BIO is the new TECH

Spring Course 2017

Syllabus

Activity Name	Philosophy of Biomimicry
Type of activity	Lecture
Number of working hours	2
Lecturer/Person responsible for the activity	Henry Dicks
Short summary of the content	1. Overview of the pre-history and history of biomimicry 2. Examination of biomimicry in relation to other similar concepts (bio-inspiration, bionics, etc.) 3. Extended analysis of the key philosophical issues raised by biomimicry, using case studies as examples
Expected effects	1. To see biomimicry not just a strategy for technological innovation, but as a philosophy in its own right 2. To provide greater awareness of methodological issues biomimetic researchers face 3. To encourage discussion into the ethical and epistemological issues raised by biomimicry 4. To provide awareness of the scope of biomimicry by considering a wide range of applications
Bibliography	Benyus, J. 1997. Biomimicry: Innovation Inspired by Nature, New York: Harper Perennial. Dicks, H. 2016. The Philosophy of Biomimicry, Philosophy & Technology, 29 (3), 223-243: DOI: 10.1007/s13347-015-0210-2, available at: https://université-lyon3.academia.edu/HenryDicks Mathews, F. 2011. Towards a Deeper Philosophy of Biomimicry. Organization & Environment, 24(4): 364-387, available at: http://www.freyamathews.net/downloads/Biomimicry.pdf

Activity Name	Biomimetic Urbanisim
Type of activity	Workshop
Number of working hours	3
Lecturer/Person responsible for the activity	Henry Dicks, Claire Lesieur
Short summary of the content	1. Introduction to biomimetic urbanism and brief presentation of case studies 2. Group work designing biomimetic cities 3. Group presentations of biomimetic cities
Expected effects	1. Awareness of different models and methodologies available in biomimetic urbanism 2. Practical experience of the complex scientific, technological, and social issues raised by the application of biomimicry to the city 3. Enhanced ability to engage in open-ended and creative team-work
Bibliography	Pedersen Zari, M. (2015). Ecosystem services analysis: Mimicking ecosystem services for regenerative urban design. International Journal of Sustainable Built Environment 4 (1), 145-157, available at: https://www.researchgate.net/publication/272102264_Ecosystem_Services_Analysis_Mimicking_Ecosystem_Services_for_Regenerative_Urban_Design

Activity Name	Link between biology and human sciences with dynamical systems: the power of love
Type of activity	Lecture
Number of working hours	2
Lecturer/Person responsible for the activity	Laurent Pujo-Menjouet
Short summary of the content	1. Reminding ODEs (Ordinary Differential Equations) (1 equation, and a system of 2 equations) 2. Steady states 3. Stability results 4. Application to predator / prey models 5. Link with models of love dynamics

Expected effects	1. Introduce the students to the notions of dynamical systems and mathematical tools involved 2. Introduce simple determinist models used to describe biological phenomena 3. Students will then understand that these mathematical tools can be used to describe other processes, and more particularly here, the ones related to human relationship
Bibliography	1. Steven Strogatz- Nonlinear Dynamics and Chao with applications to physics, biology, chemistry and engineering (Studies in Nonlinearity), Westview press, 2001 2. Lea Edelstein-Keshet, Mathematical models in Biology (Classics in Applied Mathematics), SIAM, 2005 3. James Murray, Mathematical Biology (I and II), Springer, 2007 4. John Gottman et al., Dynamics of marriage, The mathematics of marriage, MIT press, 2005 5. Hanna Fry, The mathematics of Love, TEDbooks, 2015

Activity Name	**From population dynamics to Language Dynamics, and from molecular studies to population epidemics: the power of mathematical models**
Type of activity	Lecture
Number of working hours	2
Lecturer/Person responsible for the activity	Laurent Pujo-Menjouet
Short summary of the content	1. Introduction to age structured PDEs (partial differential equations) 2. Example of population and cell dynamics 3. Link with the study of language dynamics and bilingualism 4. Introduction to models of protein dynamics: applications to prion and Alzheimer 5. Link with models applied to epidemiology at the population level
Expected effects	1. Introduce the students to the notions of PDEs with age or size structures 2. Introduce simple determinist models used to describe population dynamics (and particularly cell cycle) 3. Students will then understand that these mathematical tools can be used to describe other processes, and more particularly here, the ones related ton endangered languages and epidemiology

Bibliography	1. Benoît Perthame, Transport Equations in Biology, Birkhauser Verlag, 2009 2. Hisashi Inaba, Age structure population dynamics in demography and epidemiology, Springer, 2017 3. Stanley Prusiner, Prion Diseases, Cold Spring Harbor Laboratory Press, 2016

