2014/15

AMSI Vacation Research Scholarships

AMSI
AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

Australian Government
Department of Education and Training

AMSI Vacation Research Scholarships Report

2014-15

01

Introduction

Each year undergraduate students are funded under the AMSI Vacation Research Scholarship program to complete six-week research projects over the summer holidays. The scholarships are awarded on a competitive basis for projects in the mathematical sciences.

Students complete their research project under the supervision of academics at their home university. At the end of summer, students come together to present their findings at the Big Day In Conference.

The projects give students a taste of mathematical sciences research and aim to inspire students to continue with further research. The opportunity to meet their peers and present their findings at Big Day In gives students invaluable professional development in communication and networking skills.

For some students the Vacation Research Scholarship project leads to their first academic publication.

"Thanks to co-funding from the Department of Education and Training the Vacation Research Scholarships allow young mathematicians to dedicate their time to understanding a specific topic. And it sends them the message that they and their skills are valuable. It is an essential program to safeguard Australia's future supply of researchers with expertise in the mathematical sciences."

Professor Geoff Prince, **AMSI Director**

Research Projects 02

Out of the 72 applicants, 56 students were awarded 2014/15 AMSI Vacation Research Scholarships

University	Student	Project Title
Australian National University	Xun Chun Tee	Model selections in linear mixed model
	Omar Ghattas	Pricing contingent claims on crypotucurrencies
Deakin University	Laura Smith	Maintaining consistency of individual preferences during consensus rounds in group decision making
Griffith University	Bryce Hackett	Mathematical model of oscillatory calcium signals
	Marsel Gokovi	The travelling time across microporous potentials and the diffusion coefficient
La Trobe University	Morgan Hunter	Linear mixed models with Gaussian mixture to identify contaminants in proteomics data: a prelude to intra-experiment normalisation.
	Asha Gair	Quasi-primal cornish algebras
	Kari Matthews	Free groups generated by a pair of parabolic matrices
	Zackary Burton	Geometry of Minkowski space
Monash University	Musashi Ayrton Koyama	Programming with topology
	Jiemi (Jimmy) Lin	Modelling the use of supplemental oxygen to combat surgical site infection
	Tyson Liddell	Topological degrees and applications
	Benjamin Jones	The Interplay between knots and representations
	Rahil Valani	Wave particle duality of multiple bouncing fluid droplets
	David Ceddia	Kinetic gas theory of bone cell activation with moving surfaces
	Shmuli Bloom	Sums of power decompositions
	Angus Southwell	Knots, cords and skeins
	Max Jolley	Counting coverings of the sphere
	Gilbert Oppy	Discrete dynamics of a bouncing ball
Queensland University of Technology	Alex Browning	Random walk models on growing domains: Mean particle lifetime analysis
	Liam Polkinghorne	Nonlinear codes of length 4 on 4 symbols
RMIT University	Norah Finn	Workload and performance: "The development and application of predictive models for the Australian wheelchair rugby team"

University	Student	Project Title
RMIT University	John Tait	Ballprint identification of infants: Is it possible?
	Stephen Pang	Modelling NHL data: "Prediction, performance and analysis of ice hockey's big data"
	Mi Do	Linear codes over large alphabets
	Rohit Kumar	Smith's population model in a slowly varying environment
	Si-Zhong (Simon) Lu	Integrating multiple time-scales involved in arterial mass transport
The University of Melbourne	Naijian (Eric) Shen	Vibration of a thin rectangular cantilever plate in viscous fluid
	Campbell Wheeler	Mirror symmetry and topological quantum field theory
	Anas Rahman	Densities and moments of the beta ensembles in random matrix theory
	Bohao Yao	Algorithm for finding Hamiltonian cycle in planar graphs
The University of Queensland	Liam Hodgkinson	Understanding the effect of individual variation in epidemics
	Hamish Thorburn	Mathematical models for cricket
	Trent Skorka	Lie symmetries of differential equations
	Timothy Buttsworth	Riemannian metrics on doubled manifolds
The University of Adelaide	Parsa Kavkani	Dirichlet's theorem of arithmetic progressions and generalisations
	John Connell	Visualising complex functions
	Lachlan Bubb	A study of epidemiological models, with particular focus on estimation of R0 for Ebola virus disease
The University of New South Wales	Christopher Rock	HIV and periodic presumptive treatment of STIs in Papua New Guinea
	Terence Harris	Noncommutative calculus
	Tingyu Mao	Maximal p-negative type for different norms on R^3
The University of Newcastle	Thomas Robinson	1324 avoiding permutations
The University of Sydney	Joshua Ciappara	Spherical harmonics and categorical representation theory
	Abraham Chi Shun Ng	The Dirichlet-to-Neumann operator
	John Peter Wormell	A fast and numerically robust method for computing Pearson's exact multinomial goodness-of-fit test
	Nathan Duignan	Understanding time series of ice-core data and building models to reproduce ice ages
	Nicholas Katada	Optimal convergence rate of leave-one-out likelihood estimation for the location parameter of unbounded densities
	Kristen Emery	Sequential FDR

