PRESENTACIÓN

Breve descripción:

The subject covers the modelling and simulation of space-time and time dependent biological systems.

The first part of the subject focuses on the **drug-related pharmacological** response, an extremely dynamic environment associated with great variability, which significantly hinders both the development of new drugs and the application of individualized treatments. Currently, the development of computational and mechanistic models with the ability to predict the efficacy and safety of a pharmacological intervention in different settings, has special relevance and recognized importance in the **pharmaceutical industry**, clinical scenarios, and drug regulatory agencies. Training of professionals with quantitative interpretation skills is now fundamental to optimize the resources invested in the development and application of new therapies.

The fundamental concepts for space-time numerical models applied to **Electromagnetics and Health** will be provided as basis for data analysis in the second part. Several case studies will be modelled and simulated with CST software. The models will predict the body temperature increase due to, e.g., mobile phone usage, hyperthermia and ablation for cancer treatment, along with microwave image extraction and wireless communication range estimation for implanted devices. Particular attention will be paid to relate the input and output data to real cases. Data analysis of the outcomes will be required.

- **Titulación**: Máster en Ingeniería Biomédica
- **Módulo/Materia**: Especialidad en Análisis de Datos / Análisis de Datos Biomédicos y Moleculares (Especialidad Tecnologías, Sistemas y Dispositivos Biomédicos: Módulo Optativo/Materia Optatividad)
- **ECTS**: 5 ECTS
- **Curso, semestre**: 1º, Segundo
- **Carácter**: Obligatorio
- **Profesorado**:
- Valderas Gázquez, Daniel - Email: dvalderas@tecnun.es
- Profesor titular
- Aldazábal Mensa, Javier - Email: jaldazabal@tecnun.es
- Catedrático
- Fernández de Trocóniz Fernández, José Ignacio - Email: itroconiz@unav.es
- Catedrático
- **Idioma**: English

RESULTADOS DE APRENDIZAJE (Competencias)

- CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación
- CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos

dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

- CB8 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios
- CB9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades
- CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.
- CE11 - Modelar sistemas biomédicos desde distintas perspectivas tecnológicas
- CE12 - Conocer y aplicar la legislación pertinente en los casos de manejo y tratamiento de datos en el ámbito biomédico.
- CG01 - Conocer los fundamentos para dirigir, planificar y supervisar equipos multidisciplinares propios de la ingeniería biomédica
- CG02 - Realizar investigación, desarrollo e innovación en productos, procesos y /o métodos en ingeniería biomédica.
- CG05 - Proyectar, calcular y diseñar productos, procesos, instalaciones y sistemas de control en el área de la ingeniería biomédica

PROGRAMA

Part 0: Introduction to computer modelling

• General ideas

• Models classification

• Dimensions of models

• Visualization of models results

• Hands on: "Modelling Degradation and Drug Release"

Part 1: Pharmacometrics and Modeling of Biological Systems

Topic 1. *Biopharmaceutics, Pharmacokinetics, Pharmacodynamics*

Concept, Nomenclature, Parameters, Experimental designs. Measurements of drug exposure and response to treatment. Continuous and non-continuous pharmacological responses.

Topic 2. *Pharmacokinetic models*

Compartmental models. Non-linear (concentration and time dependent) pharmacokinetics. Mechanisms of absorption, distribution and elimination from a physiological perspective. Physiologically based pharmacokinetic models.

Topic 3. *Pharmacokinetic/Pharmacodynamic Models*

Mechanisms and corresponding models to describe the absence of a direct relationship between systemic exposure and the observed pharmacological response. Interaction between drugs. Relevance of baseline conditions. Placebo effect, and circadian variations.

Topic 4. *Models applied to biological systems*

Progression of the disease. Turn-over and regulatory mechanisms. Examples in oncology, auto-immune diseases, rare diseases, myelosuppression, diabetes, and gene therapy.

Topic 5. *Non-Linear Mixed Effects modelling*

Inter-individual variability and population approach. How the variability in response between patients is reflected. Factors responsible of the variability in drug exposure and response. Population models. Quantification of inter-individual variability. Methodology for the selection and evaluation of the significant covariates. Application in precision medicine and simulation of clinical trials.

Computer assignments

Development of population disease/pharmacokinetic/pharmacodynamic models for diferent scenarios of relevance in drug research, drug development and patien management.

The practical exercises will be carried out with the software Monolix (free license for academy that must be requested by each of the students), and Rstudio.

Part 2: Biological systems with space-time dependence: Electromagnetics and Health

1: Energy absorption from a plane wave

2: Electric Scalpel

3: Energy absorption from mobile phone usage

4: Hyperthermia for thyroid cancer treatment

5: Ablation for liver cancer treatment

6: MW imaging for cancer early detection

7: Off-body wireless link for an implanted port-a-cath infection monitoring

8: MRI EM Analysis

ACTIVIDADES FORMATIVAS

The subject combines the theoretical approach to modelling and simulation of biological systems and the practical application to real case studies. Each of the two parts has theoretical classes that will end up in practical projects on which the mark will be based on.

During the first part theoretical lectures will be combined with practical exercises to be perfomed individually including different cases of disease and drug population models.

In the second part (space-time dependence, Bioelectromagnetics) eight projects on CST software will be realized. At the end of each project, an individual report and the project file, when requested, will be delivered.

EVALUACIÓN

CONVOCATORIA ORDINARIA

The mark is broken down into the following items:

Part 1: *4 points in total.* **1** point evaluating theoretical aspects through continuous evaluation, and **3** points corresponding to the reports summarizing the results from the following computer assignments:

Assignment	Subject	Points
1	Modelling concentration-dependent pharmacokinetics	0.75
2	Auto-inhibition in drug elimination & impact on the development program	0.75
3	Target Mediated Drug Disposition Model applied to Evaluate Response of Monoclonal antibodies	0.75
4	Target Attainment as an index of optimal dosing schedule in antibiotic therapy	0.75

Part 2: 5 points, based on reports and software projects on the following assignments:

Computer assignment	Subject	Points
1	Energy absorption from a plane wave	0,4
2	Electric Scalpel	0,4

3	Energy absorption from mobile phone usage	0,7
4	Hyperthermia for thyroid cancer treatment	0,7
5	Ablation for liver cancer treatment	0,7
6	MW imaging for cancer early detection	0,7
7	Off-body wireless link for an implanted port-a-cath infection monitoring	0,7
8	MRI EM Analysis	0,7

CONVOCATORIA EXTRAORDINARIA

The student will have the chance to repeat any of the assignments/tests in part 1 and part 2 in order to pass the subject

HORARIOS DE ATENCIÓN

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BIBLIOGRAFÍA Y RECURSOS

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3. Electromagnetics fields in biological systems. James C. Lin (Ed). CRC Press. Hard copy in the library. Electronic format in the library
4. Bioeffects and therapeutic applications of electromagnetic energy. RiadhW. Y. Habash. CRC Press. Hard copy in the library.
5. Electromagnetics in Biology. M.Kato (Ed). Springer. Electronic format in the library.
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9. Rowland M and Tozer TN. Clinical Pharmacokinetics. Concepts and Applications. 3rd edition. Williams and Wilkins. PA. 1995
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