Why?

- Computers are essential to modern life
- Many of the discoveries and decisions made by the pioneers still underpin modern computers
- As a CS student you should be familiar with CS history
- There are a lot of myths and misinformation about CS history

The need for computation

- Prior to the industrial revolution there was little need for computation
- Celestial navigation tables
- Artillery firing tables
- Engineering, architecture, insurance, science, manufacturing...
Preparing a table

- 2 computers perform the calculations
- A comparator checks their results
- If they agree the table is given to a printer
- The printer typesets the table and prints it
- The comparator checks the printed table against the hand made table

Charles Babbage

- Victorian mathematician and inventor
- “by God, I wish these tables could be made by steam.”
- Decide to build a calculating engine that would use the method of finite differences to solve polynomial equations

Method of finite differences

- Consider the equation \((2x + 3x) \times x\)

<table>
<thead>
<tr>
<th>(x)</th>
<th>(f(x))</th>
<th>(\text{diff1})</th>
<th>(\text{diff2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>125</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>180</td>
<td>55</td>
<td>10</td>
</tr>
</tbody>
</table>

- We can solve for any value of \(x\) by simple addition

The Difference Engine #2

- 30,000 mechanical parts
- Never completed in Babbage’s life time
- Finally built by the British Science Museum
The Analytical Engine
- Architecture similar to a modern computer
- Could solve any problem, not just polynomials
- Could be programmed
- Supported branches, conditionals and loops
- Never built
- www.plan28.org

Ada Lovelace
- Lady Ada Lovelace hypothesised in 1842 that Charles Babbage’s Analytical Engine could manipulate symbols other than numbers and hence perhaps could compose music or poems
- The programming language ADA is named after her
- But she did not believe the Engine could think for itself
http://en.wikipedia.org/wiki/Ada_lovelace

The Frankenstein myth
- An enduring myth
- Brought to life by Mary Shelley in her gothic novella Frankenstein
- Echoed in 2001, Terminator, etc....
- Interesting relationship to the origins of computing & AI

The Frankenstein myth
- Mary Shelley was married to Percy Shelly
- Best friend of Lord George Byron
- Ada Countess of Lovelace was Byron’s daughter
- Ada worked with Charles Babbage
- and hypothesized about AI
The Frankenstein myth

- Ada must have read Frankenstein
- The idea of creating a conscious entity that may turn upon us was already in popular culture around 150 years ago
- At the birth of computing & AI
  
  www.sdsc.edu/ScienceWomen/lovelace.html

Guns to typewriters

- After the US Civil War (1865) Remington switched from guns to typewriters
- They used the “qwerty” keyboard
- Ran training schools
- Provided maintenance
- And supplies

The US census

- The 1880 US census employed 400 clerks
- Took 7 years to report the results
- The 1890 census would not report before the 1900 census was held
- A competition was held to mechanise the census
- Dr. Herman Hollerith won

The US census 1890

- Reported in 6 weeks the US pop. as: 62,622,250. 3 years for complete report

A Hollerith Electric Tabulating System
US Census 1880, 1890

- 1880 Census
  - Took 7 years to tabulate data
- 1890 Census
  - Predicted to take more than 10 years
- Dr. Herman Hollerith
  - Developed mechanical punch card tabulator
  - Used to tabulate census data
  - Completed the 1890 census in 3 years
- Tabulating Machine Company
  - Formed 1896

The Computing Tabulating Recording Company

- Hollerith founded a company
- Added other business machines to the product range
- In 1914 renamed itself - The International Business Machine Corporation - IBM

International Business Machines

- Computing Tabulating Recording (CTR) Corporation
  - Incorporated 1911, as merger of:
    - Tabulating Machine Company
    - Computing Scale Company
    - International Time Recording Company
- Thomas Watson Sr.
  - President 1915 - 1956
  - International Business Machines 1924
- Thomas Watson Jr.
  - President 1956 - 1971
  - [http://www.users.cloud9.net/~bradmcc/ibmsongbook.html](http://www.users.cloud9.net/~bradmcc/ibmsongbook.html)

The Universal Machine

- Not much happened until WWII
- BIGER need for computation
- Artillery firing tables
- Aerospace design
- Cryptography
- …
An algorithm describes how to solve an individual decision problem

At this time computers were people

Turing imagined a hypothetical factory filled with floor upon floor, rows upon rows of hundreds upon hundreds of computers

each using an algorithm to solve a particular decision problem

Such a factory could in theory solve the decision problem for all conceivable problems

This was the universal machine

Watch the video: http://vimeo.com/3359758
A Turing Machine - example

Is a string a palindrome?

