COS 116: The Computational Universe

Adam Finkelstein

Spring 2012

COS 116: The Computational Universe

- Instructor: Adam Finkelstein
- TAs: Sema Berkiten & Sourindra Chaudhuri

- Labs
  - Mon, Wed 7:30-10:20pm, Friend 009
  - This week only: take-home lab

COS116: General

www.cs.princeton.edu/courses/archive/spring12/cos116/

Computer Science 116
The Computational Universe

Spring 2012

Princeton University
Computer Science
Department

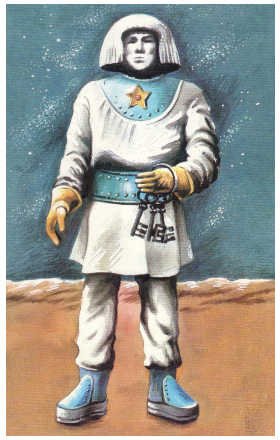
General | Policies | Syllabus | Readings | Handouts | Assignments | Labs | Extras

Course Summary

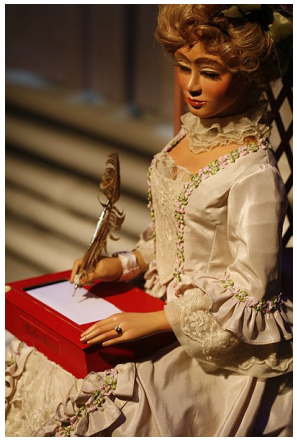
Computers have brought the world to our fingertips. We will try to understand at a basic level the science -- old and new -- underlying this new Computational Universe. Our quest takes us on a broad sweep of scientific knowledge and related technologies: propositional logic of the ancient Greeks (microprocessors); quantum mechanics (silicon chips); network and system phenomena (internet and search engines); computational intractability (secure encryption); and efficient algorithms (genomic sequencing). Ultimately, this study makes us look anew at ourselves -- our genome; language; music; "knowledge"; and, above all, the mystery of our intelligence. This course satisfies Princeton's Science and Technology (with Lab) distribution requirement.

Administrative Information

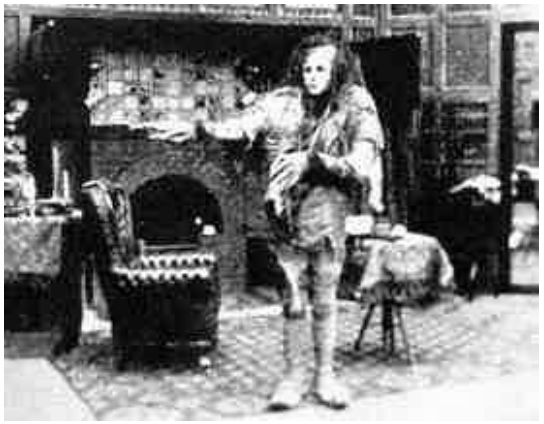
Ancient dream: “Breathe life into matter”



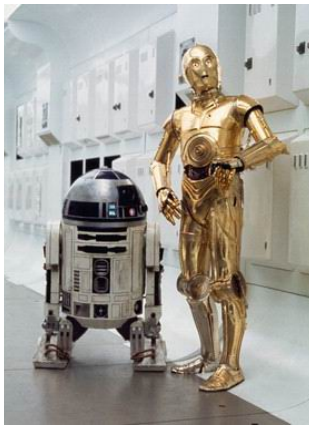
Golem (Jewish mythology)



Automaton (Europe)

