Birla Institute of Technology & Science, Pilani
Hyderabad Campus

SECOND SEMESTER 2021-2022

Course Handout Part II

Date: 15.01.2022

In addition to Part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No.	:	CS F441
Course Title	:	Selected Topics from Computer Science – Introduction to Computational Neuroscience
Instructor-in-Charge	:	Venkatakrishnan Ramaswamy

Scope and Objectives of the Course:

Computational Neuroscience is a young interdisciplinary field that lies at the intersection of Neuroscience, Computer Science, Mathematics as well as fields such as Machine Learning with which there is significant cross-fertilization. Our quest to understand the brain is compelling, perhaps because we all possess one. From the perspective of computer science, a deep understanding of the brain could help us design better intelligent systems and systems that better interface with humans and animals. Secondly, since the brain is the best-known computational device in many respects, understanding it could also better help in understanding what computation is, which is the subject of Theoretical Computer Science.

However, as you will learn from this course, many of the basic principles governing computation in the brain are yet unknown, and therefore the aforementioned applications may or may not come to pass, soon. The current state of Neuroscience is arguably comparable to Computer Science in the 1950s and perhaps pre-Newtonian Physics. That said, there has been extraordinary progress in the past decade and the field is currently undergoing great intellectual ferment.

This course will start with the basics of Neuroscience, covering basic anatomy and physiology of the brain and the basic functioning of neurons. We will cover detailed and reduced models of biological neurons and network models. The course will include talks – recorded or live – by active researchers in the field, which will be interspersed with the other material. An important component of the course will be research presentations by students that will cover one or more papers on a topic. To this end, students are expected to put in significant amount of time and effort in understanding the papers – chosen in consultation with the instructor – possibly implementing some of the methods themselves and distilling this understanding into their presentations & reports.

The objectives of the course are for the student to be able to

- Understand the basics of Neurobiology.
- Understand detailed and reduced single neuron models.
- Obtain a basic understanding of contemporary experimental neuroscience research and how it interfaces with theoretical and computational methods.
- Understand the current state-of-the-art in Neuroscience and current open questions.

Textbook:

T1. P. Dayan & L.F. Abbott, *Theoretical Neuroscience*, MIT Press, 2001.

Reference books

R1. D. Warland, R. Steveninck, F. Rieke, W. Bialek, *Spikes: Exploring the Neural Code*, MIT Press, 1996.

R2. D. Marr, *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*, MIT Press, 1982.

R3. E. R. Kandel, J.H. Schwartz, T.M. Jessell, S.A. Siegelbaum, A.J. Hudspeth, *Principles of Neural Science*, 5th Edition, McGraw Hill, 2013.

R4. J. Hertz, A. Krogh, R.G. Palmer, *Introduction to the Theory of Neural Computation*, CRC Press, 1991.

Course Plan:

Lecture No.	Learning objectives	Topics to be covered	Chapter in the Text Book / Ref. book / Others
1-2	Introducing the basics of Computational Neuroscience	Introduction to the course	R3: Ch.1
3-4	Introduce basic anatomical features and physiology of the nervous system	Brain: Basic anatomy & physiology	R3: Ch. 2
5-10	Understand basic single neuron physiology, detailed & reduced neuron models	Neuroelectronics	T1: Ch.5, Ch.6
11-12	Understand recent progress in neurotechnology	Recent advances in experimental techniques in Neuroscience	Collated from research papers
13-15	Understand topics that will be presented by students in their final research presentations	Student abstract presentations	N/A
16-18	Understand the perceptron model & the perceptron learning rule	Perceptrons, Hebbian Learning	R4: Ch.5
19-20	Understand associative memories	Hopfield Networks	R4: Ch. 2
21-23	Understand David Marr's levels framework and its criticism	Marr's Levels framework	R2: Ch.1
24-27	To understand multilayer perceptrons and how they are trained.	Multi-layer perceptrons, error backpropagation. Basics of convolutional networks and stochastic gradient descent.	R4: Ch.6
28-34	To understand several recent advances in Neuroscience	Student final research presentations	N/A
35-40	To understand basic signal processing techniques & applications in Neuroscience	System identification, Linear Time Invariant Systems, Non-Linear Time Invariant system and the Volterra expansion	R1, Ch.2

Evaluation Scheme:

Component	Duration	Weightage	Date & Time	Nature of Component
Research paper(s) Abstract presentation	In-class	5%	*Pre-midsem*, Dates TBA	Open Book
Programming Assignment	Take-home	10%	*Pre-midsem*, Dates TBA	Open Book
Mid-semester Test*	90 minutes	30%	16/03 3.30pm to5.00pm	Closed Book
Research paper(s) Final presentation	In-class	15%	TBA	Open Book
Research presentations engagement	In-class	5%	TBA	Open Book
Comprehensive Examination*	120 minutes	35%	23/05 FN	Closed Book

Note: 40% of the evaluation to be completed by midsem grading.
"For Comprehensive exam and Mid-semester Test, the mode (offline/online) and the duration are subject to changes as decided by the AUGSD/Timetable division in future."

Chamber Consultation Hour: At https://whereby.com/vramaswamy at a time that will be announced in class.

Notices: Will be posted online on the CMS course management system. Students are expected to subscribe for email notifications from CMS that they would need to check several times a day. Students are responsible for keeping up with announcements.

Make-up Policy:
No make-ups will be offered, except in case of medical or family emergencies of a severe nature or other unavoidable extenuating circumstances, as judged by the Instructor-in-Charge, for which prior permission must be sought, where feasible. Documented evidence (e.g. a Doctor's note) will be necessary before consideration of such a request.

Academic Honesty and Integrity Policy:
Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

INSTRUCTOR-IN-CHARGE
CS F441