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ABSTRACTS

1. Modelling Underwater Structures

Michael Jenkin, Andrew Hogue, Andrew German, Sunbir Gill, Anna Topol, and Stephanie Wilson

For systems to become truly autonomous, it is necessary that they be able to interact with complex real-world environments. In this article, we investigate techniques and technologies to address the problem of the acquisition and representation of complex environments such as those found underwater. The underwater environment presents many challenges for robotic sensing including highly variable lighting and the presence of dynamic objects such as fish and suspended particulate matter. The dynamic six-degree-of-freedom nature of the environment presents further challenges due to unpredictable external forces such as current and surge. In order to address the complexities of the underwater environment, we have developed a stereo vision-inertial sensing device that has been successfully deployed to reconstruct complex 3-D structures in both the aquatic and terrestrial domains. The sensor combines 3-D information, obtained using stereo vision, with 3DOF inertial data to construct 3-D models of the environment. Semiautomatic tools have been developed to aid in the conversion of these representations into semantically relevant primitives suitable for later processing. Reconstruction and segmentation of underwater structures obtained with the sensor are presented.

Keywords: autonomous robots; modeling; sensing

2. Formal RTPA Models for a Set of Meta-Cognitive Processes of the Brain

Yingxu Wang

The cognitive processes modeled at the metacognitive level of the layered reference mode of the brain (LRMB) encompass those of object identification, abstraction, concept establishment, search, categorization, comparison, memorization, qualification, quantification, and selection. It is recognized that all higher layer cognitive processes of the brain rely on the metacognitive processes. Each of this set of fundamental cognitive processes is formally described by a mathematical model and a process model. Real-time process algebra (RTPA) is adopted as a denotational mathematical means for rigorous modeling and describing the metacognitive processes. All cognitive models and processes are explained on the basis of the object-attribute-relation (OAR) model for internal information and knowledge representation and manipulation.

Keywords: abstraction; brain model; categorization; cognitive processes; computational intelligence; comparison; concept algebra; concept establishment; denotational mathematics; LRMB; mathematical model; object identification; OAR; process model; qualification; quantification; RTPA

3. Foundations of Nonconventional Neural Units and their Classification

Ivo Bukovsky, Zeng-Guang Hou, Jiri Bila and Madan M. Gupta

This article introduces basic types of nonconventional neural units and focuses on their notation and classification. Namely, the notation and classification of higher order nonlinear neural units, time-delay dynamic neural units, and time-delay higher order nonlinear neural units are introduced. Brief introduction into the simplified parallels of the higher order nonlinear aggregating function of higher order neural units with both the synaptic and somatic neural operation of biological neurons is made. Based on the mathematical notation of neural input intercorrelations of higher order neural units, it is shown that the higher order polynomial aggregating function of neural inputs can be

understood as a single-equation representation of synaptic neural operation plus partial somatic neural operation. Thus, it unravels new simplified yet universal mathematical insight into understanding the higher computational power of neurons that also conforms to biological neuronal morphology. The classification of nonconventional neural units is founded first according to the nonlinearity of the aggregating function; second, according to the dynamic order; and third, according to time-delay implementation within neural units.

Keywords: higher order neural unit; neuron, nonlinear aggregating function; synaptic junction; somatic operation; time-delay neural unit

4. Robust Independent Component Analysis for Cognitive Informatics

Neil Gadhok and Witold Kinsner

This article evaluates the outlier sensitivity of five independent component analysis (ICA) algorithms (FastICA, Extended Infomax, JADE, Radical, and β -divergence) using (a) the Amari separation performance index, (b) the optimum angle of rotation error, and (c) the contrast function difference in an outlier-contaminated mixture simulation. The Amari separation performance index has revealed a strong sensitivity of JADE and FastICA (using third- and fourth-order nonlinearities) to outliers. However, the two contrast measures demonstrated conclusively that β -divergence is the least outlier-sensitive algorithm, followed by Radical, FastICA (exponential and hyperbolic-tangent nonlinearities), Extended Infomax, JADE, and FastICA (third- and fourth-order nonlinearities) in an outlier-contaminated mixture of two uniformly distributed signals. The novelty of this article is the development of an unbiased optimization-landscape environment for assessing outlier sensitivity, as well as the optimum angle of rotation error and the contrast function difference as promising new measures for assessing the outlier sensitivity of ICA algorithms.

Keywords: higher order statistics; independent component analysis; outliers; robust statistics

5. Human Discovery and Machine Learning

Christopher Dartnell, Eric Martin, and Helene Hagege

This article studies machine learning paradigms from the point of view of human cognition. Indeed, conceptions in both machine learning and human learning evolved from a passive to an active conception of learning. Our objective is to provide an interaction protocol suited to both humans and machines to enable assisting human discoveries by learning machines. We identify the limitations of common machine learning paradigms in the context of scientific discovery, and we propose an extension inspired by game theory and multiagent systems. We present individual cognitive aspects of this protocol as well as social considerations, and we relate encouraging results concerning a game implementing it.

Keywords: discovery science; Eleusis+Nobel; epistemology; logic; machine learning

6. On Cognitive Properties of Human Factors and Error Models in Engineering and Socialization

Yingxu Wang

Human factors are the most predominated factors in all systems where humans are part of the systems. Human traits and needs are the fundamental force underlying almost all phenomena in human task performances, engineering organizations, and socialization. This article explores the cognitive foundations of human traits and cognitive properties of human factors in engineering. A comprehensive set of fundamental traits of human beings are identified, and the hierarchical model of basic human needs is formally described. The characteristics of human factors and their influences in engineering organizations and socialization are explored. Based on the models of basic human traits, needs, and their influences, driving forces behind the human factors in engineering and society are revealed. A formal model of human errors in task performance is derived, and case studies of the error model in software engineering are presented.

Keywords: Cognitive informatics; engineering applications; human factors; hybrid systems; inspection; management; model of hierarchical needs; model of human errors; personality; principle of reviews; quality assurance; socialization; traits

7. A Computational Cognitive Model of the Brain

Zhiwei Shi, Hong Hu, and Zhongzhi Shi

Recent fruitful progresses on brain science have largely broadened our understanding of the cerebrum. These great works led us to propose a computational cognitive model based on a graphical model that we carried out before. The model possesses many attractive properties, including distinctive knowledge representation, the capability of knowledge accumulation, active (top-down) attention, subjective similarity measurement, and attention-guided disambiguation. It also has “consciousness” and can even “think” and “make inference.” To some extent, it works just like the human brain does. The experimental evidence demonstrates that it can give reasonable computational explanation on the human phenomenon of forgetting. Although there are still some undetermined details and neurobiological mechanisms deserving consideration, our work presents a meaningful attempt to give further insights into the brain’s functions.