Weeks 5 and 6 - Ideas that structure computer science and digital technology

Ideas that structure our world of Computer Science

- ▶ The history and development of computer science
- ▶ The traditional mathematical basis of computer science
- ▶ Computer science and "The Curious Idea of Intellectual Property"
- ▶ Implications of applying TCIIP to mathematics and to computer science
- ▶ Implications of applying TCIIP to technology

The history and development of computer science

- Computer science is a branch of mathematics; none of the mathematics involved would have surprised Euclid or Archimedes.

- However, one has to wonder about the Pythagoreans and their reaction to Godel's incompleteness theorem considering their reaction to the existence of irrational numbers.

The history and development of computer science

- ▶ The first bit of mathematics that is particularly useful for computer science would probably be George Boole's development of Boolean Algebra in the 19th century. (Boole was a most remarkable individual, and if you ever need a real Horatio Alger story, you should study Boole's life).

The history and development of computer science

- Following that, probably the work in logic in the later 19th century and early 20th century by Frege, Russell, Whitehead — and certainly the work of Godel — are most apposite to our understanding of computer science.

The history and development of computer science

- ▶ Then the work of Claude Shannon, Alan Turing, Alonzo Church, and Haskell Curry.
- ▶ And then? What happened to the development of theory?

Computer Science realized in Technology

- Circa 2200 years ago: The The Antikythera Mechanism. An amazing analog computing device used to derive astronomical information
- Early 17th century: Pascal's calculator, precursor to centuries of mechanical calculators.
- Early 19th century: Jacquard Loom

Technology advances: the age of mechanical computing

- Charles Babbage: his Difference Engine and his Analytical Engine — which was the first "Turing Complete" computer design
- The Bombe. Specialized device for cryptanalysis.
- Konrad Zuse: the Z3 (first programmable and "functionally Turing Complete" computer, but not Turing-complete in a practical sense since it didn't have a conditional branch)

Technology advances: the age of electronics

- ▶ Atanasoff-Berry device: not programmable, but fully electronic digital device capable of some forms of computation (not Turing-complete)
- ▶ Colossus: programmable (but by switches, not stored program) electronic computer

Technology advances: von Neumann

- John von Neumann, along with Alan Turing, came up with ideas that were realized as true stored program computers and now identified as von Neumann Architecture

Your own Turing machine

- Your own Turing machine: compute on paper!

The mathematical basis of computer science

- ▶ The fundamental notions are
  - ▶ State (s)
  - ▶ Sequence of state (s_t) created by the recursive application of a machine (m) to initial state (s_0)
- ▶ That is, computer science boils down to a single problem: that of working with recursive functions of the form $s_{t+1} = m(s_t)$

The mathematical basis of computer science, and trying to include the real world

Or if you are willing to concede that there is a real world with independent input state outside your machine and that also might affected by your machine's output, then $(s_{t+1}, o_{t+1}) = m(s_t, i_t)$

The mathematical basis of computer science, and a hypothetical world function?

Since this is the real world, the relationship between i_{t+1} and o_{t+1} is not a given in the general case...

The mathematical basis of computer science, and a hypothetical world function?

Each world defines its own relationship between the two. So maybe we should create a *w* function...?

The Curious Idea of Intellectual Property

- As we saw last lecture, some people challenge even the term "intellectual property", preferring formulations like "intellectual privilege".
- Good article on the philosophy of "intellectual property" here
- Some of the odder things that have been patented: Weird Patents
- The Selden patent

What reasons can be adduced for "Intellectual Property"?

- That it fosters creativity and development by giving creators and developers incentives to do so
- That society benefits from early disclosure of information and processes that otherwise would be of more benefit to the originator if those remained secret
- Obviously, these are consequentialist arguments... are there non-consequentialist arguments?

What are some forms of intellectual property that have had some recognition?

- Copyright
- More arbitrary licensing, such as Creative Commons and copyleft, or even the Unlicense
- Patents
- Trade secrets
- Trademarks and service marks
- Geographical indicators: AOC, DOC, etc.

"Intellectual property" is a creation of governments

- While the idea of property as territory seems to be something even animals understand, the idea of intellectual property is a relatively new phenomenon.
- We can find examples of various royal grants going back to the Middle Ages that cover similar ground, such as the idea of governments sanctioning "guilds" that could (and did) control various endeavors.

"Intellectual property" is a creation of governments

- Around the 17th century, some European governments started to move toward more individualistic control of ideas.

"Intellectual property" is a creation of governments

▶ Notably, at the end of the 18th century, the new United States included language in its Constitution in Article 1, section 8:

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To promote the Progress of Science and
useful Arts, by securing for limited
Times to Authors and Inventors the
exclusive Right to their respective
Writings and Discoveries;
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"Intellectual property" is a creation of governments

- WIPO

Copyright

- This is a government-granted and government-enforced system that allows an author of a work to control copies of the author's works.
- The Berne Convention is the international copyright standard that most nations participate in
- Copyright is a more easily understood concept when applied to paper, especially when a legal system recognizes the right of first sale.

Copyright

- However, copyright becomes a much more tenuous concept when you start working with bits. Bits have no natural encodings, and non-computer scientists don't use bits directly.
- It takes a reasonably sophisticated understanding of computer science and information theory to understand that encodings made with bits are completely arbitrary; that tools that "render" a given encoding are not magically using some supernatural understanding of bits to make that rendering.

Copyright and "Digital Rights Management"

- Since bits are really, really easy to copy, people who feel that they have a "copyright" on these bits often feel like they need to be able "manage" these digital "rights".
- Additional "traditional safety valves" are "fair use" and the idea of "public domain".

Copyright and "Digital Rights Management"

- Unfortunately, "digital rights management" means that the owner of the hardware involved in this exercise loses control of that hardware. The mechanism generally used here is TPM

Other forms of licensing

- Creative Commons
- Copyleft
- Or even the Unlicense

Patents

- Even the word 'patent' is quite interesting
- Acceptance of the idea of hardware patents is fairly common globally, though not universal
- The concept of a 'software patent' is not globally recognized.

Patents

- The RSA patent