University	Student	Project Title
The University of Western Australia	Ben Luo	Analysis of irregularly sampled time series
	Anahita Haghighat	Quantum algorithms: A geometrical perspective
	Kyle Rosa	Inverse scattering by finitely parameterised planar obstacles
	Adrian Petersen	Unique and non-unique decomposition in rings
University of Wollongong	Lauren Borg	Issues in QTL analysis and association studies in plants with high dimensional marker platforms
	Anthony Flynn	Wente's inequality in higher dimensions
University of Western Sydney	Hind Abdallah	Aggregating and sampling rankings
University of Wollongong	Nicole Cocks	Statistical protocols for late maturity alpha-amylase in wheat

Student project reports can be viewed on the AMSI website:
http://vrs.amsi.org.au/projects

Student blog posts are posted throughout the year on the AMSI Higher Vacation Research Scholarship website:
http://vrs.amsi.org.au/vrs-blog

"I enjoyed having the opportunity to share my research and the experience with others who had done the same program, but had completely different interest and research areas to me."

Alex Browning, **Queensland University of Technology**

Supervisors

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AMSI would like to express its appreciation to all the Vacation Research Scholarship supervisors who lent their time and expertise to the projects. Their contribution is integral to the success of the program.

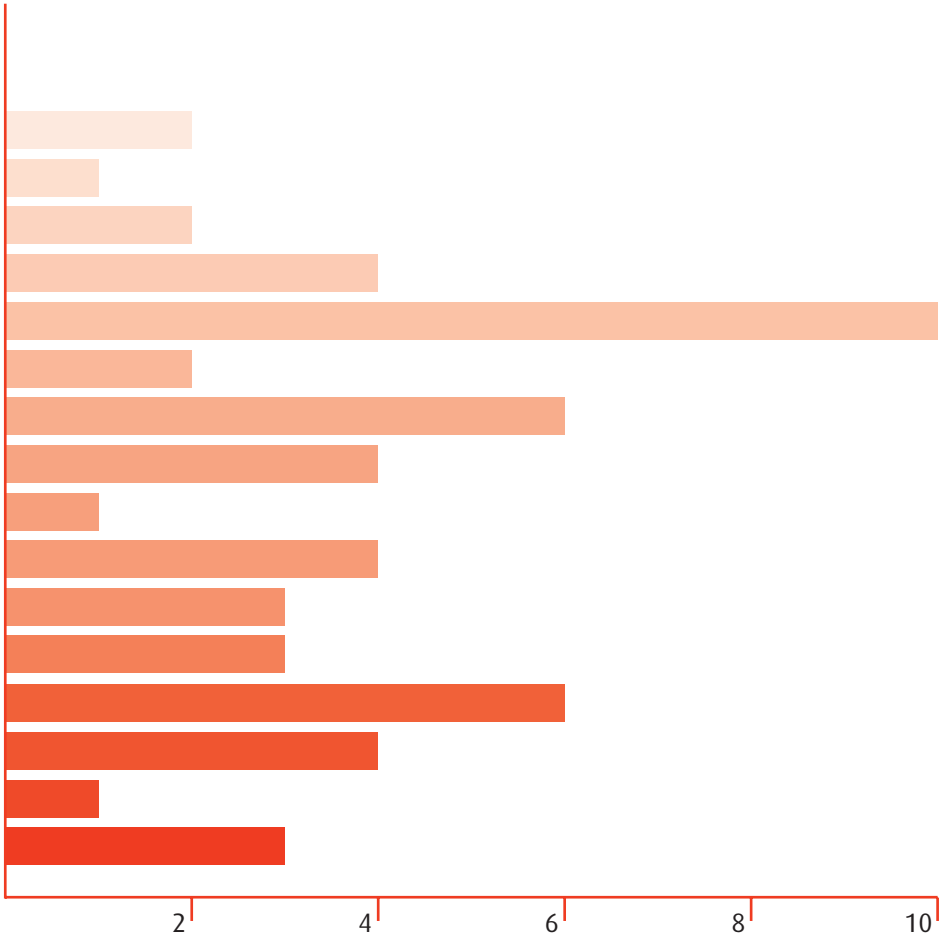
University	Supervisor
Australian National University	Alan Welsh
	Dale Roberts
Deakin University	Simon James
Griffith University	Owen Jepps
	Peter Johnston
La Trobe University	Agus Salim
	Brian Davey
	Grant Cairns
	Yuri Nikolayevsky
Monash University	Anja Slim
	Daniel Horsley
	Daniel Mathews
	Enrico Carlini
	Jennifer Flegg
	Jerome Droniou
	Joel Miller
	Michael Page
	Norman Do
	Pascal Buenzli
Queensland University Technology	Joanne Hall
	Matthew Simpson
RMIT University	Anthony Bedford
	Elsuida Kondo
	John Shepherd
	Sargon Gabriel
	Stelios Georgiou
	Stephen Davis
	Yan Ding
The University of Melbourne	Charl Ras
	Hamid Mokhtar
	John Sader
	Nicholas Witte
	Paul Norbury