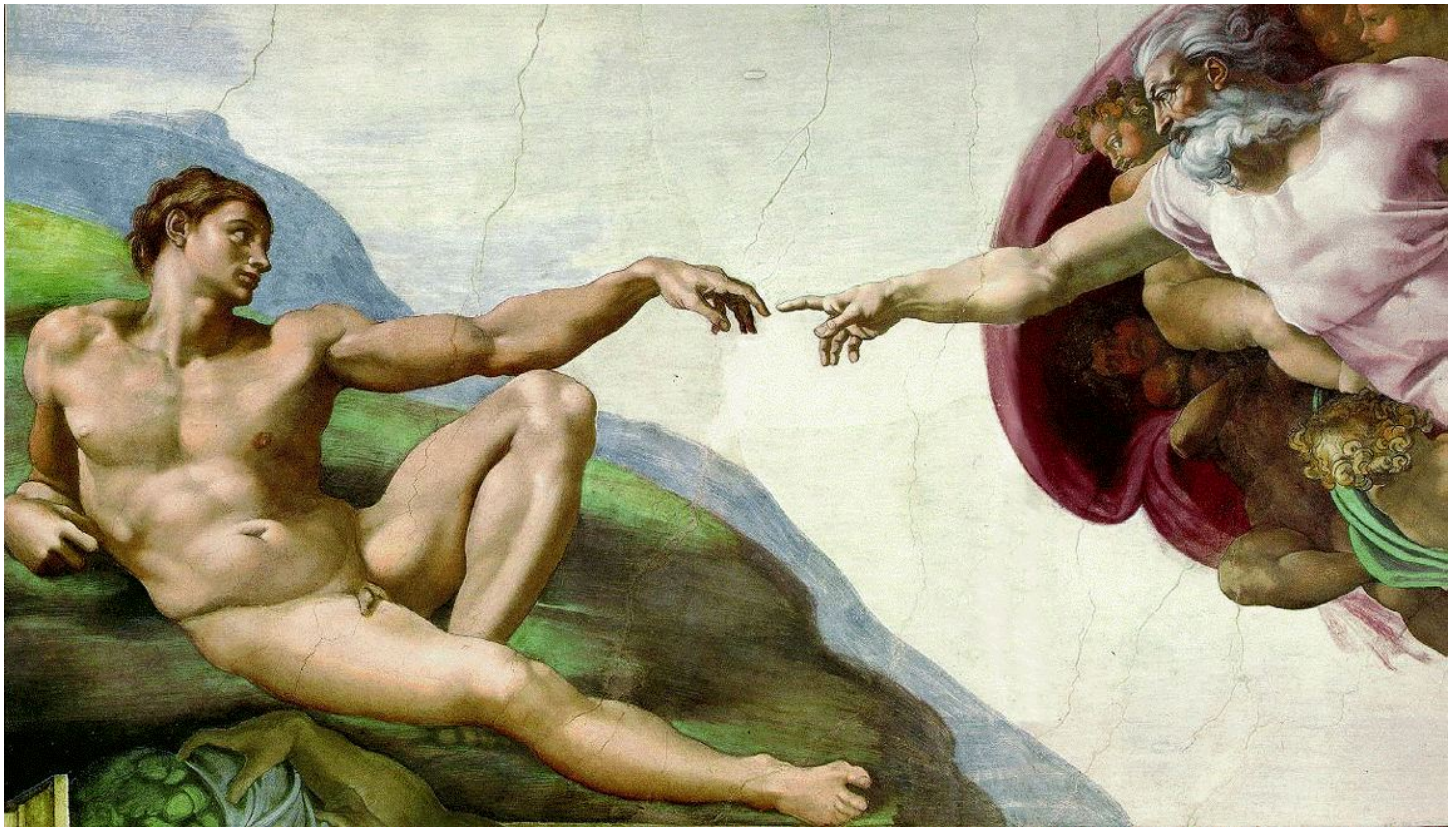


Frankenstein (Shelley 1818)

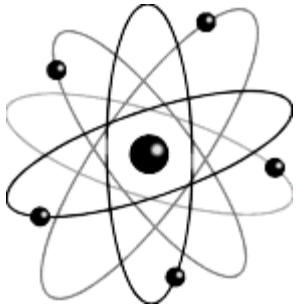


Robot (Capek 1920)

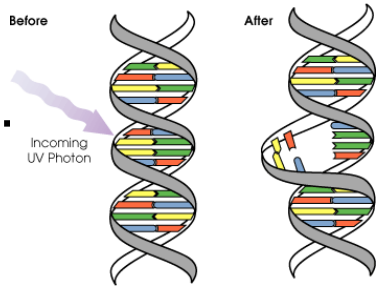
“Breathe life into matter” – Another perspective



“Breathe life into matter” – A 20th century perspective



- “Matter”: Atoms, molecules, quantum mechanics, relativity …



- “Life”: Cells, nucleus, DNA, RNA, ..

