PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Ivan Iudice

XXIX Cycle

Training and Research Activities Report – Second Year

Tutor: Prof. Giacinto Gelli

1. Information

My name is Ivan Iudice, I was born in Livorno, Italy, in 1986. I received the B.S. degree, in 2008, and the M.S. degree, in 2010, from Università degli Studi di Napoli Federico II, both in Communications Engineering. Since November 2011 I have been working as part of the Communication Systems and Signal Processing group at Italian Aerospace Research Center (CIRA) in Capua, Caserta, Italy. Since March 2014 I have been attending the PhD course in Information Technology and Electrical Engineering (ITEE), XXIX cycle, at Università degli Studi di Napoli Federico II, with Prof. Giacinto Gelli as tutor.

2. Study and training activities

During my second PhD year, I attended the following "ad hoc" course organized by Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione (DIETI):

- "Analisi funzionale: primo modulo", taught by Prof. Renato Fiorenza, focused on topological spaces, notes on the measure and Lebesgue integration, recalls of linear algebra (vector spaces, linear operators, bilinear forms, quadratic forms, isomorphisms, linear operator space, dual spaces), metric spaces, topological vector spaces, normed vector spaces, inner product spaces, convergence of sequences in various vector spaces, weak convergence in an inner product space, complete metric space (Banach spaces, Hilbert spaces), continuous functions in various spaces, sequentially continuous functions, continuous and linear operators between normed spaces.

During my first PhD year, I had the opportunity to attend many multidisciplinary seminars:

- "Lecture on Current and Future Trends in Advanced Antenna", Prof. Constantine Balanis, June 2015;
- "Predictable Real-Time Embedded Control Systems", Giorgio Buttazzo, November 2015;
- "Hardware Security and Trust", Giorgio Di Natale, November 2015;
- "Una visione integrata per la valorizzazione delle risorse geotermiche", Fausto Batini, January 2015;
- "Perception-Based Surround Sound Recording and Reproduction", Enzo De Sena, February 2015;

3. Research activities

The main goal of my research activities is to study and implement advanced technologies for communication systems to be used in aeronautical environment, specifically for Unmanned Aircraft (UA) applications, and test them on specific test-bed or flight laboratories available at CIRA. To obtain the objectives of my research, I'm currently collaborating, under the supervision of my tutor Prof. Giacinto Gelli, with Prof. Francesco Verde of DIETI, and Prof. Donatella Darsena of Dipartimento di Ingegneria of Università Parthenope di Napoli, Italy.

In particular, during the second year, my research activity focused on applying BEM channel models to equalization of CPM signals.

Continuous phase modulated (CPM) signals are widely employed for telemetry data transmission in aeronautical applications, due to its many advantages, such as constant envelope properties, spectral efficiency, and noise robustness. Indeed, the IRIG-106 standard adopts different CPM modulation techniques, starting from legacy PCM/FM and SOQPSK, to the most advanced multi-h ARTM one.

Since CPM is a modulation with memory, its main drawback is the high computational complexity of the optimal maximum-likelihood (ML) detection strategy. This issue can be tackled by exploiting the inherent trellis structure of CPM and resorting to the Viterbi algorithm (VA).

In aeronautical communications, due to the high-speed of the aircrafts, the wireless channel might exhibit joint frequency and time selectivity: when CPM is employed over such doubly-selective channels, optimal ML detection becomes prohibitive, due to the huge number of states of the VA and the need to perform fast channel estimation and tracking. Several approaches aimed at reducing the complexity of the ML receiver have been

proposed, mostly targeted at time-invariant channels. A popular approach performs preliminary frequency-domain channel equalization to mitigate the effects of inter-symbol interference (ISI), allowing thus the subsequent VA to work in an almost ISI-free setting, albeit with colored noise. However, frequency-domain equalization is not a viable strategy when the channel is rapidly time-varying, since in this case the channel cannot be diagonalized by a channel-independent transformation.

During this second year, we worked to tackle the problem by designing linear time-varying (LTV) equalizers. Specifically, the proposed equalizers leverage on the well know Laurent decomposition of a CPM signal to perform LTV-ZF or LTV-MMSE equalization in the time domain.

To reduce the complexity of the time-varying equalizers, we are working to find computationally-efficient algorithms based on a basis expansion model (BEM) representation of the doubly-selective channel. The BEM model consists on representing each time-varying tap as a superposition of time-varying base functions (e.g., complex exponentials when modeling Doppler effects) with time-invariant coefficients. In this way, the equalization can be implemented as a parallel bank of linear time-invariant filters having, as input signals, different frequency-shift (FRESH) versions of the received data.

So far, we considered the case where the channel is exactly known at the receiver. The next step will be to estimate the equalizer weights from the received data.

4. Products

- D. Darsena, G. Gelli, F. Verde, and I. Iudice “Blind LTV shortening of doubly selective OFDM channels for UAS applications,” 2nd IEEE International Workshop on Metrology for Aerospace, Benevento, Italy, 4-5 June, 2015.
- D. Darsena, G. Gelli, F. Verde, and I. Iudice “LTV equalization of CPM signals over doubly-selective aeronautical channels,” 3rd IEEE International Workshop on Metrology for Aerospace, Florence, Italy, 2016 (SUBMITTED).

5. Conferences and seminars

None.

6. Activities abroad

None.

7. Tutorship

None.

8. Credits summary

	Credits year 1								Credits year 2								3		
		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	Total	Check
Modules	20				6		13	**19**	10			7				**7**	9	**26**	**30-70**
Seminars	5				2,2	3		**5,2**	5		0,4			4,2	0,5	**5,1**	0	**10**	**10-30**
Research	35	8	8	8	2	6	4	**36**	45	10	9		9	9	11	**48**	51	**84**	**80-140**
	60	8	8	8	10	9	17	**60**	60	10	9,4	7	9	13	11	**60**	60	**120**	**180**