

On Theoretical Foundations of Human and Robot Vision

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Abstract — A set of cognitive, neurological, and mathematical theories for human and robot vision has been recognized that encompasses David Hubel's *hypercolumn vision theory* (The Nobel Prize in Physiology or Medicine 1981 [1]) and Dennis Gabor's *wavelet filter theory* (The Nobel Prize in Physics 1971 [2]).

This keynote lecture presents a theoretical framework of the *Cognitive Vision Theory* (CVT) [3-6] and its neurological and mathematical foundations. A set of *Intelligent Mathematics* (IM) [7-13] and formal vision theories developed in my laboratory is introduced encompassing *Image Frame Algebra* (IFA) [3], *Visual Semantic Algebra* (VSA) [4], and the *Spike Frequency Modulation* (SFM) theory [5]. IM is created for enabling cognitive robots to gain autonomous vision cognition capability supported by Visual Knowledge Bases (VKBs). Paradigms and case studies of robot vision powered by CVTs and IM will be demonstrated. The basic research on CVTs has led to new perspectives to human and robot vision for developing novel image processing applications in AI, neural networks, image recognitions, sequence learning, computational intelligence, self-driving vehicles, unmanned systems, and robot navigations.

Keywords — AI, computer vision, image processing, neuroinformatics, Hubel hypercolumns, Gabor filters, image frame algebra, visual semantic algebra, cognitive robots, brain-inspired systems

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ABOUT THE KEYNOTE SPEAKER



Dr. Yingxu Wang is professor of cognitive systems, brain science, software science, and intelligent mathematics. He is the founding President of International Institute of Cognitive Informatics and Cognitive Computing (I2CICC). He is FIEEE, FBCS, FI2CICC, FAAIA, and FWIF. He has held visiting professor positions at Univ. of Oxford (1995, 2018-22), Stanford Univ. (2008, 16), UC Berkeley (2008), MIT (2012), and distinguished visiting professor at Tsinghua Univ. (2019-22). He received a PhD in Computer Science from the Nottingham Trent University, UK, in 1998 and has been a full professor since 1994. He is the founder and steering committee chair of IEEE Int'l Conference Series on Cognitive Informatics and Cognitive Computing (ICCI*CC) since 2002. He is founding Editor-in-Chiefs and Associate Editors of 10+ Int'l Journals and IEEE Transactions. He is Chair of IEEE SMCS TC-BCS on Brain-inspired Cognitive Systems, and Co-Chair of IEEE CS TC-CLS on Computational Life Science. His basic research has been across contemporary science disciplines of intelligence, mathematics, knowledge, robotics, computer, information, brain, cognition, software, data, systems, cybernetics, neurology, and linguistics. He has published 600+ peer reviewed papers and 38 books/proceedings. He has presented 62 invited keynote speeches in international conferences. He has served as honorary, general, and program chairs for 39 international conferences. He has led 10+ international, European, and Canadian research projects as PI. He is recognized by Google Scholar as world top 1 in Software Science, top 1 in Cognitive Robots, top 7 in Autonomous Systems, top 2 in Cognitive Computing, and top 1 in Knowledge Science with h-index 61. He is recognized by Research Gate as among the world's top 2.5% scholars with read-index 406,000+.