ASSIGNMENTS: CN550, Spring 2006

Neural and Computational Models of Recognition, Memory, and Attention

Evaluations
Grades will be based in equal parts on:
- 10 reading journals
- 11 weekly quizzes
- class project
- final exam

Your course grade will also reflect your overall performance, progress, and participation. Please feel free to discuss your work and grades with me at any time during the semester.

Assignments

The following pages outline a schedule of dates and a description of assignments for CN550.

Additional handouts for the class project will be developed as the semester progresses. This project aims to promote student participation, responsibility, and teamwork, and to bring the classroom experience closer to the professional experience. As a continuing experiment, it is subject to ongoing modification.

The reading list and assignments allow considerable freedom of choice, but also require considerable effort. Specification of assignments at the beginning of the semester is intended to help you plan your time.

Weekly quizzes

Except for the first and last class meeting, there will be a CN550 weekly quiz at the start of each class. You should leave your things in the classroom before 5:00PM, then take the quiz in the Auditorium.

SELF–DIRECTED LEARNING PROJECT

Due Tuesday, January 24, 2006:
A list of one or more topics that you would like to study during the semester.

You should think about what YOU would like to learn but have not so far had time for.

Your topic could be almost anything. The list might include, for example, specific topics directly related to the CN550 syllabus, such as learning about particular models; skills that you would like to spend time improving; a broad topic such as the neurobiology of memory; a book you have been wanting to read; etc., etc.

Homework throughout the semester:
Devote one hour per week to your stated goals. Set the hour aside so that you may enjoy the time in a comfortable place, giving this project your undivided attention. Challenge yourself not to let this hour be pushed aside in favor of more immediate and tangible demands. This is your time for yourself, and it is only one hour per week.

As the semester goes on, feel free to amend your goals statement, but then please turn in a revised version.
CN550 LECTURE TOPICS AND ASSIGNMENT DUE DATES   Spring 2006

ALSO:   Weekly reading journals (10 total)
Weekly quizzes (class weeks 2 – 12)
Self-directed learning project (1 hour / week)
Class project

Jan 17   1. Overview, history, philosophy

Jan 24   2. Supervised learning methods: Memory-based algorithms (KNN),
statistical pattern recognition, model-independent supervised learning methods
(validation & cross-validation, c-index, ROC curves, resampling,
combining classifiers, component analysis)
   Self-directed learning statement

Jan 31   3. Unsupervised learning: Clustering (leader, K-means), competitive learning, ART

Feb 7    4. Dimensional analysis, competitive networks, phase plane analysis

Feb 14   5. ARTMAP

Feb 21   No CN550 class meeting this week:   BU Monday schedule

Feb 28   6. Associative memory networks: Back propagation, multi-layer perceptrons,
radial basis functions, cascade-correlation, higher-order networks

March 7  Spring break

March 14 7. Support vector machines

March 21 8. Physiology, psychology, and memory models

March 28 9. Content-addressable memories (CAM), active network design

April 4  10. Liapunov functions, Cohen-Grossberg theorem

April 11 11. Three-layer feedforward networks: Theory and mathematical foundations

April 18 12. Synapses, signal functions, distributed vs. winner-take-all coding

April 25 13. Invariance, spatial preprocessing, oscillations, temporal order information (TOI).
   Course evaluations, class party.

May 2   14. Final exam (5:00 - 7:30 PM)
   Class project essay (2 pages)
CN550 JOURNAL  Due weekly: you should turn in a total of 10.

Turn in journals at the start of class, and no more than 1 per week.

FORMAT:  In the UPPER RIGHT–HAND corner of each journal, please type or print, in large letters: your name and the class date when you turn in the journal.

I will read each journal, and often reply to the class via e–mail or class discussion. However, I do not usually return the journals, so you should keep a copy for your records.

Part 1: Writing
This portion of your journal should include a short, well-constructed essay based on one or more of the readings in the CN550 syllabus. The readings do not need to be from the upcoming week’s lecture, but you should vary your subjects from week to week. Begin with a brief title, and list the article(s) your writing is based upon. The written piece should be approximately one page long. Try to construct a thoughtful, coherent, interesting essay, rather than a list of notes.

A critical goal of CN550 is writing skill improvement. You should devote considerable time to polishing and editing this short writing sample, each time attempting to stretch your capabilities as a writer of clear, specific, lively scientific prose. Review Strunk & White or another writing style book from time to time during the semester. Also, see the rules for writing at the end of this handout. As you read, think about how you might emulate aspects of writing you admire.

Part 2: Reading
You may select your own readings for CN550. A large majority should be from the syllabus, but you may include some others. In each journal, list:

a full citation of each item you have read for CN550 during the previous week.
Annotate each citation with 1–2 sentences.
Select a canonical reference format, and check that your lists are complete, correct, and consistent.
Include enough weekly readings from the CN550 syllabus for you to master the core course topics and to learn about some subjects in depth.

OPTIONAL ASSIGNMENT: PHASE PLANE ANALYSIS
The following page and the notes below describe a major assignment that I used for many years in CN550. In order to make room for new projects, this assignment is no longer required. Many students have found this assignment to be of great value to them. You are welcome and encouraged to try all or part of it. Greg is available to give you help and feedback on your work.

