Parameterized Complexity for Practical Computing Workshop

Victoria University, Wellington New Zealand, Wednesday August 25th 2018

Venue: Victoria University, Cotton Building, Room CO350

Program:

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| 9-9.30am | Arrival, tea/coffee and muffins |
| 9.30-10.30am | Welcome, followed by keynote presentation from  Prof. Michael Fellows:  “The basics of parameterized complexity; origins in graph minor theory and well quasi-ordering; and the wqo functor project.” |
| 10.30-10.55am | Presentation from Peter Shaw:  “Game Theory and the Human Trafficking Dilemma.” |
| 10.55-11.20am | Presentation from Simone Linz:  “On the parameterized complexity of reconstructing phylogenetic networks.” |
| 11.20-11.45am | Presentation from Jens Dietrich:  “Making it worse to make it better: A case study on how to design a fast algorithm for static program analysis.” |
| 11.45-12.15pm | Light lunch/sustenance |
| 12.15-12.40pm | Presentation from Fran Rosamond:  “An FPT mystery: Improving the Diameter of a Planar Graph.” |
| 12.40-1.05pm | Presentation from Ljiljana Brankovic:  “Parameterized Approximation Algorithms for 3-Hitting Set.” |
| 1.05-1.30pm | Presentation from Kamran Najeebullah:  “Complexity of Optimally Defending and Attacking a Network” |
| 1.30-1.55pm | Presentation from Peter Shaw:  “Turbo charging heuristics: adjusting the parameters for optimum performance.” |
| 2-3pm | Substantial second lunch/discussions (at Milk and Honey, next to “The Hub”) |
| 3-3.20pm | Presentation from Catherine McCartin:  “Combining FPT with heuristics: network augmentation strategies for target set selection.” |
| 3.20… | Presentation of open problems from different areas:  David Bryant, Michael Fellows, Fran Rosamond, Peter Shaw, Simone Linz  followed by collaborative discussion of one or two selected problems:  lead by Prof. Michael Fellows |

Abstracts:

Michael Fellows:

“The basics of parameterized complexity; origins in graph minor theory and well quasi-ordering; and the wqo functor project.”

The talk will present, concretely, the basic ideas of parameterized complexity (PC) and algorithms, with some historical background about the graph minors project and how this stimulated the development of PC.  At the heart of graph minors is: (a) a structure theory project, and (b) a fundamental FPT result.  (FPT, fixed-parameter tractability, is the central notion in PC, generalizing polynomial-time.)  These themes remain central in current research.  The talk will end with something about the "functor project" which is about inducing wqo/FPT general algorithmic machineries for other kinds of mathematical objects, such as finite sets of points in the plane (relevant to computational geometry).

Peter Shaw:

“Game Theory and the Human Trafficking Dilemma.”

A criminal justice system has a series of stages, aimed at proving criminal offences and punishing perpetrators. Traditional procedures involve guilty pleas and criminal trials. The result can be viewed as an ever more complex strategic game where suspects who commit criminal offences may also be victims of human traffickers. This talk examines how Game Theory can be used to examine criminal justice systems. Overall, we suggest that Nash’s theorem supports the suggestion that a push for confession to prove a crime is not the best strategy unless or until the starting position for each suspect is the same and confession is a safe choice.

Simone Linz:

“On the parameterized complexity of reconstructing phylogenetic networks.”

Recent advances in whole-genome studies provide increasingly strong evidence for a vital role of hybridization in fortifying species and allowing them to adapt to new environments. To represent such complex evolutionary histories as a web of life rather than a simple bifurcating tree of life, phylogenetic (evolutionary) networks have become a popular tool. In this talk, we investigate new graph-theoretic algorithms to reconstruct a phylogenetic network from a collection of phylogenetic trees. Moreover, we analyze the parameterized complexity of the underlying problem for several special cases and conclude with an open problem.

Jens Dietrich:

“Making it worse to make it better: A case study on how to design a fast algorithm for static program analysis.”

