PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Domenico A. G. Dell'Aglio

XXXII Cycle

Training and Research Activities Report – First Year

Tutor: Antonio Iodice

1. Information

   Domenico Antonio Giuseppe Dell'Aglio, Master Degree in Telecommunication Engineering – University of Naples "Federico II"

   XXXII Cycle - ITEE - Università di Napoli Federico II

   Tutor: Prof. Antonio Iodice

2. Study and Training activities

   During my first year of the Ph.D I have taken the following courses:

   - ✓ Satellite Remote Sensing: Open challenges and opportunities (3 cfu)
   - ✓ Tomografia e imaging: principi, algoritmi e metodi numerici (9 cfu)
   - ✓ Radiolocalizzazione e Navigazione Satellitare (6 cfu)

   and I have attended the following seminars:

   - ✓ Radar and SAR Systems for Airborne and Space-based Surveillance and Reconnaissance
   - ✓ Wireless Opportunistic Networking
   - ✓ From control to interaction in multi-robot systems
   - ✓ AIS e il Sistema Nazionale per il Monitoraggio del Traffico Marittimo
   - ✓ Challenges and Opportunities for IT innovation in the space business
   - ✓ Il sensore radar: aspetti operativi, prestazionali, criteri di progetto e problemi realizzativi
   - ✓ Beyond 5G: Data Throughput Optimization at mmWave and THz Frequencies for Vehicle to Infrastructure Communications
   - ✓ Graph Queries: Generation, Evaluation and Learning
   - ✓ Dal GPS al GNSS e la modernizzazione per il Precise positioning nel campo automotive
   - ✓ Optimal control of networks: energy scaling and open challenges
   - ✓ Dynamic control: Mathematical challenges and applications
   - ✓ Large Scale Integrative Bioinformatics and Systems Biology in Cancer Genomics
   - ✓ SeeQC-eu, Hypres Quantum Engineering

   In the following table is depicted a summary of the activities presented above:

	Credits year 1								Credits year 2								Credits year 3									
		1	2	3	4	5	6			1	2	3	4	5	6			1	2	3	4	5	6			
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Total	Check
Modules	20					3	15	**18**	10							**0**	0							**0**	18	30-70
Seminars	5				1,3	1,6	2,3	**5,2**	5							**0**	0							**0**	5,2	10-30
Research	35	10	10	10	8,7	5,4		**44,1**	45							**0**	60							**0**	44,1	80-140
	60	10	10	10	10	10	17,3	**67,3**	60	0	0	0	0	0	0	**0**	60	0	0	0	0	0	0	**0**	67,3	180

3. Research activity

In the first year of my Ph.D I focused the research activity on three main topics:

a. SAR Raw Signals Simulator
b. Radiopropagation through multi-layered structures
c. SAR Sub-pixel offset technique

Here I briefly explain each of which:

a. Synthetic Aperture Radar (SAR) systems can generate microwave images by using different acquisition modes: stripmap, spotlight, scanSAR, Sliding-spotlight and TOPSAR. The proper mode to be used is chosen according to the desired spatial resolution and coverage. The activity research has had the main purpose to devise a unified formulation able to express raw signals of all acquisition modes. This formulation has then been employed to show that both sliding spotlight and TOPSAR raw signal simulation of extended scenes can be achieved by using the following approach: a 1D range Fourier domain processing, followed by a 1D azimuth time domain integration, and it can also precisely account for sensor trajectory deviations, for any acquisition mode. Effectiveness of the simulation scheme has been assessed by using numerical examples evaluated in FORTRAN 77 environment. To reach this aim, the following references has been mainly considered and studied:

[1] G. Franceschetti, M. Migliaccio, D. Riccio, G. Schirinzi, "SARAS: a SAR raw signal simulator", IEEE Trans. Geosc. Remote Sensing, vol.30, pp.110 123, 1992.
[2] S. Cimmino, G. Franceschetti, A. Iodice, D. Riccio, G. Ruello, "Efficient Spotlight SAR Raw Signal Simulation of Extended Scenes", IEEE Trans. Geosc. Remote Sensing, vol.41, pp. 2329- 2337, 2003.
[3] G. Franceschetti, A. Iodice, S. Perna, D. Riccio, "Efficient Simulation of Airborne SAR Raw Data of Extended Scenes", IEEE Transactions on Geoscience and Remote Sensing, vol.44, no.10, pp. 2851-2860, 2006.
[4] G. Franceschetti, A. Iodice, S. Perna, D. Riccio, "SAR Sensor Trajectory Deviations: Fourier Domain Formulation and Extended Scene Simulation of Raw Signal", IEEE Transactions on Geoscience and Remote Sensing, vol.44, no.9, pp. 2323-2334, 2006.
[5] F. De Zan, A. Monti Guarnieri, "TOPSAR: Terrain Observation by Progressive Scans", IEEE Trans. Geosci. Remote Sens., vol. 44, no. 9, pp.2352-2360, Sept. 2006.
[6] W. Yang, J. Chen, H. C. Zeng, J. Zhou, P. B. Wang, C. S. Li, "A Novel Three-Step Image Formation Scheme for Unified Focusing on Spaceborne SAR Data", Progress In Electromagnetics Research, vol.137, pp.621-642, 2013.

