Bots on the Brain

Cognitive Science & Bio-Inspired Robotics

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Course Overview

Some questions are too broad or diverse for a single approach to be able to answer, leading us to the wide-open world of interdisciplinary investigations. Cognitive Science and Robotics each independently fit into this category, and yet, in this Club, we are going to go one step further: investigating how the intersection of Cognitive Science and Bio-Inspired Robotics can mutually inform each other towards understanding, building, and interacting with a world filled with robots.

To do so, we will briefly explore everything thing from cognitive science (how do humans think, interact, and move around the world) to robotics (how do build robots that 'think', interact and move), and everything in between, including human-robot interaction, neuroscience, brain-computer interfaces and neuro-prosthetics.

We will do this with a mixture of some traditional lectures, discussions, demonstrations, and hands-on project work. To the extent possible we're aiming to *show* rather than *tell,* meaning this club will be heavily focused on demonstrations and a week long project, which aims to integrate across the different components of the class. The project will consist of working with and developing a brain-controlled robot.

These questions / topics are, of course, massive. In one short week we cannot possibly go in-depth into any of them. Rather, this club is designed as a case study - an example of how to take a broad, important question, and start coming at it from multiple directions. The goal is to introduce you to the main ideas from an investigation of cognitive science, robotics, and brain-computer interfaces, to get you working hands-on with these technologies, and to develop a skillset for working with and applying interdisciplinary approaches to the science and technology that is increasingly all around us. We will also consider the implications of such a changing world - what does it mean to live in a world surrounded by, perhaps even attached to, robotic devices?

Course Objectives & Goals

- Learn how to approach a question / problem in an interdisciplinary fashion.
- Foster a collaborative approach.
  - Interdisciplinary work does not mean that every person has to know everything - but rather that diverse teams comprising people from different backgrounds can work together towards a common goal, each bringing their own areas of expertise - but it takes skill and practice to be able to do this.
- Get excited about science, and gain hands-on experience working with robots, brain-computer interfaces, as well as a practical appreciation for how these technologies work.
  - More than any specific content from this week, we hope to show you how many exciting developments and opportunities currently exist in a range of different fields, and to give you real experience for what it is like to work in those fields.
  - Work on a project that allows you to control a robot with your brain.
- To better understand how technology is impacting the world.
  - Although some topics we explore may still be in research stages, or even science fiction, other aspects are or will soon quickly become part of everyday life. As we focus on the science and technology, we also hope to foster an appreciation and critical analysis of the real-world implications of such fields of science.

Course Outline

Topics Outlines

We will briefly cover a range of inter-related topics. For each, we will briefly introduce the topic, but focus mainly on how it fits into our overall goal and focus, using the project as a focal point to bring everything together. In general, each topic will be covered with a combination of lectures, discussions, demonstrations and project work. Within each topic, we will seek to cover the following ideas, and (start) to answer the following questions:

Robotics: How do robots work? How can we build, and control robots, and robotic devices? We will be focus on bio-inspired (humanoid) robots, and prosthetic devices.

Cognitive Science & Behaviour: If we want to build intelligently behaving robots, a reasonable place to start might be my modelling them on humans - how do humans move around and interact with the world? Can (and should) we model robotic design and control on humans? What does it mean to do 'bio-inspired' robotics?

Human-Robot Interaction (HRI): How do humans interact with robots? How should robots interact with humans? How does it change the human experience to have not only robots all around us, but potentially robots attached to our bodies, to our brains?

Neuroscience: What are the basics of neural processing? How does our brain control our body? Is neuroscience a good model of how to implement control systems for robots?

Brain-Computer Interfaces (BCIs) / *Neuro-Prosthetics*: Can we use neural signals to control robots, and if so, how? Can we we decode these signals accurately and quickly enough, to serve as control signals for robotic devices, including prosthetics? How?

Computation & Artificial Intelligence: Robots are computational machines, and require artificially 'intelligent' systems for either independent control, and/or as intermediary systems to decode brain signals. What are our current computational capacities and limitations in AI research?

Course Activities

Through the projects, demonstrations and course work, you will be working hands on with robots and neural recording devices. To work with these tools means using computer programming, and so we will, throughout the course, be working on learning, understanding and writing code - in our case, in the Python programming language.

Throughout the course there may be assigned readings, some of which may be to be read outside of class hours. In general each day will be subdivided such as roughly half of the day is lecture and discussion, with the other half dedicated to demonstrations and project work. As part of the course, you be expected to get involved in class discussions, hands-on demonstrations, and contribute to project work.

Project: Brain-Controlled Robots - Our main project for the week will be working on controlling robots with your brains! Using small electroencephalography (EEG) systems that (non-invasively, safely) records electrical activity from the surface of your scalp, we will work on a project to use these signals to control pre-built humanoid robots.

Demonstrations - For each topic we cover we will use a range of hands-on activities, and demonstrations to explore the ideas we're covering.