



PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Giacomo Giovanni

Cycle: XXXVI

Training and Research Activities Report

Academic year: 2021-22 - Year: Second

Giacomo Giovanni

Tutor: prof. Carlo Sansone

Carlo Sansone

Date: October 30, 2022

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Author: Giovanni Giacco

1. Information:

- **PhD student:** Giovanni Giacco
- **DR number:** DR995137
- **Date of birth:** 27/04/1988
- **Master Science degree:** Computer Engineering
- **University:** University of Naples Federico II
- **Doctoral Cycle:** XXXVI
- **Scholarship type:** *no scholarship*
- **Tutor:** Carlo Sansone

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
Designing Quantum Algorithms – Prof. Michele Amoretti, University of Parma, Parma, Italy, Department of Engineering and Architecture.	Seminar	2	0.4	16/12/2021	Prof. A. S. Cacciapuoti, DIETI - Unina	N
GDPR basics for computer scientists, Dr. Rigo Wenning	Seminar	1.5	0.3	14/12/2021	Prof. Piero Bonatti, DIETI - Unina	N
Neural Implicit Representations for 3D Vision, prof Andreas Geiger	Seminar	1	0.2	18/11/2021	IARAI	N
Learned optimizers: why they're the future, why they're hard, and what they can do now - Jascha Sohl-Dickstein	Seminar	1	0.2	16/12/2021	IARAI	N
Intelligenza artificiale e sistemi d'arma autonomi	Seminar	1	0.2	19/01/2022	Gruppo Interdisciplinare su Scienza, Tecnologia e Società (GI-STs) dell'Area della	N

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					Ricerca di Pisa del CNR	
The learning landscape in deep neural networks and its exploitation by learning algorithms – Riccardo Zecchina	Seminar	1	0.2	21/01/2022	CQB DIETI, UniNA	Y
RAILS Mid-term Project Workshop (5h workshop online)	Seminar	5	1	25/02/2022	Shift2Rail	N
Sustainable land management and Earth Critical Zone (ECZ): a journey from ECZ characterization, modelling and Geospatial Decision Support Systems	Seminar	35	7	14/02/2022 – 25/02/2022	Dipartimento di Agraria - UNINA	Y
Earth Observation in support of SDG11: Mapping urban deprivation using remote sensing - Monika Kuffer, University of Twente, Julio Pedrassoli, Federal University of Bahia, Dennis Mwaniki, UN-Habitat	Seminar	1	0.2	07/09/2022	GRSS IEEE	N
Imprenditorialità accademica - Coordinamento scientifico a cura di P. Ripa (Direttore StartCup Campania 2022 "Mario Raffa")	Course	12	4	28/09/2022	Università degli Studi di Napoli Federico II	Y
How to Boost your PhD	Course	10	3	06/10/2022	Dr. Antigone Marino, CNR-ISASI Dipartimento di Fisica Unina	Y
Big Data Architecture and Analytics -	Course	20/10/2022	5	20/10/2022	ICTH-ITEE-CQB	

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Proff. Giancarlo Sperli, Giovanni Improta, Jari Haukka, Peter van Ooijen						
Scaling Geospatial Artificial Intelligence for Disaster Response, Lexie Yang, Oak Ridge National Laboratory, USA	Seminar	1	0.2	26/10/2022	GRSS IEEE	N

- 1) Courses, Seminar, Doctoral School, Research, Tutorship
- 2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	0	1.1	6	0	7.1
Bimonth 2	0	8.4	6	0	14.4
Bimonth 3	0	0	6	0	6
Bimonth 4	0	0	6	0	6
Bimonth 5	0	0	6	0	6
Bimonth 6	12	0.4	8	0	20.4
Total	12	9.9	38	0	59.9
Expected	10 - 20	5 - 10	30 - 45	0 - 1.6	

3. Research activity:

Developments in the capability to monitor our home planet with Earth Observation (EO) satellites have led to new opportunities for science and business. There is an increasing need to exploit the large amounts of data generated by the new generation of satellites coming online. Artificial Intelligence (AI) is essential to the solution, enabling scalable big data exploration and bringing unique insight and predictive capabilities. My research topic, "**Artificial Intelligence in Earth Observation applications**," fits in this context.

