PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Alessio Di Simone

XXIX Cycle

Training and Research Activities Report – Second Year

Tutor: Daniele Riccio

1. Information

Alessio Di Simone, MSc in Telecommunications Engineering – Università di Napoli Federico II.

XXIX Cycle - ITEE – Università di Napoli Federico II.

Tutor: Daniele Riccio

My fellowship – named "Sistemi di telecomunicazione innovativi a larga banda anche con impiego di satelliti per utenze differenziate in materia di sicurezza, prevenzione e intervento in caso di catastrofi naturali" – is funded by the MIUR within the FSG program.

2. Study and Training activities
   a. Courses
      - Ad hoc Course, "*Designing and writing scientific manuscripts for publication in english language scholarly journals, and related topics",* June 2015.
      - Ad hoc Course, "*Fondamenti di Analisi Funzionale*", July 2015.

   b. Seminars
      - "*The iCub project: An open platform for research in robotics & artificial intelligence",* by Dr. Giorgio Metta, March 18th 2015.
      - *"Fundamentals of semiconductor power modules reliability"* - *"Advanced power module thermal management and design for lifetime extension"* - *"Power module on-board health monitoring",* by Prof. Alberto Castellazzi, from March 24th to March 26th 2015.
      - *"Colloquium on Robotics",* April 21th 2015.
      - "*Partial Possibilistic Regression Path Modeling*", by Prof. Rosaria Romano, April 20th 2015.
      - "*Passivity-based control of nonlinear physical systems. A port-Hamiltonian approach*", by Dr. Alejandro Donaire, May, 27th 2015.
      - "*Evoluzioni a lungo termine delle reti mobile*", by Eng. Silvio De Nicola, June 8th 2015.
      - "*Lecture on Current and Future Trends in Advanced Antenna Applications*", by Prof. C. A. Balanis, June 3rd 2015.
      - "*La Sintesi Sonora dell'Ingegner Laurens Hammond*", by Dr. Riccardo de Asmundis, November, 11th 2015.
      - "*Radar Adaptivity: Antenna Based Signal Processing Technique*", by Dr. Alfonso Farina, February, 12th 2016.
      - "*Gielis Transformation in the Natural Sciences and Technology*", by Prof. J. Gielis, February, 17th 2016.

	Credits year 1							
Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	**Summary**	**Check**
Modules 30	0	3	3	6	3	10	**25**	**20-40**
Seminars 8	1,2	0,9	0	1	1	0,9	**5**	**5-10**
Research 22	7	5	7	3	6	2	**30**	**10-35**
60	8,2	8,9	10	10	10	13	**60**	

Credits year 2								
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	**Summary**	**Check**
Modules	18	0	3	7	0	0	0	10	10-20
Seminars	8	2,9	1,3	0	0	0,4	0,7	5,3	5-10
Research	34	7,1	5,7	3	10	9,6	9,3	45	30-45
	60	10	10	10	10	10	10	60	

Credits year 3									
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	**Summary**	**Check**	**Total**
Modules	6							6	0-10	41
Seminars	5							5	0-10	15
Research	49							49	40-60	124
	60									180

3. Research activity

Information retrieval from a single SAR image

Within the DIETI, my research group is mainly active in the remote sensing field, with a particular focus on Synthetic Aperture Radar (SAR) data modelling and processing. Within the group, my research interests are in information extraction from SAR images and modelling of the electromagnetic scattering from natural surfaces. In particular, my research project is focused on the development of proper retrieval algorithms for information extraction from a single SAR image. This research activity is particularly interesting especially in those scenarios characterized by very limited resources and strict requirements about radar system complexity, costs, weight. Space missions for celestial bodies' analysis and study, as well as developing countries will benefit from this research project.

Any information retrieval algorithm is essentially an inversion procedure, so significative issues about feasibility could arise. Due to the many factors influencing SAR data (in primis topography, (complex) dielectric constant, microscopic roughness), any algorithm aimed at recovering information from a single SAR image has to deal with ill-posedness issues: one equation in many unknowns, of which only one (or few) are of interest. Even if ill-posedness cannot be removed, thus being an intrinsic property of the problem, it could be circumvented only via a proper modelling of all the phenomena and mechanisms influencing the SAR image formation. The output of this modelling step is the direct (or forward) model, i.e., the model linking the SAR image to all the parameters influencing it. In order to provide an accurate direct model, in my research activity, SAR image modelization is based on the fractal geometry, the best tool for natural surfaces representation. After a deep study of the main scattering mechanisms and existing models, the direct model has been splitted in three concatenated steps:

