

Numbers, Algorithms and Machines: 6 decades of personal computing

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Why?

- Provide one person's perspective and background to current computing scene
- Educate and entertain at same time about some details of possible historical interest
- Share some ideas on how ideas from the past have relevance to today's software and hardware
- Try to spark interest in STEM careers
- Mention the **histoRicalg** project

Why JN?

- Serendipitous intersection with people and events related to computing over my lifetime – a *Forrest Gump* pathway
- “You actually *like* numbers!”
- Continued interest in how algorithms and computing techniques develop, evolve and are integrated into working systems.
- Continued interest in informal education.

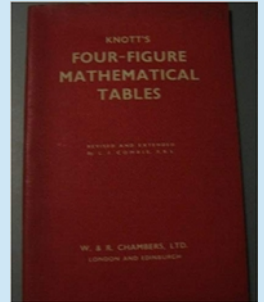
In the beginning

- Mental arithmetic – my father was a bookie (illegal, but 20% of RAF 247 Squadron ex-cons!) and computed odds (£. s. d.)
- Mother was a comptometer operator



My first computer - 1961

- Analog
- Essentially Wheatstone bridge “slide rule”
 - taught me logarithms and use of tables
- Moved on to slide rules 1962-66
- And to Monroe “portable calculator”
 - \$200 used in 1968
 - fixed point arithmetic



1973 – Ag Can

- Overqualified keypunch operator
- 20 numbers ending ONLY in 0, 3, 5, 8
- Probability under uniform distribution is 10^{-8}
- How? $\log_{10}(4) = 0.6021$
- $\text{Log}_{10}(4/10) = -1 + 0.6020$
- $\text{Log}_{10}((4/10)^{20}) = -20 + 20*0.6020 \approx -8$

Digital computing – 1966-67

- IBM 1620 CADET (Can't Add Doesn't Even Try) U Calgary
 - no clock, no h/w arithmetic (used table lookup --> hacks if you fail to reload the “monitor” card deck), 60000 character memory
 - 12 character instructions
 - 260000800009 moves 9th char (a 0) to 8th position and keeps going until “EOF” (not found, so zeros memory and lights flash)
 - Fortran II
- 1967/8: 360/50 DOS and Fortran IV
 - Ring the Bell



Oxford 1968-72

- People: Charles Coulson, Leslie Fox, David Mayers, John S Rollett, Jim Wilkinson
- Machines: KDF9 (never saw it!)
- Mathatron
- ICL 1906A
 - GEORGE OS's



Nash - 60 Years

1972-3 – annoying the operator

Intel 8008 April
1972

- Cards converted on IBM 360/95 (Harwell)
 - T J Watson buried 9 edge face down
 - ICL used 12 edge
- U of Alberta – 360/67 Michigan Terminal System.
 - Paged operating system, vs Roll-in/Roll-out, vs Single queue
 - Complex hermitian $Ax = e Bx$ in compact mode!

There are ALWAYS ways to crash computers



Compact storage

- Store matrix $A = AR + i AI$ in memory array S
 - $t(AR) = AR$
 - $t(AI) = -AI$
- $A(i,i) = AR(i,i) = S(i,i)$
- $A(i, j) = S(i, j) + i S(j, i)$ for $j \neq i$ etc.

Access: column row

FORTRAN uses columnwise access to arrays.

Agriculture Canada 1973-80

- Mainframe use needed “budgets”
- Data General Nova: Several partitions running DG BASIC (24 bit Floating Point) from 1500 to 3500 words (3K to 7K bytes), with IBM 3311 disk unit, via Teletype 10 character / second terminal having paper tape I/O. (Ear protectors!)
- HP 9820 and 9830 desktop “calculators”
 - 9830 used BASIC, cassette storage



