

# Shane Legg

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Curriculum Vitæ

Full Name: Shane Legg  
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## Motivation

I am interested in the mathematics of learning, prediction and control. Sophisticated algorithms are increasingly being applied in many areas, including bio-informatics, finance, advertising and information retrieval. In coming decades I expect that further advances in machine learning algorithms and computer hardware will continue to drive this trend, and open up important new applications.

## Education

### **2007 – Present: Post Doctorate at the Swiss Finance Institute University of Lugano and University of St. Gallen, Switzerland**

My post doctoral research is being supervised by Prof. Enrico De Giorgi and Prof. Fabio Trojani. I am currently exploring whether methods from dynamic programming can be used to study the effect of cognitive bias in portfolio selection models.

### **2003 – 2007: PhD in Computer Science Dalle Molle Institute for Artificial Intelligence (IDSIA) University of Lugano, Switzerland**

My PhD supervisor, Prof. Marcus Hutter, developed a mathematical model of optimal machine intelligence, called AIXI. Essentially, AIXI takes Solomonoff's model of universal prediction and adds sequential decision theory to produce an optimal agent for general environments. My research focused on developing aspects of this theory further, in particular: understanding the classes of environments for which AIXI converges to optimal, exploring a related measure of machine intelligence, and studying the implications for constructive theories of sequence prediction.

One of my most interesting results was to prove that although extremely powerful sequence prediction algorithms exist, mathematical analysis is unable to reveal any of these algorithms due to Gödel incompleteness. This places a fundamental limit on the performance of provably correct prediction algorithms. During my PhD I also published papers on reinforcement learning, diversity control in evolutionary algorithms and algorithmic probability theory.

### **1996: Master of Science in Mathematics and Statistics Auckland University, New Zealand**

I completed my Masters degree under the complexity theorist Prof. Cristian Calude. My dissertation was a reworking of the proofs behind Solomonoff induction: an optimal universal model of sequence prediction based on Kolmogorov complexity theory. It can be shown to generalise many standard statistical techniques such as maximum likelihood, minimum description length, maximum entropy and Bayesian methods. I also worked on the existence of finite bounds on the number of cases that need to be checked in order to either prove or disprove mathematical problems.

### **1992 – 1995: Bachelor of Computer and Mathematical Sciences Waikato University, Hamilton, New Zealand**

My area of specialisation was mathematics and statistics, in particular mathematical economics. During my degree I also worked part time for the computer science department on the WEKA machine learning project under Prof. John Cleary. My research concerned the creation of complexity measures to evaluate the performance of machine learning algorithms using the minimum description length principle.

## Work Experience

**2002 – 2003: Senior Software Engineer**  
**Adaptive Intelligence**  
**Wellington, New Zealand and Los Angeles, USA**

Adaptive Intelligence is a small artificial intelligence company based in Los Angeles. The company is creating a complex neural network system that consists of many sub-networks with different structures and dynamics. I worked on the design and coding of various things including distributing the system across multiple machines, optimising the efficiency of the neural network, and designing tests to measure the learning and prediction performance of the system. Working remotely from New Zealand was not ideal and so I left to pursue a PhD in artificial intelligence.

**1999 – 2001: Senior Software Engineer**  
**Webmind Corporation**  
**Hamilton, New Zealand and New York, USA**

Webmind was an artificial intelligence research company with around 100 employees in four countries, including 20 PhDs. I started at the Hamilton, New Zealand office where our focus was topical text classification and sentiment analysis using natural language processing and machine learning. Our system was used for various applications including document classification for internet companies and newspapers, and as input to a financial prediction system.

Due to the need for a mathematician in the head office, in mid 2000 I transferred to New York. I worked mainly on the design and testing of a probabilistic reasoning system and also advised on the application of machine learning algorithms. After a year in New York a number of our core customers went under, which in turn forced Webmind to close.

**1997 – 1999: Analyst Programmer**  
**Freightways Information Services**  
**Auckland, New Zealand**

Freightways Information Services provides IT services to the largest courier and document processing companies in New Zealand. My work involved the development of a variety of applications using Cognos Powerhouse and SQL on HP3000 mini computers as well as Java and Visual Basic development on Windows. I worked on the development of several data warehouses and associated front end reporting systems, scripting and validating the year 2000 migration of the core databases, and developing a suite of cross company customer analysis tools.

## Publications

### Dissertations

S. Legg. Machine super intelligence. PhD thesis. Department of Informatics, University of Lugano, Switzerland, 2008.

S. Legg. Solomonoff induction. CDMTCS-030, Centre for Discrete Mathematics and Theoretical Computer Science, University of Auckland, 1997.

