Basic Research on Machine Vision
Underpinned by Image Frame Algebra (VFA) and Visual Semantic Algebra (VSA)

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Abstract

Computer vison [1], [2], [3], [4], [5] studies properties of machine vision, its semantic understanding, and general manipulations by *Intelligent Mathematics* (IM) [6], [7], [8], [9], [10] [11], [12], [13], [14], [15] [16], [17]. Computer vison has been studies from various aspects such as *algorithmic methods*, *analysis methods*, *pattern recognitions*, and *neural-network-regression* (AI) technologies [2], [3]. However, there is a lack of fundamental theories for enabling autonomous image recognition and processing by machines. Basic research on contemporary IM has revealed that formal manipulations of visual objects by intelligent machines may be rigorously implemented by *Image Frame Algebra* (*IFA*) [8], [18] in the front-end and *Visual Semantic Algebra* (*VSA*) [19] in the back-end. IFA formally manipulates visual images as general 2D matrixes by a set of algebraic operators such as modeling, analyses, syntheses, feature elicitation, and pattern recognition [4], [5], [18]. Then, its counterpart, VSA, transforms the geographic relations of visual objects to their semantic interpretations by algebraic analyses and compositions. The coherent theory of IFA and VSA provides a formal methodology for machine-enabled image processing and comprehension.

This keynote presents a theoretical framework of machine vision underpinned by IFA and VSA for the structural denotations of visual objects and functional manipulations of visual mechanisms [3], [8], [9]. It demonstrates how the persistent challenges to machine vision may be rigorously and efficiently solved by the IFA/VSA methodology. Case studies on applying IFA/VSA for rigorous visual pattern detection, recognition, analysis, and composition in real world will be demonstrated [5], [18], [20]. As two coherent paradigms of IM, among others [21], [22], [23], [24], [25] [26], [27], [28], [29], [30], IFA and VSA have been applied not only in robot visual and spatial reasoning, but also in computational intelligence and AI for rigorously representing and manipulating of visual objects and patterns by machine recognition and cognition [31], [32], [33], [34], [35] [36], [37], [38], [39], [40], [41], [42], [43], [44], [45] [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65] [66], [67], [68], [69], [70], [71], [72], [73], [74], [75] [76].

***Keywords* —** *Intelligence science, computer vision, visual intelligence, AI, theoretical foundations, intelligent mathematics (IM), image frame algebra (IFA), visual semantic algebra (VSA), autonomous AI (AAI), applications.*

ABOUT THE KEYNOTE SPEAKER

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His basic research has spanned across contemporary scientific 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 65+ invited keynote speeches in international conferences. He has served as honorary, general, and program chairs for 40+ 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 8 in *Autonomous Systems*, top 2 in *Cognitive Computing*, and top 1 in *Knowledge Science* with an *h*-index 66. He is recognized by ResearchGate as among the world's top 1.0% scholars in general and in several contemporary fields encompassing artificial intelligence, autonomous systems, theoretical computer science, engineering mathematics, software engineering, cognitive science, information science, and computational linguistics. He has published formal proofs for two of the world's top ten hardest mathematical problems known as the *Goldbach conjecture* and *Twin-Prime conjecture* in 2022.

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