Will Browne

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Dr Browne's research focuses on applied cognitive systems, including learning classifier systems, cognitive robotics and modern heuristics for industrial application. His blue-skies research includes analogues of emotions, abstraction, memories, small-worlds phenomenon, dissonance and machine consciousness. Important research goals are transferring learnt knowledge from simple to more complex problems, changing robotic behaviour based on environmental needs and applying intelligent orthotics to patient rehabilitation.

Dr Browne served as track co-chair of Genetics-Based Machine Learning for the Genetic and Evolutionary Computation Conference (GECCO). He was editor-in-chief for the Australasian Conference on Robotics and Automation 2012. He is a Chartered Engineer, member of the ACM SIGEVO group and has published over 75 academic papers.

Dr Browne's specific research topics include:

- *Scalable learning systems*
  Scalable learning systems enable knowledge learnt in one problem to be transferred to a more complex or related problem (see story on reverse).

- *Robots with emotions*
  Building robots that can change their behaviour according to their situation is a key research challenge. To achieve this, Dr Browne is trying to give his robots artificial emotions that will allow them to alter their reactions.

  "With robots, it's not about falling in love or experiencing mood swings. Instead we're focused on the affective change so the robot can alter its behaviour, making it much more adaptable," says Dr Browne. "The robot needs to be able to navigate an unfamiliar environment without having seen it before—it's about giving them the adaptability to cope with the uncertainties in the world."

- *Rehabilitation Devices*
  Dr Browne's robotics research has also been in the area of stroke rehabilitation technology. The team has designed and built a tool for rehabilitating the hands of people who have had a stroke.

Will Browne's work allows robots to share learnt knowledge.

  "The device exercises a person's hand in order to help them regain control of their hand movements. It then creates resistance against the user's movements, allowing them to build up muscle strength," says Dr Browne.

- *Cognitive Robotics*
  Dr Browne's cognitive systems work aims to give robots the tools to find their way around an area and then remember an internal map. The system means the robot learns the most efficient way to get from A to B. It would allow them to explore unstructured environments, such as collapsed buildings, and potentially assist in rescuing people more quickly.

To find out more about Dr Browne's research, please contact him directly by calling **+64-4-463 5233 x8489** or emailing him at **will.browne@vuw.ac.nz**

Enabling machines to transfer learning to new problems

"Machine learning (ML) has started to have fantastic real-world successes, but there is a step towards human-like performance that has yet to be completed," says Dr Browne. "We are finding new ML techniques that can transfer knowledge learnt in one problem to another more complex or related problem."

Dr Browne is recognised internationally in the field of Learning Classifier Systems (LCS), being elected by his peers to co-organise the International Workshop on Learning Classifier Systems and contracted to produce the first textbook on LCS. LCS are a branch of evolutionary computation that learn human-readable rules from interaction with data.

- *Making learning validatable by humans*

Other machine learning systems have explored mechanisms for transfer learning, but they lack modularity and the ability for humans to validate the knowledge. LCS are cooperative in nature with rules that humans can read. These rules cover as much of the problem as possible, with a consistent prediction of environmental interaction, while avoiding redundancy and irreleveance.

- *Abstraction and scalable learning*

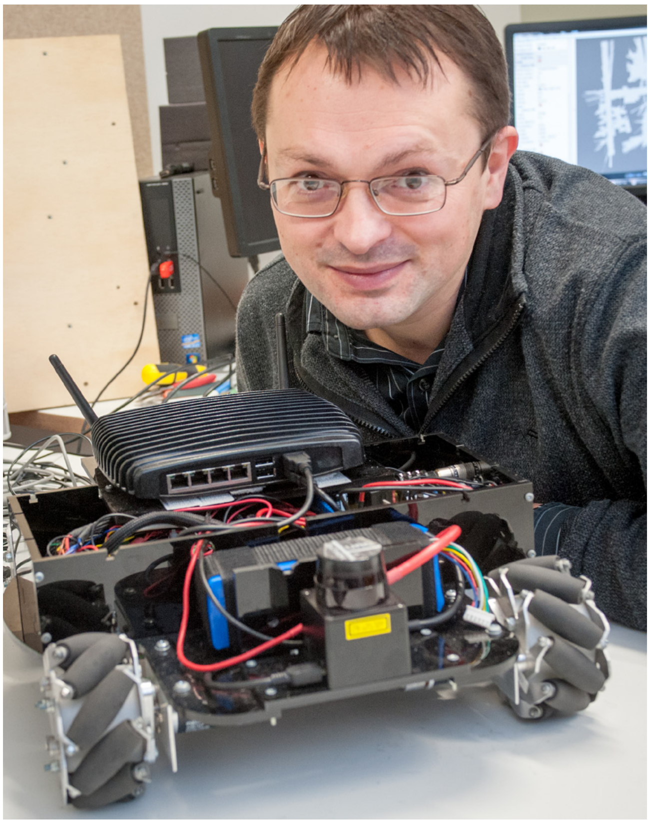
Dr Browne has helped pioneer the use of LCS in two areas: abstraction learning, where valuable patterns are established from learnt knowledge, and scalable learning, where building blocks of information are re-used to improve performance in more complex domains.

- *LCS success drivers*

There are two main reasons why LCS are more successful at transfer learning than other techniques:

1. Solutions to complex problems often have many components that do not lie in the same area of solution space. This makes it difficult to identify all parts of the solution simultaneously. LCS are cooperative and niche-based, so can maintain and develop the different parts of the solution separately.

2. LCS identify regions of interest in a problem domain in a general manner. These then form the basis of equivalent regions in harder problems. Hence, search does not restart for each problem, unlike in tabula rasa-based machine learning approaches.



Will's machine learning robot platform

- *Solving very large problems*

"Our pilot study on using these properties of LCS identified and shared information to solve problems that were previously intractable," says Dr Browne. "We were able to solve the 135 bit multiplexer problem where the optimum rules were identified from a space of 10e+40 possible rules."

- *Related expertise*

Dr Browne's expertise in cognitive agents, especially applied to robotics, complements the LCS work. His highlights include being co-author of the Cognitive Robotics chapter in the Encyclopedia of Complexity and System Science and a guest editor for IEEE Robotics and Automation Magazine special issue on Cognitive Robotics.

- *Other application opportunities*

Other applications of human-readable learning systems include data mining, knowledge discovery and control of complex systems. Please contact Dr Browne to explore partnership opportunities in these research areas.