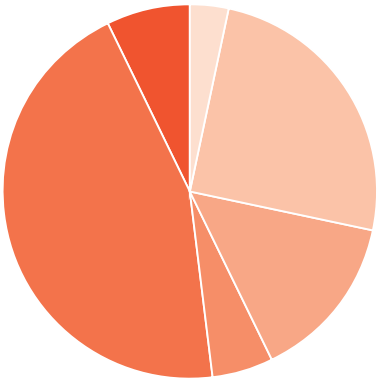
University	Supervisor
The University of Newcastle	Murray Elder
The University of Queensland	Artem Pulemotov
	Michael Forbes
	Philip Pollett
	Phillip Isaac
University of Adelaide	Hang Wang
	Joshua Ross
	Michael Murray
University of New South Wales	Ian Doust
	John Murray
	Michael Cowling
	Richard Gray
University of Sydney	Daniel Hauer
	Georg Gottwald
	John Robinson
	Oded Yacobi
	Ray Kawai
	Uri Keich
University of Western Australia	Jingbo Wang
	Lucho Stoyanov
	Lyle Noakes
	Michael Small
	Phil Schultz
	Thomas Stemler
University of Western Sydney	Glenn Stone
	Laurence Park
University of Wollongong	Brian Cullis
	Emi Tanaka
	Glen Wheeler
	Valentina-Mira Wheeler
	Yann Bernard

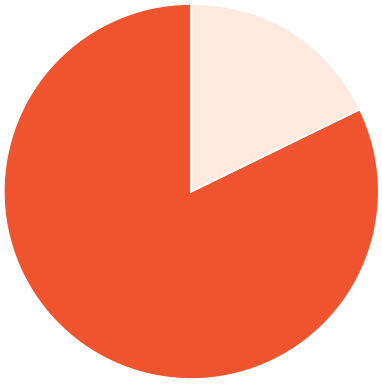
04 Participation Statistics

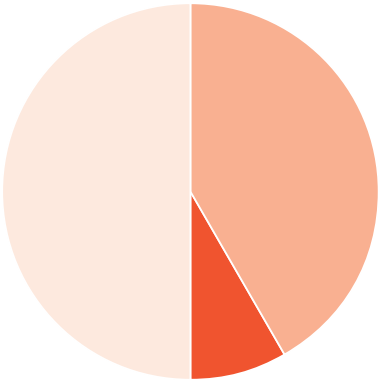
Breakdown by University

Australian National University	2
Deakin University	1
Griffith University	2
La Trobe University	4
Monash University	10
Queensland University of Technology	2
RMIT University	6
The University of Melbourne	4
The University of Newcastle	1
The University of Queensland	4
University of Adelaide	3
University of New South Wales	3
University of Sydney	6
University of Western Australia	4
University of Western Sydney	1
University of Wollongong	3
Total	56









Breakdown by State

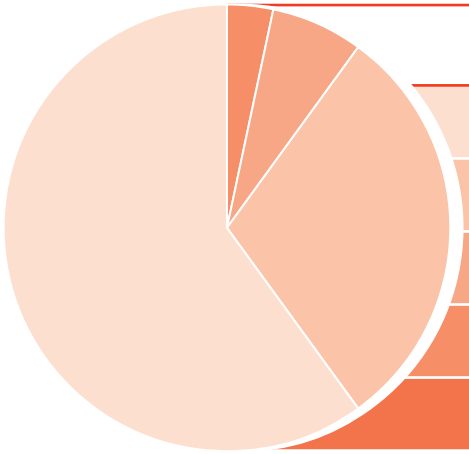
ACT	4%
NSW	25%
QLD	14%
SA	5%
VIC	45%
WA	7%

