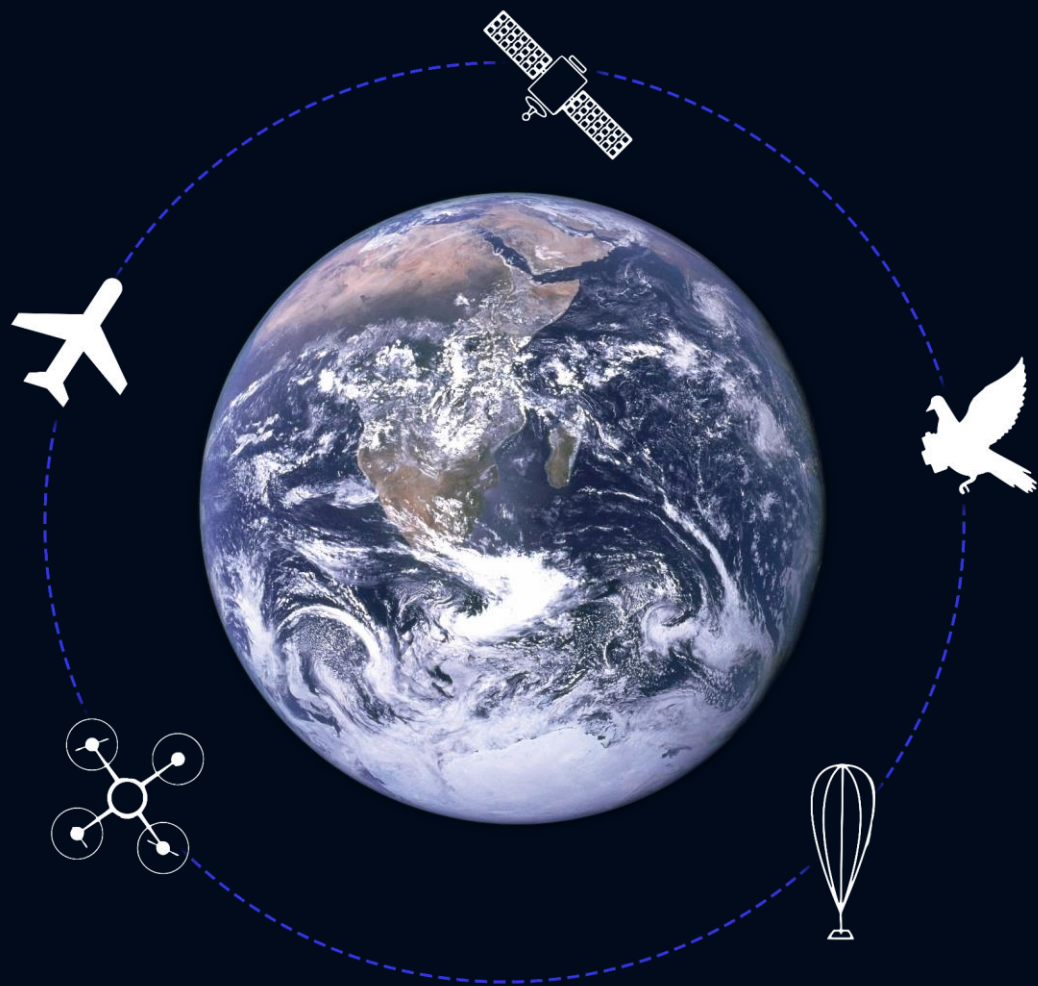


Data is incorporated in highly complex models

High Uncertainty

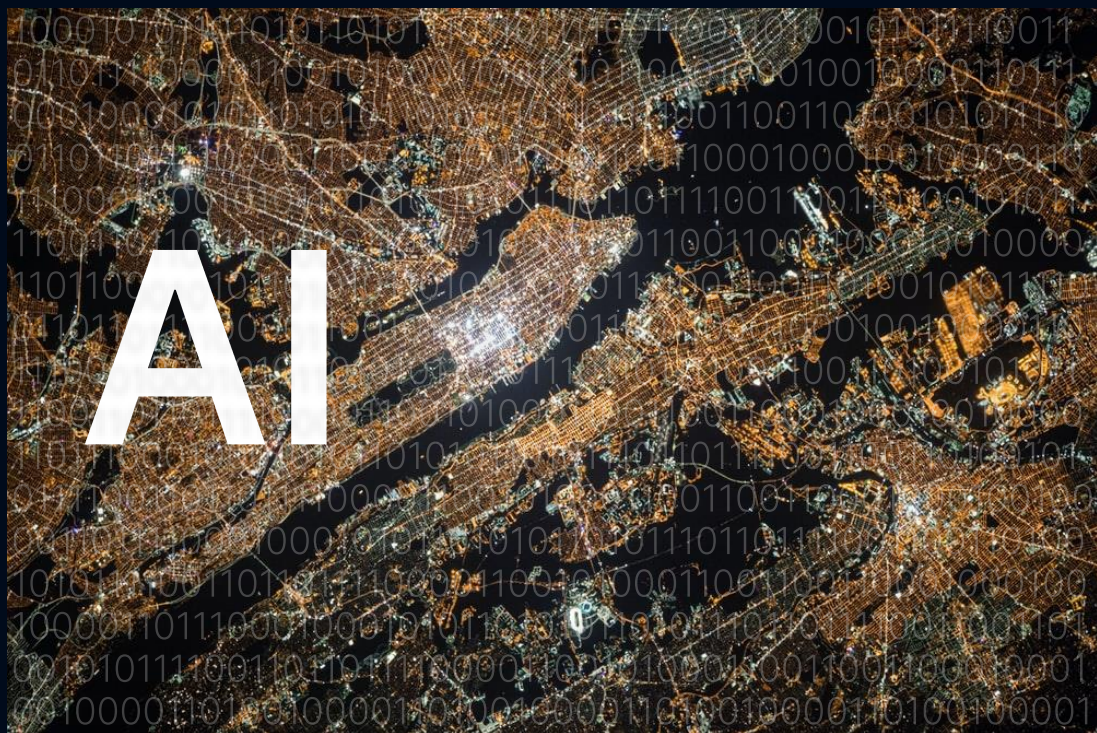


Data errors or incompleteness of data is unavoidable



HOW TO EXTRACT KNOWLEDGE IN A TIMELY MANNER?

