NZ IMAges

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New Zealand Institute of Mathematics & its Applications

taurangi

Fastest across the Atlantic

The release of Atlantic rower Kevin Biggar's book late last year made public the link between mathematical optimisation and his and rowing partner Jamie Fitzgerald's world-beating record in the 2003 Trans-Atlantic Rowing Race. Jenny Rankine explains.

In *The Oarsome Adventures of a Fat Boy Rower (How I went from couch potato to Atlantic rowing race winner)*, Biggar describes how his need to find out the fastest route between the Canary Islands and Barbados led to his meeting with two mathematical optimisation experts.

Professor Andy Philpott at the University of Auckland School of Engineering and Auckland consultant Dr Geoff Leyland told him that when the weather is uncertain, the straightest route may not be the fastest.

"What you want is a policy that adapts to the weather," Philpott said. Rowers were not allowed to use routing advice from off the boat during the race, so the pair developed an isochrone map based on 20 years of mean wind patterns across the ocean.

Isochrone means equal time, and each line represented a series of places estimated to be the same time away from the finish if the rowers followed the optimal policy from that point. Such maps start at the race destination and are calculated backwards, with each line representing one day's rowing.

Leyland wrote the code that computed the map as a completely new dynamic optimisation problem using a sample-based version of Bellman's equation for dynamic programming.

He digitised mean wind directions and entered them into a data file of location and probability. "You pick a point and run through 1,000 possible weather probabilities and how long it would take to row," says Leyland. The software calculated the isochrones using the boat speed.

Leyland estimated a speed that challenged the rowers to break the world record, which they did, crossing the ocean in 40 days, five hours and 31 minutes. ▶2

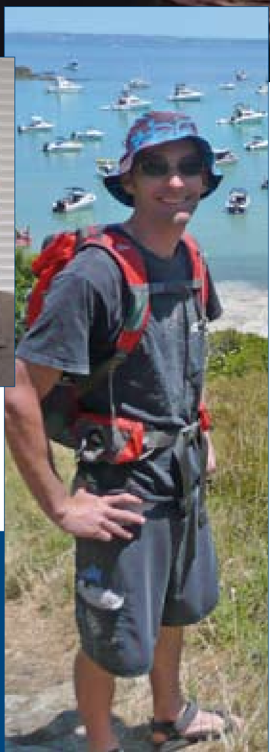
Top: Biggar, left, and Fitzgerald after their win; photo: Kenny Rodger, *New Zealand Herald*. Centre: The isochrone map, with Barbados on the left. Above: Biggar on a rowing shift, in a still from video footage taken during the race.

Welcome

Welcome to the sixth issue of IMAges, which contains a range of items on topics including "the Monster", rowing and biofuels. This issue focuses on some of the pure mathematical research being undertaken in New Zealand, especially in algebra. We hope it inspires and intrigues you.

Marston Conder and Vaughan Jones
Co-Directors

Andy Philpott, left, and Geoff Leyland.



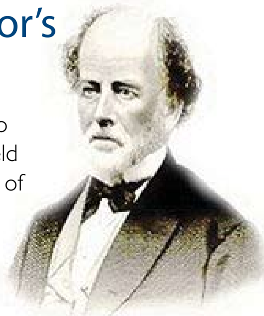
◀ In the race, the rowers used the map every shift to determine their rowing direction.

On day 32, when the pair faced headwinds, Biggar describes the map as "invaluable; it gave us the best compromise between the direction of the wind and the next isochrone. Without that, we'd have put the sea anchor out. It was an enormous psychological advantage knowing that, on average, we were going in the right direction."

Philpott says: "The remarkable thing was how accurate the isochrone timing was." Leyland tracked Biggar and Fitzgerald through the race website and was able to counter an appeal by slower boats that the pair had somehow sped up during the race. "The accusation wasn't true; on the isochrone map other teams had slowed down," says Leyland.

Philpott says the optimisation is a great application for long-distance yacht racing. Adds Leyland: "Nothing like that has been done for yacht routing, and nothing since. I still think it's one of the coolest things I've done."

In his ancestor's wake



Leyland was intrigued to use optimisation in a field that built on the efforts of his ancestor, Matthew Fontaine Maury (1806 –1873), an American oceanographer, meteorologist and cartographer.