Breakdown by Gender

Female	18%
Male	82%

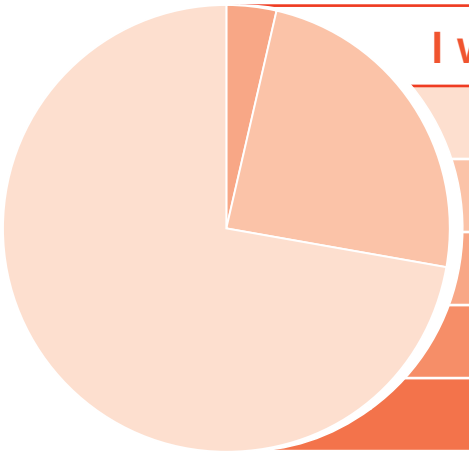
Breakdown by SES Status

High	42%
Medium	50%
Low	8%



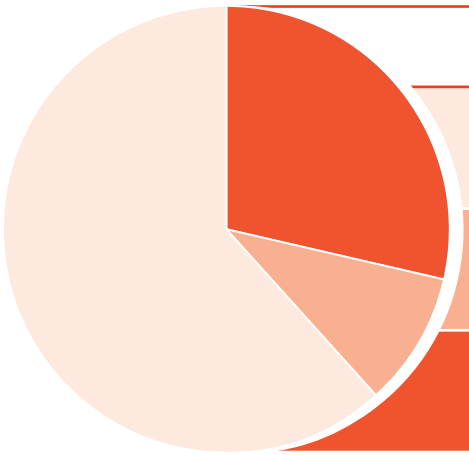
Overall, the Big Day In was well organised

STRONGLY AGREE
AGREE
NEUTRAL
DISAGREE
STRONGLY DISAGREE



I would recommend the VRS program to others

STRONGLY AGREE
AGREE
NEUTRAL
DISAGREE
STRONGLY DISAGREE

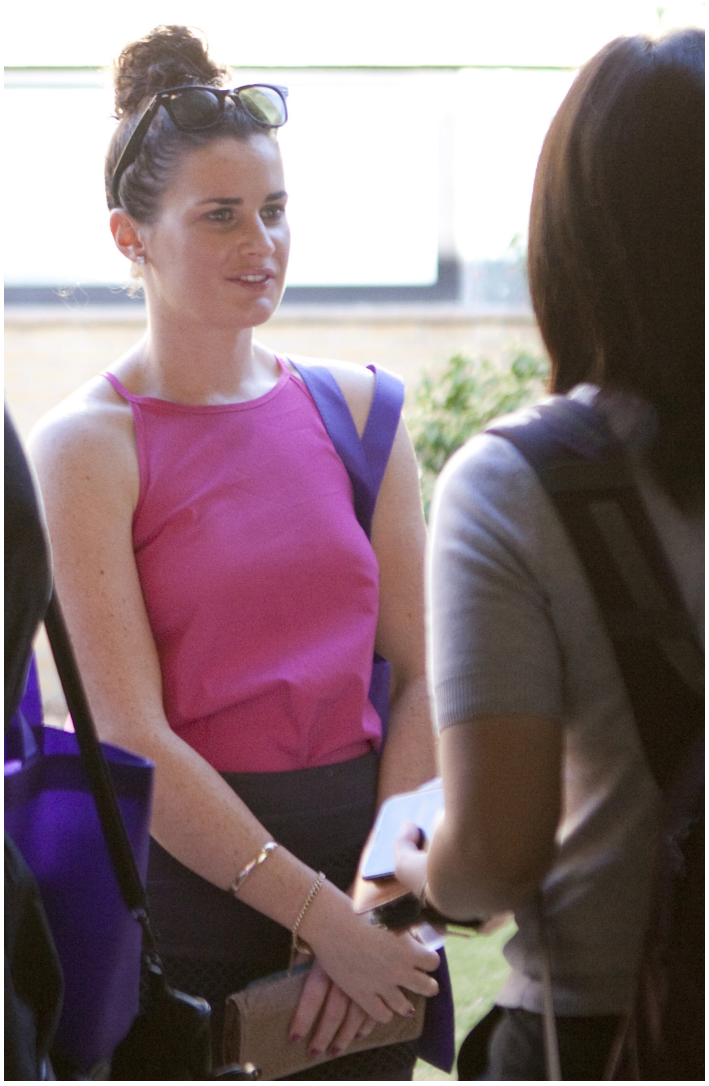


After the VRS do you expect to complete

HONOURS
MASTERS
PHD

"I enjoyed being able to present my findings to a group of other like-minded people."