From data acquired by diverse
observational systems

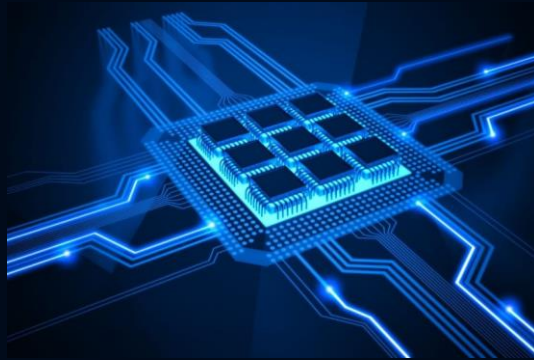


HOW TO USE ARTIFICIAL INTELLIGENCE FOR EARTH OBSERVATION?

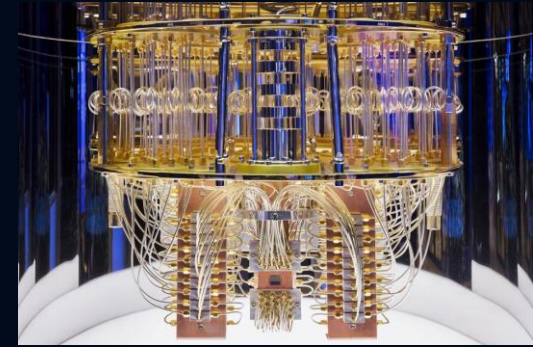
HOW TO EXPLOIT EMERGING COMPUTING PARADIGMS?