### Journal Papers and Book Chapters

S. Legg, J. Poland and T. Zeugmann. On the limits of learning with computational models. In *Knowledge Media Science. To appear 2008*.

S. Legg and M. Hutter. Universal intelligence: A definition of machine intelligence. In *Minds and Machines*, pages 391–444, volume 17, number 4, November 2007.

M. Hutter, S. Legg and P. Vitányi. Algorithmic probability theory. In *Scholarpedia*, page 19046, August 2007.

M. Hutter and S. Legg. Fitness uniform optimization. *IEEE Transactions on Evolutionary Computation (IEEE-TEC)*, pages 568–589, 10(5), October 2006.

C. S. Calude, H. Jürgensen, and S. Legg. Solving finitely refutable mathematical problems. In C. S. Calude and G. Puaun, editors, *Finite Versus Infinite: Contributions to an Eternal Dilemma*, pages 39–52. Springer-Verlag, London, 2000.

### Conference Papers

M. Hutter and S. Legg. Temporal difference updating without a learning rate. In *Neural Information Processing Systems (NIPS '07)*, 2008.

S. Legg and M. Hutter. Tests of Machine Intelligence. In *Proc. 50th Anniversary Summit of Artificial Intelligence*, Monte Verità, Switzerland. 2007.

S. Legg and M. Hutter. A collection of definitions of intelligence. In B. Goertzel, editor, *Proc. 1st Annual artificial general intelligence workshop*, 2006.

S. Legg. Is there an elegant universal theory of prediction? In *Proc. 17th International Conf. on Algorithmic Learning Theory (ALT'06)*, Barcelona, 2006.

S. Legg and M. Hutter. A formal measure of machine intelligence. In *Proc. Annual machine learning conference of Belgium and The Netherlands (Benelearn-2006)*, Ghent, 2006.

S. Legg and M. Hutter. Fitness uniform deletion for robust optimisation. In *Proc. Genetic and Evolutionary Computation Conference (GECCO'05)*, pages 1271–1278, Washington, OR, 2005. ACM SigEvo.

S. Legg, M. Hutter, and A. Kumar. Tournament versus fitness uniform selection. In *Proc. 2004 Congress on Evolutionary Computation (CEC'04)*, pages 2144–2151, Portland, OR, 2004. IEEE.

J. G. Cleary, S. Legg, and I. H. Witten. An MDL estimate of the significance of rules. In *Information, Statistics and Induction in Science*, pages 43–45, 1996.

S. Legg. Minimum information estimation of linear regression models. In *Information, Statistics and Induction in Science*, pages 103–111, 1996.

T. C. Smith, I. H. Witten, J. G. Cleary, and S. Legg. Objective evaluation of inferred context-free grammars. In *Australian and New Zealand Conference on Intelligent Information Systems*, pages 393–396, 1994.

### Conference Posters

S. Legg. A formal definition of intelligence for artificial systems. In *Proc. 50th Anniversary Summit of Artificial Intelligence*, Monte Verità, Switzerland, July 2006.

S. Legg. Incompleteness and artificial intelligence. In *Collegium Logicum of the Kurt Gödel Society*, Vienna, April 2006.

S. Legg and M. Hutter. A universal measure of intelligence for artificial agents. In *Proc. 21st International Joint Conf. on Artificial Intelligence (IJCAI-2005)*, Edinburgh, 2005.

## Grants and awards

2008 Swiss National Science Foundation Grant for Young Researchers.  
Value CHF 88,800 = US \$87,500

Singularity Institute for Artificial Intelligence Canada Academic Prize for 2008.  
Value CDN 10,000 = US \$10,000

## Press coverage of my research

C. Fiévet. Mesurer l'intelligence d'une machine. In *Le Monde de l'intelligence*, pages 42–45, issue 1, November 2005.

D. Graham-Rowe. Spotting the bots with brains. In *New Scientist magazine*, page 27, issue 2512, 13 August 2005.

## I review submissions for:

- Journal of Machine Learning Research (JMLR)
- IEEE Transactions on Evolutionary Computation (IEEE-TEC)
- Science of Computer Programming Journal (SCP)
- Neural Information Processing Systems (NIPS)
- Computational Learning Theory (COLT)
- Algorithmic Learning Theory (ALT)
- Genetic and Evolutionary Computation Conference (GECCO)
- Congress of Evolutionary Computation (CEC)
- Scholarpedia