CS 101 Research group presentation, 2006

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- Includes: algorithm analysis and design; computational geometry, information theory, cryptography, quantum computing, study of randomness, computational algebra, bioinformatics.
- Has many applications to, and is inspired by, concrete problems in science, engineering, etc.

Some big ideas in TCS

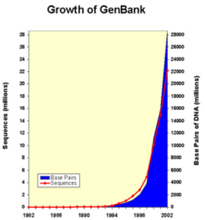
- uncomputability: not every problem can be solved by computation;
- recursion (self-reference): a program can use its own output as input;
- universality: anything a modern supercomputer can compute, an ancient laptop can too;
- a computing machine can be implemented out of almost anything (relays, tubes, transistors, DNA, molecules, . . .);
- tractability: some problems are intrinsically harder than others, no matter how clever we are;
- one-way functions: some functions are easy to compute but their inverse is very hard;
- zero-knowledge proofs (ZKP): Alice can convince Bob that she knows a secret without revealing it.

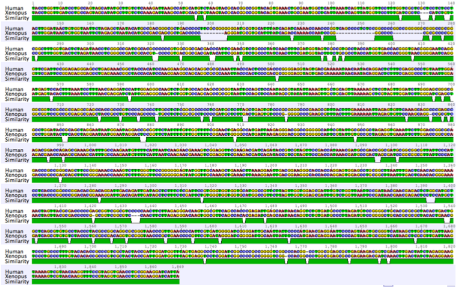
Some recent applications of CS Theory

- Engineering: Fast Fourier Transform revolutionized signal processing.
- Biology: algorithmic approach vastly speeded up work on the Human Genome Project.
- Programming languages: fast efficient algorithms for searching, sorting, string matching, . . . now implemented.
- Computer engineering: chip layout and parallel machine architecture improved by graph algorithms.
- E-commerce: public key cryptography enables you to buy things on the web; ZKP allows secure elections, auctions, etc.
- Internet: Google's success is largely due to its PageRank algorithm; routing protocols have been improved by graph algorithms.

Trendy example — bioinformatics

- Has become a central part of biological sciences with many applications in ecology, evolutionary biology, diseases, molecular and cell biology.
- Involves using mathematics, statistics and computer science tools to analyse rapidly growing databases of biological data.
- New algorithms are the biggest requirement right now, because we are being buried under an avalanche of data.





TCS group at UoA

- 6 permanent staff, active in research, with research interests from fundamental to trendy.
- 2 postdoctoral research fellows
- 10(?) PhD and Masters students
- The CDMTCS (http://www.cs.auckland.ac.nz/CDMTCS/) provides a framework for seminars, conferences, student prizes, etc.
- In 2008 there will be a major programme Algorithms: New Directions and Applications that will involve everyone from staff to the general public. Watch out for it!

CS theory staff

- Cris Calude. Professor. Originally from Romania. Research interests: unconventional models of computation.
- Michael Dinneen. Senior Lecturer. Originally from USA. Research interests: graph algorithms.
- Alexei Drummond. Lecturer. Research interests: bioinformatics.
- Bakhadyr (Bakh) Khoussainov. Professor. Originally from Uzbekistan. Research interests: automata.
- Andre Nies. Senior Lecturer. Originally from Germany. Research interests: computability theory, randomness.
- Mark Wilson. Senior Lecturer. Research interests: analysis of algorithms, discrete mathematics.

CS Theory undergraduate courses

- COMPSCI 105 (principles of computer science)

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- COMPSCI 720 (more algorithms!), COMPSCI 750 (complexity theory), and more.

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- It is important to take a good amount of mathematics also.

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- “ Part of Microsoft’s interview process is answering tough questions like the ones we put on our CS320 exams.”
- “ The software company that I am involved with has 7 fulltime software developers and they are basically all theory guys – i.e. know the hard stuff . . . We basically only hire people that know how to think. Who cares whether or not they have done some specific applied paper. They are going to have to constantly learn on the job anyway . . .

Some of our recent graduates

- Liu Xiong, developer for Microsoft (Redmond, Washington, USA)
- Tiki Wong, works for Microsoft (Redmond, Washington, USA)
- Nodira Khoussainova, PhD student at University of Washington (Seattle, USA). Had research internship at Microsoft Research.
- Jiamou Liu, PhD student with Bakh Khoussainov, spends half the year at Cornell University
- Owen Auger, PhD student in UoA Engineering Science Dept, working on electricity network modelling.
- Sasha Rubin, postdoctoral fellow supported by NZ government fellowship, visiting University of Wisconsin (USA) and Aachen (Germany).

The future: bright

- TCS provides the theoretical foundation for scientific computing.
- The older sciences have used mathematical formulae to describe phenomena.
- The newer sciences (neurophysiology, modern biology, realistic economics, . . .) have found that formulae are less useful than algorithms.
- "The Algorithm's coming-of-age as the new language of science promises to be the most disruptive scientific development since quantum mechanics."
- There are many exciting research challenges ahead!