- “Breathe life into matter”: Computation

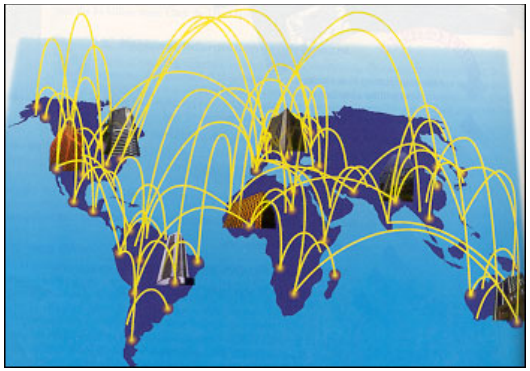
One interpretation: Make matter do useful, interesting things <u>on its own</u>

Breathing life into matter…

Military was a major sponsor of computational research in 20th century

Electric Sheep

Scott Draves



Computational Universe

Google™

Some important distinctions

Computer Science vs. Computer Programming (Java, C++, etc.)

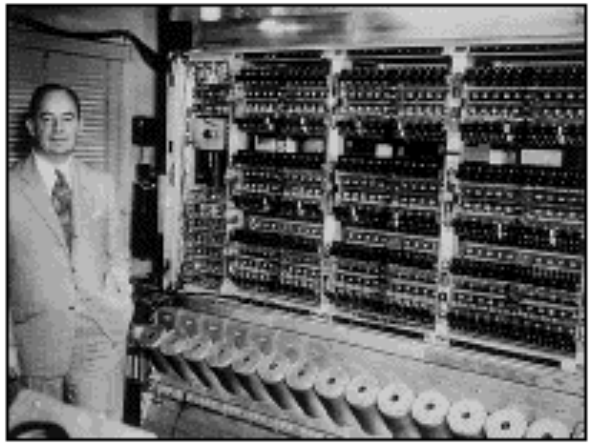
Notion of computation vs. Specific implementation (Silicon, robots, Xbox, etc.)

Course **not** about programming!

- Not necessary for understanding
- More time for to cover computer science (broader than COS126!)
- Little advantage to those who have prior programming experience

Brief history of computation

- Technological:
  - Clocks
  - Clockwork “Automata”
  - Mechanized looms, steam engines
  - Vacuum tubes, electronic calculators (1910-1930’s)
  - ENIAC (1945)
  - von Neumann Computer (1949, Princeton)

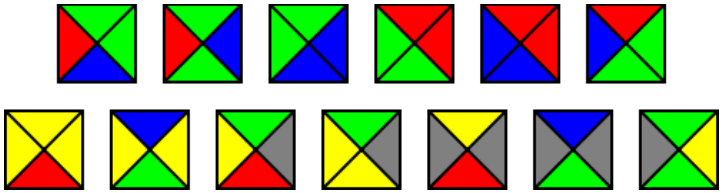


Brief history of computation

- Intellectual
  - Ancient Greeks, philosophers
    - (How to “formalize thought”)
  - Boolean logic (G. Boole, 1815-1864)
  - Crisis in math
    - Hilbert: Call to systematize math
    - Gödel: Incompleteness theorem
  - Lambda calculus (A. Church, 1936)
  - Turing machines (A. Turing, 1937)

Both at Princeton;

First clear notion of
“What is computation?”



