What is Computing? Informatics?

- What is computer science, what is its potential?
  - What can we do with computers in our lives?
  - What can we do with computing for society?
  - How will networks transform how we think, what we know, what we do?
  - How is society affecting and is affected by computing?
  - Changes in science: biology, physics, chemistry, ...

- Privileges and opportunities available if you know code
  - Writing code, reading code, understanding algorithms
  - Majestic, magical, mathematical, mysterious, ...

Computer Science: Duke Connection

- What we tell you it is
  - A bunch of courses useful in some majors

- What you want it to be or imagine it to be
  - Independent study, new courses, interdepartmental major

- What will it be in one year or two?
  - New courses, new professors, new majors, ...

- What is it outside of Duke?
  - Similar but different!

Computer Science: Duke Connection

Digitizing Books One Word at a Time

Type the words:

Submit

The words above come from scanned books. By typing them, you help to digitize old texts.
Fundamental Compsci Concepts

- “Mathematics is the Queen of the Sciences”
  Carl Friedrich Gauss
- What is Computer Science?
  - Why study it, what is it, why is it interesting (or not)?
- Historically
  - What can we program, what can we program efficiently
- Present
  - Lots of data, lots of connectivity, lots of inferences
- Future
  - Where do we go from here?

What can be programmed?

- What class of problems can be solved?
  - G5, 1000Mhz Pentium III, Cray, pencil?
  - Alan Turing proved some things, hypothesized others
    - Halting problem, Church-Turing thesis
- What class of problems can be solved efficiently?
  - Problems with no practical solution
    - What does practical mean?
  - Problems for which we can’t find a practical solution
    - Solving one solves them all
    - Would you rather be rich or famous?

Schedule students, minimize conflicts

- Given student requests, available teachers
  - write a program that schedules classes
  - Minimize conflicts
- Add a GUI too
  - Web interface
  - ...
  - ...

I can’t write this program because I’m too dumb
One better scenario

I can’t write this program because it’s provably impossible

I can’t write this program but neither can all these famous people

Still another scenario, is this better?

Entscheidungsproblem

- What can we program?
  - What kind of computer?
- What can’t we program?
  - Can’t we try harder?
- Can we write a program that will determine if any program $P$ will halt when run on input $S$?
  - Input to halt: $P$ and $S$
  - Output: yes/no halts

Good sites: [http://del.icio.us/](http://del.icio.us/)

- What is social bookmarking?
  - Why is del.icio.us interesting?
  - Who posts, who visits?
- What about a website of interesting websites?
  - What would you expect to find there?
  - Would the site list itself?
- What about sites that list/link to themselves?
  - What about a site with all sites that list themselves?

Bad sites: [http://haz.ardo.us](http://haz.ardo.us)

- Sites listing bad sites (don’t visit them?)
  - Where would this be useful?
  - What about censorship (internationally?)
  - Is this a good site or a bad site?
- What about sites that list/link themselves?
  - Is haz.ardo.us there?
- Website of all the sites that don’t list themselves?
  - Is notlisted.com listed on notlisted.com?
The halting problem: writing `doesHalt`

```java
public class ProgramUtils {
    /**
     * Returns true if program halts on input,
     * otherwise returns false (program loops)
     */
    public static boolean doesHalt(String programe, String input) {
        // ... implementation...
    }
}
```

- A compiler is a program that reads other programs as input
- The `doesHalt` method might simulate, analyze, ...

How to tell if Foo stops on 123 456

```java
public static void main(String[] args) {
    String prog = "Foo.java";
    String input = "123 456"
    if (ProgramUtils.doesHalt(prog, input)) {
        System.out.println(prog + " stops");
    } else {
        System.out.println(prog + " 4ever");
    }
}
```

- Can user enter name of program? Input?
- What's the problem with this program?

Consider the class `Confuse.java`

```java
public static void main(String[] args) {
    String prog = "Foo.java";
    if (ProgramUtils.doesHalt(prog, prog)) {
        while (true) {
            // do nothing forever
        }
    }
}
```

- We want to show writing `doesHalt` is impossible
- Proof by contradiction:
- Assume possible, show impossible situation results

Not impossible, but impractical

- Towers of Hanoi
  - How long to move n disks?
- What combination of switches turns the light on?
  - Try all combinations, how many are there?
  - Is there a better way?
Travelling Salesperson

- Visit every city exactly once
- Minimize cost of travel or distance
- Is there a tour for under $2,000? less than 6,000 miles?
- Is close good enough?
  - Within 10% of optimal
  - Within 50% of optimal
  - ...

Try all paths, from every starting point -- how long does this take?

a, b, c, d, e, f, g
b, a, c, d, e, f, g ...

Travelling Salesman: XKCD 399

What's the complexity class of the best linear programming cutting-plane techniques? I couldn't find it anywhere. Man, the Garfield guy doesn't have these problems...

Are hard problems easy? Clay Prize

- Number theory: pure mathematics
  - How many prime numbers are there?
  - How do we factor?
  - How do we determine primeness?
- Computer Science
  - Primality is "easy"
  - Factoring is "hard"
  - Encryption is possible

Theory and Practice

- Primality is "easy"
- Factoring is "hard"
- Encryption is possible
Useful Computer Science

- http://maps.google.com/maps?f=d&source=s_d&saddr=300+W+Morgan+St,+Durham,+NC+27701+(Blue+Coffee+Express)&daddr=2324+Duke+University+Road,+Durham,+NC+27708&hl=en&geocode=FcNJJQIdYw5M-yGT6vAZOfvdQg%mra=ls&sll=36.088126,-79.01786&sspn=1.333898,2.11212

How does this work?

- http://tinyurl.com/d5o8mr

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Courses of Study

- What do you take first?
- What’s next?
- In between?
- Who teaches what?