ERCIM "Alain Bensoussan" Fellowship Scientific Report

Fellow:	Alex Cartagena Gordillo
Visited Location :	The Norwegian University of Science and Technology (NTNU).
Duration of Visit:	June 20, 2009 – June 19, 2010

I - Scientific activity

During my ERCIM fellowship at NTNU I had the opportunity to work in an interesting research topic that is wireless transmission of signals from inside the human body to nodes located on the human body. This is interesting because this transmission media is new in the field of (electromagnetic) wireless communications. It has different characteristics compared with conventional wireless communications, it has high power loss with transmission distance and it also has a marked frequency selectivity. It is also an interesting topic because the objective of conveying electromagnetic signals from inside the human body is to use them for medical purposes. The final objective is to locate biometric sensors in the human body to monitor physiological functions and, I believe, other applications will arise once the technology is available.

The communications technology selected for this application is ultra wideband (UWB) technology which is has the particular characteristics of having low transmission power spread over an ultra wide frequency band. This technology was the topic of my PhD. thesis and for this reason I was specially motivated to pursue this research.

The results of my research work was included in an ongoing research project called MELODY (Medical Sensing, Localization, and Communications using Ultra Wideband Technology) which is managed by my supervisor professor Ilangko Balasingham.

At NTNU, I had the chance to enjoy a multicultural research environment with people from different countries and backgrounds, it was a rewarding experience. I would like to thank professor Ilangko Balasingham and professor Tor Ramstad and all the members of the signal processing group for the useful discussion in our weekly meetings.

At last but not the least, I would like to thank the people from the department who organized the skiing event and for letting me experience how to live in the snowy forest, it is unforgettable.

II- Publication(s) during your fellowship

During my fellowship, I have published the following papers

1. A. Cartagena Gordillo and I. Balasingham "On Directive Antennas Applications to Implant - On-body UWB Communications," The 19th Annual Wireless and Optical Communications Conference (WOCC2010), Shanghai, China, 14-15 May 2010.

ABSTRACT – This paper investigates the advantages, disadvantages and tradeoffs of applying directive antennas to implant - on-body ultra wideband (UWB) communications. Our study concludes that directive antennas can reduce unnecessary exposition of human tissue to electromagnetic radiation, reduce exposition to narrow band interference, save energy and reduce the possibility of eavesdropping. However, when using directive antennas, receive/transmit beam direction needs to be guaranteed. We have also analyzed on-body node positioning, the best aperture angle and its tradeoffs. We further conclude that, at least, directive antennas with 180° aperture angle should be used at the on-body nodes.

2. A. Cartagena Gordillo and I. Balasingham "Design Method for Smooth UWB Pulses Exploiting Non-Orthogonal Properties of the Hermite Pulses," The 19th Annual Wireless and Optical Communications Conference (WOCC2010), Shanghai, China, May 2010 (Accepted for publication).

ABSTRACT – This paper describes a method for designing smooth ultra wideband pulses that can efficiently fit symmetric (with respect to a central frequency) spectrum masks. This method relies on the fact that the sum of continuous functions is continuous and the time and frequency characteristics of the Hermite pulses. We show that the *nth* Hermite pulse spectrum can be discretized into *n+1* sub-bands and, to some extent, control their individual amplitudes without losing the softness of its time domain counterpart. However, Hermite pulses spectrum occupancy is not optimal because of zeros in their spectrum, therefore, we further propose to combine two different spectrum-modified Hermite pulses to achieve smooth and spectrum efficient UWB pulses for single-pulse ultra wideband applications.

III -Attended Seminars, Workshops, and Conferences

The results of my research where presented at the following events:

1. SAMPOS/WISENET seminar on December 2-3, 2009 at NTNU, Trondheim, Norway.

2. Friday Talks on December 4, 2009 at NTNU, Trondheim, Norway.

3. The MELODY Project Workshop on May 10, 2010 at the Oslo University Hospital, Oslo, Norway.

4. Wireless and Optical Communications Conference (WOCC2010) on May 14-15, 2010 in Shanghai, China.

5. ERCIM Exchange program at VTT on June 3, 2010 at VTT, Oulu, Finland.

IV – Research Exchange Programme (12 month scheme)

For the ERCIM exchange program I visited VTT in Oulu, Finland on June 1-5.

VTT devoted to research and prototype development of new applications in many fields of science. I have been shown ongoing and concluded projects related with manufacturing robotics, heavy duty machinery, sports, health and ubiquitous computing. Different from the research on fundamental science I am used to carry out. VTT is focused on applying new technologies to practical applications. It was rewarding to see the different ways VTT is thinking to apply technologies that people like me are working on.

I would like to thank Dr. Mikko Sallinen and his research group for kindly hosting me at VTT, Oulu.