

# Deep Reasoning and Thinking beyond Deep Learning by Cognitive Robots and Brain-Inspired Systems

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**Abstract** — Recent basic studies reveal that AI problems are deeply rooted in both the understanding of the natural intelligence and the adoption of suitable mathematical means for rigorously modeling the brain in machine understandable forms. Learning is a cognitive process of knowledge and behavior acquisition. Learning can be classified into five categories known as object identification, cluster classification, functional regression, behavior generation, and knowledge acquisition. A fundamental challenge to knowledge learning different from the deep and recurring neural network technologies has led to the emergence of the field of cognitive machine learning on the basis of recent breakthroughs in denotational mathematics and mathematical engineering. This keynote lecture presents latest advances in formal brain studies and cognitive systems for deep reasoning and deep learning. It is recognized that key technologies enabling cognitive robots mimicking the brain rely not only on deep learning, but also on deep reasoning and thinking towards machinable thoughts and cognitive knowledge bases built by a cognitive systems. A fundamental theory and novel technology for implementing deep thinking robots are demonstrated based on concept algebra, semantics algebra, and inference algebra.

**Keywords** — Cognitive informatics, cognitive computers, cognitive robotics, brain-inspired systems, deep learning, deep reasoning, deep thinking, knowledge learning, denotational mathematics, mathematical engineering

## ABOUT THE KEYNOTE SPEAKER

**Yingxu Wang** is professor of cognitive informatics, brain science, software science, and denotational mathematics. He is President of International Institute of Cognitive Informatics and Cognitive Computing (ICIC, <http://www.ucalgary.ca/icic/>). He is a



Fellow of ICIC, a Fellow of WIF (UK), a P.Eng of Canada, and a Senior Member of IEEE and ACM. He is/was visiting professor (on sabbatical leave) at Oxford University (1995), Stanford University (2008 | 2016), UC Berkeley (2008), and MIT (2012), respectively. He received a PhD in Computer Science from the Nottingham Trent University in 1998 and has been a full professor since 1994. He is the founder and steering committee chair of the annual IEEE International Conference on Cognitive Informatics and Cognitive Computing (ICCI\*CC) since 2002. He is founding Editor-in-Chief of *Int'l Journal of Cognitive Informatics & Natural Intelligence*, founding Editor-in-Chief of *Int'l Journal of Software Science & Computational Intelligence*, Associate Editor of *IEEE Trans. on SMC - Systems*, Editor-in-Chief of *Journal of Advanced Mathematics & Applications*, and Editor-in-Chief of *Journal of Mathematical & Computational Methods*.

Dr. Wang is the initiator of a few cutting-edge research fields such as cognitive informatics, denotational mathematics (concept algebra, process algebra, system algebra, semantic algebra, inference algebra, big data algebra, fuzzy truth algebra, fuzzy probability algebra, fuzzy semantic algebra, visual semantic algebra, and granular algebra), abstract intelligence ( $\alpha I$ ), the neural circuit theory, mathematical models of the brain, cognitive computing, cognitive learning engines, cognitive knowledge base theory, and basic studies across contemporary disciplines of intelligence science, robotics, knowledge science, computer science, information science, brain science, system science, software science, data science, neuroinformatics, cognitive linguistics, and computational intelligence. He has published 400+ peer reviewed papers and 30 books in aforementioned transdisciplinary fields. He has presented 31 invited keynote speeches in international conferences. He has served as general chairs or program chairs for more than 20 international conferences. He is the recipient of dozens international awards on academic leadership, outstanding contributions, best papers, and teaching in the last three decades. He is a top 2.5% scholar worldwide according to the big data system of Research Gate's international stats.