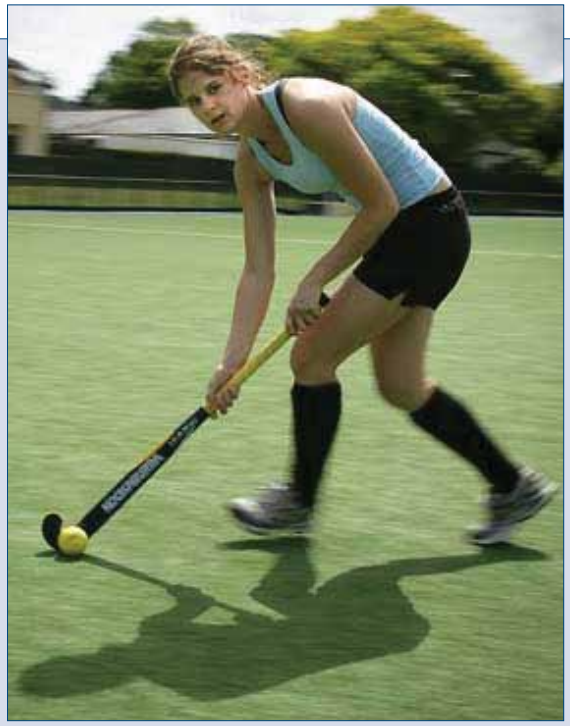
From anatomy to water

For her NZIMA-funded Masters, Kim Archibald (or Noakes as she was then) made one of the first three-dimensional anatomically-based computational models of the human pelvic floor.



The project aimed to benefit sufferers of fecal incontinence, something Archibald thinks "is really worthwhile even though it's not dinner-table conversation".

"Within medicine there wasn't a great understanding of the mechanisms of incontinence – there are often several contributing factors. People don't die of it, but it makes huge problems in their lives, and most are too embarrassed even to tell their doctor."

Developing the model was complex – "even surgeons struggle to identify on an image where different muscles start and stop. We spent hours looking at preserved tissue, cadavers, MRI scans and slides from the Visible Human Project (VHR) to develop three 3-D models – a male and female model based on the VHR slides and a female model based on MRI images of a healthy female volunteer."

"We used axial (horizontal), sagittal (left and right) and coronal slices (front and back), placed dots around the edges of each anatomical element, and used mathematical fitting procedures to create a mesh connecting all the dots. It took months to triple-check all the edges."

Then she used kinematics to model two transformations, a bearing down push in the Levator Ani muscle and squeeze pressure in the anal canal. Shannon Li has since used the model in her PhD model of childbirth, and another Auckland researcher is using it to investigate incontinence related to childbirth. "There's loads of future work to be done, this just set it up. If I did a PhD, I'd do it on this."

Archibald handed in her thesis the day before the national hockey trials in 2007, after which she was selected into the Blacksticks team. She juggled part-time work at the Auckland Bioengineering Institute with international hockey commitments, and in 2008 was a member of the New Zealand hockey team at the Beijing Olympics.

Afterwards, she played a semi-professional season with Hockey Club Rotterdam and juggled this with her first engineering job outside the university. She managed projects for Crosslinks, a small Dutch bioinformatics data analysis company, including a European Union project on mood disorders.

Back in New Zealand, she is an optimization engineer with Derceto, a local company which customises its Aquadapt software to save electricity costs for water utilities which have to use pumping stations to distribute water. This includes Greater Wellington Water and companies in Australia, North America, South Korea and the UK. The work includes detailed feasibility studies, design, implementation and support.

All her projects have used programmes that "do a lot of the maths for you, although you have to understand it. If Derceto didn't have the supercomputers, we'd spend hundreds of years trying to solve one equation."

"I did bioengineering because I really like the idea of improving people's quality of life. My cousin was born with spina bifida and I've seen how technology has helped him interact with the world, so anything that can alleviate problems like that is really good."

