

Research Statement

I'm interested in the application of graph theory, topology (in particular, knot theory) to discrete optimization problems, and to biology and chemistry.

My skills lie in solving computational problems by creating algorithms that are feasible to implement.

For example, a complete invariant I produced for a prime alternating link can be computed in linear time, and since the four combinatoric operators I devised, for enumeration are also performed in linear time, it made it possible to enumerate the prime alternating knots and links far beyond what could be done by any other existing method. We are the only research group that has enumerated past 19 crossings. Although I do not code myself, I have worked with numerous coders. Aside from presenting the algorithms to be coded, I like to work with the coders day to day until the project is completed.

I also have a polynomial time, graph isomorphism testing algorithm, which has not failed on any hard instances to date. The labelled cycle decomposition tree scheme used in the GI tester, appears to have applications for graph similarity as well.

Present and future plans

I have been actively working with various mathematicians, both with the GI tester, and the application of the labelled cycle decomposition tree scheme for comparing graphs. It plays the role of a potent graph kernel.

I still have a research program in knot theory. I would like to finish my work on an efficient algorithm which determines if a given gauss code is for the unknot. This would determine the complexity of solving the unknotting problem.

In the next few years I wish to study:

- The relevance of the labelled cycle decomposition tree wrt. graph similarity and graph kernels.
- To establish some important results for my GI tester.
- Attempt to prove my alternative formulation of the four colour theorem, which does not appeal to the snark theorem.
- To continue my work on generating particular knots and links, via various applications of the four surgeries mentioned, which lead to integer sequences, that unexpectedly appeared to be the same sequences for other unrelated mathematical objects that were enumerated. Sloane's integer sequence site has proved invaluable in this endeavour. This experimentation was first done over 10 years ago by John Schermann and myself.

Research activities from 1999-2010

- In 2010, Introducing the labelled cycle decomposition tree, to researchers in the field of graph similarity and graph kernels.
- In 2009, Testing the algorithm for distinguishing non-isomorphic graphs on hard cases, and introducing the scheme to researchers in the field.
- In 2008, Attended numerous Industrial mathematical workshops throughout 2008, and worked on problems ranging from semi conductor research to oncology, solving one problem in its entirety, using the cycle decomposition scheme.

- In 2007, I defended, and I developed an equivalent formulation of the Four Colour Theorem (FCT).

Stuart Rankin, Bruce Fontaine and myself, enumerated all the prime alternating knots and links at 24 crossings (around 500 billion) and enumerated all the oriented prime alternating knots and links at 24 crossings (around 2.5 trillion) in 40 hours distributed over 40 machines.

- In 2006, I developed a new scheme to decompose (which has no relation to another known decomposition scheme) any graph into a rooted labelled tree. With this mathematical construct I devised another algorithm which in polynomial time attempts to distinguish cospectral pairs.

Overhauled our interactive website “Knotilus” for knot and link visualization and design launched in July.

The data for all un-oriented and oriented prime alternating links was compiled during the summer of 2006 and is available online at <http://knotilus.math.uwo.ca>.

Classified some knotted molecules constructed out of synthetic DNA at Ned Seeman’s laboratory.

- In 2005, I studied a special class of 3-SATs which were derived by converting a composite integer of two primes into a 3-Sat problem. The coding was done by Jim Morey, a Ph.D. student in the Department of Computer Science.

- In 2004, I devoted a number of months on the P vs NP problem and in particular the maximum clique problem. I wrote a number of algorithms for special classes for each of the problems : the knapsack, travelling salesman, maximum clique and 3-SAT.

- In 2003, we had now completed the implementation of the algorithms as described in our first two papers, and ran them to produce the prime alternating knots of 20 crossings (completed June 26, 2003).

With a new version of the code, we enumerated the prime alternating knots with 23 crossings.

The interactive website, Knotilus was conceived by S. Rankin and myself in the summer of 2003 as a tool for the broken curve drawing of a knot or link from a given gauss code in aid of our knot theory research.

My first graph isomorphism algorithm was coded by Peter de Vries which was completed by January of 2003.

- In 2002, produced a construct for the GI testing algorithm mentioned above, called the Generalized Incidence Matrix for a graph G .

- In 2000 - 2001, Prof. Rankin and myself proved the enumeration scheme along with the invariant used that was implemented a year prior. Also, continued with independent research in discrete optimization and some work on rooted tree enumeration jointly with Prof. Greg Reid from the Department of Applied Mathematics at Western.

- In 1999, I developed the invariant called the master array and four combinatorial operators to enumerate knots and links. J. Schermann coded and implemented this scheme for all knots up to 19 crossings.

I did some research in cryptography in the Department of Applied Mathematics where I came up with a crypto scheme, but of no practical public use.