During the first year of my Ph.D., my main research activities concerned the application of Machine Learning, and Deep Learning methodologies, to remote sensing imagery to extract several kinds of information. I used free satellite imagery (e.g., Sentinel-2, Landsat-8) and commercial ones (e.g., Pleiades, Worldview-3, PlanetScope). In addition, Unmanned Aerial Vehicle (UAV) based imagery has been used too. In particular, my research focused on the automatic extraction of Soil consumption and Land Cover Land Use map from satellite imagery and the Automated crack detection for post-earthquake building damage assessment from drone imagery. During the second year of my Ph.D., I continued researching those topics, publishing two papers (see Section 4). In addition, I started the research on new cases; further details on the topics explored follow.

3.1. Research on Automated crack detection for post-earthquake building damage assessment from drone imagery

During my first year, I started a collaboration with the Department of Structures for Engineering and Architecture (DiSt) at Unina, to develop an automated solution to detect cracks on buildings surfaces. Cracks localization was a preliminary step to reach the final goal of automatically assessing the post-earthquake damages.

I developed a patch-based solution based on Convolutional Neural Networks (CNNs), to identify cracks on building surfaces. A novel dataset was created based on drone imagery and camera images, and Google Street View images to address the scarcity of drone images at our disposal. In addition, I worked on a model to detect windows in the buildings to understand where the crack is located and estimate its gravity related to where it occurs. Results showed an accuracy of around 89% for detecting patches, including cracks.

During the second year, I enhanced the work of the first year, improving the dataset's size and quality and introducing a novel methodology for the post-earthquake damage assessment considering essential features of cracks, i.e., the length and the width. For this purpose, I worked on a new deep-learning model to segment cracks on building surfaces to estimate the width and length of each crack.

3.2. Research on Carbon Sequestration Estimation from satellite imagery

Recently, the United Nations Framework Convention for Climate Change (UNFCCC) established the Reducing Emissions from Deforestation and forest Degradation (REDD+) that requires countries to report their carbon emissions and sink estimates through national greenhouse gas inventories (NGHGI). This makes it essential to develop systems that estimate the CO₂ absorbed by forests. Systems that rely on field measurements are the most reliable but time- and money-consuming.

During the second year of my Ph.D., I worked on a Machine-Learning approach to estimate the carbon absorbed by forests and nature reserves without in-situ observations, using open data from the ESA CCI Biomass Project and Sentinel-2 satellite images. Results showed that this methodology is adequate for estimating carbon absorbed in forest areas and nature reserves and could help monitor carbon sequestration capacity in any place without field measurements.

In the context of this research, I participated in the following activities:

- Speaker for the workshop “**Using AI/ML & satellite imagery to achieve city-level carbon neutrality**” at the event *Amazon re:MARS 2022 in Las Vegas, Nevada*. During a two-hour workshop, I presented a hands-on activity showing how a Random Forest model could be trained to estimate the Above Ground Biomass of trees.

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- Participant in **Innovation Village 2022** held at *Città della Scienza* in Naples. I presented a demo on using AI techniques to estimate how much CO₂ plants can absorb.

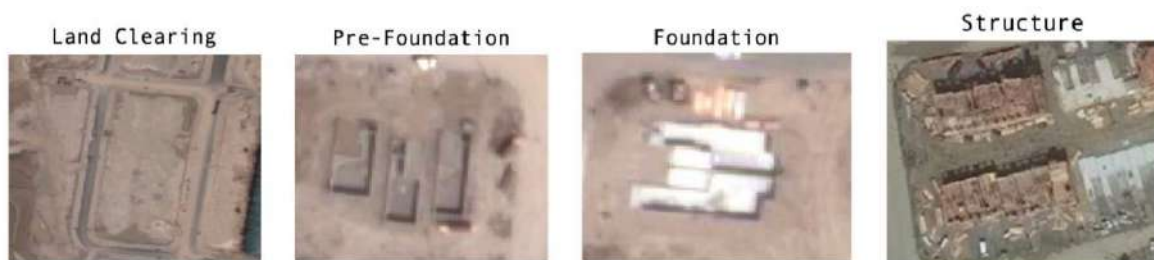
3.3. Research on Monitoring building construction stages with super-resolved Sentinel-2 satellite images

Monitoring the progress of a construction site is of paramount importance to municipal, regional, and government administrators. The government must be aware, at all relevant times, of the development and progress of the project.