Supercomputing and
Distributed Computing



Specialized Hardware
Computing



Quantum Computing

Martidaniel, CC BY-SA 4.0, MareNostrum 4 supercomputer, Barcelona Supercomputing Center
https://commons.wikimedia.org/wiki/File:2017_BSC_Superordenador_MareNostrum-4_Barcelona-Supercomputing-Center.jpg

Interior of IBM's Quantum Computer
<https://www.ibm.com/>

GEOSCIENCE AND REMOTE SENSING SOCIETY (GRSS)

One of the 39 societies of IEEE



IEEE



Mission



Develop concepts and techniques of RS of the Earth, oceans, atmosphere, and space, as well as processing, interpretation, and dissemination of this information for the benefit of society

Facts



Founded in 1961
~4,200 members in 94 countries
69 chapters, 22 student chapters, and 11 ambassadors all over the world

GRSS TECHNICAL COMMITTEES

Earth Science Informatics



Frequency allocations
in Remote Sensing



Geoscience Spaceborne
Imaging Spectroscopy



Image Analysis and
Data Fusion



Instrumentation and Future
Technologies



Modeling in Remote Sensing



Remote sensing Environment,
Analysis and Climate Technologies



ESI TECHNICAL COMMITTEE

Objectives

Advance application of informatics to
geoscience and remote sensing

<https://www.grss-ieee.org/technical-committees/earth-science-informatics/>

Chairs



Peter Baumann



Manil Maskey

IT INCLUDES TWO WORKING GROUPS

High-performance and Disruptive Computing in Remote Sensing (HDCRS)



Gabriele Cavallaro



Dora Blanco Heras



Jin Sun

Databases in Remote Sensing (DBRS)



Dai-Hai Ton That



Kesheng (John) Wu



Khalid Belhajjame

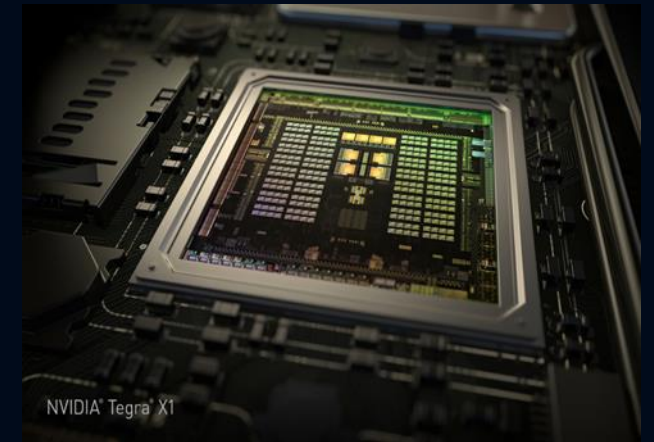
High Performance and Disruptive Computing in Remote Sensing Working Group

Main Objective:

Connect and support the community of interdisciplinary researchers in remote sensing who are specialized in emerging computing paradigms

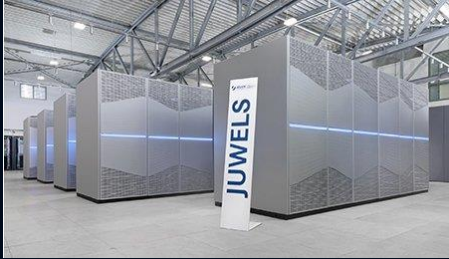
The idea:

Innovative computing technologies applied to efficient computation of remote sensing problems



<https://www.grss-ieee.org/community/groups-initiatives/high-performance-and-disruptive-computing-in-remote-sensing-hdcrs/>

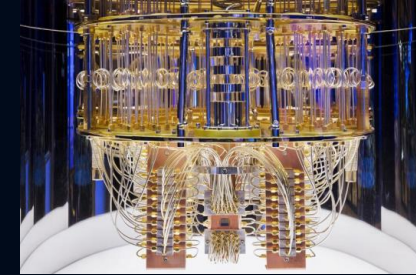
EMERGING COMPUTING PARADIGMS



Supercomputing



Specialized Hardware
Computing



Quantum Computing



Edge Computing



Cloud computing

...

