



School of Mathematics Newsletter

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The Mathematics of Designs

by ALLAN LO

Dr Allan Lo was recently awarded an EPSRC First Grant to investigate a graph theoretical approach for combinatorial designs. In this article, Allan describes what designs are and their importance.

A combinatorial design is an arrangement of elements of a finite set into patterns according to specified rules. They typically arise from considering scheduling problems, a famous recreational example being Kirkman's schoolgirl problem which dates back to 1850 and asks for an assignment of 15 schoolgirls into groups of 3 on 7 different days such that no two schoolgirls are allocated to the same group more than once. This particular problem is easy to solve and its solution is the simplest example of a Steiner triple system. Another popular example of a combinatorial design is a completed Sudoku, which is a special type of Latin square. A Latin square of order n is an $n \times n$ grid with entries from a set of n symbols arranged in such a way that each symbol occurs exactly once in each row and exactly once in each column. Its name was inspired by Euler, who began the study of Latin squares back in 1779 and used Latin characters as symbols. Latin squares appear in various area of mathematics such as in algebra (multiplication table of a quasigroup) and in finite geometry (projective planes). They also have numerous applications in the modern world, for ex-

ample, in cryptography as error-correcting codes. In the 1930s, the statistician R.A Fisher promoted the use of Latin squares and other combinatorial structures in the design of comparative experiments to "balance" treatments against systematic variations across the experimental layout.

5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

A completed Sudoku is an example of a Latin square

In the language of Graph theory, many combinatorial designs can be translated to graph decompositions. For example, a solution of Kirkman's schoolgirl problem stated above is a decomposition of a complete graph on 7 vertices into (edge-disjoint) triangles. Steiner systems, which is a generalisation of Kirkman's schoolgirl problem, corresponds to a decomposition of complete hypergraphs into cliques. They are used in group testing algorithms for identifying irregularities in a large population, e.g. disease-screening of blood samples. Despite its apparent simplicity, proving the existence of Steiner systems has turned out to be one of the most fundamental and challenging problems in design theory dating back to 1853. Many novel and powerful techniques were developed in attempts to prove this

conjecture. For instance, the semi-random construction method of Rödl has since had a great impact on combinatorics and beyond. The existence of Steiner systems was finally settled in 2014 by a striking result of Keevash.

- If you would like to hear more about the Mathematics of Sudoku, Allan will be giving the Birmingham Popular Maths Lecture on February 15th 2017 here in the School of Mathematics.



A Latin square arising in agriculture

Comings and goings

Later this month, Dr Marina Iliopoulou will be leaving the Analysis group to start a three year fellowship in Berkeley. Joining the group in September will be Dr Stefan Buschenhenke. He arrives from Kiel to undertake a 12 month postdoc position.

Dr Andrew McDowell will soon be leaving the Combinatorics group in order to start a fellowship at King's College, London. Andrew will work with Professors Colin Cooper and Tomasz Radzik, and collaborate with Professor Martin Dyer at the University of Leeds as part of an EPSRC project entitled "Randomized algorithms for computer networks". The project aims to cover a range of areas including analysis and algorithmic applications of random processes on distributed networks and self modifying random networks.

Current PhD student Valentina Grazian has recently had a double success. She was awarded a U21 PhD Scholarship which will allow her to visit the University of Auckland from November for two months. There she will work with Distinguished Professor Marston Conder, whose expertise lie in Group theory and its applications to Graph theory. Then in April, Valentina will join the University of Aberdeen for 6 months as part of an LMS Postgraduate Mobil-

ity Scholarship. There she will be working with Dr Ellen Henke, an expert in the area of Fusion Systems and alumna of the University of Birmingham.

This month we also had chance to say goodbye to eight graduating PhD students. Congratulations to Michel Bode, Hend Gabr, Paul Griffiths, Peshawa Khudhur, Stewart McGovern, Tim Townsend and Chunlei Xu! The School wishes you all the best in your future careers in academia and industry!