John Connell, The University of Adelaide



"The keynote speech was really inspiring... and it was good to swap stories with other people doing similar work, and meet a lot of people who all cared a lot about maths but in different ways."

Christopher Rock, **The University of New South Wales**

"The two things I enjoyed most about this experience were the opportunity to do independent research with the aid of an excellent supervisor and the opportunity to see such a variety of high-level research being undertaken by undergrad students."

Shmuli Bloom, **Monash University**

"For me, the VRS has been a way of experiencing research and the academic world, while being paid and without a 12 month commitment. I have tackled an interesting problem under the guidance of a supervisor. I now have an idea of what to expect from post-graduate studies in mathematics and the impact the research can have."

Laura Smith, **Deakin University**

"The best thing about Big Day In was seeing the students take ownership of their project."

Pascal Buenzli, **Monash University (supervisor)**

"It (VRS) gave me a great insight into what being a researcher involves, as well as giving me the opportunity to meet fellow students and supervisors."

John Tait, **RMIT University**

Gary Froyland and Simi Henderson with book prize recipients Liam Hodgkinson and Xun Chun Tee

Big Day In

06

AMSI's Big Day In event gives students the opportunity to present their Vacation Research findings to their fellow students and supervisors in a conference setting.

The two-day, 2015 Big Day In was opened by Professor Gary Froyland and followed by a very engaging lecture by Dr Federico Frascoli, talking about his inspirations and offering some advice to the students thinking of pursuing academic careers.

Dr Marcel Jackson led the careers panel with a top line up of well-established academics and industry professionals. Students gained some top tips for succeeding in the mathematical sciences after quizzing the panel for advice.

Our thanks to the panel:

- Dr Federico Frascoli, **Swinburne University of Technology**
- Professor Gary Froyland, **Deputy Director, AMSI**
- Michelle Roldan, **Crown Resorts**
- Dr Marcel Jackson, **La Trobe University**
- Tori McFarlin, **Biarri**
- Dr Maria Athanassenas, **Defence Science and Technology Organisation**

Over the two days students delivered high quality conference style presentations about their research projects, prompting questions and lively discussion in the groups. As well as formally finding out about each others research students had plenty of time to network at the conference dinner and during breaks.

Congratulations to Xun Chun Tee, Australian National University, and Liam Hogkinson, The University of Queensland, who won the prizes for best student presentations.

The 2015 Big Day In was held from 11-12 February at the University of Melbourne, Victoria.

How do the differences in human behaviour impact the global spread of disease?

Liam Hodgkinson, The University of Queensland

Let's talk for a minute about pandemics: epidemics of global proportions. They are some of the most imminent natural threats to human existence, and are so very difficult to predict and manage. Governments spend millions to find effective ways to minimise the spread of disease and it's lethal impact [1]. There are many avenues of research into epidemics, not the least of which is the application of mathematics in disease modelling. Unfortunately, most of the current epidemic models share one common flaw.

It is clear that people will react differently when infected and this will impact the rate at which the disease will transmit. For example, some people will stay home during a flu, limiting its transmission, while others will strive to go about their business as usual. This is difficult to implement in models, so it is assumed that this variation in people's behaviour will have negligible impact on the spread of disease on a global (or even national) scale. Instead, it is common to work with the average transmission rate. But is this a reasonable assumption to make? It has become apparent recently that it might not be.

In February 21, 2003, Dr Liu Jianlun triggered the global outbreak of SARS by transmitting the virus to 19 other people on the ninth floor of the Metropole Hotel, far more than the average 2-5 [2,3]. This 'super-spreading' event could not have been predicted by current models. A paper published in Nature in 2005 [4] considered what happens to our most basic viral transmission models when we weaken these assumptions. It was found that when we do consider that individuals can spread disease at different rates, two things happen: first, we have infrequent, but explosive outbreaks even after the introduction of only a single case, and second, the disease tends to die out faster. It turns out that though the disease has the potential to sweep through communities in rapid bursts, the simultaneous introduction of non-spreaders thwarts the global spread spectacularly.