Late 1970s

- 1975 invited to work with NAG in UK on “minicomputer” numerical library
- 1976 Tektronix 4051 Graphics system; Cartridge tape storage, BASIC, “Fuzz” in comparisons
- Data General Eclipse: Floating point goes from binary to hexadecimal.
- JN to SIGNUM (Albuquerque), TI/SMU (Dallas), U Waterloo, and sent arithmetic bug report to IEEE 754 and was asked to join committee
- First mentions of **S** (led later to **R**)

Personal computer machinery 1974-1979

- Altair 8800 announced Christmas 1974 (Jan '75 issue) of *Popular Electronics*
 - S100 bus --> many followers
- 1977 release of Radio Shack TRS-80 and Apple II
 - proprietary structures

Lack of h/w and s/w compatibility makes sharing ideas difficult

1978 My North Star Horizon

- Z80 + decimal FPU (200W!), DEC writer, 48K RAM (32 dynamic, 16 static), later added kit of 8K RAM (\$350). N* BASIC. S-100 bus.
- Total: \$10K (named THINK)
- Note switches (clock rate, interrupts)
- 2 * 80K drives. Used drive (#3) \$400 US.



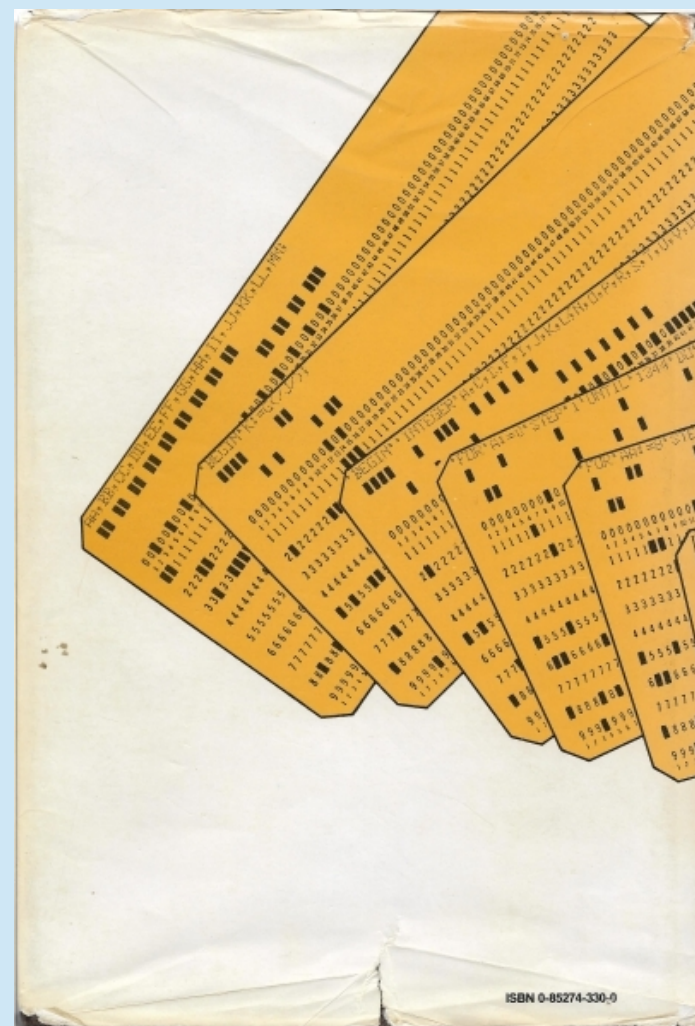
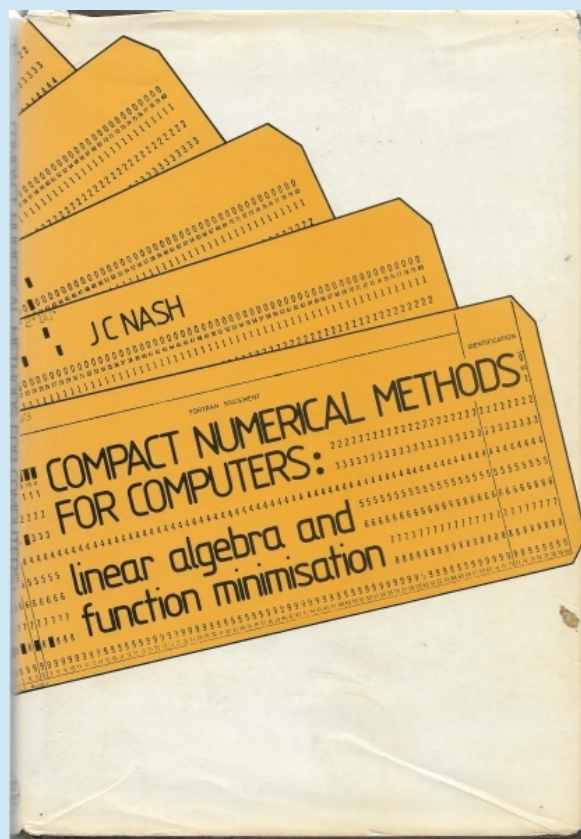
1979-80

