

# Computing may be more Classical than you think

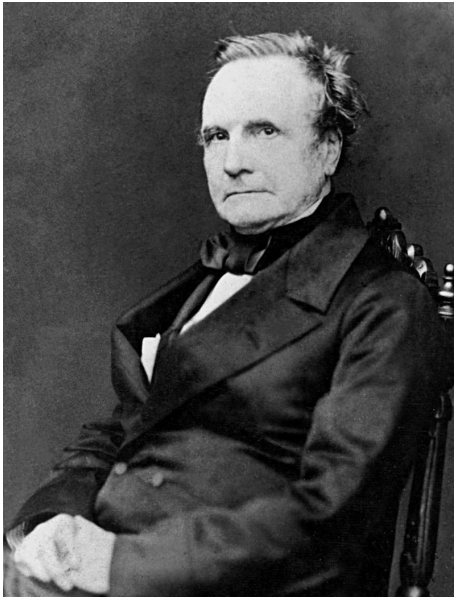
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Talk to Rotary Club of Hexham, 11 March 2019

# Development of Computing Science

- Historical timeline
- Motivation
- Tensions
- Realisations
  
- Personal tale

# Babbage vs Lovelace 1850s



Charles Babbage  
(polymath)

Analytical Engine

Designed for calculating tables for the navy. Not implemented at the time

Many features of the Turing machine



Ada (Byron) Lovelace  
(mathematician)

Corresponded with Babbage

Conceptual ideas for symbol processing and program writing

Creative approach

# Alan Turing 1940s

## Immense reputation

The father of theoretical computing science and artificial intelligence

Turing machine: the specification of a machine capable of doing general computation. Still taught today as the fundamental architecture. Von Neumann is a popular, abstract variant

He was born in England, studied at Cambridge and did his post-doc at Princeton, before moving back to England in 1938

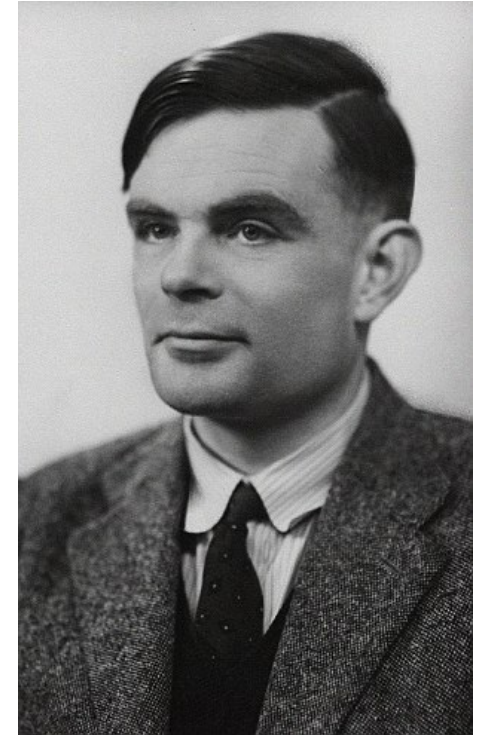
Application oriented:

Cryptanalysis: implemented the Bombe at Bletchley Park, for breaking the German Enigma-coded messages, including the Naval variant, which meant submarines could be tracked down accurately and destroyed.

Explored, in depth, writing programs for primitive machines using microcode

Artificial intelligence: wrote *Computing Machinery and Intelligence* while at Manchester University as Deputy Director of the Computing Machine Laboratory

Tragic end: died from cyanide poisoning in 1954



# The 1960s

- Machines were still small in capability but large physically
- Limitations
  - Valves/transistors
  - Paper tape/punched card for I/O
  - Tiny memories and disk sizes
    - magnetic tape used for large amounts of data
- Embryonic ideas in programming languages
  - COBOL for businesses; FORTRAN for scientific; ALGOL 60 for computing science



Elliott 803

# My early interest (as a minor cog!)

- Was a chemist with pure maths as subsidiary
- Did PhD from 1965-1968 at Hull University on isotope effects in  $\text{H}_2 + \text{O}_2$  reaction
- Last year involved solving 10 simultaneous equations
  - An overnight run on the Elliott 803, even in its autocode

- Went on ALGOL 60 course in the University
- Wrote some subsidiary programs for a new computer ICT 1900 in ALGOL 60

ICT 1900



# Oxford



Keble  
Road

- Work time!
- 4 years at Experimental Information Unit, Oxford University, from 1968-72, Research Associate
- Liaison scientist developing and evaluating information retrieval computer services for chemists
- So ½ way to computing

# Move North

Fiancée in Carlisle Record Office

Many hours on M6

She suggested I apply for a job she'd found in Newcastle and we'd live in middle at Haltwhistle

Scheme duly implemented!



