An Introductory CS Course for Students in the Sciences

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Kalamazoo College

- Undergraduate only liberal arts college.
- Approx. 1,250 students, 100 faculty.
- Ranks 18th nationally for the percentage of graduates who go on to earn doctoral degrees.*
- Some specific disciplines:
  - Life Sciences 4th
  - Chemistry 8th
  - Physical Sciences 13th
  - Sciences and Engineering 12th
  - Computer Science 25th
  - Mathematics 30th

**Higher Education Data Sharing (HEDS) Consortium, 2004*

Motivation for Designing a New Course

- Some enrollment figures for our CS0 course COMP105:
  - Fall 1998: 75
  - Fall 2001: 50
  - Fall 2007: 9

Motivation for COMP108

- Computational tools and computational thinking are becoming increasingly important in the sciences.
- Very few science majors were taking *any* CS courses.
- The courses we offered were not ideal for that audience:
  - COMP105 – Essentially a CS survey course.
  - COMP110 – Intensive Java Programming course.

COMP108: Introduction to Scientific Computing

- An intro CS course with a focus on scientific applications.
- Theme:
  - If a student is joining a computationally focused research group, what skills would they need to get started quickly?
- No prerequisites.
- Taught in Fall ’06, currently being taught again.

COMP108 Topics

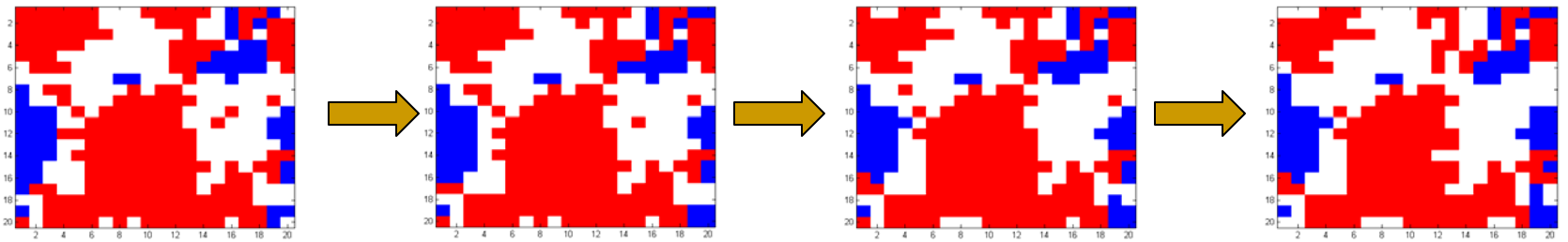
- Programming. (mostly MATLAB, some C)
  - Modeling and Data Analysis
- Core CS Concepts.
  - Algorithm analysis and design.
  - Intractable vs. tractable problems.
  - Computer organization.
  - Computer representations of data:
    - Numbers, images, audio, programs.
- Scientific Tools:
  - LaTeX
  - Unix

COMP108 Organization

- Many class sessions are 20-30 minutes of lecture followed by 50-60 minutes of “mini-lab”.
- Occasional homework assignments.
- 2 midterms.
- 3 outside projects – each includes a programming portion and a written report.
  - #1 – Modeling.
  - #2 – Data analysis.
  - #3 – Final project selected by student.

Project #1 – Lotka-Volterra Dynamics on a Grid

- We discuss:
  - $dV/dt = \alpha V - \beta VP$
  - $dP/dt = \delta VP - \gamma P$
- They implement a grid based model with similar dynamics*.



