CogSci 109: Lecture 14

Thursday Nov 9, 2006

Optimality, function minimization/maximization, examples, course review

Announcements

- Homework 4 posted later
  - **Incorporating feedback it will be shorter**
- Grading feedback
  - **Most midterms graded, so far the average is good**
    - No numeric value overall yet, but mult choice was good - most above 85/100 on mult choice that I saw, meaning most missed less than three problems out of 20
    - Short answer most did well
    - Though you may feel uncomfortable with the material, you are able to perform, demonstrating that you have learned something
      - **I said in the first week that you may not feel complete mastery of this material by the end of the class, but you would be familiar with it and know how to learn more**

Survey feedback

- No more chattering in class
- Do not spend time on your laptop doing other things in class, you may only take notes
- If you have questions raise you hand and ask, do not discuss with your neighbor
- This course is part of your cognitive science curriculum, and you chose it - I did not create the requirements
  - **10 hours on a homework stretched over 1-2 weeks is not unreasonable for a UCSD course - university of excellence**
- This course has had improved performance this quarter over previous quarters
  - **considering the number of people that failed and your current state, you are in a better place by far - I do not expect you to fail - if you complete the next few homeworks you'll more than likely do quite well**

Course update

- The structure as was presented during the first lecture is being presented exactly as described in the first lecture
  - **Modeling and data analysis has been broken into 4 parts:**
    1. Perform experiments, acquire/compile data, import into matlab or another organized system
    2. Basic data analysis, statistics, and visualization to give initial perspective on the information
    3. A set of candidate models are explored by fitting to the data, error analysis is performed and model sets are reduced to a smaller group of models which fit well
    4. The information is communicated in the form of a presentation, report, animation, or other representation

Part 1: techniques you've learned to acquire, preprocess and load data into matlab

- How to use matlab generally
- Sampling issues
  - **aliasing**
  - **Filtering**
  - **basic signal processing**
  - **two low-pass filters and high pass filters**
  - **Sub/supersampling**
- Load, import, save, binary files, ascii files, .mat files
- Digital vs. analog data
- Discrete vs. continuous signals

Part 2: Basic data analysis, statistics and visualization

- Computing the basic statistics
  - **Mean**
  - **Median**
  - **Mode**
  - **Std**
  - **Variance**
  - **Covariance**
  - **Z-scores**
- Basic data visualization
  - **Plots in 2d**
  - **Plots in 3d**
  - **Histograms**
  - **False color representation, colormaps**

Part 3: Creating models of the data and evaluating those models

- Interpolation
  - **Linear and nonlinear**
  - **LERP, SLERP, BERP, TERP**
  - **Lagrange, Splines, Bezier curves, parabolic blend**
- Least squares (regression)
  - **Linear and nonlinear**
  - **Exponential**
- Fitting curves which are nonlinear in the parameters, optimization and minimization
  - **Nelder-Mead (Matlab FMINSEARCH)**
  - ***Gradient descent/conjugate gradient***
  - ***Bisection algorithms***
  - ***Neural networks, an introduction***

Part 4: Communicating results effectively

- Formatting reports
  - **Good practice**
  - **How to present information effectively (redundant encoding of info, how to be sensitive to the context of the presentation who is reading it, how displayed)**
- Expressing numerical results in clear form
- Interpreting models and data
  - **What does it mean?**
  - **Why the model is NEVER the same as the reality you are modeling**

We still have to…

- Complete the section on minimization today
- Discuss neural networks
- Formalize some of the communication skills
- There will be a few more readings, 2-3 more homeworks, and the final
  - **The project is going to be incorporated into your homework and the final exam**
  - **No group presentation**

Cognitive science and this course

- This course is broad and covers many topics in order to give you a range of tools to apply no matter what aspect of science or cognitive science in which you choose to participate
- It covers many methods, which is different than what you may be used to
- This is a beginning of knowledge, you not only have this quarter, but all the resources now given to you to expand. Consider this as showing you the concepts, so you are aware, now you must do the learning over time
- These methods are important for many jobs, graduate school, and other professional training

If you feel lost or confused…

- Please come see me during office hours, or arrange a meeting in person
- Don’t give up! You’re doing great!!! It’s a difficult effort but you can do it!!!

