O computer, do we love you not wisely but too well?

Tony O’Hagan
1966
Calculators and computers

- When I arrived at UCL in 1966 to study for BSc Statistics, I was given a Brunsviga mechanical calculator.
- Computers had been in use at UCL since its early days, but those computers were people.
- I got to use my first computer in that first year at UCL.
  - Computing course given by Dave Walley.
  - Using the EXCHLF language on London University’s Atlas computer via punched paper tape.
- But we were also required to buy 7-figure logarithm tables.
1968

- In our third year at UCL, we graduated to using Facit electro-mechanical calculators
  - I never really enjoyed using it or became fluent on it
  - It was notorious for seizing up when asked to divide by zero
- Practical classes and exams were a key part of the course
  - In the final year, we had a 7-hour practical with just one question
- Text processing was still a long way off
  - I put Greek characters and maths symbols in my dissertation using Letraset
On graduating, I went to the Central Electricity Generating Board’s statistics group in their London computing centre
- Beside Bankside power station, now the Tate Modern
- They had one of the biggest computers in the country
  - An IBM 370 with 384KB of random access memory
1971

- I returned to UCL to study for a PhD
  - Under the supervision of Dennis Lindley
- On the theme of computers, I remember they had a Wang flat-bed copier
  - Probably also a Wang 700 series programmable calculator to drive it

- So much for my early experiences at UCL ...
Computing has changed a lot!

- And has changed all our lives

- Computers have radically changed both my working life as a statistician and my life outside work
  - But they have also seriously blurred the distinction between the two
A career of two halves

- My research has been in Bayesian statistics
- First half: 1971 to around 1990
  - Mostly theoretical papers, mostly solo authored
  - Posterior inference based first on conjugate priors, then on modes
    - Later on moments computed by quadrature in low dimensions
  - For most of this time I never dreamt I would be asked to tackle real applications
    - Frequentist statistics seemed to have all the tools when it came to serious problems
    - The one significant consulting job I had in this time was addressed using Bayes linear methods
  - But computers were steadily getting faster
Second half: around 1990 to present

- Computer power and MCMC turned things on their heads
- Bayesians now had the tools
  - And frequentist ones were revealed as fudges
  - Bayesians can compute exact inferences, where frequentists have to rely on asymptotic approximations
    - E.g. GLMs, bootstrap, estimating equations
    - Small UCL link: Florence David (UCL 1931-9, 1945-67) was an advocate for permutation tests, which are exact but highly computational

- My publications became more focussed on applications, often with multiple authors
  - Bayesian expertise is now sought out by clients in many branches of academia and industry
Uncertainty in computer models

- In almost all fields of science, technology, industry and policy making, people use mechanistic models to describe complex real-world processes
  - For understanding, prediction, control

- There is a growing realisation of the importance of uncertainty in model predictions
  - Can we trust them?
  - Without any quantification of output uncertainty, it’s easy to dismiss them
Examples

- Climate prediction
- Molecular dynamics
- Nuclear waste disposal
- Oil fields
- Engineering design
- Hydrology
Sources of uncertainty

- A computer model takes inputs $x$ and produces outputs $y = f(x)$

- How might $y$ differ from the true real-world value $z$ that the model is supposed to predict?
  - Error in inputs $x$
    - Initial values, forcing inputs, model parameters
  - Error in model structure or solution
    - Wrong, inaccurate or incomplete science
    - Bugs, solution errors
MUCM and UQ

- Managing Uncertainty in Complex Models
  - Large research grant to develop statistical methodology:
    - Quantify uncertainties (model discrepancy is particularly challenging)
    - Manage uncertainties (sensitivity analysis, calibration, data assimilation)
    - Do these things efficiently (emulators)

- Uncertainty Quantification
  - Fairly recent emphasis in the model-using community
    - Partly as a result of initiatives like MUCM

mucm.ac.uk
Contrast with the 1960/70s

- The power of computers
  - We can fit and compute inferences for much more complex models and much larger datasets – and so we do

- The rapid turnaround
  - Instead of waiting half a day for the printout to come back from the mainframe, we can fire off runs rapidly with almost no waiting time – and so we do

- Rapid communications
  - Postal communications took days or weeks, email just seconds. We can respond with almost no waiting time – and so we do

- Mobile computing
  - With mobile PCs and mobile phones we can compute and communicate wherever we may be – and so we do – and are expected to
The downside

- We don’t take time to think!
  - We trust to multiple runs to find the bugs in our programs, instead of thinking longer and harder in the first place
  - We fit loads of models instead of thinking first about what actually makes most sense
  - We dash off quick responses to emails just to clear messages from the inbox

- We don’t do things that can’t be so easily automated
  - MCMC computes posterior moments but when do we look carefully at the posterior, or ask what inferences are actually needed?
  - We use quick default priors instead of carefully eliciting real prior knowledge
  - We email rather than talking to people
Some quotations

- Others have expressed similar thoughts
  - A computer makes it possible to do, in half an hour, tasks which were completely unnecessary to do before. (Anon)
  - Spreadsheet: a kind of program that lets you sit at your desk and ask all kinds of neat "what if?" questions and generate thousands of numbers instead of actually working. (Dave Barry, *Claw Your Way to the Top*)
  - The real danger is not that computers will begin to think like men, but that men will begin to think like computers. (Sydney J. Harris)

- My title for this talk is of course a reference to another quote
  - Then must you speak of one that lov’d not wisely but too well. (William Shakespeare, *Othello*)

- And a useful reminder
  - Data is not information, information is not knowledge, knowledge is not understanding, understanding is not wisdom. (Clifford Stoll)
Computers and information technology are enormously useful

- Our lives, both at work and at home, have been immensely enriched and empowered by them
- And on a personal note, they have allowed Bayesian statistics to become a viable option

But we shouldn’t let them dictate what we do

- Make time to think
- Tackle the things that human brainpower is still needed for
- You’ll feel more human