ANZIAM Awards

Detailed Citation for Frank Robert de Hoog's Award of the ANZIAM Medal

Frank Robert de Hoog (or simply Frank to colleagues and friends) epitomises a worthy recipient of the ANZIAM medal because his contributions to applied, computational and industrial mathematical research are nationally and internationally famous, while his contributions to ANZIAM have had a significant impact especially in the development of the student support scheme.

Contributions to Applied, Computational and Industrial Mathematics Research

Frank de Hoog commenced his studies at the University of Western Australia in 1966 and graduated with first class honours in Mathematics in 1970. It was clear to his lecturers that he was gifted mathematically. During this period, his interest in applied and computational mathematics was greatly influenced by Professor J.J. Mahoney FAA, Dr Neville Fowkes and Dr Jack Williams who introduced him to applied and computational mathematics. In fact, he started a PhD at the University of Western Australia on the numerical solution of ordinary differential equations under the supervision of Dr Williams. However, with Dr Williams' return to the UK, Frank accepted a PhD scholarship at the Australian National University to work with Professor M.R. Osborne FAA on the numerical solution of ordinary differential equations. Because of the work that Richard Weiss was pursuing under the supervision of Bob Anderssen, Frank switched his focus to the numerical solution of integral equations. In hindsight, this change proved to be very important because of the success with which he, in collaboration with Richard Weiss, solved a number of important open problems.

As a direct result of the high regard that the research he performed as a PhD student established for him internationally, he was offered an Assistant Professorship in Mathematics at UCLA. With Richard Weiss at CALTECH, their research turned to the very challenging problem of the numerical analysis of singular ordinary differential equations. The resulting publications, because they resolved key issues that others working in the area had failed to resolve, immediately established international reputations for both as numerical analysts, and opened doors to an appointment for Richard Weiss in Vienna and to a return to the ANU for Frank de Hoog. Before accepting his position at CSIRO's Division of Mathematics and Statistics, he returned to earlier interests in integral equations and commenced his collaboration with his PhD student John Paine and Bob Anderssen on the numerical determination of the eigenvalues of ordinary differential equations.

The result that a simple algebraic correction formula could account for the differences between the algebraic estimates and the actual differential eigenvalues was a startling new result, the proof of which involved technically challenging and complex considerations. It has greatly influenced the subsequent design of algorithms for the computation of differential eigenvalues.

It was the significance, depth and breadth of this research which led to Frank being awarded the Australian Mathematical Society's Medal in 1988.

It was Frank's move to CSIRO that restimulated his strong interest in applied and industrial mathematics. From that point on, his research has had a very strong applied and industrial mathematical, as well as computational, impact. The success of that research has been recognized by his fairly rapid promotion to a Chief Research Scientist position on the basis of scientific merit, and his recent appointment as CSIRO Fellow. The impressive fact about this research is its phenomenal breadth, ranging over a very broad spectrum of subjects in both applied and computational mathematics, as well as its non-trivial depth and penetrating mathematical insight. There are many highlights in the research that Frank has undertaken during his more than 35 years with the CSIRO. Some, but not all, significant examples include:

(i) *Laplace Transform Inversion.* For many constant coefficient differential equations which arise in applications, it is relatively simple to determine the Laplace transform of the solution. The numerical inversion of such transforms is a very popular topic in numerical analysis and, thereby, a very challenging area in which to make a contribution that now has a science citation index score of more than 593. In part, this relates to the fact that Frank's contribution is the basis for standard algorithms in numerical analysis libraries including IMSL.

(ii) *Smoothing Spline Optimization.* The major limitation of the early methods for data smoothing with splines was the complexity of the computation of the regularization using cross-validation. In this research, it was shown how to reduce the complexity from an order n-squared activity to an order n deliberation. It is now the basis for all standard algorithms for smoothing spline fitting to observational data.

(iii) *Fast Methods for Toeplitz Matrices.* Various authors have proposed ways to exploit the special structure of a Toeplitz matrix in order to derive fast algorithms. It was a very competitive subject that required deep mathematical understanding and insight to identify an alternative strategy which improved on the earlier alternatives. Though other methods were proposed, it was the first stable numerical method for positive definite Toeplitz matrices.

(iv) *Mineral Separation.* In designing an industrial device, it is not only a matter of engineering but of matching the engineering to the operational parameters of the device. Dr de Hoog developed a mathematical model for the Kelsey Centrifugal Jig of Geologics which allowed such matching to be performed. As a result of this collaboration, these jigs are now used around the world to perform mineral separation that was not possible in the past. These jigs

are responsible for the recovery of minerals with a value in excess of half a billion dollars a year.

(v) *Sheet Metal Rolling.* The efficient production of sheet metal is a highly competitive situation. The faster the rolling can be performed, the higher the profits. However, the faster the rolling the more sophisticated must be the algorithms controlling the operation of the rolling. The work that Dr de Hoog and colleagues have accomplished has given BHP a competitive edge internationally.

(vi) *Mode Coupling in the Vibration of Beams and Shells.* The mode coupling that occurs in beams and shells is quite complex, and the earlier publications that aimed to explain this phenomenon were complex and cumbersome. The importance of this work is that it identified the key issues involved in a way that yielded a clear simple explanation.

(vii) *Conditioning and Dichotomy of Boundary Value Problems.* This research established for the first time that there are uncoupled boundary conditions that have similar conditioning to the most general situations. It thereby laid a theoretical framework for the formulation of robust algorithms for two-point boundary value problems.