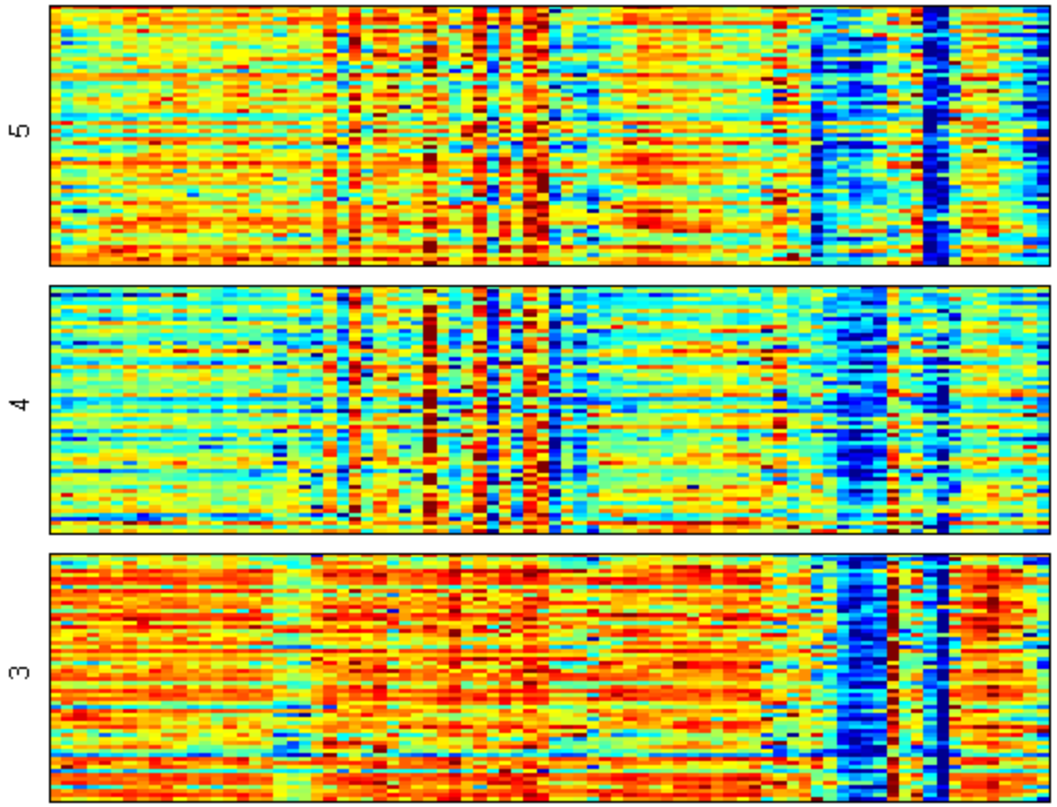
*A. Provata, G. Nicolis, and F. Baras. Osciallotory dynamics in low-dimensional supports: A lattice Lotka-Volterra model. Journal of Chemical Physics, 110(17), 1999.

Project #2 – Clustering Gene Microarray Expression Data

- We read:
  - Eisen, et. al. *Cluster analysis and display of genome-wide expression patterns*. PNAS, 95:14863–8, 1998.
- Students reproduce those results on the same data set using K-Means clustering.

Project #2 – Clustering Gene Microarray Expression Data

- Example Clusters:



Final Project

- Some Examples
  - Automatic music transcription.
  - MATLAB music player.
  - Parachute modeling.
  - Sequence based analysis of flu virus evolution.
  - Analysis of whale sighting data.
  - Analysis of homerun statistics.
  - Investigating fractals.
  - Financial Analysis of big three auto makers.

Results: The Positive

- Anecdotally, science students seem to find the course valuable:
  - Senior biology major: "I really enjoyed this course and will definitely be taking more computer science courses after I graduate in hopes of being able to incorporate it into my graduate studies."
  - Sophomore physics major was accepted for an REU at Caltech to work on the LIGO project, in part because of her MATLAB experience.
- Overall, students who completed the course thought it was valuable:
  - Average course evaluation 4.22/5.
  - Typical average evaluation for our CS0 courses 3.8/5.

Challenges: Enrollment

- Fall ’06 – 14 students enrolled, 2 withdrew.
- Fall ’07 – 8 enrolled, 0 withdrew (so far).
- Science students have very tight schedules:
  - Extensive general education requirements.
  - Around 80% study abroad.

Challenges: Mixed Audience

- Humanities majors fulfilling general education requirements.
  - “At least it isn’t a math class!”
- First year CS majors.
- Senior science majors.

Challenges: Appropriate Projects and Exercises

- Goal is to avoid “toy” projects.
- My own area is not really computational science.

Moving Forward

- More outreach to science faculty.
- Maybe drop C?