

Bioe 2696/ECE 2695 Projects

2 February 2009

The project assignment in this class is meant to be the core of the course. We hope that these projects will provide students the opportunity to delve into the details of a body of literature, apply the skills they have learned in control theory, and potentially, implement or discover something that advances that field! Projects constitute 35% of the grade in this class. Again, you are welcome to work in pairs or groups. Part of the assignment is to identify and design your own project - the ideas on this page are just to get you thinking. Feel free to consult your professors, guest lecturers and TA while you design a project. We are very excited to see what you can accomplish, and we anticipate that several projects will result in work that can be published, or presented at a conference!

Some dates to keep in mind:

- This week: be thinking about the topics ahead in the course, and which in particular you are intrigued by. Of course, you are not limited to what we've discussed in class. Over the next few days, some example research papers for many of the upcoming lectures will be posted to the website. These aren't necessarily the assigned readings for that lecture, so skim them to get a sense for the field and its questions.
- Next Monday, Feb 9: After class will be a social hour with pizza. You can use this time to identify potential collaborators that you may not have known before class. We will go around the room, and each person will tell us what topic they are interested in. Then, over pizza, we will encourage you to get to know each other.
- Wednesday March 4: Project proposals due, and project presentations delivered. Each group will submit a ~2 page document describing what they intend to accomplish. During recitation, each group will give a ~5 minute report describing their project.
- April 8-15: Project reports due. Each group will submit a written report on their work. Class time will be devoted to 15 minute presentations of each project.

Projects can take the form of, for example:

- 1) Implementing an existing model in the literature, recreating behavioral or neural data, then extending the model, or observing how it behaves under parameter adjustments.
- 2) Implement a quantitative model for an aspect of neuroscience, behavior, or psychology where only conceptual models exist. This type of project will require a more extensive literature review.
- 3) Collect new data, and model it. Hopefully in a way that meaningfully extends the current body of literature. This type of project may be conceptually simpler, but will require a big head start, because good data can be elusive.
- 4) Compare two modeling methodologies - two completely different strategies of control theoretic models, or for example, a neural network model and a control theory model, and compare performance, robustness, etc.

You can choose any neuroscience or behavioral phenomenon you are interested in. The topics covered in the course are especially worth considering:

- 1) Eye movement control: saccades, vestibular-ocular reflex, etc.

- 2) Arm movement control: time constants, damping, stability, etc.
- 3) Plasticity: adapting arm movements to a force field, or eye movements to a VOR gain change, or a saccade target jump.
- 4) Posture: keeping balance despite perturbations.
- 5) Specific brain areas: basal ganglia, cerebellar, and/or cortical circuits for control.

Putting these ideas together, some examples of a project might be:

- 1) Implement a control model of the oculomotor system. Can you make novel predictions from it? For example, if you change parameters or time constants to it, or change transfer functions, can you recreate an eye movement abnormality in the neurological literature? Or, can you extend the model, so that it accounts for other data in the literature?
- 2) Can you take a conceptual feedback model in the literature, and ground it out as a detailed quantitative model that accurately captures behavior?
- 3) Several labs around campus may be able to help you attain new data (posture, eye movements, arm movements). Can you design a simple experiment, collect data, and account for it with a feedback model, or a variant of a published model? For example, what if you vary the time delay of sensory feedback - how is performance affected, and can your model recreate that?
- 4) Compare a control theory model to a neural network model that accomplishes the same goal. Which better captures reality? Which is more robust to changes in parameters, or to the destruction of components?
- 5) Simulate a mass-spring model of the arm, and study conditions under which it is well damped. What features of the anatomy of the arm, and the neurophysiology of its control provide it with stability? What new experimental predictions can you make?
- 6) Build a control theory model of a specific brain area, or a network of areas. Given realistic constraints like neural conduction velocities, neural firing rates, the sign of synaptic connections (excitatory or inhibitory) can you recreate neural firing properties (spatial and temporal tuning)? Can you make predictions for other neural signals beyond those that have already been reported in the literature?