



UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II

itee^{PhD}
information technology
electrical engineering



Federico Fiorenza

Magnetic control and reconstruction in fusion devices/Analysis of Discrete Event Systems

Tutor: Prof. Gianmaria De Tommasi

Cycle: XXXVIII

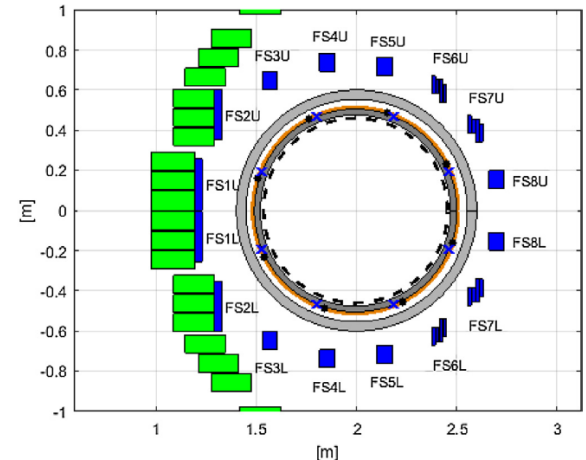
Year:2022/2023

My background

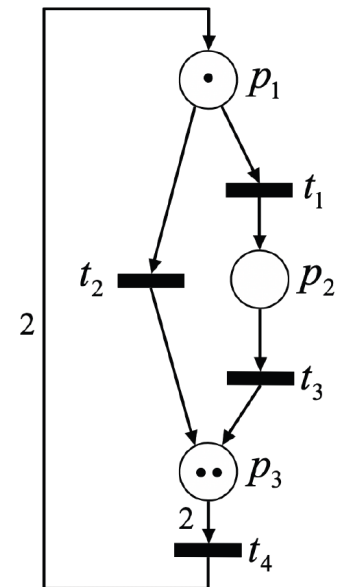
- MSc degree in Automation & Control Engineering
- Research group/laboratory: DIETI Plasma Control Group
- PhD start date: 1/01/2023
- Scholarship type: PNRR NEFERTARI

My research fields

- Plasma magnetic control and reconstruction in fusion devices. In controlled thermonuclear fusion, plasmas can reach very high temperature (100×10^6 °C) so it is needed an effective control system to keep it away from the walls of the vacuum chamber

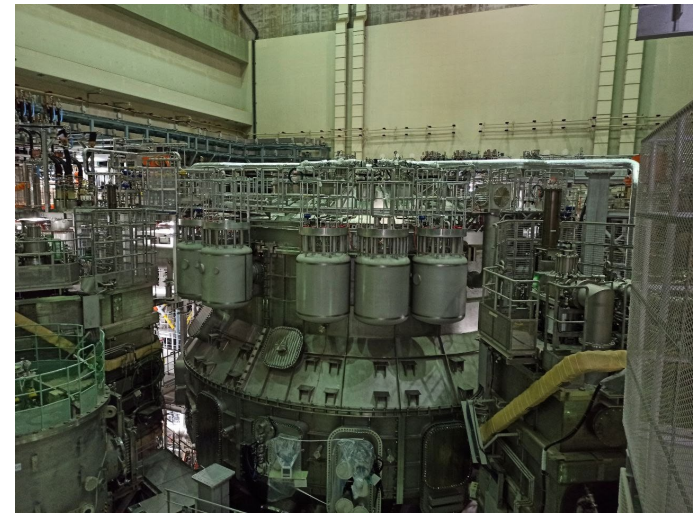


- Analysis of Discrete Event Systems (DES) modeled as Petri Nets. In particular, necessary and sufficient conditions to assess the opacity property. The goal is to check if an intruder that can observe the behaviour of the DES can deduce information that we want to keep secret