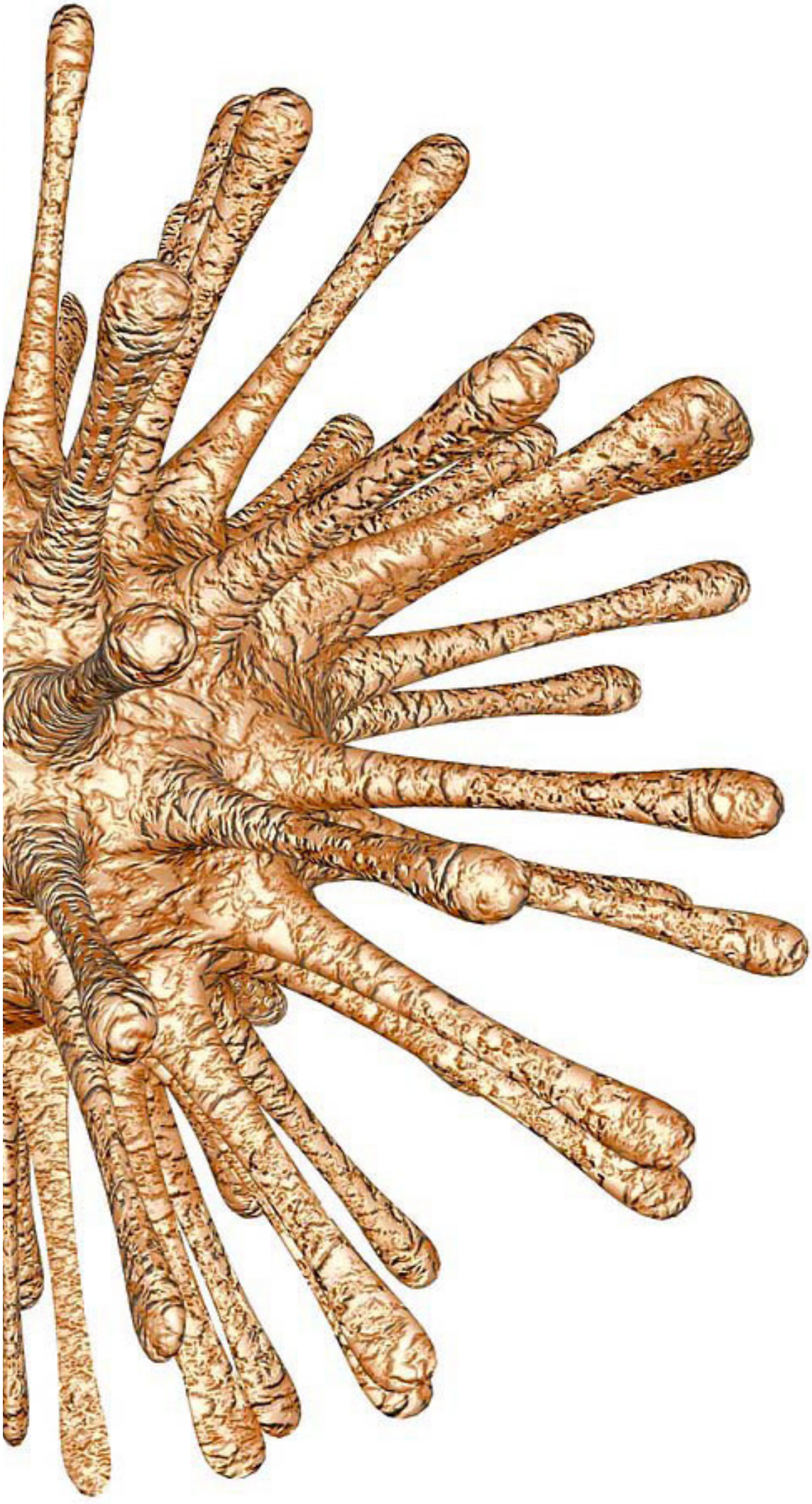
Now, I will emphasise that these results were found using simpler models which do not take spatial factors into account. Are these results duplicated with more complicated models that do? The research I did over the summer implies the affirmative; the same behaviour is found when simulating disease transmission using more advanced models. It would seem the current modelling schemes tend to underestimate the initial outbreak and overestimate the disease's longevity. Based on this, we need to focus on controlling the initial outbreak by prioritising high-risk people and locations. To do that, governments would be wise to also seek help from sociologists, but in the meantime, we mathematicians have some work to do. Incorporating variation in individual infectivity may be key to our understanding of the spread of disease in the future.

1. National Health and Medical Research Council. NHMRC research funding datasets based on burden of disease and health issues [Internet]. National Health and Medical Research Council; 2013. Available from: http://www.nhmrc.gov.au/grants/research-funding-statistics-and-data/burden-disease-and-health-issues

2. World Health Organization. How SARS changed the world in less than six months. Bull World Health Organ [Internet]. 2003; Available from: http://www.scielosp.org/pdf/bwho/v81n8/v81n8a14.pdf

3. Wallinga J, Teunis P. Different Epidemic Curves for Severe Acute Respiratory Syndrome Reveal Similar Impacts of Control Measures. Am J Epidemiol. 2004;160(6):509–16.