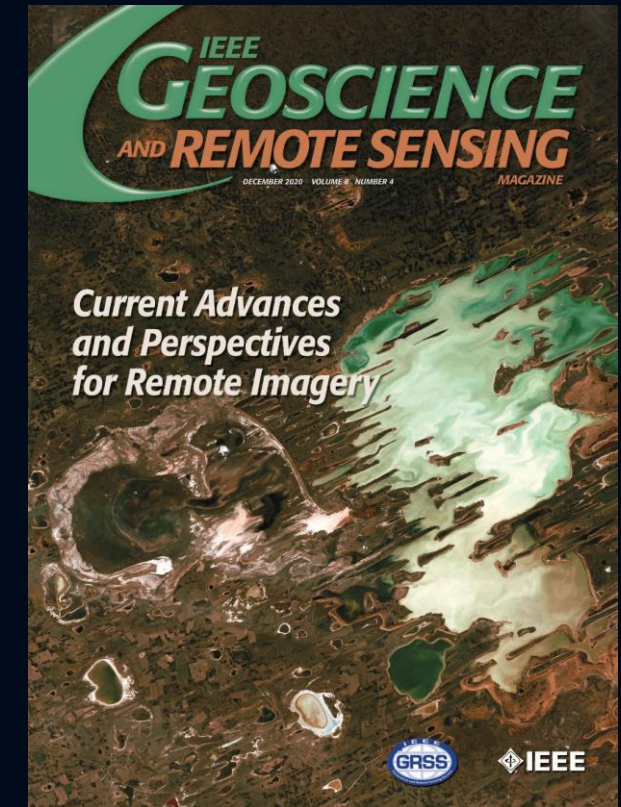


Blockchain

High-Performance and Disruptive Computing in Remote Sensing

HDCRS—A new Working Group of the GRSS Earth Science Informatics Technical Committee

GABRIELE CAVALLARO, DORA B. HERAS, ZEBIN WU, MANIL MASKEY, SEBASTIÁN LÓPEZ, PIOTR GAWRON, MIHAI COCA, AND MIHAI DATCU



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," in IEEE Geoscience and Remote Sensing Magazine, <https://doi.org/10.1109/MGRS.2022.3145478>

COME ABOARD

About Earth Science Informatics



MISSION

The Earth Science Informatics Technical Committee (ESI TC) provides a venue for informatics professionals to exchange ideas and share knowledge. It aims at advancing application of informatics to geosciences and remote sensing, assessing technology to support data stewardship and management, and promoting best practices and lessons learned.

The mission of the ESI TC is to bring together informatics experts and practitioners to share ideas and information to support open science and maximize the use of science data for research and applications.

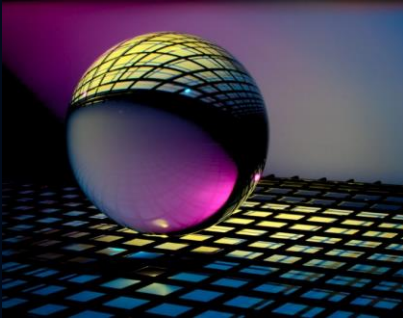


<https://www.grss-ieee.org/technical-committees/earth-science-informatics/>

Activities

SUMMER SCHOOL - 2021

From HPC to Quantum paradigms in Earth Observation



Mihai Dactu

Programming GPUs and Accelerators with Directives



Sergio Bernabé García
Carlos García Sánchez

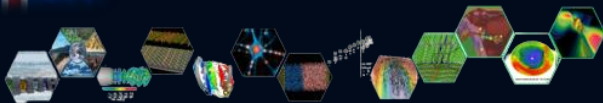
Scaling Machine Learning for Remote Sensing using Cloud Computing



Manil Maskey, Iksha Gurung,
Muthukumaran Ramasubramanian,
Shubhankar Gahlot



IHPC National Competence Center
for HPC & AI in Iceland



UNIVERSITY OF ICELAND





IEEE GRSS HDCRS Working Group

High Performance and Disruptive
Computing in Remote Sensing

Summer school
30 May - 2 June, 2022

In cooperation with and sponsored by



<https://www.grss-ieee.org/community/groups-initiatives/high-performance-and-disruptive-computing-in-remote-sensing-hdcrs/hdcrs-summer-school-2022/>