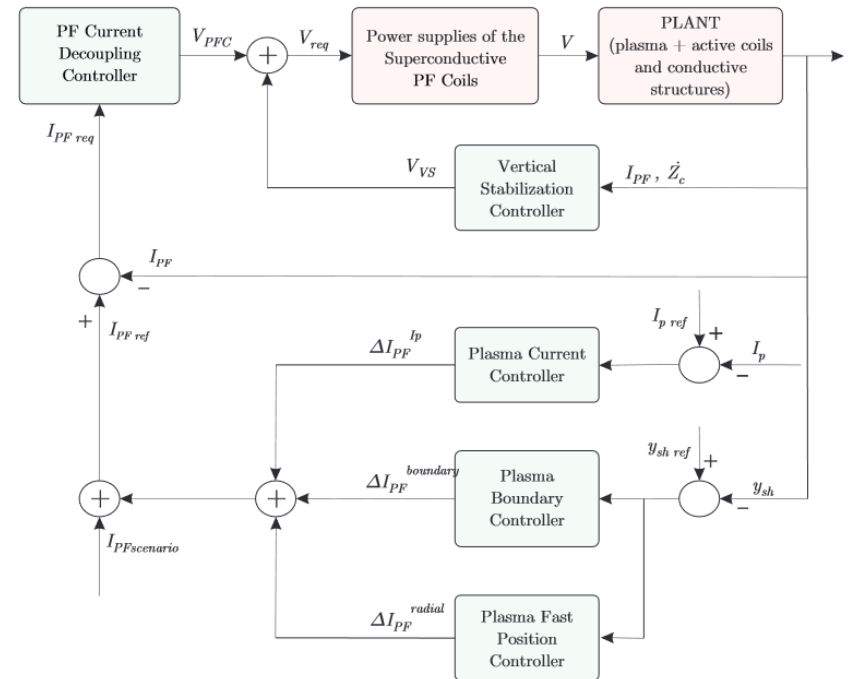
Summary of study activities

- Ad hoc PhD courses / schools
 - “Linear Parameter Varying Systems”
 - “Neural Networks and Deep Learning”
 - “Plasma physics and diagnostics”
 - SIDRA 2023 PhD summer school
- Period abroad:
 - Participation to the Integrated Commissioning of JT-60SA at Naka Fusion Institute from 30/10/2023 to 01/12/2023



