Incremental Aquisition of Compositional Schemata based on Behavioral Learning

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Piaget described an infant's developmental learning process by using the term "schema". The schema system is characterized by its distributed architecture and dynamic adaptability. The basic adaptation in the schema system consists of a pair of universal dynamics: assimilation and accommodation (Flavell, 1963). How we can describe the development of the schema system computationally is a challenging problem (Sirois and Shultz, 2003). If we can construct such a computational model, we will be able to understand an infant 's development deeper, and we will also be able to create developmental robots.

In this poster session, we are presenting a developmental learning architecture, the dual-schemata model, inspired by Piaget's schema system. An infant constructs its schemas through its interactions with its physical environments, especially in its sensory-motor period. Through the developmental process, not only perceptional experiences but also behavioral experiences perform important roles. Therefore, the schema formation process must include behavioral learning. The dual-schemata model illustrates such a schema construction proesses.

The dual-schemata model has two types of modules: perceptional and intentional schemas. Perceptional schemas become representing concepts of environments or objects through interaction with the agent's environment. In contrast, intentional schemas become representing concepts of several behaviors. At first, the dual-schemata model has only a pair of schemas, a perceptional schema and an intentional schema. However, when the dual-schemata model finds phasic changes in its environment, the dual-schemata model decides not to assimilate the novel experiences to existing schemas but to allocate a new schema. The new schema assimilates incoming experiences and accommodates itself by using the experiences. Perceptional schemas perform model learning, and intentional schemas perform reinforcement learning. The dual-schemata model is different as a whole learning architecture because the learning

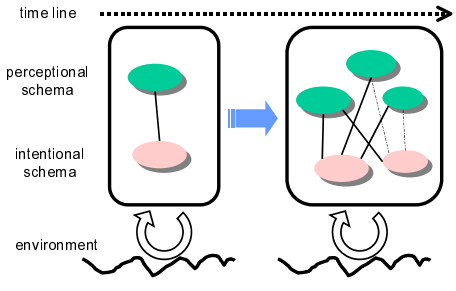

Figure 1: Abstract figure of emerging schemas in the dual-schemata model

modules, i.e. schemas, are managed by the assimilation and accommodation rules described above, so the dual-schemata model can construct distributed schemas that represent sensory-motor memories automatically (Fig. 1). We'll give the concrete examples and the mathematical formulation of the dual-schemata model on our poster.

After acquisition, intentional schemas and perceptional schemas can be combined arbitrarily. If an agent acquires the two perceptional schemas representing "on slope" and "on flat" environments, by performing "to circulate a ball on a table", which was acquired in an intentional schema, and "to balance a ball at the center of a table" which was learned in the "on flat" environment, the agent can connect the "on slope" perceptional schema to the "to balance a ball at the center of a table" intentional schema. This means the agent can balance a ball at the center of a table on a slope.

We evaluated this learning architecture in a simulation experiment to demonstrate an agent can acquire several schemas as described above.

References

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