Claremont Tower

So now working in 1972 as Senior Research Associate at Newcastle University in the Computing Laboratory on a medical information retrieval project

Writing a system Medusa and evaluating it

Considerably more programming in PL360, an assembler-type language

Project finished 1975



# IR Research to Commercial Adoption

Enormous activity in information retrieval research in late 1960s and early 1970s

Very little to show for it in commercial terms

Then in 1996 work at Stanford University, under National Science Foundation grants, resulted in a project called BackRub, developing massive use of such techniques

This evolved into a start-up company in 1998, which became settled into Mountain View CA in 2003:



30 years!!

# Databases

In 1975 became a programming advisor in the Computing Laboratory at Newcastle University, a tenured position

Special responsibility for databases (structured IR) in teaching and practice; latter implementing large databases for users

Started lecturing in databases at all levels – UG and PG as the Laboratory, modelled on Cambridge, did teaching, research and application

So now a fully-fledged computing scientist!

The 1970s saw a major theoretical advance in databases, with the definition of the relational model

Ted Codd, from the UK, working at the IBM Research Laboratory, San Jose CA, wrote:

Codd, E. F. (1970). "A relational model of data for large shared data banks" Communications of the ACM 13 (6): 377–387.



Ted Codd

# Controversy

Abstract in design,  
Powerful SEQUEL (SQL) query language  
Very strong mathematical basis:  
Standard set operations

But terrible performance on 1970s machines.  
Unanimously approved by university lecturers but not  
by practitioners

RDBMS developed over time include:

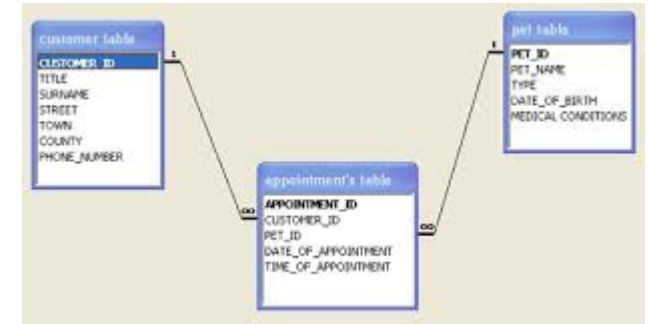
System R, Oracle, Access, MySQL, Db2, PostgreSQL, SQL Server (all from USA,  
except MySQL - Sweden)

I was appointed in 1980s as Newcastle University's representative on the national IUSC  
(Inter-University Software Committee)  
and became chair of the database working group

We pushed through relational database deals, steering users away from earlier  
products

From 2000 over 90% of the world's business data is stored in relational databases. Fast, large  
disks, enormous memories, powerful CPU, integrated circuits make the abstraction possible

30 years!! a generation



3 linked relations

# Off the Fence

- In 1989 the Computing Laboratory split into teaching+research on one side and application on the other
- Applied for lectureship and secured it:
  - databases, systems (business) analysis
- The other appointee was a lecturer in neural networks, based on training neuron connections by synapses
- AI was a very hot topic in the 1980s
  - Enormous hype
  - Impressive theoretical results
    - Could not be easily implemented

# We've all got one!

From the 1970s personal PCs were developed

These became a mass market in the 1980s

Computing power was being distributed

2 pioneers:

Microsoft (Bill Gates) – Redwood, Washington  
Operating system DOS (fell off lorry from IBM!)  
Office suite with Word at the centre

Apple (Steve Jobs) – Cupertino CA  
The Mac (high-grade graphical interface)  
Appealing for scientific and business applications

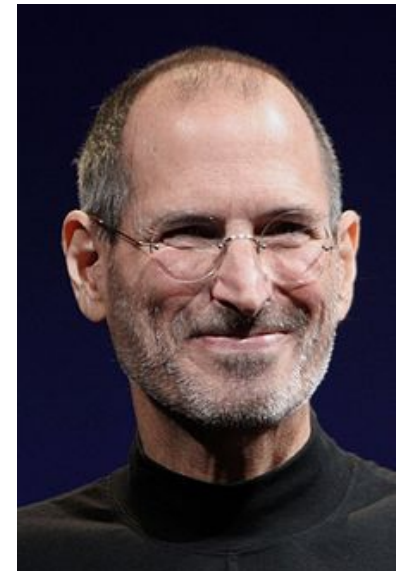
Major transformations:

PCs as phones (e.g. iPhone from Apple)

Smart phones:

Connection to web (Safari with Apple, Google/Android with others)

Bill Gates



Steve Jobs

# We get connected

The interconnected network (internet) was initially developed in 1960s by ARPA for US defence but momentum increased in 1980s, supported by National Science Foundation.



Tim Berners-Lee, from the UK, invented the World Wide Web in 1989, while at CERN, the European Particle Physics Laboratory

WWW gave URIs, HTTP and HTML as Web technology to standardise the protocols and communication between machines located anywhere

This uniformity massively improved the ease of connectivity



# Markets jump the Gun

With online searching, PCs, network connectivity, the web, database support:  
e-commerce shares went into major boom in 1999-2000

Buying frenzy quickly ended in dot.com crash  
NASDAQ (New York, founded 1971) off 78%, 15 years to recover



The markets were partly right: in 1999 the science was there but the infrastructure was not

By 2015 e-commerce was indeed a major player in world trade and conventional retail was in trouble. 20-30 years time-lag from the science. The markets did not understand the time-lag between scientific acceptance and realisation on the large-scale in engineering

Tech stocks: FAANG – Facebook, Amazon, Apple, Netflix, Google (Alphabet)  
Could add: IBM, Microsoft, and many more but need new term!

