Lecture 2

What is (Computer Science) Research?

UNIVERSITY OF AUCKLAND

COMPSCI 289

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Learning Objectives

- To be able to define what research is in science
- Learn about markers of research quality
- Learn about the research strengths of the school
- Learn about the breadth of research at the school

What is Research?

- "Creative and systematic work undertaken to increase the stock of knowledge, including knowledge of humans, culture and society, and the use of this stock of knowledge to devise new applications." (OECD 2015)
- Process of scientific research?
  - Observations and formation of the topic
  - Hypothesis
  - Gathering of data
  - Analysis of data
  - Data interpretation
  - Test, revising of hypothesis
  - Conclusion, reiteration if necessary

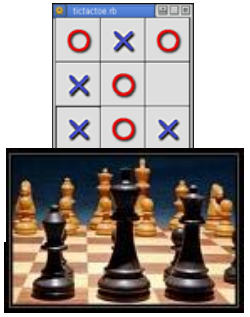
Research = Courses?

Computer Graphics

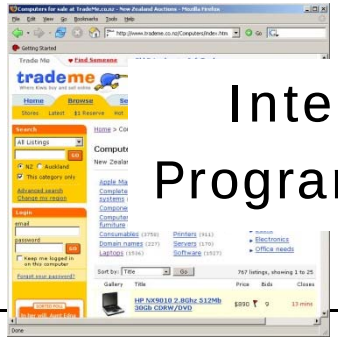
Operating Systems

Data Communications

Artificial Intelligence



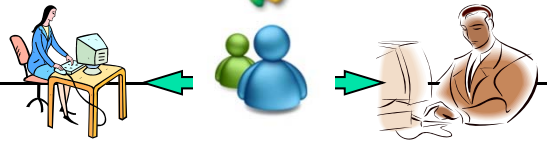
Human Computer Interaction

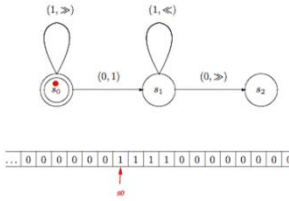


Google™ New Zealand

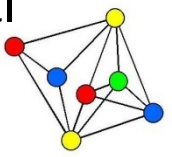
YouTube™

Internet Programming





Theoretical Computer Science



What Do You Know About the School?

- Who are our most famous researchers?
  - What does that even mean?

History at UoA

- Department of Computer Science
  - Founded in 1980
  - Now a school with over 60 academics

Notable Achievements in CS

- 4 Fellows of Royal Society (FRSNZ)
  - John Hosking (Dean of Science)
  - Bakhadyr Khoussainov (Theory)
  - Andre Nies (Theory)
  - Alexei Drummond (Bioinformatics)

- 1 Member of Academia Europaea
  - Cristian Calude (Theory)

Highest Cited Researchers in CS

- Google Scholar
  - Alexei Drummond – 77,619
  - Clark Thomborson – 10,268
  - Remco Boukaert – 9,471
  - Mark Gahegan – 7,127
  - Ian Watson – 6,596
  - Cris Calude – 5,892
  - Michael Witbrock – 5,141
  - John Hosking – 4,557

  - University of Waikato
    - Ian Witten – 108,134
- Different research disciplines are different sizes
  - Impacts how many people can cite your research

Rankings

- QS International Ranking
  - Computer Science and Information Systems
  - 51-100 bracket since 2016
    - Were sub-50 in previous years
  - Next closest in NZ is in 201-250 bracket (VUW)

- New Zealand's PBRF Ranking
  - Computer science, information technology, information sciences
  - Top Computer Science school in NZ
  - Around 1/3 of all A-ranked researchers in discipline

Types of Researcher

- Academic
  - 40% Research
  - 40% Teaching
  - 20% Service
  - Often blue-sky research
- Research Institute
  - Applied research role, no teaching
  - Often at behest of government
  - Typically short/medium-term (6-12 months)
- Industry-based (R&D)
  - Company-focused research, no teaching
  - Startups
  - Typically short-term (6 months or less)

Research Groups

Artificial Intelligence & Machine Learning

- Artificial intelligence is the study and design of a system that perceives its environment and takes actions that maximize its chances of success.
  - Machine Learning is a sub-field that focuses on algorithms that learn. Our research asks how we can build algorithms that automatically improve with experience, taking into account the fundamental laws that define this process.
  - Recent advances have increased the impact on many areas of society, science, medicine, and everyday life.
- Our research covers a wide range of topics, from general AI such as adaptive problem solving, heuristic search, or multi-agent systems, to diverse machine learning areas, such as natural language processing and data streams. We also have interests in geospatial data mining, Bayesian and reinforcement learning, ensembles, recommender systems, matrix factorization, equation discovery, fairness in machine learning, multi-label classification, adversarial learning, and privacy.

