Ph.D. in Information Technology
Thesis Defense

July 8, 2022
at 10:00
Room Conferenze "Emilio Gatti" and online by Webex

Francesco LATTARI – XXXIII Cycle

Learning to Observe Earth from Satellite Synthetic Aperture Radar Sensors through Deep Learning Methodologies

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Abstract:

Synthetic Aperture Radar (SAR) sensors have undoubtedly reinforced the growth potential of Earth observation (EO) applications. SAR sensors allow collecting information about the physical properties of the illuminated surface and its distance, thus allowing the monitoring of ground deformation phenomena. To this end, ground displacements must be estimated and accurate tools of analysis must be implemented to skim the huge amount of information to focus on the events that deserve a thorough investigation. Advanced SAR interferometry (InSAR) techniques allow obtaining displacement time series with millimeter accuracy. However, errors due to a particular noise known as speckle or an incorrect phase unwrapping, an unavoidable step in the InSAR analysis, may affect the estimate.

This thesis strengthens the analysis of satellite SAR images through the use of deep learning (DL) methods. First, we address the problem of reducing the speckle effect in SAR images using simulated data to train an encoder-decoder deep neural network (DNN). We introduce a finetuning stage on real SAR images and provide a modified total variation (TV) regularization to obtain smoother results while preserving the details. The use of the encoder-decoder architecture with skip connections enables better preservation of the details compared to state-of-the-art approaches and the finetuning strategy guarantees a better generalization. In addition, we report the promising results obtained in our preliminary attempt to learn the speckle filter in an unpaired image-to-image translation setting that uses generative adversarial networks (GANs). Then, we provide a solution to the problem of automatically detecting trend changes in InSAR time series. The proposed method consists of a deep recurrent neural network (RNN) that combines the information about the ground displacement and the temporal baseline associated with the SAR acquisitions to predict the change points. We demonstrate the validity of the proposed approach in several simulated scenarios, where it outperforms the reference algorithm. In addition, we show how the provided method can generalize when applied to real InSAR time series by reporting the analysis on a continuous monitoring project. Finally, we provide a novel solution to the phase unwrapping problem, a well-known challenging task in InSAR analysis. The proposed method, which outperforms state of the art, replaces traditional black-box end-to-end architectures with an explainable learnable system that automatically learns to interface with a phase unwrapping optimization algorithm by predicting intermediate representation that improves the algorithm solution, effectively exploiting the benefits of both learnable and algorithmic approaches. Overall, this thesis provides novel solutions for analyzing satellite SAR-derived data through the exploitation of deep learning techniques, thus increasing its operational use.

PhD Committee

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