- Henry Wolcovicz (Waterloo) gave me an “email” account on ARPANet.
 - BUT: had to write own drivers for 300 bps acoustic coupler modem. (Hand coded assembler.)
- Solved modeling problem that exhausted \$2K budget at Ag Can in 44hr run (with roll-out at each iteration). Found published solution had wrong signs on parameters!

Independent solution an important check!

1979 February/March

***Compact Numerical Methods for Computers:
Linear algebra and function minimisation***, Adam
Hilger: Bristol -- published



Nash - 60 Years

1980s

- University of Ottawa (Fac. of Admin.) 1981
- Society for Industrial and Applied Mathematics Visiting Lecturer, 1982 - 1983
- Interface Age “MicroMathematician”
- IEEE 754 released 1985
- Byte, Scientific Computing Editor
 - Interview with Jim Wilkinson about building Pilot ACE with Alan Turing
 - Same Householder Gatlinburg meeting saw Cleve Moler demo Matlab



1980s Machinery?

- Initial burst of wildly different offerings: Commodore 64, NABU (failed overheating), S-100, Atari, Sinclair, Osborne, etc.
- IBM PC launched Aug 12, 1981
 - 8087 slot (numeric coprocessor)
- Clones and MS-DOS “near-compatibles” from 1983 onwards – compatibility issues gradually diminish
- Decline of CP/M OS
- 8”, 5.25” and eventually 3.5” diskettes over decade

1980s Machinery? (cont.)

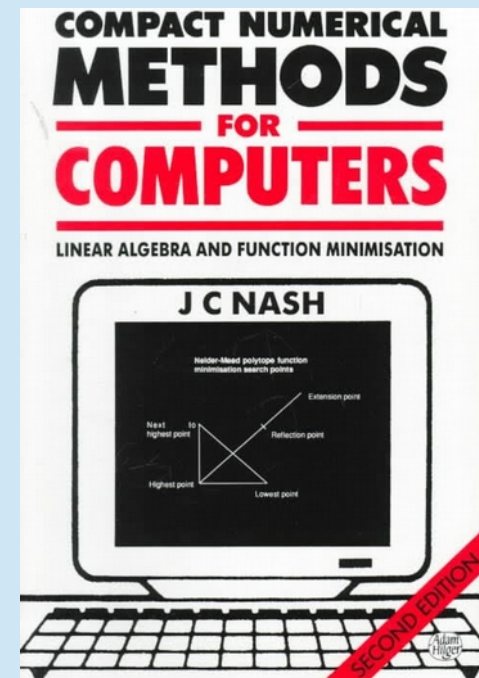
- Apple continues Apple II, tries Apple III and Lisa
- Macintosh starts in 1984, starts own fan-base
 - quite difficult to collaborate with PC users
 - this doesn't resolve until nearly 2000
- Many programmable calculators, following introduction of HP-65 in 1974.
 - HP-15C, supposedly Kahan's own design