Static program analysis tries to find bugs and vulnerabilities in software by building models from programs, and then to reason about or query those models. In many cases, the models are based on digraphs, and reasoning includes the computation of the transitive closure. Due to the complexity of this task, many static analyses don’t scale well, this has been dubbed the cubic bottleneck of static program analysis.

In this talk I will present an algorithm we have developed to compute a certain type of context-free language reachability on labelled digraphs used in memory analysis. It turns out that while this algorithm has sub-cubic worst-case complexity, it shows near-linear behaviour for graphs extracted from real-world programs.

Fran Rosamond:

“An FPT mystery: Improving the Diameter of a Planar Graph.”

This talk will describe one of the most famous concrete open problems in parameterized complexity and algorithms (on the top ten lists in the famous books of the field).  The problem is defined:

Input: A planar graph G, and a positive integer k.

Parameter: k

Question: Can we add edges to G (any number) to obtain a planar graph G' that has diameter at most k?

The diameter of a graph is the worst-case shortest distance between any two vertices. Although this beautiful problem is still not known to be NP-hard (!) it can be classified in FPT by the mysteriously powerful graph minors machinery.  A realistic algorithm with any hope of practical significance is currently unknown. It turns out that the problem is a special case of a general operator on ideals. This will be explained.  There is a natural sister problem: Improving  the Minimum Domination Number of a Planar Graph, concerning which there has been substantial recent progress.

Lijiljana Brankovic

“Parameterized Approximation Algorithms for 3-Hitting Set”

In this talk we present a  parameterised search tree algorithm for approximating 3Hitting Set, focussing on the case of factor-2 approximations. The main ingredient of our algorithms are exact and approximation-preserving reduction rules. We also derive several results for hypergraph instances of bounded degree, including a new polynomial-time approximation algorithm.

Kamran Najeebullah

“Complexity of Optimally Defending and Attacking a Network”

The inverse geodesic length (IGL) is a well-known and widely used measure of network performance. It equals the sum of the inverse distances of all pairs of vertices in the network. A Stackelberg game is a strategic game in which one player commits to a strategy while taking into account that other players will respond accordingly. We propose a natural defender-attacker Stackelberg game on a network in which the defender wants to maximize the IGL level of the network and commits to protecting parts of the network while having knowledge of the strength of an attacker that wants to weaken the network. We present several algorithmic and complexity results concerning the problem of finding the optimal commitment for the defender. Some of our computational hardness results also answer open problems posed in prior work on IGL.

Peter Shaw:

“Turbo charging heuristics: adjusting the parameters for optimum performance.”

Turbo-charging is a recent algorithmic technique for hard problems that  employs an FPT subroutine as part of a heuristic. We demonstrate the effectiveness of this technique and develop the turbo-charging idea further. In this talk we will explore how the performance can be improved through adjusting the parameters and moment-of-regret function.

We implement both the initially proposed ``turbo-greedy'' algorithm of Downey et al. and a new hybrid heuristic for the W[2]-hard Dominating Set problem and evaluated their performance for a range of parameters and datasets. Our algorithm often produced results that were either exact or better than all the other available heuristic algorithms. The results vary depending on the parameter, with the best results obtained for larger values of k and r.

Catherine McCartin:

“Combining FPT with heuristics: network augmentation strategies for target set selection.”

It is well known that many real-world networks, such as social, biological and communication networks, have distinctive topological features. However, in general, it is an open question whether or not these features can provide any algorithmic benefits. In this talk, we investigate the values of some of the parameters commonly employed by the parameterized complexity community in a range of real social, biological and communication networks. In all cases, the parameter values are much too high to be of practical use. Because of this lack of tractability in practice, we investigate dynamic strategies for exploiting the distinctive topological features of real-world networks to improve the prospects for efficient computation of acceptable problem solutions, using both fixed-parameter and greedy approaches. Our strategies involve simple targeted operations: vertex deletion and edge addition, which could easily be applied in cases such as social networks. As a case study, we consider the target set selection problem, a ubiquitous problem that models many problems concerning the spread of information in networks.