PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Vincenzo Romano Marrazzo

XXXIII Cycle

Training and Research Activities Report – Second Year

Tutor: Giovanni Breglio

1. Information

   I Graduated in Electronics Engineering from University of Naples "Federico II" in March 2017 with the thesis "Design and Characterization of an Interferometric Module for High Gamma Measurement" developed at TUDELFT (NL). I participated at XXXIII cycle of Information Technology and Electrical Engineering (ITEE) PhD, winning a not founded scholarship. My tutor is Prof. Giovanni Breglio and my research activity concerns Photonic and Optoelectronic topics.

2. Study and Training activities

   During my first year I attended many courses and seminars to improve my knowledge in many different topics and earn module and seminar credits.

   Courses:
   - Machine Learning;
   - Elettromagnetismo e Relatività.

   Seminars:
   - Medical Thermal Therapy and Monitoring Using Microwave Inverse Scattering;
   - MATLAB and Embedded Systems;
   - Spin-Orbit Optical Phenomena;
   - Robots in Medical Applications: An Overview of the Current Medical Robotics From the Industry's Point of View;
   - How to write a scientific paper;
   - Ethics, science & society in brain computer interface;
   - Lo spazio cibernetico come dominio bellico;
   - Design matter: Meta-Material nteraction with Light, Radio-Waves and ;
   - Technology Foresight for the Amed Forces: A Structured Journey between Science-Fiction and Reality;
   - Distributed Radio Systems, virtual Ran and the Path to 5G;
   - How to Turbo Boost your PhD.

   External courses:
   - SIE Ph.D. School.

	Credits year 2							
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary
Modules	**10**	5	0	7		0	0	**12**
Seminars	**5**	0	1,9	4,8	0	0,9	0,4	**8**
Research	**45**	5	8,1	0	10	9,1	9,6	**41,8**
	60	10	10	11,8	10	10	10	**60**

3. Research activity

My second year research activity was about the design of an innovative wide bandwidth, modulable and low cost interrogation system to pick up the information from the sensor measurement. Despite all the advantages obtained employing optical fiber sensors, the high cost of the interrogation systems limits the usage of them: the higher is the accuracy that is needed the higher is the expensiveness of the interrogator. Furthermore, it depends also on the type of variation: very fast variations, can be appreciated with an interrogation system that is optically and electrically more complex and definitely more expensive than a normal interrogator employed to monitor temperature or vibration of high buildings or bridges.

Taking into account a Fiber Bragg Grating (FBG) sensor, this works as an optical filter with a very narrow band whose central wavelength is called Bragg wavelength and is dependent with the modulation period of the refractive index, created inside the fiber core, and the refractive index of the mode propagating inside the core. The Bragg wavelength is very sensitive to temperature or strain variation, experiencing a wavelength shifting which has to be detected from the interrogator. The proposed interrogation concept can be described in this way: a broadband spectrum generates the light irradiated towards a FBG sensor through an optical circulator. The FBG reflects part of the signal which becomes, again through the optical circulator, the input signal of the Arrayed Waveguide Grating (AWG) whose working principle is to separate a polychromatic spectrum in many output channels depending on the wavelength, as an integrated prism. Due to the AWG, when the Bragg wavelength shifts, it will space among the channels, becoming very easy to detect. Every AWG channel, four in this case study, is connected to a photodiode to transduce the signal from optical to electrical. The signal is then converted from current to voltage through a transimpedance amplifier (TIA) and digitalized with an Analog to Digital Converter (ADC), ready to be read by a FPGA performing the interrogation algorithm and detecting the wavelength deviation.

The electrical side (TIA + ADC) can be called an Optical-to-Digital Converter (ODC) and was designed and developed on the basis of circuital simulations, satisfying the constrains given by the interrogation system. The proposed ODC is composed by a two-stage low noise, low input current and low input capacitance operational amplifier which is used since high gain and wide bandwidth are needed. The gain required was chosen on the basis of the consideration that the AWG output optical power has to be converted in a voltage that matches the ADC input characteristics.

