Computer Science

What it is,
What it's not,
and
How it is changing the world

Readings for Today

Article 1: Coding is Coming to Every Industry You Can Think Of…
  Question 1: What are some areas of industry that computing impacts?
  Question 2: Are there any particularly surprising things in this article?

Article 2: A Commencement Speech for Graduating 2013 CS Majors
  Comment 1: You spend a lot of your life on your career - you better like it!
  Comment 2: “Continuing Professional Development” is a part of every field
  Question: Did anything strike you as particularly interesting/relevant in this article?

Things you should be doing...

Before Wednesday:
- Finish reading Blown to Bits Chapter 1, and submit Reading Reflection (before Wed. class) - on-line discussion starts Wednesday!

Before Friday:
- Pre-lab reading for Lab 2
Question to Start the Day...

What year did people start talking about computers?

New York Times announces first Electronic Computer (ENIAC) in Feb 1946

Before **Electronic** Computers, "Computers" were people!

NY Times "Want Ad" from 1892:
From a book in 1855
(but reporting on writings from 1727)

From "Memoirs of the Life, Writings, and Discoveries
of Sir Isaac Newton" by Sir David Brewster (1855)

Sir Isaac Newton’s life: 1642 - 1727

We cannot find in the seven unpublished letters which
Flamsteed wrote to Newton from February 7th to July
5th 1695, anything to justify this letter. Flam-
steed begins his letter of February 7th with a long tirade
against Halley, and promises that when they meet he will
tell him his history, which is too foul and large for a letter: He
mentions two different reports from London of New-
ton’s death, which he was able to contradict: He tells him
that his servant, a computer, has run away, and that he
is looking another. He mentions observations on refra-
tions and on the eclipses of the moon in 1678 and 1682,
and he complains of a report which, at his request, New-
ton succeeds in putting down, that Flamsteed refused to

One of the earliest recorded English-language
uses of "Computer" - from 1692

From "A Tale of a Tub" by Jonathan Swift
written around 1692

Now the method of growing wise, learned, and sub-
line, having become so regular an affair, and so estab-
lished in all his forms; the number of writings must needs
have increased accordingly, and so a pluch that has made
it of absolute necessity for them to interfere continually
with each other. Besides, it is reckoned, that there is
not at this present a sufficient quantity of new matter
left in nature, to furnish and confirm any our particular
subject, to the extent of a volume. This I am told by
a very skilful computer, who has given a full demonstra-
tion of it from rules of arithmetic.

Definition from the Current Oxford
English Dictionary

computer, n.
1. A person who makes calculations or computations; a calculator, a reckoner;
spec. a person employed to make calculations in an observatory, in surveying,
etc. Now chiefly hist.

2. A device or machine for performing or facilitating calculation.
a. An electronic device (or system of devices) which is used to store,
manipulate, and communicate information, perform complex calculations,
or control or regulate other devices or machines, and is capable of
receiving information (data) and of processing it in accordance with
variable procedural instructions (programs or software); esp. a small, self-
contained one for individual use in the home or workplace, used esp.
for handling text, graphics, music, and video, accessing and using the Internet,
communicating with other people (e.g., by means of e-mail), and playing
games.
b. by (also on) computer: by means of a computer or computers.
What's the Point?

Broaden your perspective!!

A computer is something that computes.

*It can be:*
- An electronic device
- A mechanical machine
- A person

Next Question....

What is science?

A definition from dictionary.com

Science

1. a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws: the mathematical sciences.
2. systematic knowledge of the physical or material world gained through observation and experimentation.
3. any of the branches of natural or physical science.
4. systematized knowledge in general.
5. knowledge, as of facts or principles; knowledge gained by systematic study.

Question: Which of these apply to computer science?
Applied to Computers (of any kind)

We care about "body of facts or truths" and "general laws"

- Core focus is not on "studying" computers
  - However: The electronic computer is our main tool, so we learn how to use them very effectively!
- Computer science is what makes computers useful!
- Computer science truths are independent of technology
  - Held 2000 years ago and will hold 2000 years from now
  - Why study computer technology when you can study computer science?

Computer science is about the fundamental truths and general laws that govern computing, whether the computer is electronic, mechanical, or human.

