Adaptive Behavior Observed in Stepping-Over An Obstacle

Kentaro Kodama (Kanagawa University, kkodama@kanagawa-u.ac.jp)
Kazuhiro Yasuda (Waseda University)
Kohei Sonoda (Ritsumeikan University)

Keyword
Affordance, Dynamical systems approach, Synergy, Adaptation, Obstacle avoidance

The present study aims to describe the dynamics of a human adaptive behavior, stepping-over an obstacle to avoid a contact or collision in various environments. The purpose of our preliminary study is to investigate how stepping-over behavior changes depending on the height of the obstacle. Our study is based on the theoretical framework of affordance theory in ecological psychology and the dynamical systems approach (DSA) based on self-organization theory.

According to affordance theory, in order to act safely and adequately in the environment, animals must accurately perceive the relationship between environmental properties and their own body properties. In other words, environmental properties are scaled by individual animals' body properties and animals perceive them based on the relationship between each individual and its environment. For example, in a stair climbing behavior, the height of a displayed stair (an environmental property) is perceived relative to the individual's leg length (an animal's body property), and when the ratio of each property (stair height/leg length) reaches specific values, qualitative changes occur in the animal's behavioral pattern.

Conversely, within the framework of the DSA, an animal's behavioral pattern at the macro-level of the complex system can be modeled as a motion equation using a control parameter and an order parameter. The order parameter describes the low-dimensional behavior (the system's macroscopic pattern) that emerges from the high-dimensional neuromuscular system (the micro components of the system). The model predicts the behavior of a system comprising numerous mutually interacting components (degrees of freedom) at the micro-level, as the dynamics of a few order parameters. Empirical studies from the viewpoint of the DSA, however, have mainly described behaviors with variables defined by elements of an animal system but not by elements of an animal-environment system.

According to the Ecological approach, we apply the variables defined by elements of an animal-environment system to the DSA framework. In the current presentation, we propose an integrative approach using ecological and dynamical approaches and an empirical framework to examine the validity of our approach and report the preliminary data from our pilot experiments investigating adaptive behaviors in the stepping-over task with regard to how stepping-over behavior changed depending on an obstacle's height. The present study is still in progress. However, if we can reveal the dynamics of stepping-over behavior and the critical point at which the behavior destabilizes, then this knowledge may lead to better understanding of safe obstacle avoidance.