PhD position in Automatic Control open in 2025 Palaiseau, France

Observer (state estimator) design for a winemaking fermentation process

Context

World production of wine is around 25 billion litres per year and France is the world's second largest producer (17%). The wine industry is undergoing major transformations in response to global climate change and societal concerns. In particular, it needs to reduce its energy footprint, while maintaining the organoleptic quality of wines. Although winemaking fermentation is naturally exothermic, it is generally conducted at low temperatures to achieve the desired aroma content, resulting in a highly energy-intensive process. Moreover, wine quality is a highly multidimensional criterion. Consequently, reducing the energy footprint without altering wine quality is a very complex problem and requires the development of breakthrough strategies to find a suitable compromise between these two key factors.

The overall aim of the DigitWine project (ANR-24-CE10-4479-01) is to demonstrate how state-of-the-art IT tools in advanced interaction with a human decision-maker can perform the complex task of improving the environmental impact of the wine fermentation, while achieving a specified user-perceived product quality.

Objectives of the PhD thesis

In the global framework of the DigitWine project, the proposed PhD will focus on the design of an observer (state estimator) of the wine fermentation process.

Since wine fermentation is subject to strong variability of the biological material (grapes, yeasts) and the existing dynamic models, however accurate, are still imperfect, available on-line measurements will be used to update the knowledge of the current process state in real time. Based on a literature survey, the PhD candidate will explore several options, ranging from classical observers such as Luenberger observer and Kalman filter to modern tools based on artificial intelligence [1,2] or fuzzy logic [3]. The advantages and limitations of various options will be compared and a number of promising strategies will be explored more in-depth.

The work will start with existing dynamical models of the process and available experimental data and will be progressively enriched and updated as the partners of the DigitWine project will develop new models and acquire additional experimental data. The designed observer will be integrated in the digital twin developed for the wine fermentation process.

Keywords

Dynamical system, observer, state estimation, control theory, digital twin, wine fermentation, aroma synthesis

Skills

Applicants should have a Master degree in automatic control or applied mathematics with a taste for biological applications. Alternatively, applicants may have a Master degree in chemical or process engineering with a good background in control theory and applied mathematics. Knowledge of biological processes is a plus. Good programming skills are required (Python and/or Matlab) as well as a research experience establishing the candidate's capacity for research.

About the research lab

The doctoral candidate will be based at UMR SayFood on the AgroParisTech/INRAE campus in Palaiseau, Ile-de-France and will be supervised by Emmanuel Bernuau, Arnesh Palanisamy and Cristian Trelea, professors at AgroParisTech school of engineering, part of Université Paris-Saclay. The project will be held in collaboration with UMR SPO (Sciences pour l'Oenologie) in Montpellier and the INRAE Pech Rouge Experimental Unit.

General information

Duration: 3 years
Registration: Université Paris-Saclay, ABIES Doctoral School
Location: Palaiseau, Ile-de-France
Salary: gross 2200€ per month in 2025, 2300€ from 2026 onwards
Benefits: reimbursed public transport (75%), flexible working hours, multidisciplinary scientific group
Starting date: October 2025
Secularism: the recruited person will be subject to the charter on secularism in public services (French law 2021-1109 of 24 August 2021). In particular, no religious symbols may be worn in the workplace.
Application deadline: 15 June 2025. Early applications welcome
Application: please send CV, motivation letter and last 3 years' academic transcripts to the contacts below.

Contacts

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References

[1] Alexander R et al. (2020). *Challenges and opportunities on nonlinear state estimation of chemical and biochemical processes*, Process 8(11) 1462.

[2] Feng S et al. (2023). *A review: state estimation based on hybrid models of Kalman filter and neural network*, Systems Science & Control Engineering, 11(1) 2173682.

[3] Marquez-Vera et al. (2018). *Stable fuzzy control and observer via LMIs in a fermentation process*, J of Computational Sci, 27 192-198.