Last time we discussed…

- Function minimization, optimization concepts
  - **Examples**
- Nelder-mead simplex algorithm built into matlab
  - **Example code for fitting data**
- Potential for a group project
  - **And potential for shortened final exam**

This time we will discuss…

- The project
  - **There will be a compromise**
    - Project will be part of your last homework
    - Individual
    - Same format as homework, so nothing unexpected
- And…

We will also discuss…

- More optimization, minimization, maximization
  - **Gradient descent algorithm**
  - **Conjugate gradient algorithm**
  - **How to solve a set of linear equations using these**
  - **How to extend the above to nonlinear equations and over-constrained problems (i.e. least squares solutions)**
  - **EXAMPLES/APPLICATIONS - why should you care?**

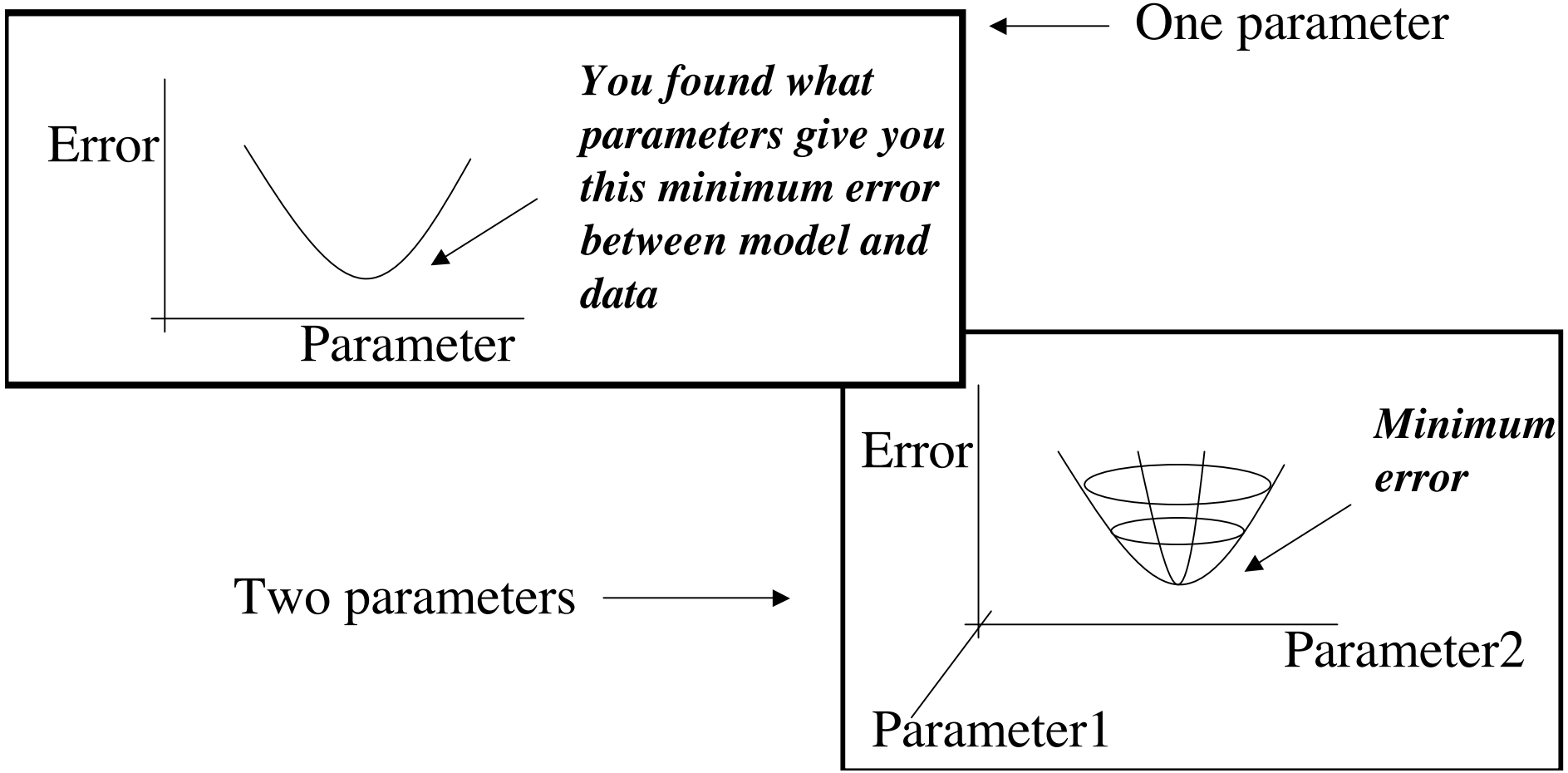
The project…

- You will choose some REAL data from the web site repository OR you can find your own (as long as you have it approved)
