Charles Babbage: Part 2

Babbage's Analytic Engine

James Tam

Babbage's Analytic Engine: Background

- Recall:
  - While Babbage was working on the Difference Engine, often a lack of funding halted work.
  - One time it was so drastic that work halted entirely.
  - When work re-started Babbage and Clement had a dispute over Clement's new working conditions.

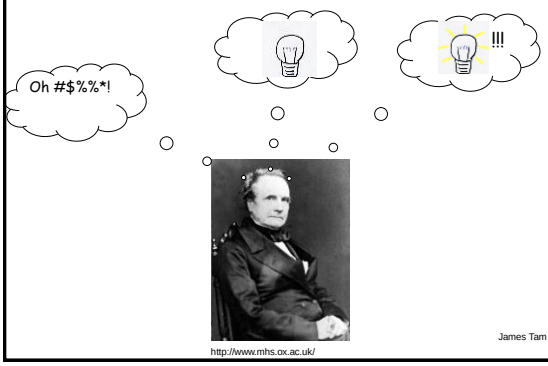
Babbage

Clement

www.colorbox.com

James Tam

Babbage's Analytic Engine: Background



http://www.mhs.ox.ac.uk/

James Tam

Babbage's Analytic Engine: Significance

- The Difference Engine was an important step in the development of computation.
- The Analytic Engine ushered in an entirely new and critical concept: a computing machine that was a controlled by an external program. ("A programmable device!")
- Earlier devices were physically created to perform a specific task.
  - Either: a major design, or a completely new design would be needed to perform different functions.

James Tam

Babbage's Analytic Engine

- It's difficult to determine the exact operation of the Analytic Engine:
  - Not completed (re-created from complex diagrams)
  - Many iterations continuously produced (right up to Babbage's passing)
- A re-creation (based on the snapshot of the original machine in 1840) was produced under the direction of Major-General H.P. Babbage (1906) – the son of Charles Babbage.

"A History of Computing Technology" (Williams)

James Tam

Components Of The Analytic Engine

- Store
- Mill
- Control Barrel
- Counter Mechanism

James Tam

Analytic Engine: Implementation Of The Store

- Information was stored in registers in the form of gears.
- Each gear was used to represent a single digit and it could rotate to 10 different positions .
- Different source writings specified different storage capacities:
  - Source 1: 100 forty digit numbers.
  - Source 2: 1000 fifty digit numbers.

Analytic Engine: Implementation Of The Mill

- An extremely complex arrangement of gears and linkages between the gears was employed.
- Operations:[1]
  - 4 basic mathematical operations (addition, subtraction, multiplication, division), logical comparisons, and computing square roots was an option.
- To understand the relationship between the mill and store a weaving metaphor may be used.[1]
  - Store: the location where numbers are held (value stored = a pattern in the cloth).
  - Mill: the location where numbers are 'woven' into their new patterns based upon the operation to be performed.

1 Source: https://turing.plymouth.edu/~zshen/Webfiles/notes/CSDI1400/note2.pdf

Analytic Engine: Implementation Of The Control Barrel

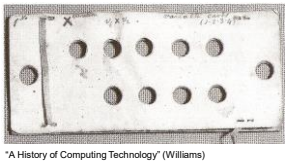
- Similar to a old-time music box but instead of storing melody this control barrel would store microcode instructions.
- Reference website from IBM (note they use the term 'firmware' rather than 'microcode'):
  - https://www.ibm.com/think/topics/firmware#:~:text=Firmware%2C%20also%20known%20as%20%E2%80%98%E2%80%98software%20for%20hardware%2C%E2%80%99%E2%80%99%20is,enables%20them%20and%20their%20features%20to%20function%20properly.