4. Lloyd-Smith JO, Schreiber SJ, Kopp PE, Getz WM. Superspreading and the effect of individual variation on disease emergence. Nature. 2005;438:355–9.



Student Profile

09

Laura Smith grew up on a farm in South Gippsland. She always liked problem solving and mathematics. So much so, that when she reached Year 12 and her high school didn't offer specialist mathematics she took it up via correspondence – that's dedication.

Laura says that at high school one of her teachers was "very-very" smart and he used to give her extra problem solving puzzles to do whenever she desired. "I really like using ad hoc methods to figure things out; I really enjoy the satisfaction," says Laura. "That's probably pretty common amongst people in the mathematical sciences," she continues, smiling.

Laura Smith spent her summer as one of fifty-six AMSI Vacation Research Scholarship (VRS) students. Through AMSI's VRS program some of our brightest undergraduates work throughout summer on a research project with a supervisor. Laura's research was in fuzzy logic, or how mathematics can help ensure minorities cannot skew ratings.

"Say you have a group of four food bloggers who want to rank three restaurants. Three agree and vote restaurant A the top restaurant, followed by restaurant C then B. However, the fourth is bribed by restaurant C, so gives restaurant C a really high score to increase C's average and A a really low score to decrease A's average," Laura explains.

"The algorithms we have been looking at can identify and remedy these biases, giving a more accurate view of the majority. In this case the fourth blogger's scores will be given a lower weighting in the overall scores as they differ greatly from the others, hopefully resulting in a fair result: A being voted top restaurant," she says.

While this may seem like a low impact application the same technique is used widely throughout the business sector. Financial institutions, government bodies, large boards — just to name a few — use the technique to manage risk and make decisions where a group of experts each contribute an opinion.

Laura says that her plan for VRS was to complete the six weeks before Christmas, nut it all out and have a few weeks off before getting stuck into honours. That didn't quite go according to plan; other opportunities came up; and research isn't always smooth sailing. 'But that's part-and-parcel of research life,' Laura admits.

"The VRS program is important because it encourages us [students] to 'practice' research," Laura says, "and is a really good indicator of whether or not we will enjoy research enough to continue through to honours and then perhaps a PhD."

Laura's supervisor, Dr Simon James, completed a VRS himself (also in fuzzy logic) back in 2006. "Being a VRS student gave me the confidence to believe I could pursue mathematics as a career; all of a sudden I was being paid to do mathematics. And as a VRS supervisor I can pass that message on; I can make sure students know that they, and their skills, are valuable," says Simon.

Students from all over Australia participate in the VRS; and just before semester starts back AMSI brings them all together for a Big Day In (BDI).

The BDI helps students get a taste for presenting their research to peers, and is good experience for careers in both the research and commercial arenas. "BDI was awesome," Laura says. "I loved seeing other "mathsy" people and hearing about their research projects. The BBQ was a great idea; I made some friends and it gave us all the opportunity to hang out and discuss things less formally."

The final task for AMSI VRS students is a blog post. Laura believes these are beneficial because they force students to think hard about how to communicate their research in a basic way. "You know you understand what you're doing when you can communicate it simply and concisely to the 'Average Joe'," she says.

Overall, Laura feels that the VRS program offers something unique; something you can't find anywhere else. "We are able to do a short project, present our findings and practice communicating with peers, academics and the general public – all while getting paid."

HOTmaths Blog

for maths teachers, by maths teachers

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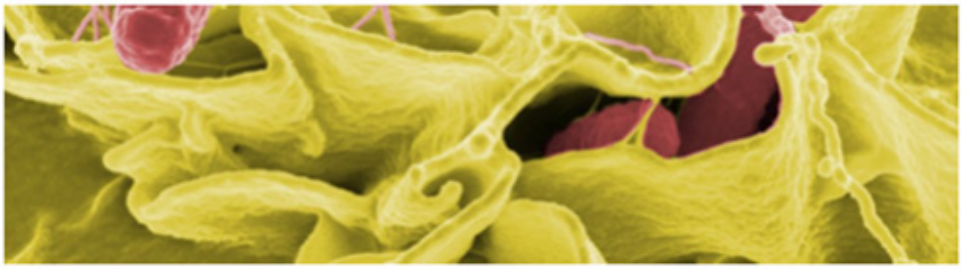
The importance of maths – Disease modelling with mathematics

Posted on April 16, 2015 by monell



Higher Education
Australian Mathematical Sciences Institute

By Stuart Roberts, RMIT

Growing up I never had a full understanding of just how important mathematics was in everyday life. Mathematics was always my favourite subject in school, but despite how interested I was, I never saw that it was an option for a career. Even in maths class in my final year of high school I had no idea the extent to which what I was taught was being applied in real life, and I certainly had no idea that everything I had learned to that point had barely scratched the surface of what I would come to learn.