A main purpose of this assignment is for you to be able to make rapid, accurate sketches of phase plane dynamics without resorting to a computer.
Another goal is to give you a sense of exploring a problem mathematically. Computer simulations can test hypotheses, but rarely generate them. In recent years, students have come to rely increasingly – even exclusively – on this mode of analysis. This assignment is a chance for you to think about the strengths and weaknesses of complementary analytic tools.
Specify each case in terms of the set of all parameters $a, b, c$ that produce that case. The phase plane illustration of each case chooses a specific example of parameters from this case, but this does not give the whole analysis.
Try your best to explore the entire parameter space, following the model of the class notes.
It would take you a very long time, without much benefit, to do local analysis (eigenvalues, eigenvectors, etc.) at each critical point. Indicate how to do this, with an example calculated for 1–2 characteristic points. In your phase portraits, use local geometry to obtain accurate estimates of how trajectories approach critical points.
A complete assignment is a coherent analysis which is illustrated by ~15 phase planes diagrams – not an undigested pile of plots.
OPTIONAL ASSIGNMENT: PHASE PLANE ANALYSIS

DO NOT USE COMPUTERS FOR THIS ASSIGNMENT, EXCEPT FOR WORD PROCESSING.

Use phase plane analysis to describe the dynamics of the two-dimensional, on-center, off-surround, shunting, competitive network (with inputs $\equiv 0$) given by:

\[
\frac{dx_1}{dt} = -x_1 + f(x_1) - x_1[f(x_1) + f(x_2)]
\]

\[
\frac{dx_2}{dt} = -x_2 + f(x_2) - x_2[f(x_1) + f(x_2)]
\]

where $f(x)$ is the piecewise-linear function shown below.

Analyze and show HAND-DRAWN phase portraits of the solutions to this system for characteristic values of the (dimensionless) parameters $a, b,$ and $c$.

All parameters are $\geq 0$, and $a \leq b$.

Include details (arrows, etc.) to clarify dynamics, as in the lecture notes.

State the range of parameter values that yield each class of dynamics. For example (hypothetically), “for $0 < ab < c$, all solutions $\to 0$.”

Illustrate each class with a characteristic phase portrait, approximately $3\times3$ in size.

Describe your analysis of the phase planes (e.g., nullclines, critical points etc.).
RULES FOR WRITING

The following list includes many of the things that I find myself writing, or thinking, over and over again when reading, revising, or reviewing papers. Write your own rules for your journals and class project.

Try not to be boring.

Avoid the passive tense – see if you can eliminate it altogether.

Avoid jargon.

Draw pictures – lots of pictures.

For drafts, hand–drawn pictures are OK – computer pictures take too long.

Include all notation and network design in summary figures, if possible.

Explain by example.

List parameters, etc., in figure captions or tables.

Specify your system fully, so that a CNS student could replicate your results without having to ask you questions.

Edit your PRINTED text, in many drafts. Word processors are great, but computer screens give you tunnel vision.

Use consistent format (e.g., section headings) and notation throughout.

Cross–check all references cited in the text.

Be sure that each reference is complete, correct, and in a consistent format (e.g., capitalization of titles, page nos., dates). Choose a journal such as Neural Networks for your citation format (journals, books, chapters), and maintain that reference format in all your work. [Exception: Most publications have a required format.]

Omit all useless words and phrases lest you lose your busy and impatient readers.

Name your model, at least for purposes of internal exposition.

Check your text compulsively for small errors, including spelling, fonts, subscripts, references to figures, tables, and equations, ...

Use a spell check program – but do not rely on this as a substitute for proofreading.

Do not use footnotes.

Aim to write short sentences with short words.

Ask a friend to read your work and to ask you questions. Read your friend’s work, too. Be kind but honest. This is good practice for the rest of your life. Try to remain friends.

Give a talk on your work (to more friends) before writing a final draft, if possible.

Keep thinking about your reader.
Be punctual.
Thank people who invite you to write a chapter in their book, help you improve your paper, etc., etc.
Submit your work for presentation at a small or large meeting.
Be specific rather than vaguely general.
Be especially specific if you are being even slightly critical of another author, and be sure you are accurate. Err on the side of kindness. Use description, examples, and quotes, then let the reader draw conclusions.
Spell out acronyms (MLP, ART, ...) on first use and after a long time since prior use.
Begin each section with a strong, descriptive sentence.
Build a paper around figures and tables whenever possible.
On computer–generated figures, make lettering large enough to read, or put the information into the text or caption.
Define terms on first use.
Read the whole paper, on paper, before anyone else does. Check for order, flow of ideas, interest, consistency of style, tenses, and notations, ...
Allow plenty of time for writing and editing.
Use specific headings and subheadings to guide the reader with information (cf. vague headings such as: Introduction, Results, Conclusion).
Don’t apologize.
Don’t say that anything is obvious or trivial.
Notice and learn from the styles of authors whose work you consider well written.
Make your own list of rules.