Lecture #1: Course Introduction

Randy Cogill
SYS 605 - Stochastic Systems
Fall 2007

Basic course information

- **Course:** SYS 605 - Stochastic systems
- **Instructor:** Randy Cogill (rcogill@virginia.edu)
- **Teaching Assistant:** Himanshu Gupta (himanshu@virginia.edu)
- **Time/place:** Tues. & Thurs., 2PM-3:15PM in MEC 216
- **Office hours:**
  - **Randy:** Tues., 10AM-12PM in Olsson 102G
  - **Himanshu:** Mon. and Weds., 4PM-6PM in Olsson 105B
- **Web:** `http://people.virginia.edu/~rlc9s/sys605/`

Workload and grading

- **Homework:** Expect about 10 assignments, one each 1.5 weeks
  - All homework due in class on due date
  - You are allowed **one** 24-hour extension. Use it wisely...
- **Exams:** One midterm and one final, both take-home
- **Grading:** Homework 50%, Midterm 20%, Final 30%

Books and notes

- My slides will be available on the class web page...
- ...however, I will use both slides and blackboard
- There is no required textbook for the class
- Some good references you might want to look at:
  - "Markov Chains", by J.R. Norris
    `http://www.statslab.cam.ac.uk/~james/Markov/`
  - "Introduction to Probability", by D. Bertsekas and J. Tsitsiklis
    `http://www.athenasc.com/probbook.html`
  - "Matrix Analysis and Applied Linear Algebra" by C.D. Meyer
    `http://www.matrixanalysis.com/DownloadChapters.html`

Topics covered

- A rough outline of the topics covered:
  - Probability review
  - Introduction to Markov chains
  - Linear algebra review
  - Finite-state Markov chains: steady-state behavior
  - Finite-state Markov chains: transient behavior
  - Countable-state Markov chains
  - Applications of Markov chains
  - Poisson processes
  - Martingales
  - Examples and course wrap-up

Your background

- I'm assuming that you:
  - Have taken an undergraduate level probability course
  - Are somewhat familiar with basic linear algebra
- I plan to review basic probability and linear algebra...
- ...however, these reviews will move at a very quick pace

Matlab

- Some homework and exam questions will require use of **Matlab**
- Matlab is a numerical linear algebra software package
- Matlab is available to users connected to the UVa network:
  - `http://www.itc.virginia.edu/research/matlab/`
- Many tutorials can be found on the web
- **Octave** is a free (mostly compatible) alternative to Matlab:
  - `http://www.octave.org`

Stochastic processes

- This is an introductory level class on **stochastic processes**
- What is a stochastic process?
  - **The idea:** A quantity evolving over time in an uncertain manner
  - **Definition:** Set of random variables X_t, indexed by parameter t
- Let's see some examples...

Example: Queues

- For example, passengers arriving at an airport security line
- Typical questions we would like to answer:
  - Before we arrive at the airport, how long of a wait do we expect?
  - After seeing the line, how long of a wait do we expect?
  - How likely is it that we miss our flight due to a long line?
- Systems similar to the waiting line arise in a number of areas:
  - Communication networks
  - Transportation networks
  - Inventory management

Example: Queues (cont.)

- Model passenger arrivals by a stochastic process
- Model individual service times by a stochastic process
- Can then estimate waiting times, etc. from this model
- We'll see more on queueing models later in the course...

Example: Communication systems

- For example, transmission between laptop and wireless router
- Router sends a string of bits, say 0000000011111111
- External noise can corrupt some of the bits
- Say we receive 0010000011110111 instead
- Can we guess which bits were sent?

Example: Comm. systems (cont.)

- Have some notion of 'typical' transmissions and errors
- Model transmitted bits as generated by a stochastic process
- Model noise as generated by a stochastic process
- Can use stochastic model to find most likely transmitted bits
- We'll see how this is done later in the course...

Example: Financial derivatives

- **Derivative:** Financial contract with value derived from some assets
- Global derivatives market estimated at $300 trillion
- An example of a derivative is a **call option**:
  - Have option of buying stock at a given price in the future
  - "Can buy shares of IBM one month from now for $120 each"
  - Exercise option if value in one month is greater than $120
- How much should you pay for this opportunity?

Example: Financial derivatives (cont.)

- Option pricing relies heavily on stochastic process models
- The underlying stock price is modeled as a stochastic process
- Option price is derived from the stock price model
- Can learn more about this in **SYS 654 - Financial Engineering**

Example: Epidemics

- Suppose there is an outbreak of a new disease
- When sick, individuals can infect others
- After a short period, individuals recover
- Some questions about this disease:
  - At any given time, what percentage of the population is infected?
  - Does it eventually die out, or does it continue to spread?
  - If this disease eventually disappears, how long will this take?

Example: Epidemics (cont.)

- The number of infected individuals is modeled as a stochastic process
- In each time period:
  - An individual infects n others with some probability
  - An individual recovers with some probability
- A reasonable model for this process is given by a Markov chain
- You'll probably see a homework problem related to this...

Example: Google's PageRank

- **PageRank** was first major innovation of the Google search engine
- Give every web page an 'importance' score...
- ...return search results ranked by importance
- The way Google ranks pages is related to Markov chain theory
- I'll show the details later in the course...