Course title: Mind, Brain and Machines

Language of instruction: English

Professor: Fernando Giráldez and Jordi Garcia Ojalvo

Professor’s contact and office hours:
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Office hours on demand

Course contact hours: 45

Recommended credit: 3 US credits / 6 ECTS credits

Course prerequisites: There are no prerequisites for this course

Language requirements: Recommended level in the European Framework B2 (or equivalent : Cambridge Certificate if the teaching language is English, DELE or 3 semesters in the case of Spanish)

Course focus and approach:
This course aims at providing an interdisciplinary view of intelligence, grounded on the understanding the human brain provided by neuroscience and artificial intelligence.
Neuroscience and engineering study the brain or artificial forms of brain function. This knowledge has strong implications in many areas of human activity including not only medicine, psychology, computer engineering, robotics, and data analysis, but also economics, law, philosophy or art. The course focuses on a solid dialogue between neurosciences and humanities (see Giraldez, 2020 Teaching Neuroscience as a Liberal Art, Front. Educ. 4:158).

Course description:
This course centers on the interaction between Neurosciences, Engineering and the Humanities, by posing crucial questions on intelligence, perception and aesthetics. How brains and machines build up knowledge? What is intelligence and “what do we talk about when we talk about artificial intelligence”? We will analyze how sensory systems build up a representation of the world, with particular attention to vision and audition. In parallel, we will explore the minimal requirements of a brain, building on our age-old attempts to build artificial intelligent systems. We will review the history of artificial intelligence and brain science, focusing on the connections that the two fields have had, on and off, over the years. This leads to a more general discussion on the foundations and limits of knowledge and the evolutionary roots of belief. Can we gather reliable knowledge? Are we prone to believe? What is the relationship between genes and environment? Beyond that, how does biology conditions our experience of Art? And further, can computers mimic creativity in Art? The course attempts to frame the above questions into the current scientific knowledge of the brain and the engineering of complex systems.

Learning objectives:
By the end of the course, the student
• will be able to describe the basic elements of the brain: genes, neurons, synapses and circuits, and have an intuitive understanding of the operation of neural networks
• will be familiar with the general principles of organization of the sensory systems and perception, and will know why perception is said to be a constructive process
• will be able to apply neuroscientific knowledge to art perception and the rules of art
• will be acquainted with the evolutionary roots of perception and behavior
• will be able to describe the interactions between genes and environment, and frame discussion on the nature vs. nurture question into current scientific knowledge.
• will be familiar with the history of artificial intelligence, and with its connections with the study of the human brain
• will be able to hypothesize about the minimal fundamental mechanisms for a brain to function

Course workload:
The course is based on discussion sessions and lectures. Students will read short articles (two-three pages), fragments or book chapters and write short papers/reports (one page) along the course. Students will do a ten-minute oral presentation to the class and bring their own piece of “little artwork”. There will be a mid-term and a final exam.

Teaching methodology:
The course will combine a set of lectures and seminars with activities based on flipped classroom. Lectures are intercalated with discussion sessions. Materials, presentations, handouts, and readings will be available through the Aula Global. Demonstrations include animations and interactive materials. It is expected that students contribute with their own background to discussions and works.

Assessment criteria:
Midterm exam: 25%
Final exam: 25%
Class participation: 20%
Student presentation and Q&A: 30%

Midterm and final exams are of essay-type with short questions and problems. Each exam covers about half of the subject, respectively.

Class participation is evaluated from class activities, questions, comments, etc. and from a “bring your artwork” task and discussion. Simple attendance does not fill the participation slot.

