Ph.D. in Information Technology: Thesis Defenses

February 25th, 2020

Room Beta – at 14.00

Giovanni Ludovico MONTAGNANI – XXXI Cycle

"Development of a 3" LaBr3 SiPM-Based Detection Module for High Resolution Gamma Ray Spectroscopy and Imaging"

Advisor: Prof. **Carlo Fiorini**

Abstract:

The current trend in indirect-conversion gamma-ray spectroscopy is to replace Photomultiplier Tubes with Silicon Photomultipliers (SiPMs). SiPMs are cheaper, provide the same performance and are insensitive to magnetic fields. This thesis work aims to review the design process of a full custom gamma-ray spectrometer, providing state of the art resolution performance introducing also a novel readout circuit for SiPMs: the GAMMA ASIC. This multichannel analog readout circuit aims to provide a robust and low-noise asset for the high dynamic range readout of SiPMs, the thesis reviews the main innovative circuital solutions introduced by the GAMMA ASIC. The engineering of the main components of the instrument, like the photo-detectors, the mechanical enclosure and the digital readout electronics will be also illustrated. The presentation will also show the main preliminary results obtained with a simplified version of the designed instruments: state of the art energetic resolution and innovative position of interaction reconstruction measurements will be also illustrated.

Giorgio MUSSI – XXXII Cycle

"Sub-µA Polysilicon MEMS Real-Time Clock with Deterministic Jitter Compensation"

Advisor: Prof. **Giacomo Langfelder**

Abstract:

Over the last years algorithmic game theory has received growing interest in AI, as it allows to tackle complex real-world scenarios involving multiple artificial agents engaged in a competitive interaction. These settings call for rational agents endowed with the capability of reasoning strategically, i.e., taking into account not only how their actions affect the external environment, but also their impact on the behavior of other agents. This is achieved by exploiting ideas from game theory, and, in particular, equilibrium concepts that prescribe the agents how to behave

strategically. The challenge faced by the researchers working in algorithmic game theory is to design scalable computational tools that enable the adoption of such equilibrium notions in practice.
We study the computational properties of a specific game-theoretic model known as the Stackelberg paradigm. In a Stackelberg game, there are some players who act as leaders with the ability to commit to a strategy beforehand, whereas the other players are followers who decide how to play after observing the commitment. Recently, Stackelberg games and the corresponding Stackelberg equilibria have received considerable attention from the algorithmic game theory community, since they have been successfully applied in many real-world settings, such as, e.g., in the security domain, toll-setting problems, and network routing. Nevertheless, the majority of the computational works on Stackelberg games study the case in which there is one leader and one follower, focusing on instances enjoying very specific structures, such as security games. A comprehensive study of Stackelberg games with multiple leaders and followers is still lacking.
In this thesis, we make substantial steps towards filling this gap. In particular, in the first part, we address the largely unexplored problem of computing Stackelberg equilibria in games with a single leader and multiple followers, analyzing different classes of games, from general normal-form Stackelberg games to games with a compact representation, such as Stackelberg congestion games. Then, in the second part, we study games with multiple leaders, proposing a new way to apply the Stackelberg paradigm in such settings. Our idea is to let the leaders decide whether they want to participate in the commitment or defect from it by becoming followers. This is orchestrated by a suitably defined agreement protocol, which allows us to introduce interesting properties for the commitments. Finally, in the last part, we focus on Stackelberg games with a sequential structure, addressing, for the first time in such setting, the problem of equilibrium refinement. This has been widely investigated for the Nash equilibrium, as it is well-known that refinements can amend some of its weaknesses, such as sub-optimality off the equilibrium path. We show that such issues also arise in Stackelberg settings, and, thus, we introduce and study Stackelberg equilibrium refinements based on the idea of trembling-hand perfection so as to solve them.

Andrea RAGNI – XXXII Cycle

"High-Speed and Low-Noise Multichannel Electronics for Broadband Coherent Raman Imaging"

Advisor: Prof. **Giorgio Ferrari**

Abstract:

The main objective of this study is to present an innovative 32-channel readout and acquisition system for broadband Raman imaging, combining a low-noise pseudo-differential front-end based on the lock-in technique, with a parallel acquisition and real-time data elaboration. This work is conducted as part of VIBRA - Very fast Imaging by Broadband coherent RAman - an ERC project headed by Prof. Dario Polli of the Physics Department of Politecnico di Milano (Italy). The final aim of VIBRA is to develop an innovative Raman microscope for real-time and non-invasive imaging of

cells and tissues, which promises to make a revolutionary impact on many fields of biology and medicine as a ground-breaking tool for tumour identification and analysis.
A broadband laser, containing the Raman information over a wide range of wavelengths, is spatially diffused on a photodiode array so that each wavelength of the spectrum can be separately acquired by a specific element of the array and amplified simultaneously with a custom multichannel lock-in amplifier. An analog pseudo-differential processing of the signals reduces the noise added by the laser allowing a shot noise limited detection of the Raman signal. Once validated the acquisition scheme with a discrete-components prototype by acquiring a first Raman spectrum, a 4-ch system, operating a custom IC based on the same scheme, is designed and tested. Finally, particular emphasis is placed on the hardware description of a 32-ch modular platform for high-speed Broadband Raman Imaging, based on a Xilinx FPGA and the custom IC. With an average power of approximately 300µW on each photodiode, both the 4-ch and 32-ch systems can correctly acquire a Raman image with a time constant of 10µs, goal of VIBRA, validating the proper operation of the whole Raman microscope, from the optics to the electronics and graphical user interface.

PhD Committee
Prof. **Marco Carminati**, DEIB
Prof. **Cristoforo Marzocca,** Politecnico di Bari
Prof. **Alberto Pullia,** Universita' degli Studi di Milano