- - A B B A -

- Step right until you detect 1st character
- - A B B A -

- Erase the “A” and apply a rule looking for an “A” at the string’s end
- - B B A -

- Step right until you detect blank character then go back one cell to the left – is this an “A”?
- - B B A -

- - - B B A -

- If NOT(A) then STOP – it’s not a palindrome
- Else erase A step left to first character of string
- - - B - -

- Repeat steps above until either all characters erased (it’s a palindrome) or program STOPs (it’s not a palindrome)

Turing Machine - example

| # | 1 | 0 | 1 | 0 | 1 | # |

q0 start state, looking for the first input character
q1 remembering a 0, looking for an end marker
q2 remembering a 1, looking for an end marker
q3 remembering a 0 having found an end marker, looking for a match
q4 remembering a 1 having found an end marker, looking for a match
q5 returning to the front of the string after a successful match
q6 mismatch detected, final rejection state
q7 if input character at tape head is #, accept, else same as start state

Colossus

- 1943 First programmable digital computer - Colossus
- 10 machines built for Bletchley Park, England to crack German High Command’s Lorenz code
- Designed by Tommy Flowers
- 1,500 valves (vacuum tubes)
- TOP SECRET until 1970’s
- ENIAC in 1945 was publicised as the “first computer”
The Stored Program Computer

1943: Colossus Mark 1

1945: ENIAC
- Hard-wired program – settings of dials and switches.
- Presper Eckert and John Mauchly – first general-purpose electronic computer.
  (or was it John V. Atanasoff in 1942?)
  (or was it Konrad Zuse in 1941?)

1944: Beginnings of EDSAC
- Maurice Wilkes, inspired by conversations with Eckert & Mauchly
- Among other improvements, includes program stored in memory

1944: Beginnings of EDVAC (working 1949)

1945: John von Neumann
- Wrote a report called, First Draft of a Report on EDVAC, on the stored program concept,

The basic structure proposed in the draft became known as the “von Neumann machine” (or model)
- a memory, containing instructions and data
- a processing unit, for performing arithmetic and logical operations
- a control unit, for interpreting instructions
- input/output (I/O) devices

John von Neumann (1903-1957) with the ENIAC
Early Computers

- Babbage’s Analytical Engine (1837)
  - Never built, decimal, mechanical, programmable via punch cards
- Universal Turing Machine (1936)
  - Theoretical, binary, programmable – the basis of all computers
Early Computers

- Zuse Z3 (1941)
  - Binary, electro-mechanical, programmable via punched 35mm film (no conditional branching)

- Harvard Mark 1 (early 1940s)
  - Decimal, electro-mechanical, programmable by punched paper tape (no conditional branching)

- Colossus (1943)
  - Binary, electronic, programmable patch cables and switches

- ENIAC (1946)
  - Decimal, electronic, programmable patch cables and switches
Early Computers

- Manchester Mark 1 “the Baby” (1948)
  - binary, electronic, first stored program digital computer
  - Led to the Ferranti Mark 1 – first commercial general purpose computer

32 bit words
2's complement

Who built the first computer?

- This depends on how you define computer (and on who you ask).
- 1936-41: The Z1, the first programmable computer, originally created by Germany’s Konrad Zuse in his parents’ living room
- 1936: An abstract machine proposed by Alan Turing became the foundation for theories about computers.
- 1943: The Colossus was the first electric programmable computer, developed by Tommy Flowers at Bletchley Park, UK
- 1937-42: The ABC, the first digital computer, built by Atanasoff and his student Berry at Iowa State College
- 1943-46: ENIAC at Pennsylvania University, 14,000 vacuum tubes, 200 sqm, 50 tons. Considered to be first fully functional computer
- 1949: EDSAC in the UK, the first stored-program electronic computer.
  - computerhope.com/issues/ch000984