INVITED SESSION ON DATA INTENSIVE COMPUTING FOR REMOTE SENSING

M. Riedel, G. Cavallaro and J. A. Benediktsson

"Parallel and Scalable ML in RS from HPC Over Cloud to Quantum Computing"

À. Ordóñez, D. B. Heras and F. Argüello

"Comparing Area- and Feature-Based Methods for Co-Registration of Multispectral Bands on GPU"

M. Díaz, R. Guerra, S. López, J. Caba and J. Barba

"FPGA-Based method of a Hyperspectral Anomaly Detection Algorithm for Real-Time Applications"

R. Sedona, G. Cavallaro, M. Riedel and M. Book

"Enhancing Large Batch Size Training of Deep Models for RS Applications"

D. Coquelin, R. Sedona, M. Riedel and M. Götz

"Evolutionary Optimization of Neural Architectures in RS Classification Problems"





MO4.O2: Quantum computing and ML in GRSS

Mon, 18 Jul, 16:00 - 17:30 Malaysia Time (UTC +8)
 Mon, 18 Jul, 10:00 - 11:30 Central European Time (UTC +2)
 Mon, 18 Jul, 08:00 - 09:30 UTC
 Mon, 18 Jul, 04:00 - 05:30 Eastern Time (UTC -4)

Location: Conference Hall 2
Session Type: Oral In-Person
Session Co-Chairs: Gabriele Cavallaro, Forschungszentrum Jülich and Mihai Datcu, German Aerospace Center (DLR)
Track: Invited Sessions

MO4.O2.1: HYBRID QUANTUM-CLASSICAL WORKFLOWS IN MODULAR SUPERCOMPUTING ARCHITECTURES WITH THE JÜLICH UNIFIED INFRASTRUCTURE FOR QUANTUM COMPUTING

Gabriele Cavallaro, Thomas Lippert, Kristel Michielsen, Forschungszentrum Jülich, Germany; Morris Riedel, University of Iceland, Iceland

Mon, 18 Jul, 16:00 - 16:30 Malaysia Time (UTC +8)
 Mon, 18 Jul, 10:00 - 10:30 Central European Time (UTC +2)
 Mon, 18 Jul, 08:00 - 08:30 UTC
 Mon, 18 Jul, 04:00 - 04:30 Eastern Time (UTC -4)

MO4.O2.2: HOW QUANTUM COMPUTING-FRIENDLY MULTISPECTRAL DATA CAN BE?

Manish Kumar Gupta, Piotr Gawron, Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Poland; Martin Beseda, Technical University of Ostrava, Czechia

Mon, 18 Jul, 16:30 - 16:45 Malaysia Time (UTC +8)
 Mon, 18 Jul, 10:30 - 10:45 Central European Time (UTC +2)
 Mon, 18 Jul, 08:30 - 08:45 UTC
 Mon, 18 Jul, 04:30 - 04:45 Eastern Time (UTC -4)

MO4.O2.3: QUANTUM COMPUTING FOR EARTH OBSERVATION SCIENTISTS – INTRODUCING SOME KEY CONCEPTS

Tobias Guggemos, Andreas Spoerl, German Aerospace Center (DLR), Germany

Mon, 18 Jul, 16:45 - 17:00 Malaysia Time (UTC +8)
 Mon, 18 Jul, 10:45 - 11:00 Central European Time (UTC +2)
 Mon, 18 Jul, 08:45 - 09:00 UTC
 Mon, 18 Jul, 04:45 - 05:00 Eastern Time (UTC -4)

MO4.O2.4: A PHYSICS-BASED ML APPROACH FOR CORN PLANT HEIGHT ESTIMATION WITH SIMULATED SAR DATA

Lorenzo Giuliano Papale, Fabio Del Frate, Leila Guerriero, Giovanni Schiavon, Tor Vergata University of Rome, Italy

Mon, 18 Jul, 17:00 - 17:15 Malaysia Time (UTC +8)
 Mon, 18 Jul, 11:00 - 11:15 Central European Time (UTC +2)
 Mon, 18 Jul, 09:00 - 09:15 UTC
 Mon, 18 Jul, 05:00 - 05:15 Eastern Time (UTC -4)