Wang tiles 1961

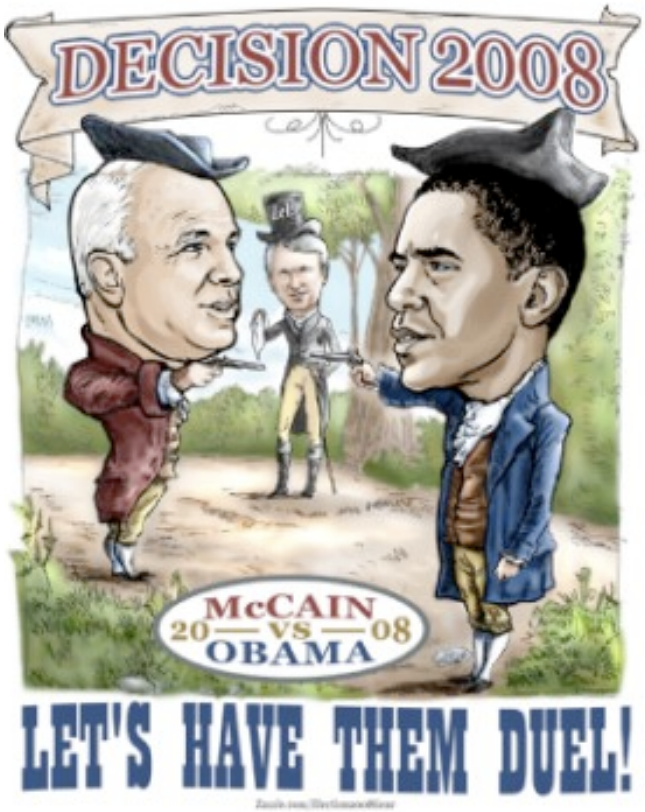
Computer Science:
A new way of looking at the world

Example 1:

Google™

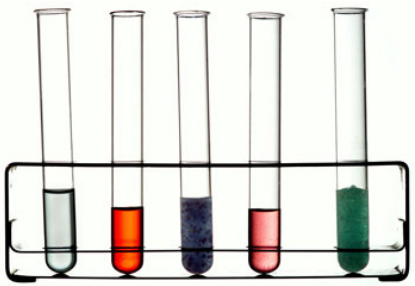
Example 2: Public closed-ballot elections

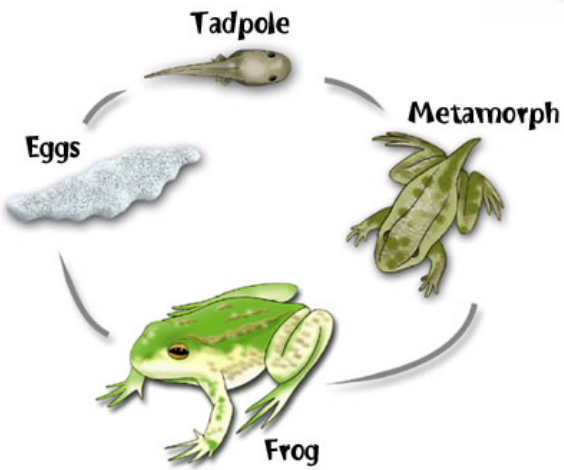
- Hold an election in this room
  - Everyone speaks publicly (no computers, email, etc.)
  - End: everyone agrees on who won and margin
  - No one knows how anyone else voted
- Is this possible?
  - Yes! (A. Yao, Princeton)



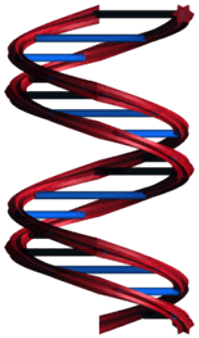
Example 3: Computational Biology

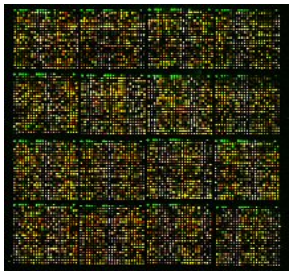
Old Biology



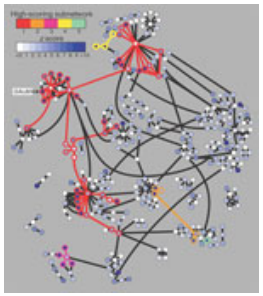


New Biology





Microarrays



Pathways

COS 116

- First 10 lectures:
  - Cool things computers do and how
- Next 8 lectures:
  - What's inside, internet, silicon chips
- Last 6 lectures:
  - Complexity, cryptography, viruses, search engines, artificial intelligence

This week's reading:

Brooks
pp 12-21, pp 32-51
See course web page.

This week's lab: Web 2.0

Take-home lab – see course web page.

Grading

- Midterm: 15%
- Final: 35%
- Lab reports: 35%
- Participation (class, blog): 15%

- Attendance expected at lectures and labs

Next couple labs: Scribbler. What determines its behavior?