Vannevar Bush

- Head of the US Office of Scientific Research and Development during WWII
- In 1945, Bush published “As We May Think” in which he predicted that:
  “...wholly new forms of encyclopedias will appear, ready made with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified”

The Memex

- “a mesh of associative trails”
- = hypertext – the web
LEO – The Lyons Electronic Office

- First computer used for commercial business applications (1951)
- Maurice Wilkes (Cambridge University) commissioned to design the machine
- Multiple I/O methods, punch cards, paper tape and a tabulator
- 2K memory (mercury delay lines) 35-bit words
- First program was for bakery valuations
- Provide computing bureau services to other companies
- Still in use by British Telecom in 1981

SABRE – American Airlines

- SABRE – Semi-automated Business Research Environment
- Rapid growth in air passenger numbers causing the manual ticketing system to collapse
- 1960 IBM built a ticketing system based on 2 IBM 7090 mainframes
- Could handle 80,000+ daily ticketing requests
- Sabre GDS – still being used by 350,000 travel agents, 400 airlines, car rental companies, hotel chains, cruise ships – LastMinute.com, Expedia

Claude Shannon

- Engineering and maths graduate
- 1938 his MSc “A Symbolic Analysis of Relay and Switching Circuits” showed that electrical switches could implement boolean algebra and binary arithmetic
- The most influential MSc thesis in history!
- He invented digital logic, his method replaced the ad hoc methods used before
- Worked on cryptography during WWII
- Then pioneered the study of information theory

Watch the video: [http://go.shr.lc/1oodYtP](http://go.shr.lc/1oodYtP)
The Birth of Silicon Valley

- ... was no accident
- Frederick Terman, Dean of Engineering at Stanford University, established a science and technology park for tech companies adjacent to the Uni in 1951
- A small company called Hewlett Packard was one of the first to arrive helped by venture capital from the Uni

"When we set out to create a community of technical scholars in Silicon Valley, there wasn't much here and the rest of the world looked awfully big. Now a lot of the rest of the world is here."

The Mother of All Demos

- Doug Englebart established the Augmentation Research Centre at SRI
- Invented the mouse, bit mapped graphical displays, a collaborative networking environment, video conferencing and hypertext (derived from Vannevar Bush’s Memex)
- On Dec 9 1968 he gave "The Mother of all Demos" to an audience in San Francisco
- Watch the demo http://go.shr.lc/1nYcExL

The Stanford AI Lab

- John McCarthy founded SAIL in 1968
- He coined “Artificial Intelligence”
- Englebart wanted to “augment” human’s McCarthy wanted to replace them
- McCarthy helped design UNIX at Bell Labs and believed computing power would become a utility like electricity
- Developed A* used in your GPS satnav for route planning
- Pioneered robotics with Shakey
The first microprocessor

- Intel
  - Formed 1968
  - Gordon Moore
  - C4004 released 1971
  - 8080 released in 1974
  - First micro processors
  - Entire CPU in a single chip
- Moore’s Law
  - Coined in 1965: Number of components in integrated circuits will double every year
  - Revised in 1975: doubles every two years
  - Exercise: Compute your PC/laptop specs Moor’s law

Xerox PARC

- Interested in the “office of the future”
- Opened a research centre on the US West Coast removed from head office
- They invented:
  - The GUI
  - WISYG word processing
  - Ethernet
  - Postscript
  - The laser printer
  - Object oriented programming
  - The personal computer
- They commercialised none of it!!!

Your first computer...

- The MITS Altair 8800
- Sold by mail order in Jan 1975
- As a kit set for $439
- No keyboard
- No screen
- No printer
- A Harvard student quit to write software for the Altair

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“Micro-Soft”

- Bill Gates started programming in school
- Quit Harvard to create BASIC for the Altair
- and a Lunar Lander game

Apple

- Two friends Steve "Woz" Wozniak and Steve Jobs started by building a selling a device for phone phreaking (hacking)
- In 1976 Woz built the Apple I and they started selling them as a kit for $666.66
- BYO keyboard and home TV
- The Apple II was released in 1977
- Sold for 15 years!
Predicting the future?

So we went to Atari and said ‘Hey, we've got this amazing thing, even built with some of your parts, and so what do you think about funding us? Or we'll give it to you. We just want to do it. Pay our salary and we'll come work for you.’ And they said "No."