MO4.O2.5: RETRIEVAL OF RAINFALL INFORMATION BY SPACEBORNE C-BAND SAR BASED ON MACHINE LEARNING

Shanshan Mu, Xiaofeng Li, Institute of Oceanology, Chinese Academy of Sciences, China

Mon, 18 Jul, 17:15 - 17:30 Malaysia Time (UTC +8)
 Mon, 18 Jul, 11:15 - 11:30 Central European Time (UTC +2)
 Mon, 18 Jul, 09:15 - 09:30 UTC
 Mon, 18 Jul, 05:15 - 05:30 Eastern Time (UTC -4)

https://igarss2022.org/view_session.php?SessionID=1309



WE5.V16: Harnessing the Power of Quantum Computing for Machine Learning

Wed, 20 Jul, 19:50 - 21:20 Malaysia Time (UTC +8)
 Wed, 20 Jul, 13:50 - 15:20 Central European Time (UTC +2)
 Wed, 20 Jul, 11:50 - 13:20 UTC
 Wed, 20 Jul, 07:50 - 09:20 Eastern Time (UTC -4)

Location: Virtual Room 16
Session Type: Oral Virtual
Session Co-Chairs: Datcu Mihai , DLR & UPB and Jacqueline Le Moigne, NASA
Track: Invited Sessions

WE5.V16.1: QUANTUM SUPPORT VECTOR REGRESSION FOR BIOPHYSICAL VARIABLE ESTIMATION IN REMOTE SENSING

Edoardo Pasetto, Amer Delilbasic, Gabriele Cavallaro, Madita Willsch, Kristel Michielsen, Forschungszentrum Jülich, Germany; Farid Melgani, University of Trento, Italy; Morris Riedel, University of Iceland, Iceland

Wed, 20 Jul, 19:50 - 20:05 Malaysia Time (UTC +8)
 Wed, 20 Jul, 13:50 - 14:05 Central European Time (UTC +2)
 Wed, 20 Jul, 11:50 - 12:05 UTC
 Wed, 20 Jul, 07:50 - 08:05 Eastern Time (UTC -4)

WE5.V16.2: QUANTUM CONVOLUTIONAL CIRCUITS FOR EARTH OBSERVATION IMAGE CLASSIFICATION

Su Yeon Chang, Sofia Vallecorsa, Michele Grossi, CERN, Switzerland; Bertrand Le Saux, European Space Agency (ESA), Italy

Wed, 20 Jul, 20:05 - 20:20 Malaysia Time (UTC +8)
 Wed, 20 Jul, 14:05 - 14:20 Central European Time (UTC +2)
 Wed, 20 Jul, 12:05 - 12:20 UTC
 Wed, 20 Jul, 08:05 - 08:20 Eastern Time (UTC -4)

WE5.V16.3: QUANTUM-ASSISTED GREEDY ALGORITHMS

Ramin Ayanzadeh, Georgia Institute of Technology, United States; John Dorband, Milton Halem, Tim Finin, University of Maryland, Baltimore County, United States

Wed, 20 Jul, 20:20 - 20:35 Malaysia Time (UTC +8)
 Wed, 20 Jul, 14:20 - 14:35 Central European Time (UTC +2)
 Wed, 20 Jul, 12:20 - 12:35 UTC
 Wed, 20 Jul, 08:20 - 08:35 Eastern Time (UTC -4)

WE5.V16.4: AUTOMATING ANTENNA SCHEDULING PROBLEMS USING QUANTUM COMPUTING AND DEEP REINFORCEMENT LEARNING

Brian Wilson, Jet Propulsion Laboratory / Caltech, United States; Edwin Goh, Alexandre Guillaume, Ryan Alimo, Thomas Claudet, Hamsa Venkataram, Jet Propulsion Laboratory, United States

Wed, 20 Jul, 20:35 - 20:50 Malaysia Time (UTC +8)
 Wed, 20 Jul, 14:35 - 14:50 Central European Time (UTC +2)
 Wed, 20 Jul, 12:35 - 12:50 UTC
 Wed, 20 Jul, 08:35 - 08:50 Eastern Time (UTC -4)