Prices in 1980s

Corona March 1984 \$3950

2 360K floppies, 512K, MS DOS 1.25, GWBASIC, Multimate, 8087, silked monitor;
Tally Spirit Printer \$472; Cable \$75; DeSmet C March 1984 US\$114 MS Fortran
March 1984 \$485 (Compumart); MS Basic August 1984 \$366 & upgrade to MS BASIC 6.0
Oct 1988 \$151; Pure Data 128K Memory/clock \$535 (Computerland); New BIOS Aug
1988 \$20; Microscience HD 30 July 1988 \$567

This machine used for most of work
on CNM2. BUT ... I seem to have left
out purchase of Turbo Pascal (about
\$110 US with 8087 support)



Software issues in 1980s & 1990s

- Price!
- Incompatibility – MS Pascal vs Turbo Pascal vs several others
- Curse of diskettes, then CD, along with special license keys
- Proprietary data formats – not backward compatible!
- Legal fights over interfaces (Visicalc, Lotus 123, Excel and so on)

Social development

- Conferences on software, e.g., Symposium on the Interface: CS and Statistics
 - John Nelder and Leo Breiman at 1986 Interface
 - 1995 meeting with Brian Ripley in Oxford
 - in old office of C A Coulson
 - **R** optim() routines Nelder-Mead, BFGS and CG
- Being generous to others earns dividends***

AND ...

- Stallman's GNU project had workable tools by early 1990s
- Linus Torvalds released Linux kernel as GPL in early 1990s, with Debian distro starting in 1993
- No widespread use of GPL until late 1990s
- At same time Internet and WWW burst onto scene
- 1992: Ihaka/Gentleman start **R**

1995-2005

- dot.com bubble bursts
- users expect network capability
- Most, but not all, software becomes friendlier to “foreign” file types, esp. on import, sometimes on export

File and communication compatibility enhances utility of machines and software.

- Price/performance drops markedly
- Linux distros become fully functional
- Open source movement more visible

2006 -

- Smartphones and tablets
 - mostly unsuitable for numerical software
 - limited floating point / limited power
 - edit / develop tools missing
- Tower/desktop machines lose popularity
 - but are still best-suited for development work
- laptop capability increases
 - 2015 Asus UX303 \$1750 CDN, 12 GB RAM, 512 GB SSD drive, I7 processor, 3800 pixel screen

2006 – (cont.)

- **R** has become a significant system for scientific and statistical computing, as well as for “big data”
- Also seeing other capable computing environments, esp. Python, that have open versions
- Still some important proprietary platforms, e.g., SAS, IBM Data Analytics, MATLAB, but these have expensive regular per-seat pricing (> \$25K/year), though may be “cheap” for academics or students

Lessons

Independent solution an important check

There are ALWAYS ways to crash computers

File and communication compatibility enhances utility of machines and software

Being generous to others earns dividends

histoRicalg

- check and document older algorithms that are part of the **R** infrastructure, some in Fortran, C

<https://gitlab.com/nashjc/histoRicalg>

<https://gitlab.com/nashjc/histoRicalg/wikis/home>

<https://lists.r-consortium.org/g/rconsortium-project-histoRicalg>

- Motivated by functions “misbehaving”, typically in rarely used edge-cases
- Some wrapped codes still in C or Fortran, and essentially opaque and weakly documented (if at all!)

histoRicalg (cont.)

- Want to transfer expertise (C, Fortran) between older/younger workers
- Want documentation, tests, re-implementations, especially in form of vignette articles
- Modest funding by R-Consortium
- Workshop?
 - hands-on, small but real tasks
 - prototypes for class / course projects that give a taste of what R&D is like in computer science and engineering
 - when and where!

Links

- War years and bookmaking:
 - **bio:** https://archive.org/details/AcrossAnOceanAndTime_201411
 - **novel:**
<https://archive.org/download/ThursdayAfternoon160507/ThursdayAfternoon-pandoc-170331.epub>
- Building Turing's Pilot ACE
 - <http://history.siam.org/wilkinson.htm>
 - Audio files available (contact speaker)
- www.r-project.org