Is there a place for computational neuroscience at a liberal arts and sciences undergraduate college?

Sorinel A. Oprisan, Department of Physics and Astronomy, College of Charleston, Charleston, SC

Introduction

Computational neuroscience is an interdisciplinary research field that bridges physics, chemistry, biology, computer science, and psychology. The liberal arts and sciences environment offers the necessary breadth of knowledge for such an endeavor. At the same time, most undergraduate classes gravitate around a well-defined major and, therefore, are strictly specialized. Is it then possible for an undergraduate student to master both the depth and breadth required for a successful career in computational neuroscience? How do we introduce computational neuroscience concepts and methods to undergraduates with significant breadth of knowledge, but with very narrow depth specialization in physics, biology, chemistry, computer science, or psychology?

We developed a new an innovative curriculum in computational neuroscience that reaches across four different departments (physics, biology, psychology, and computer science) and integrates current research topics into lectures and hands-on activities. The core course of our newly approved Computational Neuroscience Concentration is called “Biophysical modeling of excitable cells.” Our goals were to offer our physics and biology undergraduates an overview of the mathematical and computational methods used in the modeling of excitable cells. We introduced an innovation in terms of prerequisites: differential requirements for physics and biology students who enroll in this class. For example, physics students are required to have calculus-based physics and only introductory biology classes, whereas biology students are required to have advanced biology and algebra-based physics. The envisioned career goal for a typical student enrolled in this computational neuroscience class is a health-related job or medical graduate studies. In order to make such a career transition smooth for our undergraduates, this class was used a Teaching Training Fellow from the Computational Neuroscience Concentration is called “Biophysical modeling of excitable cells.”

Mathematics

Core courses

- Biophysical modeling of excitable cells
- Digital signal and image processing with biomedical applications
- Computational neuroscience concepts and methods
- Neuroscience, biology, chemistry, computer science, or psychology?

Our CNS concentration

Our curriculum

Biphasic modeling of excitable cells

Biology track

- Algebra-based physics
- Advanced biology
- Introduction to Cell and Molecular Biology (BIOL 111)
- Evolution, Form, and Function of Organisms (BIOL 112)
- Biodiversity, Ecology, and Conservation Biology (BIOL 211)
- Genetics (BIOL 305)

Psychology track

- Algebra-based physics
- Advanced biology
- Behavioral Neuroscience (PSYC 214)

Physics track

- Calculus-based physics
- Intro biology (BIOL 111 and BIOL 112)

Electives

- Neurobiology
- Neuropharmacology
- Intro biology (BIOL 111 and 112)
- Advanced biology (BIOL 111 & BIOL 112)
- Behavioral neuroscience (PSYC 214)

What is computational neuroscience (CNS)?

- Biology
- Physics
- Computer science
- Psychology
- Mathematics

Textbooks


Digital signal and image processing with biomedical applications

- Matlab

Software packages

- XPP
- Biophysical modeling of excitable cells

Teaching and Research

Undergraduate student results (last 5 years):
- Invited talks (10)
- Presentations: local (25); state (10), regional (5), national/international (11)
- Published abstracts (25), peer-reviewed extended abstracts (5), research papers (3).

Career paths

Former undergraduate student from the CNS lab (last 5 years):
- Ph.D. in (computational) neuroscience (2)
- Ph.D. in other fields (2)
- M.D. (2)
- Healthcare professionals (5)

Acknowledgments

This curriculum development effort is supported by NSF CAREER IOS-1054914 grant to SAO.