MATHEMATICAL EVENTS

29-30 November 2012, Dunedin
NZ Statistical Association 2012 Conference
www.maths.otago.ac.nz/nzsa2012/

4-6 December, Palmerston North
2012 NZ Mathematical Society Colloquium
http://nzmathsoc.org.nz/colloquium/home.php

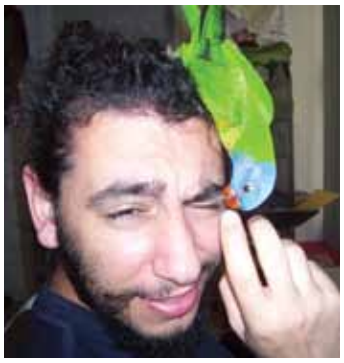
4-7 December, Queenstown
Australasian Applied Statistics Conference 2012
www.aasc2012.com/

10-14 December 2012, Sydney, Australia
36th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing
http://conferences.science.unsw.edu.au/36accmcc/

3-7 February 2013, Newcastle, Australia
ANZIAM'13: Annual Conference of ANZIAM
http://anziam2013.newcastle.edu.au/

24-28 June 2013, Shanghai, China
Second Pacific Rim Mathematical Congress
www.primath.org/prima2013/

1-4 October, Wellington
NZAMT Conference 2013: Absolutely Positively Mathematics and Statistics
See www.nzamt.org.nz/component/content/article/1-latest-news/171-nzamt-conference-2013



Optimising fleets around the world

Eyal Loz was overseas when he heard he had won a postgraduate scholarship in the NZIMA combinatorics programme – "without the scholarship I would have done my PhD overseas instead of here". He went on to do a PhD with a Top Achiever Doctoral scholarship.

His thesis on the degree diameter problem combined theoretical investigation with the design of original computer programmes in C++. He used covering and voltage graph techniques to construct many of what are now the largest known connected regular graphs of given degree d and diameter k, for d up to 20 and k up to 10.

During his PhD he also worked on a project with Tanglin Consultancy for Pacific Horizon Motorhomes. "They have bases all around the country and needed to schedule vehicles as bookings come in. The company was doing this manually, and had no way of analyzing data."

"Campervans are expensive - if you are running low, you can't buy one as easily as car rental companies can, so it is important to optimise usage of your fleet, and to deal with running out of vans in one base. I developed a component of a large application which automates and optimizes booking allocations. It improved their overall profitability, and can reduce costs by 20 percent."

Loz was able to use code from his PhD work. "Sometimes people don't understand how practical maths can be. I was finding very large graphs for particular problems which might have no applications. But the code you write, the theories you develop, and the problems you solve, all have applications. Most people completely miss this about high level mathematics."

He finished his PhD at the University of Auckland and worked as a C++ developer in the financial industry in Sydney, building trading platforms. He then worked as an assistant trader for Susquehanna International Group. "SIG recruits people with backgrounds in maths, computer science and physics - every trader there has a quantitative science degree. Options trading is extremely mathematical - you need to understand and apply models in a dynamic environment."

He is now working with partners from Tanglin on a startup software service called Sort-it, "a system to manage and optimize rental fleets for the tourism industry. It can take bookings online 24/7 and everything is optimized." The model is different from their earlier one, because it is designed to integrate easily with different systems. "Usually this kind of technology is completely outside of what smaller businesses can afford, but we want it to work for small and large firms."

The New Zealand company is not just aiming at the local market, but hopes to sell the software internationally.

See www.sort-it.co.nz/

Loz with Kakashi, the rainbow lorikeet he adopted when she fell out of a tree as a fledgling.

Causal effect in clinical trials

Jean Zhaojing Gong says that without her NZIMA doctoral scholarship she would never have achieved a PhD, which she found "an invaluable experience".

Her thesis research at the University of Canterbury in Christchurch estimated the results of treatment through causal effect on survival probabilities for groups of patients in randomised clinical trials, by creating potential outcome survival models with a finite number of parameters.

Estimating causal effect is complicated in clinical trials because patients don't always take treatment as prescribed (called non-compliance), and because some outcomes are missing. For example, a trial may attempt to find out the number of years patients live after receiving a particular treatment (called their survival time). If some patients are still alive at the end of a trial's observation period, this outcome is not available and their survival time is said to be censored.

Gong's PhD applied new survival models, to take into account non-compliance, time-to-event outcomes, and censoring mechanisms in randomised trials with control groups. She applied these models on data from the 1960s New York Health Insurance Plan breast cancer screening trial. "Most models ignore censoring mechanisms when making their survival models," she says. "If we ignored the censored mechanism from the model, we would have got very strange results in some situations."

During her PhD, she also took part in a study of the variability in hospital treatment outcomes with other staff at the Department of Public Health and General Practice. The study found almost a two-fold variation in several health outcomes between and within hospitals, suggesting that a "hospital effect" on patient outcomes may operate at the level of wards and services.

Gong also created computer programmes and analysed clinical research data using the Statistics Analysis System software as an assistant research fellow in the department. She has since had a bout of serious illness, but is applying for jobs in New Zealand working in health statistics. "I would like to analyse data on a range of health topics," she says.

$S(t) = Pr(T > t)$