WE5.V16.5: QUANTUM-COMPATIBLE VARIATIONAL SEGMENTATION FOR IMAGE-TO-IMAGE WILDFIRE DETECTION USING SATELLITE DATA

Ata Akbari Asanjan, Aaron Lott, USRA at NASA Ames Research Center, United States; Milad Memarzadeh, Thomas Templin, Eleanor Rieffel, NASA Ames Research Center, United States

Wed, 20 Jul, 20:50 - 21:05 Malaysia Time (UTC +8)
 Wed, 20 Jul, 14:50 - 15:05 Central European Time (UTC +2)
 Wed, 20 Jul, 12:50 - 13:05 UTC
 Wed, 20 Jul, 08:50 - 09:05 Eastern Time (UTC -4)

WE5.V16.6: CORESET OF HYPERSPECTRAL IMAGES ON A SMALL QUANTUM COMPUTER

Soronzonbold Otgonbaatar, German Aerospace Center Oberpfaffenhofen, Technical University of Berlin, Germany; Mihai Datcu, German Aerospace Center Oberpfaffenhofen, Germany; Begüm Demir, Technical University of Berlin, Germany

Wed, 20 Jul, 21:05 - 21:20 Malaysia Time (UTC +8)
 Wed, 20 Jul, 15:05 - 15:20 Central European Time (UTC +2)
 Wed, 20 Jul, 13:05 - 13:20 UTC
 Wed, 20 Jul, 09:05 - 09:20 Eastern Time (UTC -4)

https://igarss2022.org/view_session.php?SessionID=1269

WORKSHOP

Searching and Mining Large Collections of Geospatial Data (GeoSearch)

Objectives



Forum for researchers and practitioners interested to develop search engine with geospatial data modeling, data processing and management

Chairs



Gabriele Cavallaro (Forschungszentrum Jülich), Dora B. Heras (University of Santiago de Compostela), Dalton Lunga (Oak Ridge National Laboratory) , Martin Werner (TU Munich), Andreas Züfle (George Mason University)

<https://www.grss-ieee.org/events/1st-international-workshop-on-searching-and-mining-large-collections-of-geospatial-data-geosearch/>



SPECIAL ISSUE

IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing

Quantum Computing for Earth Observation



Mihai Dactu, Jacqueline Le Moignes, Bertrand Le Saux

<https://www.grss-ieee.org/events/special-issue-on-quantum-computing-for-earth-observation/>

TUTORIALS

From Big EO Data to Digital Twins: Hybrid AI and Quantum based Paradigms



Mihai Dactu

Scalable Machine Learning with High Performance Computing and Cloud Computing



Gabriele Cavallaro, Shahbaz Memon, Rocco Sedona

International Geoscience and Remote Sensing Symposium



<https://igarss2021.com/tutorials.php>

END-TO-END MACHINE LEARNING WITH HIGH PERFORMANCE AND CLOUD COMPUTING

Morning session: 9:30-13:00

9:30 – 10:00 Lecture 1: Work and Activities of the GRSS ESI HDCRS Working Group

10:00 – 10:30 Lecture 2: Introduction and Motivations

10:30 – 11:15 Lecture 3: Levels of Parallelism and High Performance Computing

11:15 – 11:45 Coffee Break

11:45 – 13:00 Lecture 4.1: Distributed Deep Learning with High Performance Computing

Afternoon session: 14:00-17:30

14:00 – 15:00 Lecture 4.2: Distributed Deep Learning with High Performance Computing

15:00 – 16:30 Lecture 5: Deep Learning with Cloud computing

16:30 – 17:00 Coffee Break

17:00 – 17:30 More time for hands-on, Q&A and wrap-up

INSTRUCTORS



Gabriele Cavallaro



Rocco Sedona



Manil Maskey



Iksha Gurung



Muthukumaran
Ramasubramanian



JÜLICH
SUPERCOMPUTING
CENTRE



Thank you for your attention