The joys of a mid-career change of direction

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Ian's career move

One notable aspect of Ian's career is his migration from theoretical physics to applied mathematics and numerical analysis

- 1964, PhD in theoretical physics at UCL
- 1964-1965, industrial research
- 1965 onwards, Dept of Applied Mathematics → School of Mathematics → School of Mathematics and Statistics, UNSW
- 1965-1975, publications in physics journals (numerical methods for theoretical physics problems)
- 1975 onwards, publications in mathematics journals

I can't comment on Ian's motivation for the migration, but I can talk about my own move, but I was slower and didn't get around to it until mid-career.

My CFD days with Rolls-Royce

My BA was in Mathematics at Cambridge, but I was also an "engineering undergraduate apprentice" at Rolls-Royce, working there each summer, including in the CFD group soon after it was formed.

This inspired me to take a scholarship to MIT to study aeronautical engineering, which led to an MSc, then a PhD and then a faculty position, with research funding from Rolls-Royce.

7 years later, in 1992 Rolls-Royce funded my move to Oxford.

A comment: engineering (like theoretical physics?) is often firmly based on intuitive understanding — my research did involve mathematical analysis but I didn't write my first theorem/proof until the age of 45.

My move

In around 2003, after 25 years collaborating with Rolls-Royce on computational fluid dynamics for aero-engines, I decided to change fields.

Why?

Who inspired me?

What to do next?

The engineering approach – where's the money? what do people want?

- Health
  - computational biology / medicine
    (e.g. simulation of heart action)
- Wealth
  - computational finance

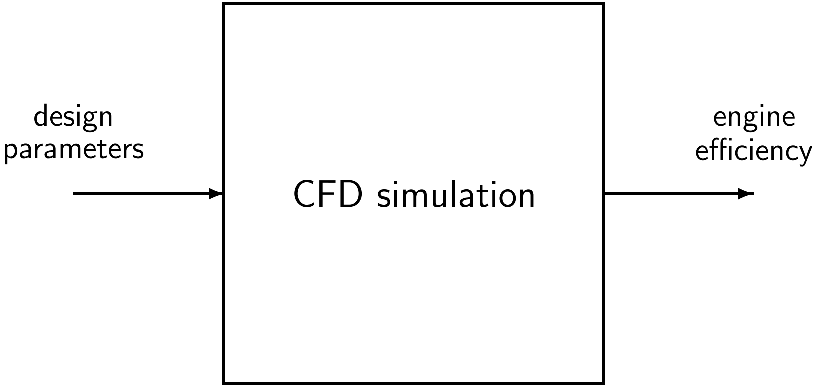
In both cases, my idea was to carry over my knowledge of numerical solution of PDEs, but others (e.g. Peter Forsyth, Univ. of Waterloo) had moved from CFD to computational finance before me.

Serendipity

When moving fields of research, sometimes ideas from your old field can be helpful in your new one:

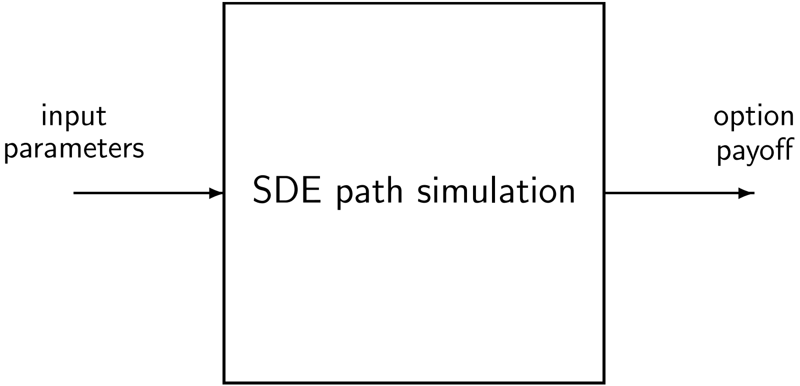
> *In developing a theory for such general lattice rules, I could take advantage of earlier experience in teaching the theory of group representations in quantum mechanics, and was also helped by looking back at my old books on solid-state physics, where the dual lattice plays an important role (e.g., in the scattering of X-rays from crystals).*

Serendipity 1



Needs lots of sensitivities for optimisation – major development and use of highly efficient adjoint methods.

Serendipity 1



Needs lots of sensitivities for hedging / risk analysis. Led to paper with Paul Glasserman on "Smoking Adjoints: Fast Monte Carlo Greeks" in Risk Magazine – very influential despite being mathematically unoriginal.

But ...

Moving into a new area can be very challenging:

- big step change from being an expert to a novice
- some pressure to establish yourself in new field
- significant language barrier to overcome
  ("Let $(\Omega, \mathbb{P}, \mathcal{F})$ be a σ-algebra with the usual filtration.")

On the other hand:

- able to approach and talk to leading experts
- always a possibility of re-using old ideas, perhaps in new ways
- maturity / experience makes many things easier, particularly recognising the importance of collaboration
- possible to make a research contribution without being an expert and knowing everything

Serendipity 2

Given my background in using multigrid methods in CFD, it was natural for me to think about how to combine Monte Carlo simulations with different levels of accuracy.

This led to Multilevel Monte Carlo (MLMC) for SDE path simulations, with P_ℓ being value based on approximation with 2^ℓ timesteps:

$$\mathbb{E}[P_L] = \mathbb{E}[P_0] + \sum_{\ell=1}^{L} \mathbb{E}[P_\ell - P_{\ell-1}]$$

Key point: relatively few samples are needed on finer levels to accurately estimate $\mathbb{E}[P_\ell - P_{\ell-1}]$

This has been the basis for most of my research for the past 10 years, once I had help from others (esp. Des Higham and Xuerong Mao) in learning stochastic numerical analysis.

Ian and UNSW

I met Ian in Oxford in early summer 2006, shortly after developing the MLMC idea. (We had also corresponded by email a few months earlier on adjoint methods.)

I already knew about the importance of QMC methods (but almost none of the details), and Ian was interested in computational finance applications.

Ian kindly invited me to UNSW for Jan 2007, and I learned a lot then from Ian, Frances Kuo, Ben Waterhouse and others.

It led to a paper with all three on "QMC for finance applications", and a paper with Ben on "Multilevel QMC path simulation".

Have continued to collaborate since then, with a new paper on aspects of MLMC + QMC in the MCQMC16 proceedings.

Other collaborations

- Des Higham and Xuerong Mao: numerical analysis
- Klaus Ritter: SDE approximations, and more recently approximation of CDFs and complexity of random bit approximations
- Rob Scheichl: elliptic SPDEs
- students, research fellows, colleagues in Oxford

Closing thoughts

- I've never regretted the move from CFD into Monte Carlo methods
- I'm very appreciative of the warm welcome from the MC/QMC (and finance) communities
- I'm definitely an applied mathematician at heart, not an engineer
- I encourage others to at least consider a mid-career change of direction – I've really enjoyed it