MSc internship position 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 MSc internship

In the global framework of the DigitWine project, the proposed internship 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 internee 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 limited number of promising strategies explored more in-depth. The work will be based on existing dynamical models of the process and available experimental data.

The DigitWine project offers the possibility to deepen the subject in a follow-up 3-year PhD contract.

Keywords

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

Skills

Applicants should have a background automatic control or applied mathematics with a taste for biological applications. Knowledge of biological processes is a plus. Good programming skills are required (Python and/or Matlab).

About the research lab

The internship will be based at UMR SayFood on the AgroParisTech/INRAE campus in Palaiseau, Ile-de-France. It will be supervised by Emmanuel Bernuau and Cristian Trelea, professors at AgroParisTech school of engineering, part of Paris-Saclay University. 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: 4 to 6 months
Starting date: March or April 2025
Location: Palaiseau, Ile-de-France
Allowance: around 650€ per month, depending on the number of working days for each month
Benefits: reimbursed public transport (75%), flexible working hours, multidisciplinary scientific group

Application and contacts

Please send application letter, CV and transcript of grades for the last 3 years to the contacts below:

Emmanuel Bernuau	emmanuel.bernuau@agroparistech.fr
Cristian Trelea	cristian.trelea@agroparistech.fr

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.