Activity Name	What motivates biomimicry?
Type of activity	Workshop
Number of working hours	3
Lecturer/Person responsible for the activity	Claire Lesieur
Short summary of the content	Hour 1: Lecture 1. Human engineering vs natural engineering 1.1. Solutions 1.2. Performances 1.3. Need 2. Strategy to biomimicry 2.1. Delineate the problem 2.2 Datamining : look for a natural solution or a natural performance 2.3. Data analysis: building blocks, conception and mechanisms 3. Example of counter intuition Genetic diseases: fragility or adaptability? Hour 2 : Training Observe proteins and learn Hour 3 : Training Conception of a robust and adaptable object
Expected effects	1. Introduction to biomimicry 2. Experience conception from theory to practice 3. Strength of interdisciplinary interactions
Bibliography	Helbing, D. Globally networked risks and how to respond. Nature 497, 51–9 (2013). http://www.rcsb.org/pdb/home/home.do

Activity Name	Synchronization of biological systems
Type of activity	Lecture
Number of working hours	2
Lecturer/Person responsible for the activity	Samuel Bernard
Short summary of the content	1. Synchronization of biological oscillators: from fireflies to circadian clocks 2. Pulse-coupled oscillators 3. Phase-coupled oscillators 4. Kuramoto model
Expected effects	1. Introduce the students to the notions of large-dimensional dynamical systems and mathematical tools involved 2. Introduce simple determinist models used to describe biological phenomena 3. Students will then understand that these mathematical tools can be used to describe collective behavior
Bibliography	1. Strogatz- Nonlinear Dynamics and Chao with applications to physics, biology, chemistry and engineering (Studies in Nonlinearity), Westview press, 2001 2. Pikovsky, Rosenblum, and Kurths, Synchronization: a universal concept in nonlinear sciences, Cambridge university press, 2003

Activity Name	Memory and learning in biological networks
Type of activity	Lecture
Number of working hours	2
Lecturer/Person responsible for the activity	Samuel Bernard
Short summary of the content	1. Introduction the concepts of learning and memory 2. Learning in the Kuramoto model 3. Hebbian learning and Hopfield networks

Expected effects	1. Introduce the students to the notions learning and memory 2. Introduce simple determinist models that can store and retrieve information 3. Students will then understand that these mathematical tools can be used as a basis for pattern recognition software, learning and optimization algorithms, etc.
Bibliography	No bibliography is needed.

Activity Name	Synchronization of phase-coupled oscillator
Type of activity	Exercise
Number of working hours	2
Lecturer/Person responsible for the activity	Samuel Bernard
Short summary of the content	1. Analysis of the Kuramoto model for N=2 2. Numerical study of the Kuramoto model 3. Further numerical studies
Expected effects	1. Introduce the students to methods for solving large dynamical systems 2. Introduce the students to numerical exploration and visualization 3. Students will then understand how these numerical tools can be used to explore and detect non-trivial dynamical behaviors in complex systems
Bibliography	No bibliography is needed.

Activity Name	Hopfield Networks
Type of activity	Exercise
Number of working hours	2
Lecturer/Person responsible for the activity	Samuel Bernard
Short summary of the content	1. Implementation of a Hopfield Network 2. Implementation of Hebbian learning rules 3. Application to image recognition 4. Exploration of the properties and limits of learning and memory
Expected effects	1. Introduce the students to the learning notions and memory 2. Introduce algorithms to solve efficiently large dynamical systems 3. Students will then have the basic knowledge for developing tools for learning and memory
Bibliography	No bibliography is needed.

Activity Name	Exam preparations
Type of activity	Case Study
Number of working hours	4
Lecturer/Person responsible for the activity	Renaud Passieux
Short summary of the content	The students will be split into teams and during the time given, the professor will give each team a case study to work on. The topics of the Case Study will be about different Biomimicry inventions and their implementation.
Expected effects	The students will learn to cooperate with the others and work as a team. The will have to examine and understand deeply the topic of their team.
Bibliography	All the pre-materials and materials. Course Lectures and knowledge acquired during the Workshops and Exercises.

Activity Name	Final examination
Type of activity	Presentation
Number of working hours	3
Lecturer/Person responsible for the activity	Henry Dicks, Claire Lesieur, Laurent Pujo-Menjouet
Short summary of the content	The teams will make their presentations with the outcomes of their work to the Course Responsible Professor and to the rest lecturers of the course.
Expected effects	The presentation aims for the students to show what they have learnt during the course. They are expected to have understood the principles of Biomimicry and their applications.
Bibliography	No bibliography is needed.