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- Surface Model: the natural sensed surface is modelled as a 2-D fractional Brownian motion (fBm) stochastic process.
- Scattering Model: scattering mechanisms are properly modelled via a model suitable for fractal surfaces, namely the Small Perturbation Method (SPM). The scattering model provides a link between the backscattering coefficient and the geometrical and electromagnetic parameters of the surface.
- SAR image model: it links the intensity SAR image to the backscattering coefficient through the SAR acquisition system geometry. A simple model based on independent scattering from different resolution cells has been derived.

The forward model, obtained just concatenating the previous ones, provides the relationship between data and the surface parameters.

During this second year, starting from this direct model, my research activity was splitted in two formally separated, but conceptually linked concepts, namely despeckling on one hand and surface parameters retrieval on the other. For what concerns the first topic, a novel despeckling approach based on scattering concepts was theoretically derived and experimentally assessed with both simulated and actual SAR images. The basic idea is to exploit somehow the a priori information on the scattering behaviour of the surface. In particular, the a priori scattering information is estimated assuming the knowledge of the local topography, i.e., of the local incidence angle, due to its most relevant contribution to scattering. Besides a naïve approach [5], in which a scattering distance based on the local incidence angle was introduced in a nonlocal framework, these ideas were applied to two well-known and well-assessed filters, namely PPB [1] and SARBM3D [2]. A sensitivity analysis of the scattering-based version of PPB was also derived [3].

For what concerns the second topic of research, the estimation of the local incidence angle from single-look SAR images has been carrying out by applying a least squares fitting method. Some preliminary results will be available soon [6]. Extraction of such information will be relevant not only per se, but also for numerous other applications and products, such as DEM reconstruction/refinement, terrain corrected products and despeckling also.

In the next year, the two topics will be deepened separately by developing other scattering-based despeckling algorithms on one hand and a DEM refinement/reconstruction procedure on the other. It will be also interesting to merge the two topics for the development of a despeckling algorithm based on scattering requiring no extra information.

Products

Journals

[1] Di Martino, G., Di Simone, A., Iodice, A., Riccio, D., "Scattering-Based Non-Local Means SAR Despeckling," *IEEE Trans. Geosci. Remote Sens.,* (in press).

[2] Di Martino, G., Di Simone, A., Iodice, A., Riccio, D., "Scattering-Based SARBM3D," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (in review).

[3] Di Martino, G., Di Simone, A., Iodice, A., Riccio, D., "Sensitivity Analysis of a Scattering-Based Nonlocal Means Despeckling Algorithm", *European Journal of Remote Sensing* (in review).

Conferences
[4] Di Martino, G., Di Simone, A., Iodice, A., Riccio, D., and Ruello, G., "SAR Shape from Shading in Suburban Areas," Joint Urban Remote Sensing Event (JURSE), Lausanne, March, 30 – April 1, 2015.

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[5] Di Martino, G., Di Simone, A., Iodice, A., Riccio, D., and Ruello, G., "Non-Local Means SAR Despeckling Based on Scattering" International Geoscience and Remote Sensing Symposium (IGARSS), Milan, July, 26-31, 2015.

[6] Di Martino, G., Di Simone, A., Iodice, A., Riccio, D., and Ruello, G., "Estimation of the Local Incidence Angle Map from a Single SAR Image", ESA Living Planet Symposium 2016 (accepted).

4. Conferences and Seminars

During this second year, I participated to the SIEm-GTTI joint meeting held at the University of L'Aquila, L'Aquila, on 17-19 June. I also participated to the Young Professionals (ex GOLD) conference on Remote Sensing, held at the Polytechnic University of Catalonia, Barcellona, from 2 to 4 December 2015. Within this conference, in an oral session, I presented my recent results on SAR despeckling based on scattering and a journal paper for a special issue of the European Journal of Remote Sensing has been submitted.

5. Activity abroad

I have been at the Polytechnic University of Catalonia, Barcellona, from 2 to 4 December 2015 in order to participate to the Young Professionals Conference.

6. Tutorship

I assisted a MSc student with her thesis on despeckling of SAR images based on non-local means approach. Furthermore, I was awarded a grant from the University of Naples, Federico II in order to assist first-year BSc students in preparing their exams.