During my second year, I worked on a research project in collaboration with Statistics Canada (www.statcan.gc.ca/), the national statistical office of Canada, to identify building construction phases from satellite imagery. The challenge was the ability to accomplish the task using free-of-charge satellite imagery to minimize the operational cost of the solution.

For this purpose, I implemented a model to super-resolve Sentinel-2 satellite images, increasing the original 10 m spatial resolution of a Sentinel-2 RGB image to 2.5 m spatial resolution, i.e., 4X zoom. The super-resolution model was based on a Generative adversarial network. After that, a Convolutional Neural Network (CNN) was trained to classify building stages among four classes: *Land Clearing*, *Pre-foundation*, *Foundation* and *Structure*.

Preliminary results show the ability to classify stages with an F1 score of 80,01%.



4. Research products:

Published papers:

- Giovanni Giacco, Giulio Mariniello, Stefano Marrone, Domenico Asprone and Carlo Sansone, Toward a system for Post-Earthquake Safety Evaluation of Masonry Buildings, International Conference on Image Analysis and Processing (ICIAP 2021), Lecce, May 23-27, 2021; https://doi.org/10.1007/978-3-031-06430-2_26
- ReFuse: Generating Imperviousness Maps from Multi-Spectral Sentinel-2 Satellite Imagery - Giovanni Giacco, Stefano Marrone, Giuliano Langella and Carlo Sansone, Future Internet 2022, 14(10), 278; <https://doi.org/10.3390/fi14100278>

Submitted papers:

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- Journal: Cities (<https://www.sciencedirect.com/journal/cities>)
Luca Battisti, Giovanni Giacco, Massimiliano Moraca, Giacomo Pettenati, Egidio Dansero, Federica Larcher, “Prioritizing the Implementation of Nature-based Solutions in an Urban Context: the Case-study of Turin (Italy)”.

In preparation papers:

- Giacco Giovanni, Antonio Elia Pascarella, Stefano Marrone, Carlo Sansone; “*ReUse: REgressive Unet for carbon Storage Estimation*”
- Giacco Giovanni, Mattia Rigioli, Stefano Marrone, Carlo Sansone; “*Monitoring building construction stages with free-of-charge super-resolved satellite images*”

5. Conferences and seminars attended

During my second PhD year I participated as speaker to the following conferences:

- *Sevizi ecosistemici, aree verdi urbane e dati spaziali: una formula vincente per città resilienti ed ecologicamente attente*; Luca Battisti, Giovanni Giacco, Massimiliano Moraca, Federico Cuomo, Giacomo Pettenati, Egidio Dansero – *III Edizione delle Giornate di Studi interdisciplinari Geografia e Tecnologia - Pisa 30 Giugno 2022*

6. Periods abroad and/or in international research institutions

During my second PhD year I did not spend any time abroad.

7. Tutorship

During my second PhD year I did not make any tutorship activity.

8. Plan for year three

For the third year of my Ph.D., I will continue research activities regarding Carbon Sequestration monitoring and building damage assessment from drone imagery. As part of the research activity regarding carbon sequestration, an experiment will be carried out in collaboration with Movyon, part of the Autostrade per l'Italia group, to estimate the amount of CO₂ sequestered along the entire Italian highway network.

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In addition, I will work on the use of deep-learning models for the super-resolution of open and free-of-charge satellite imagery to increase spatial resolution. I will also evaluate how these images could help tasks such as land cover classification, tree cover density assessment, etc. The ability to estimate these parameters at higher resolutions with free-of-charge data is of fundamental importance because it enables the study of various ecosystem services in urban and micro-urban settings without increasing the operational costs due to commercial satellite imagery. The validity of these models will be validated through the use of their output data for the analysis of several phenomena, e.g., urban heat islands, in different case studies for some Italian and European cities, such as Naples, Milan, and Helsinki.