So then we went to Hewlett-Packard, and they said, "Hey, we don't need you. You haven't even made it through college yet."

*Steve Jobs, talking about the Apple II*

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**Visicalc**

Dan Bricklin, Bob Frankston, 1979

1st Killer application

Spreadsheet

Proved necessity of owning an Apple II

Apple captured 50% of market by 1980

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**Meanwhile...**

- IBM exemplified corporate America
  - Incredibly successful
  - Everyone wanted to be IBM
  - 1971
    - 270,000 employees
    - 8 billion dollar turnover
    - HAL computer in "2001- A Space Odyssey" 1968
- Built and maintained large computer systems
  - Computers were leased
  - Computer time was expensive
  - Difficult to get access

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**The IBM PC**

- In 1981 IBM launched the PC to compete with the Apple II
- Invited Microsoft to make its operating system
- Licensed MSDOS from Microsoft
- IBM allowed others to "clone" the PCs hardware
- Compaq, HP and others quickly flooded the market

"My own IBM computer. Imagine that!"
### Attack of the IBM Clones
- Compaq Portable, 1983
  - Same parts as IBM PC
  - Reverse-engineered the BIOS (software in ROM, called firmware)
- Microsoft DOS
  - MS retained rights to DOS
  - Licensed to clones
- Lotus 1-2-3
  - Released 1983
  - Based on Visicalc
  - Outsold Visicalc same year

Compaq Portable, 1983

22/05/18

### The Macintosh
- Steve Jobs was working on the Lisa, a successor to the Apple II
- He visited Xerox PARC and was shown the Star with its GUI
- Started working on a secret project that would become the Macintosh
- Released on January 1984
- 1st mass-market computer with a GUI and mouse

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### The Macintosh
- 128k
- No hard drive!!!
- Included MacWrite and MacPaint
- Cost $1,995
- In 1985 the Apple LaserWriter and Adobe PageMaker were released
- Desktop publishing became the Mac’s killer app
- Mac 512k launched 1985 for $3,195
- Microsoft Windows 3.0 released 1990

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### MS Windows
- Windows 3.0 was first fully functional version
- Previous versions were DOS shells
- Quickly became the dominant OS
- Microsoft provided the OS and a complete range of productivity apps (MS Office)
- Internet Explorer released with Win95
- Started the “browser wars”

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NeXT

- Steve Jobs forced out of Apple in 1985
- Starts NeXT Computers
- Powerful computer workstations for higher education and business
  - innovative object-oriented NeXTSTEP OS and development environment OpenStep
- Buys Pixar (for their computers)

WWW

- Invented by Tim Berners-Lee at CERN
- An implementation of hypertext
- No permission required to link to a webpage
- Public domain
- Free
  - [http://info.cern.ch/hypertext/WWW/TheProject.html](http://info.cern.ch/hypertext/WWW/TheProject.html)
Smartphones

A mobile phone with advanced computing capability and connectivity, replacing
- a personal digital assistant (PDA)
- a media player
- a digital camera
- GPS navigation
- with web browsing
- Wi-Fi
- 3rd-party apps and accessories

Early Days

- In 1974, the concept of a phone integrating computing capability was developed.
- 1992 The first mobile phone with PDA (personal digital assistant) features was developed by IBM.
- 1994 BellSouth produced the “Simon Personal Communicator”, a mobile phone capable of sending and receiving faxes and e-mails through a touch screen display.
- 1997 The term “smartphone” was coined by Ericsson for its GS 88 “Penelope”.
- 2000-now The operating systems such as Palm OS, BlackBerry OS or Windows CE/Pocket PC developed for PDAs evolved into mobile operating systems.

Mobile computing

- 2007 Apple release the iPhone
- Smartphone combined:
  - Cell phone
  - Camera
  - MP3 player
  - Personal digital assistant
  - Web browser
  - App store
  - Revolutionary!

Smartphones - Near Future

- Designed for identity protection (security, encryption)
- with curved organic light emitting diode (OLED) technology
- foldable
- energy from radio, cellular or Wi-Fi signals
- dustproof and waterproof
Far Future

Ambient or pervasive computing

- Devices will disappear but will be everywhere in our environment
- Computers will be embedded in rooms, our vehicles, appliances and clothing
- We will interact by voice, vision and even direct brain links