[7] W. Yang, J. Chen, W. Liu, P. B. Wang, C. S. Li," A Modified Three-Step Algorithm for TOPS and Sliding Spotlight SAR Data Processing", IEEE Trans. Geosci. Remote Sens., vol.55, no.12, pp. 6910-6921, Dec. 2017.

b. This research activity has been carried out in several phases. In a first phase, the classical study of the electromagnetic propagation through multilayered media has been approached: in the canonical case of the flat and parallel surfaces, and by considering a plane wave which affects on it, it is possible to model the system using the transmission lines theory. Thereafter, in order to extend the case of study to more complex stratified structures, some models have been analysed (in particular, see the references below [1] and [2]): the solution to the problem of the electromagnetic field evaluation, in the presence of a system composed by an arbitrary number of rough surfaces, is provided, in a closed form, by the First Order Perturbative Model. Finally, some simulations and numerical examples has been carried out in order to validate the goodness of the analysed models.

[1] P. Imperatore, A. Iodice, D. Riccio, "Transmission through layered media with rough boundaries: first-order perturbative solution", IEEE Transactions on antennas and propagation, vol.57, no. 5, May 2009.
[2] P. Imperatore, A. Iodice, D. Riccio, "Physical meaning of perturbative solutions for scattering from and through multilayered structures with rough interface", IEEE Transactions on antennas and propagation, vol.58, no. 8, August 2010.

c. The sub-pixel offset technique (SPOT technique) allows us to obtain an estimation of the time-varying displacements of a given Earth surface by using only the SAR amplitude information, overcoming the limitations of the classic InSAR methods. The main limitations are: (a) the assumption that different rates of movements over a given distance can not exceed a thresh-old value, which depend on the pixel spacing of the SAR images and on the radar wavelength; (b) areas with low coherence because of the presence of a densely vegetated layer covering the surface. We have applied the SPOT technique on a dataset of three COSMO-SkyMed Spotlight images of the Slumgullion landslide (in Colorado) and the results have been compared with those presented in the literature obtained through in-situ measurements and GBInSAR processing, as explained in [1]. We have shown that the displacements velocity retrieved through SPOT technique, for this case of study, is more in line with the in-situ measurements than those obtained by using the GBInSAR method. We have also implemented a consistency check, in order to verify the reliability of the displacements retrieved by the approach analyzed: the average error results to be in the order of three centimeters (thus below the resolution of the method, which is 1/8 of pixel, thus about 10 centimeters).

[1] W. H. Schulz, J. A. Coe, P. P. Ricci, G. M. Smoczyk, B. L. Shurtleff, and J. Panosky, "Landslide kinematics and their potential controls from hourly to decadal timescales: Insights from integrating ground-based InSAR measurements with structural maps and long-term monitoring data," *Geomorphology*, vol. 285, pp. 121–136, 2017.
[2] A. Singleton, Z. Li, T. Hoey, J.-P. Muller, "Evaluating sub-pixel offset techniques as an alternative to D-InSAR for monitoring episodic landslide movements in vegetated terrain", *Remote Sensing of Environment*, vol. 147, pp. 133-144, 2014.
[3] Pietro Milillo, Eric J. Fielding, William H. Shulz, Brent Delbridge, and Roland Bürgmann, "COSMO-SkyMed Spotlight Interferometry Over Rural Areas: The Slumgullion Landslide in Colorado, USA", *IEEE journal of selected topics in applied earth observations and remote sensing*, vol. 7, no. 7, JULY 2014.

4. Products

    a. Publications:

    "A Unified Formulation of SAR Raw Signals from Extended Scenes for All Acquisition Modes" submitted on IEEE Transactions on Geoscience and Remote Sensing

    "Efficient Simulation of Extended-Scene SAR Raw Signals with Any Acquisition Mode" submitted on IGARSS 2018

    In preparation:

    "Suitability of Sub-Pixel Offset Estimation for Monitoring Large Landslide-Induced Movements: The Case Study of the Slumgullion Landslide"

5. Conferences and Seminars

I have not taken part at any conference/seminar

6. Activity abroad

I have not spent any time abroad

7. Tutorship

As winner of a "Tutoring Grant", I have given lectures in *Programming Foundamentals* to the first year students of the Polytechnic School of Engineering (31/50 hours)