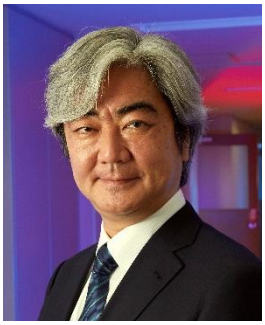

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Title

A Constructive Study of Emergence and Development of Embodied Cognition from Fetal Period

Abstract

Recently many problems are pointed out with current AI systems concerning their reliability and appropriateness. The problems have their roots on the fundamental framework as optimization of input-output systems with regard to large but limited data sets. This severely lacks essential accounts for open-ended dynamic real wold interaction and alignment to human nature.

Therefore, revealing new principles of real world human intelligence is an urgent issue. We propose that constructive investigation of the very early human development in the context of emergence and development of behaviour and cognition from embodied interaction is crucial.

Development is a continuous causal process involving complex interaction between genes, body, nervous system and environment. Although the whole process may be too complicated, fetal interaction and development can be relatively more tractable to model. From a dynamical systems point of view, the beginning part of the temporal development trajectory provides an important information about the underlying principles governing the developmental dynamics.

After explaining the nature of embodiment based on several robotic exeriments, we present our model and experiments on emergent embodied behaviour. The model consists of chaotic maps embedded in sensory-motor loops and coupled

via embodiment. Behaviours that are consistent with embodiment and adaptive to environmental structure emerge within a few seconds without any external reward or learning.

Then, our model and experiments on human foetal development are presented. A precise musculo-skeletal foetal body model is placed in a uterus model. Driven by spinal non-linear oscillator circuits coupled together via embodiment, somatosensory signals are evoked and learned by a model of cerebral cortex with 2.6 million neurons and 5.3 billion synapses (the latest version has 5.25 and 24.8, respectively). The model acquired cortical representations of self-body and multi-modal sensory integration. Also, by changing the model parameters, we can simulate "atypical" development. Our series of experiments shows that sensory-motor experiences in the fetal period can be crucial to the formation of body representations and multi-modal sensory integration, which are significantly affected under "preterm birth" conditions, providing new insights about the developmental origins of social cognition and autism spectrum disorders. The work is important as it models very early autonomous development in realistic detailed human embodiment. This approach continues on to target infant development on actual robotic platforms.

Finally, discussions on artificial development toward human-like cognition is presented including other important factors including motivation, emotion, internal organs and genetic factors.

Biography

Yasuo Kuniyoshi received Ph.D. from The University of Tokyo in 1991 and joined Electrotechnical Laboratory, AIST, MITI, Japan. From 1996 to 1997 he was a Visiting Scholar at MIT AI Lab. In 2001 he was appointed as an Associate Professor and then full Professor in 2005 at The University of Tokyo. He is also the Director of RIKEN CBS-Toyota Collaboration Center since 2012, the Director of Next Generation Artificial Intelligence Research Center of The University of Tokyo since 2016, and an affiliate member of International Research Center for Neurointelligence (IRCN) of The University of Tokyo since 2018.

He published over 300 refereed academic papers and received IJCAI 93 Outstanding Paper Award, Gold Medal "Tokyo Techno-Forum21" Award, Best Paper Awards from Robotics Society of Japan, IEEE ROBIO T.-J. Tarn Best Paper Award in Robotics, Okawa Publications Prize, and other awards.

He is a Fellow of Robotics Society of Japan and a member of IEEE, Science Council

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For further information about his research, visit http://www.isi.imi.i.u-tokyo.ac.jp/ and http://www.ai.u-tokyo.ac.jp/