Mentoring African Research in Mathematics

Congratulations go to Kay Maggaard and Sergey Shpectorov for being awarded a grant as part of the Mentoring African Research in Mathematics (MARM) programme funded by the London Mathematical Society. The aim of the MARM programme is to enable all mathematicians in Africa to pursue academic careers of the highest standard. In particular, MARM provides the means and opportunities for African mathematicians to develop international working relationships while also improving the quality of academic provision within their home institution.

The School's partnership is with the School of

Mathematics, Statistics and Computer Science at the University of Kwazulu–Natal, South Africa. The proposed areas of collaboration include Group Theory, Algebraic Coding Theory, General Topology, Functional Analysis, Metric Spaces, Combinatorics, Graph Theory, Number Theory and Applied Cryptography.

Workshop on Numerical Linear Algebra and Optimization

by MICHAL KOČVARA

The School of Mathematics is organising and hosting the Fifth Biennial IMA Conference on Numerical Linear Algebra and Optimization on 7-9 September 2016. The meeting is co-sponsored by SIAM and NAG.

The success of modern codes for large-scale optimization is heavily dependent on the use of effective tools of numerical linear algebra. On the other hand, many problems in numerical linear algebra lead to linear, nonlinear or semidefinite optimization problems. By bringing together leading researchers from both communities, this conference series contributes significantly to the development of new ideas, algorithms and technologies in classical and emerging disciplines such as compressed sensing, machine learning, and big data. The conference is regularly attended by about 100 international researchers in all stages of their career. The invited speakers are leading researchers from the UK, European and American institutions. The conference is typically attended by many PhD students and research fellows from the UK.

This year the invited plenary speakers are Tim

News in Brief

- Congratulations go to Dr Alessio Martini for being awarded an EPSRC First Grant. This will fund Alessio's research on Sub-Elliptic Harmonic Analysis for two years. Together with Dr Allan Lo's award, this means the School received two out of only seven EPSRC First Grants in Mathematics awarded nationally in the latest round of funding!
- On August 3rd, the School will be hosting the

Davis (Texas A&M University), Anders Forsgren (KTH Stockholm), Andreas Frommer (University of Wuppertal), Jacek Gondzio (University of Edinburgh), Laura Grigori (INRIA Paris-Rocquencourt), Jennifer Scott (Rutherford Appleton Laboratory) and Lieven Vandenberghe (UCLA).

School of Mathematics staff and postgraduate students are welcome to attend any of the lectures. For further information, contact Michal Kočvara.

Best practice in model parameterisation for predictive medicine

by SARA JABBARI

The School of Mathematics recently hosted a 4-day Wellcome Trust funded workshop on parameterising ordinary differential equation models in mathematical medicine. Run under the Birmingham–Nottingham strategic collaboration and organised by Drs Sara Jabbari and Joanne Dunster (University of Nottingham), the workshop consisted of a mixture of hands-on computer labs and lectures covering topics that included optimisation, frequentist, Bayesian and model selection methods. We had 23 participants from a full range of career levels (from undergraduates to lecturers), in addition to 10 expert tutors and speakers from both academia and industry. Attendees came from as far afield as New Zealand to learn about how to get the best out of combining mathematical models with experimental data. The workshop included a social programme in the evenings and we hope to have helped form some long-lasting friendships and collaborations within the mathematical biology community!

Birmingham Student Combinatorics Day. Talks will be in Lecture Room C of the Watson Building and the speakers are Jake Cooper (Warwick), Ewan Davies (LSE), Wei En Tan (Birmingham) and Adam Wagner (Illinois). Also that afternoon there will be an event run by Will Perkins and Andrew Treglown discussing how to prepare for academic interviews. All PhD students and research fellows are welcome to attend. More details of the event will be available closer to the time on <http://willperkins.org/CombDay2016.html>.