PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Vincenzo Di Capua

XXXIV Cycle

Training and Research Activities Report – First Year

Tutor: Prof. Pasquale Arpaia

Information

Vincenzo Di Capua, Master degree in electronic engineering–Università di Napoli Federico II
XXXIV Cycle- ITEE – Università di Napoli Federico II
Fellowship with CERN
Tutor: Prof. Paquale Arpaia

Study and Training activities

- Dominique Bertola, "Training on Communication to become a CERN Guide" 15/1/2019, CERN, Geneva (0.4 CFU)
- Daniel Hugo Campora Perez,"A practical approach to Convolutional Neural Networks", 04/03/2019, CERN, GENEVA (1 CFU)
- Patrick Emonts,"Tensor Networks - Introduction and Matrix Product States", 04/03/2019, CERN, GENEVA (1 CFU)
- Patrick Emonts,"Tensor Networks - The iTEBD Algorithm", 05/03/2019, CERN, GENEVA (1 CFU)
- Giorgio Lopez,"Hardware Acceleration Through FPGAs - Basic Concepts", 05/03/2019, CERN, GENEVA (1 CFU)
- Giorgio Lopez,"Hardware Acceleration Through FPGAs - Basics of VHDL", 05/03/2019, CERN, GENEVA (1 CFU)
- Vaggelis Motesnitsalis,"Big Data Technologies and Physics Analysis with Apache Spark", 06/03/2019, CERN, GENEVA (1 CFU)
- Riccardo Poggi ,"t How container orchestration can strengthen your micro-services: the approach of Kubernetes", 06/03/2019, CERN, GENEVA (1 CFU)
- Mikhail Sizov,"Efficient C++ implementation of custom FEM kernel with Eigen", 07/03/2019, CERN, GENEVA (1.2 CFU)
- Koetting Torsten, "Cryogenic Safety - Fundamentals" 03/10/2019 (0.4 CFU)

	Credits year 1								Credits year 2								Credits year 3								Total	Check
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary		
Modules	10	0	0.4	0	8.2	0	0.4	9	15							0	15							0	9	30-70
Seminars	4	0	0.5	0	0	0	1.5	2	5							0	5							0	2	10-30
Research	52	9	9	9	9	9	9	54	50							0	40							0	54	80-140
	66	9	9.9	9	17.2	9	10.9	65	70	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	65	180

Research activity

Real-time measurement and prediction of the magnetic field in particle accelerators

My research activity is focused on the development of advanced systems, electronic components and firmware for the Real-time measurement and prediction of the magnetic field in particle accelerators, including in particular the BTrain project at CERN. The main themes can be summarized as follows:

Prediction of the magnetic field in magnets for particle accelerators

I worked on the introduction of a predicted field subsystem, aiming initially to supplement the existing simulated facility, but with the long term goal to reach an accuracy good enough to complement or even fully replace the measurement when it is not possible to perform real time measurements (this is the case of the quadrupoles). I analyzed first of all the closed-form mathematical models studying the state of the art present in literature in these field. Since the accuracy obtained in the state of the art was not enough to satisfy the operations' requirements of a particle accelerators and the computational time was not adequate to be implemented in real-time I thought to replace the mathematical model by an Artificial Neural Network (ANN), in particular I developed a proof of concept solution based on a Deep neural network (DNN) in order to model the hysteretic response of the magnets in terms of an appropriate set of features in the input signals.

Metrological characterization and diagnostics

In order to characterize and monitor in real-time the BTrain system it was necessary to include in the system a new set of diagnostic outputs at multiple levels and time scales, from the real-time low-level inherent to each electronic card to the highest level concerning the offline comparison of multiple parallel acquisition chain In particular, real-time diagnostic outputs are needed for the integrator and the White-Rabbit transmission. for this reason in collaboration with national Instruments (NI), after a market research and a study of the WR protocols and the compact RIO (cRIO) platform, I developed a diagnostic tools based on custom cRIO modules and on a commercial compact RIO controller a new solution able to monitor the BTrain frame over the WR and store the data in order to perform also offline analisis. Right now the study is focused on the possibility to use a more powerful PXI system with the aim to perform also analog measurement in the same system and to have a more professional system able to be included in the CERN Technical Network.

Development of high performance digital flux integrators

This activity consist finalizing and the debugging of the existing prototype integrators; the implementation of new techniques to estimate and correct without jumps the drift caused by coil voltage offset.The integrators we are speaking about is a digital integrator realized on a FPGA Spartan6 from Xilinx. The main challenge of this research activity is that it is necessary to develop a system able to operate in Real-time in the CERn control loop, this means that the whole system has to be really reliable and all the operations performed on the FPGA have tight time constraints.

Collaborations

- National Instruments (NI)
- European Organization for Nuclear Research (CERN)

Products

○ F. M. Velotti, H. Bartosik, M. Buzio, K. Cornelis, V. Di Capua, M. A. Fraser,B. Goddard, V. Kain, "CHARACTERISATION OF SPS SLOW EXTRACTION SPILL QUALITY DEGRADATION" 10th Int. Particle Accelerator Conf. IPAC2019, Melbourne, Australia. (complete)

○ Pasquale Arpaia, Vincenzo Di Capua, Marco Roda and Marco Buzio, "Real-Time Magnetic Measurement Monitoring under cRIO-LabVIEW Based Platform" (submitted)

- ○ Vincenzo Di Capua, "Hysteresis modeling in iron-dominated magnets based on a Deep Neural Network approach", 4 Oct 2019 (presentation)

- ○ Pasquale Arpaia, Vincenzo Di Capua, Maria Amodeo, Francesco Donnarumma and Marco Buzio , "Hysteresis mo deling in iron-dominated magnets based on a Deep Neural Network approach" International Journal of Neural Systems (IJNS) (internal revision)

Conferences and Seminars

- Patrick Delarive, "The journey of a serial entrepreneur" 11/02/2019 (0.5 CFU)
- Lionel Quettier, "Completion and Commissioning of the Iseult whole-body 11.7 MRI Magnet", Geneva, 30/10/2019 (1.5 CFU)

Activity abroad

Date	Place
from: 1/10/2018 to: 31/10/2019	Geneva, European Organization for Nuclear Research (CERN)