Another type of monitoring system for industrial applications is under development: Fiber optic sensors, whose advantages have made them widely used in many applications, are not employed for the monitoring of industrial processes. This happens due to the expensiveness end complexity of the sensors monitoring systems, which are usually substituted with low performance but easier to manage sensors in agreement with industrial monitoring standards. To mitigate the problems described above and to extend the environments in which optical fiber sensor can be employed, an optoelectronic system was designed during this research period. The system handles the transduction, from optical to electrical, of the signal codification in terms of wavelength shifting with a full-analog variable gain circuit.

Also during my second year, the collaboration with ICAROS (Interdepartmental Centre for Advances in Robotic Surgery) centre Federico II is still going on for the improvement of a three-fingered underactuated miniature tool for minimally invasive surgery. The new finger prototype has reduced dimensions with FBG sensors embedded during the printing process.

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Also the collaboration with OptoSmart s.r.l and Leonardo s.p.a is still going on for the development of an anti-ice system for airplane. A new prototype was developed and tested numerically and experimentally.

Collaborations:

- ICAROS (Interdepartmental Centre for Advances in Robotic Surgery), Università di Napoli "Federico II";
- Leonardo s.p.a;
- DII (Dipartimento di Ingegneria Industriale), Università di Napoli "Federico II".

4. Products

Conference:
i. Marrazzo V.R. et al., ''Analytical and Numerical Simulations of a Fast Wide-Range AWG-Based Interrogation Technique for FBG Sensor", in 7th International Symposium on Sensor Science;
ii. Marrazzo V.R. et al., ''FBG-based monitoring system for smart tires application with wireless instrumentation under real- time rolling condition", in 7th International Symposium on Sensor Science;
iii. Riccio M. et al., "Wireless electronic sensing system for real-time monitoring of pneumatic tires", in 7th International Symposium on Sensor Science;
iv. V.R.Marrazzo et al., "Wide Range AWG-Based FBG Interrogation System With Improved Sensitivity", Conference on PhD Research in Microelectronics and Electronics (PRIME) 2019;
v. V.R.Marrazzo et al., "Simulation of an Optical-to-Digital Converter for High Frequency FBG Interrogator ",Applications in Electronics Pervading Industry, Environment and Society (APPLEPIES) 2019;
vi. G. Breglio et al., "Feel-tire Unina: Development and Modeling of a Sensing System for Intelligent Tires", 5th International Forum on Research and Technologies for Society and Industry (RTSI) 2019;
vii. Abstract: V.R.Marrazzo et al., "FBG-based wireless dynamic measurement system for smart tires",Scuola Italiana Elettronica (SIE) 2019;
viii. Abstract: V.R.Marrazzo et al., "Simulation of an electronic circuit for an innovative high frequency interrogation method for fiber Bragg grating sensors", Workshop on Electronics for Sensors (WSESII) 2019.

5. Conferences and Seminars

i. 7th International Symposium on Sensor Science (i3s) – Naples – Italy – May 2019 – 3 Poster;
ii. 51th SIE meeting – Naples – Italy – June 2019 – Poster;
iii. Conference on PhD Research in Microelectronics and Electronics (PRIME) – Lausanne – Switzerland – July 2019 – Oral;
iv. Applications in Electronics Pervading Industry, Environment and Society (APPLEPIES) – Pisa – Italy – September 2019 – Oral;
v. Workshop on Electronics for Sensors (WSESII) – Rome – Italy – September 2019 – Oral.

6. Activity abroad

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Conference on PhD Research in Microelectronics and Electronics (PRIME) – Lausanne – Switzerland.

7. Tutorship

- As Bachelor of Science correlator, the student Vincenzo Silvestro have been supported by me for their BSc thesis.

- I also had laboratory exercise for Integrated Photonics course (16 hours);
- I also had lecture in Integrated Photonics course (2 hours).