Type d'offre : Laboratory offer

Post date : 04.03.25

INRAE-LBE

PhD offer - Multi-Criteria Optimization of Anaerobic Digestion Processes Using Artificial Intelligence

Informations générales

Contract type : Fixed-term contract

Contract length : 3 years

Contact :

Jean-Philippe Steyer / **Rémi Servien**

Starting date : Wed 01/10/2025 - 12:00

Trade : PhD

Topic : Autre

INRAE's **Laboratoire de Biotechnologie de l'Environnement** (LBE) is a leading research institute dedicated to innovative environmental technologies. We focus on developing sustainable solutions to the world's most pressing environmental challenges. Our interdisciplinary team of scientists and engineers work collaboratively to advance the field of environmental biotechnologies, with a particular focus on resource recovery, wastewater treatment and bioenergy production. Find out more here.

Détail de l'offre (poste, mission, profil) :

General Context

Large Language Models (LLMs), exemplified by GPT-4, have found diverse applications in fields such as robotics, education and medicine. In robotics, intelligent robots use LLMs to understand their environment, facilitating interaction and collaboration with humans (Open X, 2023). Currently, LLMs are mainly used to control robots. Building on this paradigm, we propose to explore a new application: using an LLM to optimize substrate feeding in anaerobic digestion (AD) according to several criteria that are difficult to integrate in a classical approach (i.e. using mechanistic models only). LLM models offer several advantages over traditional control methods, warranting further exploration and examination. Firstly, they allow a degree of explicability: the control algorithm solves the question behind the substrate selections, enabling the plant operator to evaluate and actively participate in the decision-making process. This open dialogue between operator and algorithm then facilitates iterative improvement based on mutual understanding and collaboration. It also makes full use of knowledge: by drawing on the wealth of information documented in all the scientific and technical literature on anaerobic digestion, MFRs can be trained efficiently. As a result, the operator of a single plant is likely to benefit from global expertise. For example, Open Source LLMs, exemplified by Llama 2 (Touvron et al., 2023), offer adaptability by enabling local training on new data or access to literature without requiring additional training. Finally, in terms of human-machine interaction, one of the main advantages of LLMs is their ability to dialogue with their operators. This dialogue enables operators to dynamically adjust setpoints, signal substrate availability or depletion, ask for

clarification of measurement results and assess farm stability, which is particularly important for farmers who may not have advanced skills in these complex areas with diverse and sometimes contradictory objectives. The initial results obtained by Gaida (2024) on this subject show that the use of LLMs for this purpose is promising, but that a great deal of work is still needed to calibrate and stabilize the models before they can be used on an industrial scale.

PhD Mission and Objectives

The objectives of this PhD are of various kinds. The general objective is to demonstrate the usefulness of AI models, and LLMs in particular, as controllers for optimizing anaerobic digestion processes. In addition to using mechanistic models of the material balance type to guarantee a certain robustness to the approach, the LLM will be able to make recommendations for process management, e.g. for substrate feeding, offering transparent and comprehensible justifications for its decisions. Ultimately, this will enable the models to be exploited according to a multi-criteria approach (energy, economic and environmental).

This overall objective will be divided into various sub-objectives:

1. A bibliography on the different implementations of LLM models, comparing their various advantages and disadvantages;

2. A methodological comparison on the different tests of the selected models;

3. An application for real-time management of methanizers through an implemented algorithm.

Requirements

We are looking for a highly motivated Fellow for this position. The ideal candidate should possess the following qualifications:

- A master's degree or an engineering degree at the interface between agriculture and data science ;
- A good knowledge of programming;
- Fluency in English;
- An interest in environmental issues would be an advantage.

Conditions

- Contract duration: 3 years ;
- Location: Unité LBE, Narbonne INRAE, France ;
- Gross salary: 2100€ (including social security) ;
- Scientific benefits: Funding to attend various conferences;
- Other benefits: 45 days vacation per year, access to gym and other sports activities ;
- Supervision: Jean-Philippe Steyer and Rémi Servien ;
- Funding: Half of the funding for the thesis has already been obtained. Half of the funding is requested and a further request will be made with the candidate.

References

1. *Open X-Embodiment Collaboration, Open X-Embodiment : Robotic Learning Datasets and RT-X Models, 2023, https://doi.org/10.48550/arXiv.2310.08864.*

2. *Touvron, H., Martin, L., Stone, K., Albert, P., Almahairi, A., Babaei, Y., and Scialom, T. Llama 2 : Openfoundation and fine-tuned chat models, 2023, https://doi.org/10.48550/arXiv.2307.09288.*

3. *Gaida, D. Synergizing language models and biogas plant control : A GPT-4 approach, 2024. In : Proceedings ofthe 18th IWA World Conference on Anaerobic Digestion, https://iwa-ad18.org/proceedings-book/.*

URL de l'offre : https://www.dataia.eu/sites/default/files/phd2025.pdf

Lien vers l'offre sur le site dataia.eu :https://da-cor-dev.peppercube.org/node/1251