Robotics and Emotion

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Robotics studies have developed at many places across the globe and explored many different approaches. Among others, Japan has been one of the leading countries promoting robotics studies, breaking new ground with establishing Human Robot Interaction as an international society and leading the world with very human-like Geminoids. In the 1940's, Masanao Toda, a founder of cognitive science in Japan, proposed a visionary robotic system to explore and understand the function of emotion as a trigger of cognitive mechanisms for survival. For example, when a human was exploring in the ancient wilderness, fear must have worked as a switch between the exploratory mode and the find-an-escape mode to promote survival. The thought-experimental robot, the Fungus Eater, seeded some of the early AI research when it was introduced to psychologists in the U.S. and the Netherlands (Toda, 2000, 1982).

In this symposium, we will look to a few of the starting points of robotics research, like that of Toda's, and explore how this has expanded to include AI and robotics researchers in Europe, particularly with emphasis on embodiment and emotion, and how this has influenced new developments of robotics research in Japan. Our aim is to explore how to extend our understandings of human cognition through the eye of robotics, allowing us to reflect upon ourselves more directly than carefully scripted experiments.

The first speaker, Rolf Pfeifer, who has once connected his work on robot's emotion to Toda's fungus eater robots, will reflect on his own and Toda's work, to foresee the future of cognitive sciences, through the development of robotics studies. The second speaker, Yuichiro Anzai, has witnessed the beginning of the raise of active cognitive sciences in the U.S. in Herb Simon's lab during the late 1970's, and actually worked with Toda at Hokkaido University, to implement Toda's ideas into robotics reality. Reflecting on his own trajectory as a cognitive scientist, reflects on Toda's work to push open new research topics under the theme of robotics and emotion. The third speaker, Hiroshi Ishiguro, as a leading robotics engineer studying human cognition through the eyes of most human-like robots like his own Geminoid, will push him further to integrate neuro-scientific studies, to gain further insights. Putting all three together, we hope to see how the topics of robotics and emotion would re-open a new research field for cognitive sciences.

Do robots need emotions? An embodied perspective

Rolf Pfeifer (University of Zurich)

Traditionally, in robotics, artificial intelligence, and neuroscience, there has been a focus on the study of the control or the neural system itself. Recently there has been an increasing interest into the notion of embodiment in all disciplines dealing with intelligent behavior, including cognitive science, psychology, philosophy, and linguistics. In an embodied perspective, cognition and emotion are conceived as emergent from the interaction of brain, body, and environment, or more generally from the relation between physical (including physiological) and information (neural, control) processes. It can be shown that through the embodied interaction with the environment, in particular through sensory-motor coordination, information structure is induced in the sensory data, thus facilitating categorization, perception and learning. The patterns thus induced depend jointly on the morphology, the material characteristics, the action and the environment. Because biological systems are mostly "soft", a new engineering discipline, "soft robotics", has taken shape over the last few

years. This is of particular interest to the fields of developmental, social and service robotics, where robots will share their living space with humans and safe and pleasant interaction is at center stage. I will analyze the different roles that emotion can play in this process. Moreover, I will discuss the far-reaching implications of embodiment, in particular of having a soft body, on our view of the mind and human behavior in general: Cognition and emotion are no longer centralized in the brain, but distributed throughout the organism. Because in "soft" systems part of the functionality is in the morphology, the physiology, and the materials, there is no longer a clear separation between control and the to-be-controlled, which implies that we need to fundamentally re-think the notion of control. These ideas will all be illustrated with case studies from biology -- humans and animals -- and robotics. Finally, I will try to establish the relation between these thoughts, Toda's "Fungus Eaters", and his theory of emotion.

From fungus-eater robots to emotional, socially interact-able robots

Yuichiro Anzai (JSPS)

Toda had been trained as a theoretical physicist before he changed his research fields into psychology. This shift contributed to free him from the burden of stereotypic academic psychological thinking, venturing into under-researched topics of emotion, not in isolated fashion but in a more integrated, general-systemic perspectives of his own. Toda's combination of the two fields has given him some unique insights on the nature of man and time. Toda believed that a system of emotions is an evolutionally organized survival mechanism with nearly optimal operating characteristics, which would explain the complexities of our social interaction, altruism, social coalition, as well as the structures of the society. As one of the closest younger colleagues with him, I will develop my own interpretation of his work, to foresee the research only possible with an engineering orientation like robotics.

Cognitive Neuroscience Robotics

Hiroshi Ishiguro (Osaka University/ATR)

Robotics is not just engineering but also human science. The current robotics focuses on *interaction* in addition to *navigation* and *manipulation* that were major topics in previous robotics. Researchers are developing interactive humanoids and androids with humans by using technologies developed in robotics and knowledge found in cognitive science and neuroscience. On the other hand, the developed robots, humanoids and androids, are important research platforms for cognitive science and neuroscience.

Thus, robotics is tightly coupled with the human sciences. For example, we can studies effects of human-like appearance in inter-personal and social situations by using androids mimicking human appearances. We can study social relationships and the dynamics among humans and robots by using multiple interactive humanoids.

We call this new robotics *cognitive robotics* or *cognitive neuroscience robotics*. This talk will introduce a series of robots developed in Osaka University and ATR and discuss cognitive experiments using then. Especially, the androids give us various insights on human-human and human-robot interactions in inter-personal and social situations.

Researchers joining to the Center Of Excellence program titled *cognitive neuroscience robotics* in Osaka University are sharing this new interdisciplinary research area and working together. This talk also introduces several topics from the program, some of which are related to the topics on studies of emotion.

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