- You will use the methods developed this quarter in class and your homeworks to perform the 4 steps of modeling and data analysis as we have structured the course
  - **You will answer specific questions about each step**
- It will be essentially the same as your homework has been, but with a choice on your part as to the source of the data, and thus what your analysis will mean
- An opportunity to apply what you have learned
- You will not present in front of the class

Minimization review

- Last time we introduced minimization of a scalar function
- You have already done a form of function minimization with least squares
  - **but you solved the equations analytically rather than approximately (solving the equations)**
  - **What does this mean?**

You've found the minimum exactly (by solving the equations exactly)



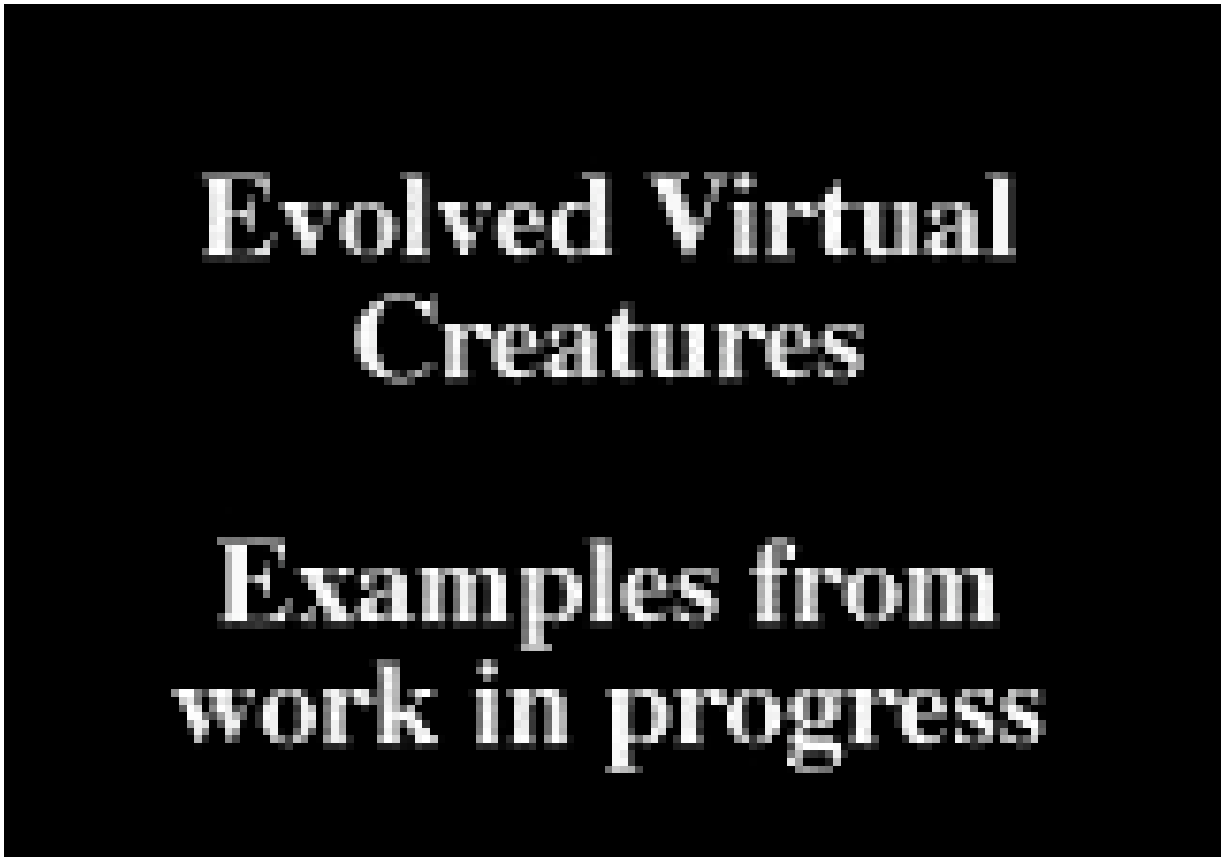
And we've introduced approximate solutions

