1SC2294 – Controlled release systems for pharmaceutical agents

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Department: DOMINANTE - VIVANT, SANTÉ, ENVIRONNEMENT
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description

The design of a pharmaceutical solution requires to consider the kinetics of release of its active agent into the bloodstream or tissue, and to maintain the adequate drug concentration over a specific period. Indeed, a too slow release of the active agent leads to an underdose and renders the drug ineffective, while a too fast release can lead to a toxic overdose for the patient. For this reason, active agents are usually formulated in specific forms to control their release.

Despite the variety of controlled drug release systems, their operating principles are based on the physics of mass transfer. Thus, in the design phase, modeling tools are particularly useful for scaling and predicting drug release dynamics before entering the more expensive stage of production and testing. This leads the pharmaceutical industry to call upon engineers to design systems that increase drug efficacy and facilitate patient use, while reducing the frequency of administration and dosage-related side effects.

Quarter number

ST2

Prerequisites (in terms of CS courses)

None

Syllabus

Presentation of the project

Analysis and formulation of the problem

- Bibliographic research

- Identification of the objectives of the model (transfers, concentrations, kinetics)

- Identification of the required data

- Writing of the model equations (mass balances, geometry)

Analytical resolution for a simple case

Implementation of numerical method in a more complex case

- Programming of the model

- Validation of the model on test configurations

- Presentation of case studies by the customer

- Development of a solution for the customer

- Presentation of the solution to "decision takers"

- Presentation of the solution to "engineers"

Class components (lecture, labs, etc.)

The teaching focuses on the spatiotemporal modeling of the concentration of a pharmaceutical active agent released by different drug delivery systems. The proposed approach is incremental: (i) Study of a simple classical case (e.g. intravenous free agent), formulation of the problem, modelling, analytical resolution, and scaling for a specific active agent. (ii) Adaptation of the model to a more complex case for which the analytical solution is not available (e.g. multiple organs, nanocarriers). Development of a numerical resolution code and exploitation for scaling. (iii) Application of the approach to a case study presented by the client (researcher at the Galien Institute, Faculty of Pharmacy of UP Saclay, restitution of the recommended solution and implementation strategy in the form of a presentation.

Grading

The evaluation will take into account: individual attendance, group involvement, relevance of the model, its digital implementation, quality of programming, oral presentation and discussion (question/answer).

Course support, bibliography

Slides of the various presentations, scientific articles and websites will be provided during the course.

Resources

Teaching team: Morgan Chabanon (MCF, CS, EM2C laboratory), Elsa Vennat (MCF, CS, HDR, MSSMat laboratory), Eloisa Barbel-Manaia (Researcher at Institut Galien, Faculty of Pharmacy, Université Paris-Saclay, CNRS)

Size of the class: 24

Software tools: Matlab, Spyder-Python (free software).

Learning outcomes covered on the course

Upon completion of the course, students will be able to:

1. Estimate the different time and space scales involved in a process;
2. Choose the most relevant scale to solve the problem at hand;
3. Discriminate and conserve the most important phenomena;
4. Reduce the dimensions and complexity of a problem in a relevant way;
5. Establish a multiphysics model by aggregating knowledge from different disciplinary fields (medicine, chemistry, transfer science);
6. Numerically implement a mathematical model;
7. Have a critical look at a model and its limitations;
8. Present a modeling approach in a structured and argued manner.

Description of the skills acquired at the end of the course

C1 Analyze, design, and build complex systems with scientific, technological, human, and economic components

C4 Have a sense of value creation for his company and his customers

C7 Know how to convince

C8 Lead a project, a team

ST2 – 23 – TELECOMMUNICATION SYSTEMS

Dominante : SCOC (Connected Systems and Communicating Objects)
Langue d'enseignement : French
Campus où le cours est proposé : Paris-Saclay

Engineering problem

This topic deals with the sizing of wireless communication systems in the context of civil systems (cellular networks 4G, 5G) or systems for crisis management (vital emergencies, law enforcement, civil security, armed forces, events, coverage of desert areas, interventions in case of natural disasters, resistance to failures, accidents, attacks ...). Coverage and continuity of service are critical. The rapid deployment of a transmission system in case of crisis when no infrastructure is available can rely on several networks and/or on complementary components such as ground relays, drones, balloons, satellites...
In order to design these communication systems, it is necessary to model all the elements of the transmission chain and the network architecture. These models allow the construction of simulation platforms which, together with test scenarios, allow engineers to understand the behavior in case of failure or incident.
In this sequence, students will be made aware of the choice of models and their uncertainties, the quality of service with coverage and availability requirements close to 100%.

Adviced prerequisites

None; having taken at least one of the science courses for the "Networks and Security" or "Electromagnetics" engineer in SG1 would be a plus.

Context and issue modules: These modules aim to give a vision of the theme from several angles, in particular

- An introduction on telecommunication systems followed by a conference "telecom and society

- A conference on technological barriers (frequencies, ad hoc networks, turbo receivers, ...)

- A round table at the end of the sequence on the theme "telecom and industry", allowing to understand the contribution of the 5G for the industry, by experts of Thales, Orange, EDF, SNCF, ...

Specific course (40 HEE): Principles of wireless telecommunications

Short description: The objective of this course is to give students the keys to choose the right models in the context of an engineering problem which is here to be able to transmit an information with full fidelity/security taking into account regulatory constraints (frequency, power), physical constraints (antennas, propagation, disturbances), quality constraints (bit error rate, coverage) and traffic constraints (Erlang's law). This course also presents the theoretical and applicative elements that have enabled the development of smart antennas (antennas and array antennas), ranging from antenna technologies specific to wireless and mobile communications, to signal processing techniques that make these antennas capable of adapting to severe transmission conditions, and which are currently the focus of the development of 5G and pervasive communications.

Challenge week: Sizing of a communication system mixing modeling, experimentation, simulation, measurement, identification of parameters

- Associated partners: Thales, Nokia, Bouygues Telecom

- Location: Paris-Saclay campus

- Short description: The three integration lessons of the ST2 SCOC will consist in dimensioning a set of wireless links to establish (or restore) wireless communications. Several scenarios could be considered: establishing communications in a developing country, re-establishing communications in an island after a hurricane, forecasting the sizing of a national cellular network by 2025, ... Students will design a communication network based on the technical characteristics of our industrial partners' equipment (power, frequency, etc.), propagation models (topography, distance, etc.) and traffic models (number of communications, throughput, etc.). Each AR will focus on a particular issue: economic constraints, speed of deployment (use of drones), antenna sizing, channel modeling from measurements, ... During the IE, the students will be supervised by teachers and researchers from the school as well as by engineers from partner companies (Thales, Nokia, Bouygues Telecom).