Embodied Artificial Intelligence for Human Interaction

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Keywords: Embodiment, Mirroring, Human Robot Interactions

1. Introduction

AI-based solutions have been getting common in various fields of human activities, since advanced computing technologies such as deep learning techniques and generative AI appeared. When we turn our attention to creatures' intelligence, we see that creatures are developing their intelligence through the interaction with environments, and there all creatures are skillfully using their bodies. The entity of the body seems to restrict creature's action and perception due to the finiteness in time and space. On the other hand, the restriction of the finite body gives the creature good motivations to optimize the link of action and perception that causes development of intelligence. In this paper, the development of intelligence is overviewed from the viewpoint on physical and/or cybernetic interaction with environments, and explore a new paradigm to develop intelligence effective for both human and machines with the following two examples.

2. Developmental perception of the self and action

This section describes a developmental framework for action-driven perception in anthropomorphic robots. The key idea of the framework is that action generation develops the agent's perception of its own body and actions (Fig. 1). Action-driven development is critical for identifying changing body parts and understanding the effects of actions in unknown or non-stationary environments[(1)]. We embedded minimal knowledge into the robot's cognitive system in the form of motor synergies and actions to allow motor exploration. The robot voluntarily generates actions and develops the ability to perceive its own body and the effect that it generates on the environment. The robot, moreover, can compose this kind of learned primitives to perform complex actions and characterize them in terms of their sensory effects. After learning, the robot can recognize manipulative human behaviors with cross-modal anticipation for recovery of unavailable sensory modality, and reproduce the recognized actions afterwards. We evaluated the proposed framework in experiments with a real robot. In the experiments, we achieved autonomous body identification, learning of fixation, reaching and grasping actions, and developmental recognition of human actions as well as their reproduction (Fig. 2).

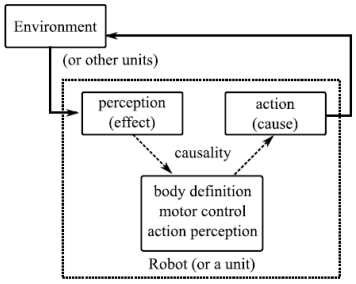


Fig. 1. Action-driven developments of the causal relation between action and perception.

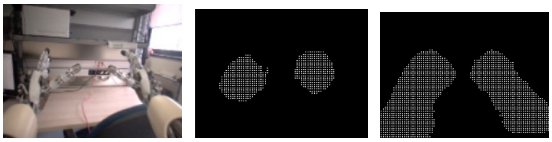


Fig. 2. Body image obtained by learning. Hand domains and forearm domains are presented.

3. Robotic measurement for walk rehabilitation

The extension of health expectancy is getting a more important subject for developed countries with higher rate of elderly population. In order to sustain their societies, aged people are encouraged to participate in the social activities, while the social participation requires them to keep their locomotive function high enough to accomplish their missions. From this reason, the easy and frequent assessment of the locomotive function thought the people's daily lives is strongly expected[(2)]. One of the promising methods to evaluate locomotive function is the Timed Up and Go test (TUG test), which is a widely used method in the field of physical therapy for locomotive rehabilitation in medical facilities (Fig. 3). Throughout our research activities, we have been investigating robotic approaches to assess cognitive and motor functions of aged people in the purpose of their health expectancy extension. In this paper, we will propose a novel method of a gait measurement system that will be incorporated with health care mobile robots developed previously. We demonstrated experiments to measure the walking patterns of 23 subjects of aged people in order to evaluate their locomotive functions using the proposed gait measurement system (Fig. 4).

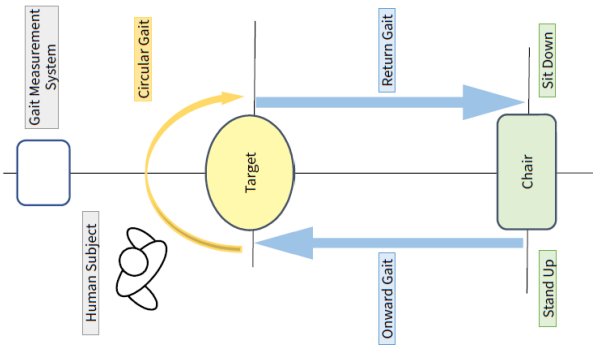


Fig. 3. A standard course used in a TUG test. The motions primitives of a single episode are presented.

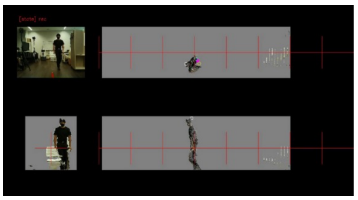


Fig. 4. 3D Visualization of walking from the front, side and top viewpoints.

4. Conclusion

The two examples of human-robot interaction were presented, where the one reviewed the developmental perception of the self and action, and the other reviewed the robotic measurement for walk rehabilitation. The first example showed that a robot could learn its own body schema and object manipulation from interaction with the environment and human. The second example showed that locomotive functions of aged people could be measured and robotic physical guidance was effective for walk rehabilitation, In the future work, the bidirectional developmental learning between human and robot will be discussed in terms of coherency in learning motivation.

Reference

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Biography



Ryo Saegusa is an associate professor at Kanagawa Institute of Technology. His research interest includes symbiotic interaction between human and machines towards coevolution.