

How does an infant acquire the ability of joint attention?: A Constructive Approach

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Abstract

This study argues how a human infant acquires the ability of joint attention through interactions with its caregiver from the viewpoint of a constructive approach. This paper presents a constructive model by which a robot acquires a sensorimotor coordination for joint attention based on visual attention and learning with self-evaluation. Since visual attention does not always correspond to joint attention, the robot may have incorrect learning situations for joint attention as well as correct ones. However, the robot is expected to statistically lose the data of the incorrect ones as outliers through the learning, and consequently acquires the appropriate sensorimotor coordination for joint attention even if the environment is not controlled nor the caregiver provides any task evaluation. The experimental results suggest that the proposed model could explain the developmental mechanism of the infant's joint attention because the learning process of the robot's joint attention can be regarded as equivalent to the developmental process of the infant's one.

1. Introduction

A human infant acquires various and complicated cognitive functions through interactions with its environment during the first few years. However, the cognitive developmental process of the infant is not completely revealed. A number of researchers (Bremner, 1994, Elman et al., 1996, Johnson, 1997) in cognitive science and neuroscience have attempted to understand the infant's development. Their behavioral approaches have explained the phenomena of the infant's development, however its mechanisms are not clear. In contrast, constructive approaches have potential to reveal the cognitive developmental mechanisms of the infant. It is suggested in robotics that the building of a human-like intelligent robot

(a) 6th month (b) 12th month (c) 18th month

Figure 1: Development of infant's joint attention

based on the insight of the infant could lead us to the understanding of the mechanisms of the infant's development (Brooks et al., 1998, Asada et al., 2001).

Joint attention with a caregiver is one of the abilities that help the infant to develop its social cognitive functions (Scaife and Bruner, 1975, Moore and Dunham, 1995). It is defined as a process that the infant attends to an object which the caregiver attends to. Owing to the ability of joint attention, the infant learns other kinds of social functions, e.g. language communication, mind reading (Baron-Cohen, 1995), and so on. On the basis of the insight, robotics researchers have attempted to build the mechanisms of joint attention for their robots (Breazeal and Scassellati, 2000, Scassellati, 2002, Kozima and Yano, 2001, Imai et al., 2001). However, their mechanisms of joint attention were fully-developed by the designers in advance, and it was not argued how the robot can acquire such an ability of joint attention through interactions with its environment.

Butterworth and Jarrett (1991) suggested that the infant develops the ability of joint attention in three stages: ecological, geometric, and representational stages. In the first stage, the infant at the 6th month has a tendency to attend to an interesting object in

