2SC5292 – Life support system for space missions

Instructors: Sihem Tebbani, Cristian-Felipe Puentes Mancipe
Department: DOMINANTE - VIVANT, SANTÉ, ENVIRONNEMENT, DOMINANTE - GRANDS SYSTÈMES EN INTERACTION
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description
L'enseignement Système de support de vie pour le spatial est l'un des 3 Enseignements d'Intégration (EI) qui concluent la Séquence Thématique n°5 (ST5) Commande de bioprocédés pour l'environnement et les biofabrications.

L'Agence spatiale Européenne (ESA) développe un système de support de vie biorégénératif permettant aux astronautes de vivre de façon autonome, sans ravitaillement de la Terre, lors de missions spatiales de longue durée. Cet enseignement d'intégration porte sur le bioprocédé qui permet de régénérer l'atmosphère de l'habitacle. Il s'agit d'un photobioréacteur mettant en œuvre des microalgues qui consomment le CO2, produisent O2 et des compléments nutritifs.
L'objectif est de modéliser et dimensionner le photobioréacteur pour 5 astronautes en autonomie totale pendant 1000 jours, assurer le contrôle de la production en O2 via le transfert de lumière pour des critères ALiSSE raisonnables (en lien avec la fiabilité de fonctionnement, la sécurité et les risques pour l'équipage, le taux et l'efficacité du recyclage, les activités requises pour l'équipage, la consommation d'énergie, l'encombrement et la masse du système).

Quarter number
ST5

Prerequisites (in terms of CS courses)
There are no specific prerequisites.

Syllabus
- Suivi de culture de microalgues et caractérisation de la cinétique de croissance
- Pré-dimensionnement du photobioréacteur
- Modélisation multi-physique du photobioréacteur
- Implémentation du modèle sur Simulink
- Implémentation du couplage physique entre le photobioréacteur et l'habitacle

- Stratégie de commande du photobioréacteur
- Implémentation de régulation sur Simulink
- Tests de robustesse
- Optimisation du dimensionnement et de la régulation

Class components (lecture, labs, etc.)
This training course is dedicated to Problem solving. Students will confront the multiphysics aspects of bioprocesses. They will apply the concepts introduced in the chemical engineering course of the ST5 and in the control theory course of the common core.
The course is scheduled over 5 consecutive days. It begins with a half-day project launch (7/11/2022 morning). During the week, the students work in groups of 4 and are supervised by a team of teachers from LGPM and L2S laboratories. Each group addresses the different aspects of the modelling approach and confront reality through a cell culture training.
Updates will be held daily: sharing of information, methodological input, additional courses. The training course ends with a debriefing session (14/11/2022 afternoon) in front of ESA Engineers.

Grading
The final mark depends on: individual assiduity, group involvement, relevance of the multiphysics model, control strategy of the bioreactor, final design of the bioreactor, presentation, report.

Course support, bibliography
Presentation slides, scientific and technical articles will be provided during the course.

Resources
Teaching staff: H. Duval (Professor, CS, Département MEP, LGPM) S. Tebbani (Professor, CS, Département MEP, L2S), B. Taidi (Professor, CS, Département MEP, LGPM).
Maximum enrolment: 30
Software, number of licenses required: Matlab Simulink (30)
Equipment, specific classrooms (department and room capacity): biology preparation room (LGPM)

Learning outcomes covered on the course
At the end of the course, the students will be able to:
1. size a bioreactor;
2. establish a multiphysics model by aggregating knowledge from different scientific fields (biology, transport phenomena, biochemical engineering);
3. propose a relevant control strategy;
4. keep a critical eye on a model and test its robustness.

5. perform cultivation to estimate the proliferation kinetics of a microorganism strain;
6. provide a comprehensive presentation of a complete control strategy combining modeling, estimation, and control strategies.

Description of the skills acquired at the end of the course

– C1.1, Analyze: study a system as a whole, the situation as a whole. Identify, formulate and analyze a system within a transdisciplinary approach with its scientific, economic, human dimensions, etc. Milestone 1
– C1.2, Modeling: using and developing the appropriate models, choosing the correct modeling scale and the relevant simplifying assumptions. Milestone 2
– C2.3, Identify and independently acquire new knowledge and skills. Milestone 2
– C4.2, Propose one or more solutions answering the question rephrased in terms of value creation and complemented by the impact on other stakeholders and by taking into account other dimensions. Quantify the value created by these solutions. Arbitrate between possible solutions. Milestone 1
– C7.1, Basically: Structure ideas and arguments, be synthetic (assumptions, objectives, expected results, approach, and value created). Milestone 2
– C7.2, On the relationship with others: Understand the needs and expectations of his interlocutors evolutionarily. Encourage interactions, be a teacher, and create a climate of trust. Milestone 2