Contributions to Industrial Mathematics Study Groups

In addition to the above contributions, it is important to acknowledge that Frank played a key role, along with others, in the successful establishment of the Mathematics-in-Industry Study Group Meetings, which are now an important part of the R&D image of ANZIAM. The first Study Group Meeting was organized by the then CSIRO Division of Mathematics and Statistics, with Noel Barton and Frank playing lead roles along with strong support from Kerry Landman and Terry Speed. The Study Group's successful implementation would not have been achieved with the speed and impact that it has if it were not for the dedicated and insightful commitment of Frank, Noel, Kerry and Terry, as well as others.

In many ways, one of Frank's great personal characteristics, which is the basis for his highly successful collaborative research endeavours, is his understanding, fair and unselfish approach to colleagues. An example is his work on the winding of coils, which arose initially through the Mathematics-in-Industry Study Group framework. In collaboration with CSIRO and industrial colleagues, he developed and applied theory which established explicitly the winding stress required to achieve specified residual stresses in the wound coils. As an immediate consequence of such endeavours, the damage due to excess stress was minimized while the stability of the wound coil was maximized. These results have become the basis for the processing of coils in both the aluminium (Comalco) and steel industries (BHP/Blue Scope), and contributed directly to the cost-efficiency with which aluminium and steel sheets are now rolled and coiled.

Contributions to ANZIAM

Frank has been a regular attendee since 1976 invariably giving a talk. He was a key organizer for the meeting in Merimbula in 1984.

As an extension of his strong support for students in CSIRO, in terms of student support schemes and internship programs, Frank garnered financial support for ANZIAM from CSIRO on the understanding that the funds would be exclusively used to support student participation at ANZIAM. This has turned into the CSIRO-ANZIAM Student Support Scheme and has become a feature of AustMS conferences as well as those of ANZIAM.

The Selection Committee unanimously agreed that, for all these contributions, Frank de Hoog be awarded the ANZIAM Medal for 2016.

2016 J.H. Michell Medal

The J.H. Michell Medal is awarded by ANZIAM in honour of John Henry Michell to an outstanding new researcher, within 10 years of their PhD, who has carried out distinguished research in applied and/or industrial mathematics, and where a significant proportion of the research work has been carried out in Australia and/or New Zealand.

The committee (Harvi Sidhu, Matthew Simpson and Yvonne Stokes) is unanimous in recommending that the 2016 J.H. Michell Medal be awarded to Associate Professor Joshua Ross from the University of Adelaide. Joshua has made significant contributions to methodology in Applied Mathematics and, through its application, to conservation biology and public health policy.

Joshua completed his undergraduate and postgraduate education at the University of Queensland: a Bachelor of Arts (Economics) in 2002, a Bachelor of Mathematics & Statistics in 2003, a Graduate Certificate in Higher Education in 2006 and his PhD in Mathematics in 2007. After a year as a post-doctoral research fellow in the Mathematics Institute, The University of Warwick, Joshua went to the University of Cambridge as a Zukerman Junior Research Fellow at King's College (October 2007 to March 2010). In March 2010 he joined the School of Mathematical Sciences, The University of Adelaide, as a Lecturer. He was promoted to Senior Lecturer in 2013 and to Associate Professor in 2015.

Joshua has accrued an impressive list of accomplishments. Over the last five years he has had three successful ARC Discovery Projects (one as a sole applicant), a Royal Society International Exchanges Scheme grant, and an NHMRC grant for the Centre of Research Excellence in Policy Relevant Infectious Disease Simulation and Mathematical Modelling. He was awarded an ARC Future Fellowship for 2013–2017. He is also a contributor to the Data to Decisions Cooperative Research Centre established in 2014 through which he has a project grant. In 2013 he received an Australian Institute of Policy and Science Young Tall Poppy Award.

The success Joshua has had with grants and awards bears witness to the quality and impact of his research. Joshua has a strong publication record of 45 journal articles, 7 as sole author, and he has papers in a number of high-quality journals including *The Proceedings of the Royal Society A, The Journal of Theoretical Biology* and *Global Change Biology*. In 2006 he had a sole-authored paper in *Science*.

Scopus reports 290 citations of his work in separate documents. A paper from his first post-doctoral position was selected as a 'Technological Advance' by the Faculty of 1000 Biology — a panel of over 2300 world leading biological researchers who identify research of other scientists which they believe to be particularly interesting or important.

Joshua's work, from his PhD and onwards, is noted for novel methodologies. The four key papers (of ten) arising from his PhD studies have collectively attracted 88 citations to date. Highlights from his work as a Zukerman Junior Research Fellow include:

- the fusing of network moment-closure methods with the theory of diffusion approximation to establish the first analytical understanding of the impact of network structure and stochasticity in disease dynamics, in the process providing a probabilistic explanation of the standard pair moment-closure approximation which is widely used in mathematical epidemiology, and
- the development of a suite of novel methods for the efficient evaluation of several epidemiologically relevant quantities for stochastic households models.

Since then he has been the first to publish methods for evaluating the basic reproduction number and the full distribution of the number of secondary infections, accounting for finite population size and stochastic effects (*Journal of Theoretical Biology*, 2011, sole author). Another highly innovative contribution, which exemplifies the novelty of Joshua's work, is his paper published in *Ecological Modelling* in 2013 which combined methods from Applied Mathematics with the theory of Optimal Experimental Design, to determine the optimal use of state-of-the-art micro-GPS tracking devices in order to explore species movement patterns. Recently Joshua has made progress on a problem that has, with the exception of one special case, eluded researchers since the 1950s, namely providing a robust and efficient method of evaluating the distribution of the final size of an epidemic. His paper in the *Journal of Theoretical Biology* in 2015, provides the *best* algorithm available for evaluating this distribution, not only for the special case already considered, but for a wider class of models with phase-type infectious period distributions.

Joshua's many achievements include supervision to completion of a PhD student and two MPhil students, and a number of government consultancies. He is, clearly, an outstanding researcher and a worthy recipient of the J.H. Michell Medal.

Congratulations Joshua!