"Computer science is no more about computers than astronomy is about telescopes.”
- Edsger Dijkstra

Some core computer science questions

Science is about asking questions - what kind of questions do we ask?

- Is it possible to compute some function? [Computability Theory]
- What is the most efficient way to compute this function? [Computational Complexity]
- How do we express how to compute something clearly and unambiguously? [Programming Languages]
- How can we organize a large amount of information so it can be used in our computations? [Data structures and Databases]
- How can we make machines/devices that can compute things quickly? [Computer Architecture]
- How can we coordinate multiple computations that might require the same resources [Operating Systems]

Sample computational problem

How do we find the greatest common divisor (GCD) of 135 and 210?

Euclid figured out how to do this efficiently ... around 300 BC!

Euclid was solving a computer science problem 2400 years ago!!!

Differences:

- His computer was the human mind - dealing with maybe dozens of operations in an involved calculation.
- He didn't have a clean way to express his algorithm.
- He didn't have the background to understand "efficient computation" in the way we do today (Euclid's algorithm first analyzed in 1844).
Fast Forward to Today...

We still use Euclid’s algorithm in cryptographic operations!

*Example:* What is the GCD of 153103965093671035918341035160983 and 9813587135019680294860958134060915?

Those are 33 and 34 digit numbers. In cryptography we routinely work with *600 digit numbers* (and longer!).

Question: If your computer does a billion computations a second, how long would it take to find the GCD of these numbers doing “trial division” (testing all possible divisors by division)?

How Fast Can People Compute?

We are going to have a calculation race - how fast are you?

Make sure you have a sheet of paper and pencil/pen

On the following screen are three arithmetic problems

When I change slides, start working on these and solve them as fast as you can - I’ll time you!

Raise your hand when you have the answers.

The Problems

\[
\begin{array}{c}
132831 \\
+476884 \\
\hline
942 \\
\times 837 \\
\hline
412856 \\
-304158
\end{array}
\]
The Answers

\[
\begin{array}{c}
132831 \\
+476884 \\
\hline
609715
\end{array}
\quad
\begin{array}{c}
942 \\
\times 837 \\
\hline
788454
\end{array}
\]

\[
\begin{array}{c}
412856 \\
\hline
-304158 \\
\hline
108698
\end{array}
\]

How Fast?

If t is the fastest time, then \( t/3 \) seconds per calculation (or \( 3/t \) calculations per second)

Obviously, computers can do this faster, but...

In June 2014 the most powerful computer on earth could do 33,860,000,000,000,000 calculations per second (33.86 petaflops).

See [http://www.top500.org/](http://www.top500.org/)

Thinking about computations on this scale is incredibly different from thinking about computations at a few calculations per minute.

Thus..... Computer Science becomes an active field of its own.

Some Other Questions...

How accurate were you?

Were all the calculations the same difficulty?

- What makes some calculations harder than others? A fundamental computer science question!

What about cost?

- How much would it cost to do 1 calculation per second non-stop for a year, paying $10/hour?
The value of tools...

Tools often enhance human capabilities

- enhances... movement!
- enhances... lifting!

And the electronic computer?

More tools...

Tools often enhance human capabilities

- enhances... vision!

Electronic Computer as a tool...

Tools often enhance human capabilities

- enhances... information processing!
- or... analysis
- or... thinking

“Thought enhancement” enables many things that were never possible before!
"Information tool" opens many possibilities

Consider “Grand Challenges”
Selected by the National Academy of Engineering

These are “game changers” for the future - how many can computing impact?

1. Make solar energy economical
2. Provide energy from fusion
3. Develop carbon sequestration methods
4. Manage the nitrogen cycle
5. Provide access to clean water
6. Restore and improve urban infrastructure
7. Advance health informatics
8. Engineer better medicines
9. Reverse-engineer the brain
10. Prevent nuclear terror
11. Secure cyberspace
12. Enhance virtual reality
13. Advance personalized learning
14. Engineer the tools of scientific discovery

No End in Sight...

What does the future hold?

I’m not bold enough to predict the future, but leave you with this:

"The best way to predict the future is to invent it."
-- Alan Kay, 1971

You can be part of creating the future!
Final reminders…

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