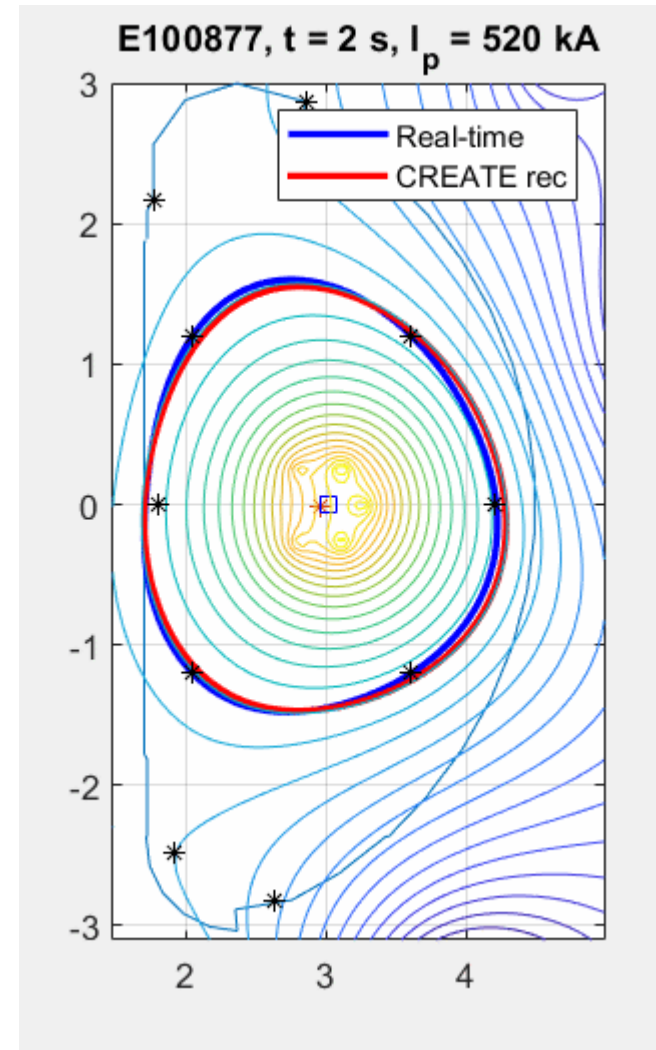
Magnetic control in fusion devices

- Plasma magnetic control problems:
 - Plasma shape control
 - Plasma current control
 - Vertical stabilization
- Need for robust controllers with respect to model uncertainties
- Achievement of good performances in case of different operating conditions (e.g. absence of passive stabilizers and in-vessel coils)



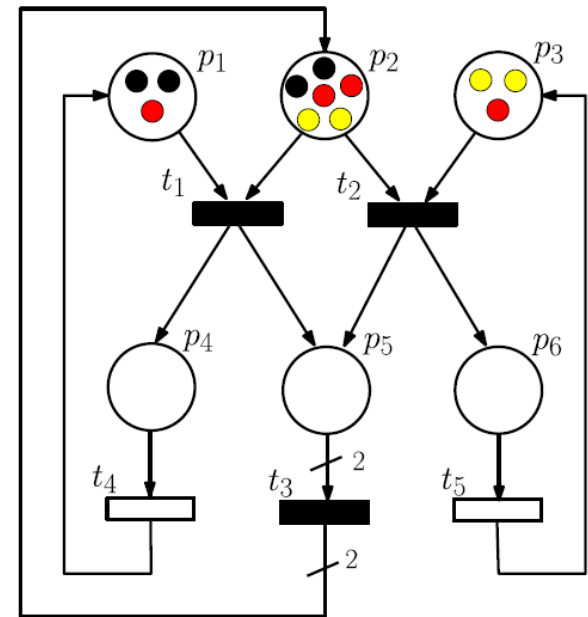
Algorithms for plasma boundary identification

- Given the magnetic measurements it is important to have a good estimation of the plasma boundary in order to achieve good performance on the control objectives
- Development of a reconstruction algorithm for the DTT tokamak
- Testing of the CREATE filamentary reconstruction during JT-60SA Integrated Commissioning



Opacity in Petri Nets

- Opacity is a confidentiality property of partially observable DES $G = (P, T, Pre, Post, m_0)$ with $T = T_o \cup T_{uo}$ that captures whether an intruder can infer a “secret” (for example a particular marking)
- It is possible to verify if a system satisfies this property by solving ILP problems. In this way it is easier to check also for high dimensionality nets



- = Secret initial marking \vec{m}_s
- = Non-secret initial marking \vec{m}_{ns1}
- = Non-secret initial marking \vec{m}_{ns2}

Products

[P1]	<i>EUROfusion internal report: SA-SE.OP.RT.01-T003-D001 Report on the commissioning of the JT-60SA plasma equilibrium control system</i>
[P2]	<i>Journal paper (to be submitted):“Control of elongated plasmas in superconductive tokamaks in the absence of in-vessel coils”, G. De Tommasi, L. E. di Grazia, S. Dubbioso, F. Fiorenza, D. Frattolillo, M. Mattei, A. Pironti</i>

Next year

- Modelling and development of RFX-mod2 magnetic control scheme
- Investigate the possibility of using data-driven techniques for the vertical stabilization problem
- Continue the development plasma boundary reconstruction algorithm and testing for both the DTT and RFX-mod2 devices
- Extend the ILP approach to different types of *opacity* (e.g. Current State Opacity, Initial and Final State Opacity)