During my final week of high school my math teacher suggested to me that I look into a degree in mathematics. I was surprised to hear that mathematics degrees even existed or that it could lead on to exciting careers. After looking into the outcomes of these courses I realised just how important mathematics was to the world we live in. From then on I didn't see it as just another subject in school. I saw it as a language used to describe and model nature. That was when I knew I wanted a career in mathematics.

Mathematics has a wide range of applications. One of those applications is modelling disease, which is important in identifying treatment strategies and controlling public health. For my project I focused on a model we hope can be used to model the evolution of a population of tumour cells after undergoing chemical treatment. We live in a world of constant change, so it is important that the model can be implemented in a constantly changing environment. The goal of my project was to investigate the dynamics of a model that could be used to model the growth and decay of tumour cells in a slowly varying environment.

If the model is successful in fitting real data, and the factors that influence the model parameters can be identified, this work could be used to assist estimating the time or intensity of the treatment needed to rid the body of tumour cells.

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Students' summer of maths keeps voting fair and babies safe!

MELBOURNE, TUESDAY 10 FEBRUARY 2015

Would you call a food blogger an expert? In the eyes of some mathematical algorithms that is exacty what they are. Online restaurant reviews are a way of seeing group decision making in action: Hundreds and thousands of diners rate a restaurant, the ratings are summed together to give a single rating, but how do these sites stop average restaurants from inflating their rating?

Laura Smith has spent her summer researching how mathematics can help ensure minorities cannot skew ratings.

"Say you have a group of four food bloggers who want to rank three restaurants. Three agree and vote restaurant a the top restaurant, followed by restaurant c then b. However, the fourth is bribed by restaurant c, so gives restaurant c a really high score to increase c's average and a a really low score to decrease a's average," Laura explains.

"The algorithms we have been looking at can identify and remedy these biases, giving a more accurate view of the majority. In this case the fourth blogger's scores will be given a lower weighting in the overall scores as they differ greatly from the others, hopefully resulting in a fair result: a being voted top restaurant," she says.

While this may seem like a low impact application the same technique is used widely throughout the business sector. Financial institutions, government bodies, large boards — just to name a few — use the technique to manage risk and make decisions where a group of experts each contribute an opinion.

Laura's project is one of 56 student projects sponsored by the Australian Mathematical Sciences Institute (AMSI) through their Vacation Research Scholarship program (VRS).

Over the past eleven years 428 students have taken part in the program. Dr Simon James, Laura's supervisor, was a VRS student himself. He gives an insightful view into the program: "VRS gave me the confidence to believe I could pursue mathematics as a career; all of a sudden I was being paid to do mathematics." Simon also said the program encourages students to continue their studies as it gives them a taste of the research world.

And Laura agrees: "For me, the VRS has been a way of experiencing research and the academic world, while being paid and without a 12 month commitment!" Laura says. "I have tackled an interesting problem under the guidance of a supervisor. I now have an idea of what to expect from post-graduate studies in mathematics and the impact the research can have."

Professor Geoff Prince, AMSI Director, says: "Thanks to co-funding from the Department of Education and Training the Vacation Research Scholarships allow young mathematicians to dedicate their time to understanding a specific topic. And it sends them the message that they and their skills are valuable. It is an essential program to safeguard Australia's future supply of researchers with expertise in the mathematical sciences."

Hear Laura and other VRS students present their research at the Big Day In hosted by AMSI.

Research & Higher Education

Australian Mathematical Sciences Institute

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Get funding to complete a six-week summer research project under the guidance of a supervisor!

Scholarships:

- Australia wide
- $450/week for six-weeks
- Present at CSIRO's Big Day In
- Fully funded travel and accommodation
- Open to intending honours and masters students

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CSIRO

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2015/16

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Get funding to complete a six-week summer research project under the guidance of a supervisor!

SCHOLARSHIPS:

- Australia wide
- $450/week for six-weeks
- Present at AMSI's Big Day In
- Fully funded travel and accommodation
- Open to intending honours and masters students

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Australian Mathematical Sciences Institute

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