# Final career change

2002 after 13 years as Lecturer at Newcastle University  
appointed Reader (Assistant Professor) at Northumbria University

Why move?

Was only database lecturer at Newcastle, wanted some company!  
There were 6 of us at Northumbria

Database systems at Newcastle were demonstration ones  
Wanted to teach using industrial-strength ones  
Oracle was the system in use at Northumbria

Oracle was an early SQL (relational) product, marketed 1979.  
Oracle, based in Redwood Shores CA, is now third largest software  
supplier, after Microsoft and Google, heavily into Cloud computing

At Northumbria led research in databases and was  
Postgraduate Research Director for the School CEIS  
(Computing, Engineering and Information Science) with 80 PhD and  
MPhil students, serving on committees at University level

Retired in 2009 after 41 years continuous service from finishing PhD studies



Pandon Building



Larry Ellison

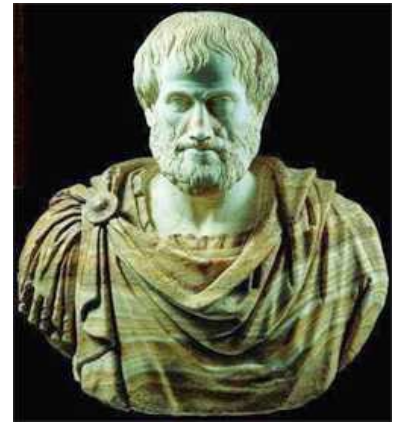


# What was my research?

Attempting to use Category Theory as a basis for computing concepts

Category theory is an abstract mathematical formalism based on the dynamic rather than the static

Its philosophy is based partly on Aristotelian ideas expressed in the *Organon* in the section *Categories*, dealing with logic (predicates)



Aristotle

Further philosophy comes from Heraclitus:

All is flux

“Everything flows and nothing stays”

His unity of opposites was an early description of a natural relationship

The building block in category theory is the arrow: an action



Heraclitus



# Development of Category Theory

- 1945: original paper by Eilenberg and Mac Lane, US mathematicians
- To 1970s: regarded as province of pure mathematicians
- From 1980s used by computing scientists to tackle problems, including:
  - Semantics/design of programming languages
  - Natural language processing
  - Databases, information systems, security
- 2010s: implementations in programming language Haskell available

# Advantages of Category Theory

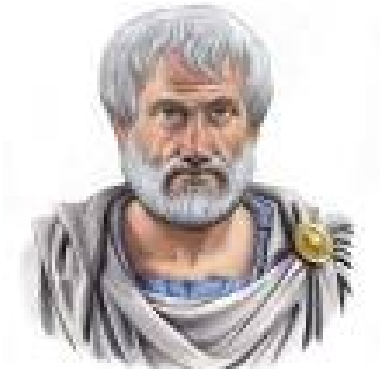
- Higher-order logic
  - Handling side-effects, complex situations (e.g. climate change where many indirect effects)
- Relating one system to another
  - Interoperability (systems built on different models talk to each other e.g. smart meters)
- Extremely rigorous over multiple levels
  - Security (complex transactions e.g. Blockchain used for Bitcoin and elsewhere)
- New logic – intuitionistic - explores all connections
- No Closed World - can handle black swans

# Further classical themes

Aristotle in his work on rhetoric developed the idea of the topos, a place holder for arguments

The topos can either prove or disprove a premise

A type of category for collections of data and their relationships



Aristotle

Gottfried Leibniz developed the idea of a monad, a 'substance' that is indivisible and whose internals cannot be explored

Used for process on categories

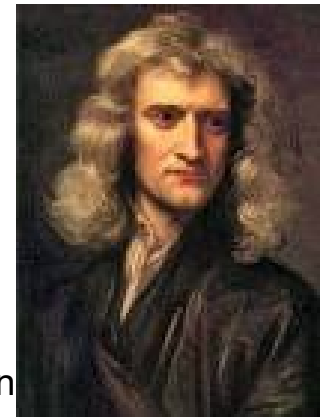


Leibniz

Isaac Newton inferred that everything is connected to everything else by exploring the laws of gravity

You cannot partition the universe

In a category everything is connected



Newton

# Research Results

- Over 250 papers published, mainly with Michael Heather, a colleague since 1980
  - We still publish a few each year
  - Michael is very interested in metaphysics
- Supervised 10 PhD students to completion
- Research is not an option for an academic
  - It is essential to develop ideas for next generation

déjà vu!

Flavanol  
(chemistry)