- We saw a demonstration of function minimization using matlab's **fminsearch** algorithm
  - **Works when you CAN'T easily solve the equations exactly (which is VERY frequent in nonlinear systems such as the brain, behavior, motor control, speech processing/synthesis/comprehension, perception, and more cognitively relevant topics)**
- Today we'll see how this applies specifically to cognitive science, and how it is helpful
  - **Will also see two more algorithms which are very popular**

How does this relate to behavior and cognition?

- One popular model group used by cognitive science relates decision processes to minimization of cost and maximization of rewards (behaviorism)
  - **“I’m hungry, I need to eat” ->this hunger instinct and the dislike of discomfort leads us to make choices to minimize hunger, unless another cost/reward outweighs that choice**
  - **You drive on the correct side of the road because you don’t want to have a head on collision with another car, or get a ticket because either of those would be a cost**
- Motor control (control of movement)
  - **Many aspects of human sensorimotor system are optimal in some sense (specifics vary, but examples are energy expenditure/recovery, time to goal, obstacle avoidance)**

Graphical example - evolving organisms optimize cost, maximize rewards



Remind me again, what exactly are we ‘minimizing’ or ‘maximizing?’

- Minimize cost
- Maximize reward
- We decide what that function is
  - **Then have some unknown constants**
  - **Then we use these methods to find the constants**
  - **Those constants give us the smallest cost or largest reward function**
    - Can be then interpreted as the ‘best fit’ given a definition of what ‘goodness’ is

What is a way to do this?

- Skiing - you want to get to the bottom of the hill as fast as possible to get the hot chocolate
  - **Obvious approach is to choose the direction of steepest descent down the mountain**
- Leads us to
  - **The *method of steepest descent***
  - ***Do exactly what we just said***

How does gradient descent work?

- Start with the cost function
  - **Make it quadratic so it has the nice bowl shape, and a definite global minimum (though complicated functions may have local minima)**
  - **We want to find a way to make**
    - Ax-b = *something* as *small as possible*
    - *So we'll start at some guess for x, then change x at each step to be going 'down the hill' of the cost function*

The algorithm

- Algorithm:

  Choose a starting point x(0)

  - **Repeat this until we're satisfied that we're close**
    - Compute the distance to change the vector x
    - Compute the direction to change the vector x
    - Update x
  - **Goto repeat**

- It turns out that the steepest direction and step distance is found by looking at the 'gradient' of the cost function