Babbage's Analytic Engine: Significance #1

- Babbage merely conceived of the Analytic Engine as an academic exercise rather than having the goal of producing a model to be used to solve actual problems.
- Significance (Metrics from Williams): Speed/advanced technology
  - Although slow by today's standards the Analytic Engine was far in advance of it's time.
  - Addition time, Analytic Engine: (3 seconds, 1 second with later version, ~1830- 1871)
  - Addition time, Harvard Mark I: 0.3 second ~World War II (1939 – 1945)

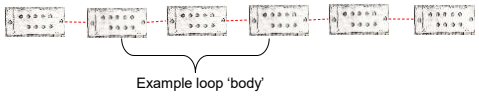
Babbage's Analytic Engine: Significance #2

- Significance: it included the concept of a stored program
- Instructions for the Analytic Engine were to be stored on a series of punched cards.



"A History of Computing Technology" (Williams)

Babbage's Analytic Engine: Significance #2 (2)



Images: "A History of Computing Technology" (Williams)

Did Babbage Ever Build An Analytic Engine?

- He viewed the design process as an academic exercise.
- Some parts were created as part of an experiment but he never built a complete machine.
- Major-General Henry P. Babbage (son) completed the construction of a Mill in 1906.
  - It calculated and printed many different multiples of PI to 29 decimal places as a proof of concept.
  - The mill now resides in the Science museum (London) along with some other early Babbage machines.

James Tam

Ada Augusta Countess Of Lovelace

- Considered by many as the first computer programmer.
- One of her parents was a trained mathematician while the other was a famous poet.
  - Mother (Anne Isabella "Annabella" Milbanke) : a dedicated scientist
  - Father (George Gordon Byron "Lord Byron"): a famous, brilliant poet "biggest celebrity of his time" [1], "among the greatest of English poets" [2], "mad bad and dangerous to know")[1]
- A close friend of Babbage.
- While in Italy Babbage wrote a description of the inner workings of the Analytic Engine (Italian).
  - Lovelace demonstrated that she understood Babbage's work:
  - Lovelace produced an English translation (added extensive explanations).

Image: www.computerhistorymuseum.org

1 Dr. Hannah Fry (faculty member at the UCL Centre for Advanced Spatial Analysis)

James Tam

2 "The Nation's Favourite Poet Result – TS Eliot is your winner!". BBC. Retrieved 25 May 2019

Ada Augusta Countess Of Lovelace (2)

- She also demonstrated the ability to leap beyond them in creative ways:
  - Abstract symbols = general instructions
  - Conceived of using the device for much more e.g. the program would compose (unique/new music
  - JT: this was in the 1800s and only recently ~2020s can generate A.I. produce creative works.

James Tam

Optional External Video:

- Ada Lovelace Biography, her contributions to computing and her relationship with Babbage.
  - Short video:
  - https://www.youtube.com/watch?v=1kLsW0NLsO8
  - Longer documentary video from the BBC:
  - https://www.youtube.com/watch?v=QgUVrzkQgds
  - A lighter presentation about her life and accomplishments.
    - Not necessarily as careful with the facts as the other two videos.
    - How they interpret Lovelace's intellectual and technical prowess vs. Babbage around 2:00 is a hoot (especially his reaction to her suggestions). https://www.youtube.com/watch?v=4kueyMImxhY

James Tam

Percy Ludgate (1883 – 1922)

www..history-computer.com

- Designed (and may have constructed) his own version of an Analytic Engine (1908).
  - The unit was controlled by instructions on paper tape.
  - Control could also occur from instructions entered on a special keyboard.
  - It could store 192 variables that were 20 digits long..
- Like Babbage's machine it was entirely mechanical however the mechanism was powered by an electric motor.
- "Unfortunately all of Ludgate's drawings and manuscripts appear to have vanished forever." (Williams: Scientific Proceedings of the Royal Dublin Society)

James Tam

After This Section You Should Know

- How work on the Analytic Engine came out of some of the challenges experienced while developing the Difference Engine
- What was the purpose of the Analytic Engine and when was it designed
- The significance of the Analytic Engine
- Ada Lovelace's relationship with Babbage and significance of her work on the Analytic Engine
- Who was the other person who designed/developed a version of the Analytic Engine

James Tam

References

- "A history of computing technology" (2nd Edition) Williams, M.R.
- ""Lovelace & Babbage and the creation of the 1843 'notes'". *IEEE Annals of the History of Computing*. **25** (4): 16–26.

James Tam