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

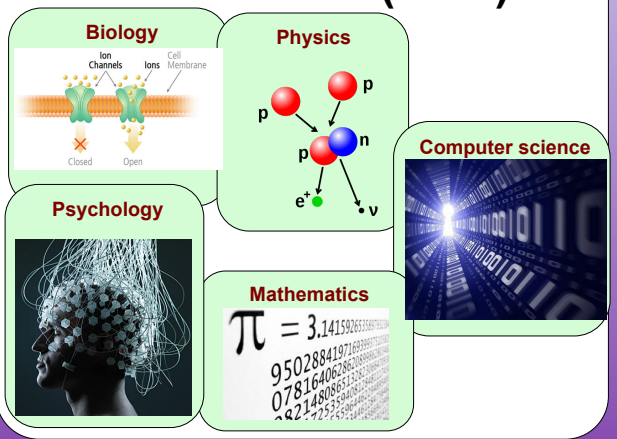
issotl 13 International society for the scholarship of teaching & learning
October 2 – 5, 2013
Raleigh, North Carolina

Introduction

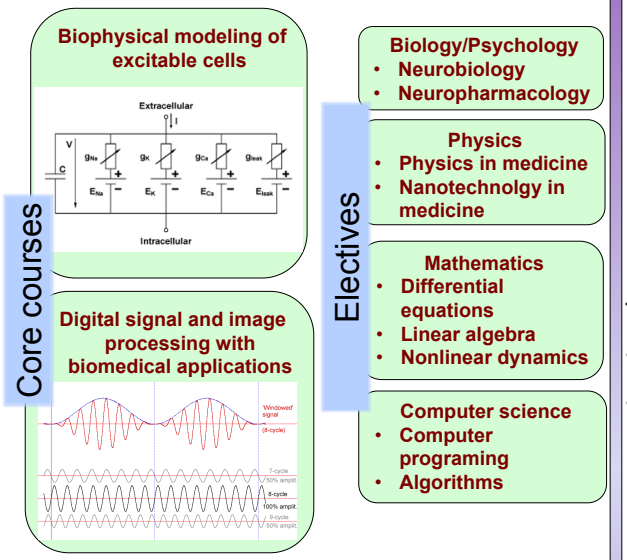
Computational neuroscience is an interdisciplinary research field that bridges physics, chemistry, biology, computer science, and psychology. The liberal arts and sciences environment offers the necessary breadth of knowledge for such and endeavor. At the same time, most undergraduate classes gravitate 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 in 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 Neuroscience Institute of the Medical School of South Carolina (MUSC). The MUSC graduate student conducted wet labs with undergraduate students and also lectured during the semester.

What is computational neuroscience (CNS)?



Our CNS concentration



Our curriculum

Biphysical 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)

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

Psychology track
- Algebra-based physics Advanced biology (BIOL 111 & BIOL 112)
- Behavioral Neuroscience (PSYC 214)

Software packages
- "Neurons in Action: Computer Simulations with NeuroLab", J.W. Moore and A.E. Stuart, 2000.
- XPP

Textbooks
- Principles of Neural Science, E.R. Kandel, J.H. Schwartz, T.M. Jessell, 2005.
- Computational Cell Biology: An Introduction to Computer Modeling in Molecular Cell Biology. Chris Fall, Eric Marland, John Tyson, and John Wagner (editors). Springer-Verlag. New York, NY. 2002.

Digital signal and image processing with biomedical applications

Software packages
- Matlab

Textbooks
- Eugene N. Bruce, Biomedical Signal Processing and Signal Modeling, John Wiley & Sons, 2000
- Edward Neuman, Matlab Tutorials, Southern Illinois University at Carbondale (available for downloading through course management website).

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 paprs (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.