“Bring your own artwork”. The task is to produce a little piece of art, something that in student’s consider “beautiful” or “aesthetically pleasing” or “interesting”. In general, a photograph will be the easiest support, but a painting or a collage will do if you have some expertise. The work can start from the rules of perception or from your intuition. Works will be collectively analyzed, the question being: Where is beauty in the picture? Why is it appealing? Which are the perceptual rules followed? Which are subverted?
Chalk-Talks (ChT). Students will make an oral presentation to their classmates and teachers. Students have to deliver an abstract by week 8, when presentations begin. The activity includes: 1) One page abstract of no more than 550 words (Arial 10) containing the relevant information and three references. A figure may be included if appropriate. 2) A talk of 10 minutes + 10 minutes discussion. The presentation is on the blackboard, a so-called "chalk talk" (no PowerPoint allowed).

**BaPIS absence policy**
Attending class is mandatory and will be monitored daily by professors. Missing classes will impact on the student’s final grade as follows:

<table>
<thead>
<tr>
<th>Absences</th>
<th>Penalization</th>
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<tbody>
<tr>
<td>Up to two (2) absences</td>
<td>No penalization</td>
</tr>
<tr>
<td>Three (3) absences</td>
<td>1 point subtracted from final grade (on a 10-point scale)</td>
</tr>
<tr>
<td>Four (4) absences</td>
<td>2 points subtracted from final grade (on a 10-point scale)</td>
</tr>
<tr>
<td>Five (5) absences or more</td>
<td>The student receives an INCOMPLETE (“NO PRESENTADO”) for the course</td>
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The BaPIS attendance policy **does not distinguish between justified or unjustified absences**. The student is deemed responsible to manage his/her absences.

Only absences for medical reasons will be considered justified absences. The student is deemed responsible to provide the necessary documentation. Other emergency situations will be analyzed on a case-by-case basis by the Academic Director of the BaPIS.

The Instructor, the Academic Director and the Study Abroad Office should be informed by email without any delay.

**Classroom norms:**
- No food or drink is permitted in class.
- Students will have a ten-minute break after each one-hour session.

**Weekly schedule**

**WEEK 1**

**Session 1**: Welcome and Introduction to the course  

**Session 2**: A brief history of thinking machines. The nature of artificial brains. Approaches to artificial intelligence (AI). The timeline of AI.

**WEEK 2**

**Session 3**: The synapse and neural circuits. Elementary synaptic circuits: gates, lateral inhibition, feed-back and forward loops in real life.
Session 4: The mechanization of thought. Early approaches to logic: From Aristotle to Ramon Llull. The laws of thought: from Boole to Turing. Symbolic logic and heuristics: Newell and Simon’s Logic Theorist.

WEEK 3

Session 5: The Allegory of the Cave and the Neurosciences. The logics of perception: the representation of the world. What are ideas made of? Where are concepts in the brain?


WEEK 4


WEEK 5

Session 9: Nature and Nurture. Genes and culture. The biology of learning, what is in the brain before learning?


WEEK 6

Session 11: Mid-term exam

Session 12: Vision and Art.

WEEK 7


Session 14: Audition and Music. Workshop

WEEK 8

Session 15: Deeper into Learning. Recurrent networks and reservoir computing. Workshop

Session 16: Deeper into Concept Representations. Deterministic chaos, dynamical attractors, and state-dependent computations. Workshop

WEEK 9

Session 17: Artificial intelligence and the arts: computational creativity.

Session 18: General Discussion. Workshop: The debate on the human condition.

WEEK 10

Session 19: Chalk talks / student presentations

Session 20: Chalk talks / student presentations
WEEK 11
Session 21: General Discussion and Pre-Exam Review
Session 22: Final exam

Last revision: April 2021

Readings:
Livingstone, M.S. (2018) What Art Can Tell Us About the Brain - YouTube
Stanford Encyclopedia of Philosophy http://plato.stanford.edu/
Wolfe et al. (2017) Sensation and Perception (5th Ed.) chapter 6, Monocular cues to three-dimensional space pp 178-190

Links of interest:

BrainFacts.org: [https://www.brainfacts.org](https://www.brainfacts.org) an educational page by the Society for Neurosciences with many interesting posts, a useful glossary, and a basic “textbook”

Aeon: [https://aeon.co](https://aeon.co) An interesting site for the “Third Culture” and challenging ideas