PHYSICS OF THE MIND

tutorial proposal

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Abstract

What is physics of the mind? Is it possible? Physics of the mind uses the methodology of physics for extending neural networks towards more realistic modeling of the mind from perception through the entire mental hierarchy including language, higher cognition and emotions. The presentation focuses on mathematical models of the fundamental principles of the mind-brain neural mechanisms and practical applications in several fields. Big data and autonomous learning algorithms are discussed for cybersecurity, gene-phenotype associations, medical applications to disease diagnostics, financial predictions, data mining in distributed data bases, learning of patterns under noise, interaction of language and cognition in mental hierarchy. Mathematical models of the mind-brain are discussed for mechanisms of concepts, emotions, instincts, behavior, language, cognition, intuitions, conscious and unconscious, abilities for symbols, functions of the beautiful and musical emotions in cognition and evolution. This research won National and International Awards.

A mathematical and cognitive breakthrough, dynamic logic is described. It models cognitive processes "from vague and unconscious to crisp and conscious," from vague representations, plans, thoughts to crisp ones. It resulted in more than 100 times improvements in several engineering applications; brain imaging experiments at Harvard Medical School, and several labs around the world proved it to be a valid model for various brain-mind processes. New cognitive and mathematical principles are discussed, language-cognition interaction, function of music in cognition, and co-evolution of music and cultures. How does language interact with cognition? Do we think using language or is language just a label for completed thoughts? Why the music ability has evolved from animal cries to Bach and Justin Bieber? I briefly review past mathematical difficulties of computational intelligence and new mathematical techniques of dynamic logic and neural networks implementing it, which overcome past limitations. Dynamic logic reveals the role of unconscious mechanisms, which will lead to revolution in psychology.

The presentation discusses cognitive functions of emotions. Why human cognition needs emotions of beautiful, music, sublime. Dynamic logic is related to knowledge instinct and language instinct; why are they different? How languages affect evolution of cultures. Language networks are scale-free and small-world, what does this tell us about cultural values? What are the biases of English, Spanish, French, German, Arabic, Chinese; what is the role of language in cultural differences?

Relations between cognition, language, and music, are discussed. Mathematical models of the mind and cultures bear on contemporary world, and may be used to improve mutual understanding among peoples around the globe and reduce tensions among cultures.

Outline

Physics methodology

First principles, testable models

The mind-brain first principles
- The mind is more powerful than algorithms
- Can we learn from the mind?

Mathematical models and experimental tests
- Big Data in “simple” perception
- Big Data in abstract concepts

Cognitive algorithms and engineering applications
- Big data, deep learning, cybersecurity, financial predictions, etc.

Mind higher abilities, models, and experimental tests
- Language, cognition, conscious and unconscious,
- The beautiful and musical emotions

Future research directions

Intended audience

Everybody interested in working of the mind. From students to professors, captivating for everyone. No special or math. knowledge is required. This wide audience is addressed by discussing the new area of science "in the making." Every few minutes discuss a new unexpected revolutionary idea in psychology, modeling of the mind, and cognitive algorithms. All ideas are explained conceptually. Mathematical details are in references.

If deemed desirable, I propose to include in course registration a new book by Academic Press, "Music: Passions and Cognitive Functions". This book addresses the entire mind from basic principles to learning mechanisms, to higher cognition (will be published in Feb-Mar, 2017).

Expected attendance number 300+

Bio

Dr. Leonid Perlovsky is Visiting Professor at Harvard University School of Engineering and Applied Science, Harvard University Medical School, Professor at Northeastern University Psychology and Northeastern University Engineering, Professor at St. Petersburg Polytechnic University, CEO LPIT, past Principal Research Physicist and Technical Advisor at the Air Force Research Laboratory (AFRL). He leads research projects on neural networks, modeling the mind and cognitive algorithms for integration of sensor data with knowledge, multi-sensor systems, recognition, fusion, languages, aesthetic emotions, emotions of the beautiful, music cognition, and cultures. He developed dynamic logic that overcame computational complexity in engineering and psychology. As Chief Scientist at Nichols Research, a $0.5B high-tech organization, he led the corporate research in intelligent systems and neural networks. He served as professor at Novosibirsk University and New York University; as a principal in commercial startups developing tools for biotechnology, text understanding, and financial predictions. His company

predicted the market crash following 9/11 a week before the event. He is invited as a keynote plenary speaker and tutorial lecturer worldwide, including most prestigious venues, such as Nobel Forum, published more than 500 papers, 20 book chapters, and 8 books, including "Neural Networks and Intellect," Oxford University Press 2001 (currently in the 3rd printing), "Cognitive Emotional Algorithms" Springer 2011, "Music: Passions and Cognitive Functions" Academic Press 2017. Dr. Perlovsky participates in organizing conferences on Neural Networks, CI, Past chair of IEEE Boston CI Chapter; serves on the Editorial Boards for ten journals, including Editor-in-Chief for "Physics of Life Reviews", IF=9.5, T-R rank #3 in the world, on the INNS Board of Governors, a past chair of the INNS Award Committee. He received National and International awards including the Gabor Award, the top engineering award from the INNS; and the John McLucas Award, the highest US Air Force Award for basic research.

Track record of this tutorial

2016 IJCNN, 400 people (full audience + huge overflow in the hall)
Previously, earlier versions at every IJCNN and at other conferences over many years