Computational Biology

- Researchers in computational biology specialise in creating computational models of living systems and fitting them to real data. We develop state of the art software for probabilistic modelling of genomic data and other evolving systems.
- Our interests span topics such as the origins of life and artificial life, genomic sequence analysis, representing and reasoning about biological knowledge, the evolution and spread of infectious diseases, and the theoretical aspects of phylogenetics and networks.

Computer Networks, Internet & Mobile Computing

- We investigate research questions at every layer of the communication stack, from coding at the physical layer via data link layer protocols in edge networks to the coding of satellite links at the network and transport layers.
- We develop frameworks for mobile apps and security at the application layer and measure network user behaviour on a global scale. In our research, we address fundamental questions and concrete problems in the communications industry.

Computer Vision & Computer Graphics

- The fields of computer vision and computer graphics deal with the acquisition, processing, analysis and rendering of visual information in different representations such as images, videos, volumetric data, and 3D models. This includes disciplines such as image processing, medical imaging, video processing, pattern recognition, visualisation, virtual and augmented reality, computer games, and includes aspects of HCI and ML.
- Computer vision mimics human vision with computational techniques and explores challenging tasks such as recognition, localisation and mapping of individual objects of interest, scene characterisation, and integrative scene understanding, to mention a few. Researchers in this field focus on areas of particular relevance to NZ, especially in critical sectors such as forestry, farming, health, marine science and environmental conservation.
- Computer graphics involves the generation, rendering, and use of 3D representations. Researchers in this field are particularly interested in 3D modelling (procedural, sketch-based, image-based), serious games (for education and health interventions), innovative AR/VR solutions (for training, education, skill development), scientific and biomedical visualisation, and effective applications (e.g. in robotics).

Computing Education

- Computers play an increasingly important role in modern education as tools to communicate knowledge, engage students in active learning, and facilitate collaboration.
- Our research explores how novices learn to program, differences between programming languages and environments used in computer science education, cybersecurity education, visualisation of computing concepts, curriculum design and delivery, attitudes and diversity in the computing classroom.
- We also design, build and evaluate a range of different educational technologies and explore how computer software can enhance traditional education practice, including educational games, mobile learning and tools that support collaboration.

Cybersecurity

- Our research develops ways to assure the privacy and security of individuals and enterprises in the cyber world. When designing secure systems, we follow a holistic approach, covering both theoretical and practical aspects.
- We have wide-ranging interests and expertise in cybersecurity, including blockchain and IoT security, privacy-preserving systems, security extensions of Android, steganographic protocols, encrypted search, secure cloud services, privacy patterns, access control systems, network security, software obfuscation, online privacy, consent management, autonomic middleware, and digital forensics.

Human-Computer Interaction

- Human-Computer Interaction (HCI) combines methods from computer science, mathematical-technical sciences, behavioural sciences and design to study and develop new interactions and experiences.
- Advances in HCI have dramatically shaped computing, from the invention of the mouse to interactivity in nearly every facet of our modern existence. Smartphones and watches, voice assistants, social media, and computers in everything from cars to thermostats to refrigerators are just some of the examples of HCI in modern life.
- Our research covers topics such as multitasking, affective interaction, gesture interaction, brain interfaces, eye-gaze interaction, games, and augmented and virtual reality applications for immersive, embodied experiences and wellbeing.

Parallel & Distributed Computing

- The design and implementation of a parallel and distributed system may involve the development, utilisation and integration of techniques in computer networks, software and hardware.
- We have a focus on parallel and distributed algorithms or protocols and their fundamental principles. Our research aims to contribute to breakthrough advancements for computer architectures and networked computer systems and so support the practical development of future and emerging ICT applications.

Software Engineering

- Software engineering research seeks to improve the efficiency of software system construction while maintaining or improving quality.
- Efficiency covers such things as the time to completion, the cost of completion and resource requirements, such as staff. Quality considers areas of functional correctness, code readability, design quality, short-term and long-term maintainability, reusability, return on investment, and staff satisfaction and effectiveness.
- Our research covers a range of artefacts, including the source code that makes up the software system, the requirements, documentation, and test plans. It encompasses the software development environment, such as the tools and processes used, and the people involved. We also investigate how to determine the quality of the software system and the efficiency of the development practices used.

Theoretical Computer Science

- Our areas of interest include automata theory, computational complexity, computability and randomness, design and analysis of algorithms, quantum information theory and unconventional models of computation.
- Related research covers a range of subjects areas such as biology, combinatorics, data science, logic, and theoretical physics.

Summary

- Research grows the knowledge of the world
  - Can benefit humanity, a nation, or just a company
- Auckland is highly ranked with famous researchers
  - Top in NZ
  - Very competitive internationally
- 10 major research areas are promoted by the school