Maury's *Wind and Current Chart of the North Atlantic* showed sailors how to use the ocean's currents and winds, and drastically reduced the length of ocean voyages. His uniform system of recording oceanographic data was adopted by navies and merchant marines around the world and used to develop charts for all the major trade routes.

Jones in Rome

Vaughan Jones, co-director of the NZIMA, was one of 29 invited international mathematicians and scientists to speak in March at the annual Italian Festival della Matematica, organized by Piergiorgio Odifreddi of the University of Turin and others from Creazioni e Ricreazioni Matematiche.

The previous festival attracted a total of 55,000 people, including the President of Italy, to hear other Fields medalists, Nobel Prize winners and notables in chemistry, physics and economics.

Five hundred people heard Jones's talk, titled *Flatlandia, il luogo ideale per imparare l'algebra,* in the Auditorium Parco della Musica in Rome.

See also -

2009 Festival - http://www.auditorium.com/eventi/festival/4937211
2008 Festival - www.auditorium.com/eventi/podcast?id_podcast=4919070

> **Discovering the surreal numbers was like discovering a whole new continent. There's a world that no one has seen before. Of course, it's not the same. The surreal numbers are not a physical thing. On the other hand you can carry the concept around in your head, which you can't do with Australia.** *John Conway.*

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Revelling in abstract maths

University of Auckland mathematician Eamonn O'Brien is making the most of his 2008 NZIMA Maclaurin Fellowship. He spoke with Jenny Rankine.

O'Brien describes himself as "a bit of a butterfly collector; a lot of my work has been on the development of good algorithms for the construction and classification of groups. I've developed techniques to count the number of groups of prime-power order; for example, we can count the groups of the order 1024, 2^{10}. The answer is about 50 billion and it involves a lot of computing."

During his fellowship, O'Brien completed the verification of the long-standing Ore conjecture on finite simple groups with Professor Martin Liebeck of Imperial College, London; Professor Aner Shalev of the Hebrew University of Jerusalem and Professor Pham Tiep at the University of Arizona.

The conjecture, posed in 1951, states that every element of every finite non-abelian simple group is a commutator. "Despite its elegance and simplicity, it has withstood many attacks," he says.

O'Brien also worked with a University of Auckland post-doctoral fellow, Henrik Bäärnhielm, on the development and implementation of Monte Carlo algorithms to construct a chief series for a linear group.

Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to compute their results; they tend to be used when it is infeasible to compute an exact result with a deterministic algorithm. The chief series algorithm breaks groups into simple building blocks. Knowledge of such a series allows the use of many other algorithms to study the groups.

He and Professor Charles Leedham-Green, from Queen Mary University of London also worked on constructing short presentations for the classical groups of Lie type.

These groups form the central classes of non-abelian finite simple groups. "Such presentations are useful theoretically and practically, particularly in verifying the putative chief series for a linear group," he says.

With Mike Newman from the Australian National University, O'Brien studied the structure of odd order p-groups of fixed coclass.

These are groups that have a power of an odd prime number as their number of elements, with a fixed difference between their composition length and their smallest central number series. With Professor Bettina Eick at the Braunschweig University of Technology and Leedham-Green, they are attempting to understand periodicity among these p-groups, and how it can be used to describe infinite families of groups by a finite diagram or tree.

In May, O'Brien will give a series of lectures to graduate students in China, and in August he will give four invited lectures at the Groups St Andrews Meeting in Bath, the biggest international conference in group theory.

O'Brien describes himself as "very comfortable with abstraction". Despite this, many of his algorithms are part of the basic infrastructure of Magma, a computational algebra system. "People doing computation will frequently use algorithms I'm responsible for, and often for applications or areas I didn't have in mind."

The product replacement algorithm he developed with others in the 1990s has become a standard for mathematicians and statisticians wanting to choose an element reflective of certain properties in large finite groups.

See also

The Magma computational algebra system - http://magma.maths.usyd.edu.au/magma/

"Mathematical reality cannot be located in space or time, [so] it affords - when one is fortunate enough to uncover the minutest portion of it - a sensation of extraordinary pleasure through the feeling of timelessness that it produces..."

Alain Connes, French mathematician

$$\left\langle \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix} \right\rangle = G$$

$$|G| = 6$$