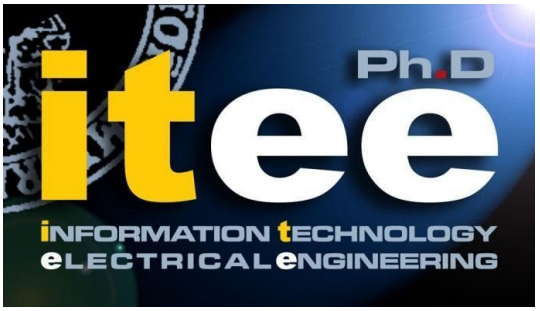

PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Vincenzo Di Capua

XXXIV Cycle

Training and Research Activities Report – Second 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. Pasquale Arpaia

Study and Training activities

- Multiple speakers, “Inverted CERN School of Computing 2020” 15/1/2019, CERN, Geneva (online) (5 CFU)
- Multiple speakers,”International PhD Excellence School "Italo Gorini", 04/09/2020-09/09/2020, online (2 CFU)
- FESA course, CERN,Geneva (3 CFU)

	Credits year 1								Credits year 2								Credits year 3									
	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	Total	Check
Modules	10	0	0,4	0	8,2	0	0,4	9	10	0	0		0	0	10	10	20							0	19	30-70
Seminars	4	0	0,5	0	0	0	1,5	2	10	0,5	0,5	0,5	0,5	0,5	6,5	9	5							0	11	10-30
Research	52	9	9	9	9	9	9	54	50	9	9	9	9	9	9	54	40							0	108	80-140
	66	9	9,9	9	17,2	9	10,9	65	70	9,5	9,5	9,5	9,5	9,5	25,5	73	65	0	0	0	0	0	0	0	138	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 consists in 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.

Development of a neural network based innovative solution for laparoscopic surgery
This activity consists in building a system capable to identify, given a video extracted from a laparoscopic camera and a Region of Interest (ROI) given by the surgeon, if the portion of image contained into the ROI is or not well vascularized after an injection of indocyanine green.
The system we designed uses a ML algorithm as the final stage to evaluate the vascularization. However the ML algorithm alone is not sufficient but we need some pre-elaborations on the video to build the actual input of the network.
The precise tuning of the ML algorithm parameters allows our proposed architecture to have an accuracy in the prediction high enough to permit the use of our system in a real surgery room in real time.

Machine Learning based Bolus wizard for prandial insulin bolus prediction
This activity consists in designing a system capable of predicting the correct bolus of insulin to inject, to patients affected by type 1 diabet, during a meal taking into account not only the carbohydrates but he palso proteins and fats. To reach the goal the taken decision was to use a Machine Learning (ML) approach. Starting from a database of real patients it is necessary to use the ML to find a law that explains the relation between carbohydrates, proteins and fats that compose the meal and the change of the glucose in the blood, taking into account also the physiognomy of the patient and his/her history. This activity is the baseline for a new innovative artificial pancreas able to improve the quality of the life for patients affected by type 1 diabet.

Collaborations
- National Instruments (NI)
- European Organization for Nuclear Research (CERN)
- Azienda Ospedaliera Universitaria Federico II

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, "Autoregressive Recurrent Neural Network Field prediction applied to the reference SPS Quadrupole", 3 Apr 2020 (presentation)
- Pasquale Arpaia, Vincenzo Di Capua, Maria Amodeo, Francesco Donnarumma and Marco Buzio , "Hysteresis modeling in iron-dominated magnets based on a Deep Neural Network approach" International Journal of Neural Systems (IJNS) (ready for submission)
- Christian Grech, Maria Amodeo, Anthony Beaumont, Marco Buzio, Vincenzo Di Capua, David Giloteaux, Nicholas Sammut, Joseph Vella Wallbank "Error Characterization and Calibration of Real-Time Magnetic Field Measurement Systems", Nuclear Inst. and Methods in Physics Research (submitted)
- Pasquale Arpaia, Marco Buzio, Vincenzo Di Capua, Alessandro Parrella "Virtual marker-based offset correction for digital integrators"International Journal of Neural Systems (IJNS) (internal revision)
- Joseph Vella Wallbanka, Maria Amodeo, Anthony Beaumont, Marco Buzio, DavidGiloteaux, Vincenzo Di Capua, Christian Grech, Nicholas Sammut "Development of a Real-Time Magnetic Field Measurement System for Synchrotron Control"(ready for submission)
- Pasquale Arpaia, Roberto Prevete, Vincenzo Di Capua, Umberto Bracale "Neural Network based indocyanine green detection and analysis for abdominal laparoscopic surgery"International Journal of Neural Systems (IJNS) (internal revision)

Conferences and Seminars

- Multiple speakers, "Weekly Machine learning seminar", Geneva, 30/10/2019 (cumulative 3 CFU)
- Multiple speakers,"24th IMEKO-TC4 International Symposium & 22nd INternational Workshop on ADC/DAC modeling and testing" ,Palermo (online), 14/09/2020-16/09/2020 (6 CFU)

Activity abroad

Date	Place
from: 1/11/2019 **to:** 31/10/2020	Geneva, European Organization for Nuclear Research (CERN)