Proactive learning mechanism of sensory perception and behavior generation for an autonomous robot

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***Abstract*—How does the brain learn to transform sensory data into accurate perceptual information while, at the same time, learning to solve complex behavioral tasks? Poor quality perceptual information, due to incomplete development, can interfere with learning to solve behavioral tasks. Previous research has shown that actions that maintain sensory invariance enable the brain to learn about the external world [1], and that specific actions, such as head rotation, which maintains the distance from the observer to a target object, can be used to constrain perceptual judgments for depth estimation. Physical invariances can expose perceptual inconsistency, which can be used to train a perceptual process [3]. Behavioral tasks can be solved through reinforcement learning by trial-and-error methods, but the quality of the learned behavior depends on perceptual accuracy. We propose that the brain exploits action to improve perception, and this updated perceptual process helps to improve behavioral quality in an ongoing cycle. An alternative approach is to first learn to map sensory data to perceptual information and then, only after the perceptual problem is solved, solve the behavioral task. Focusing on distance estimation as the perceptual process, we implement these two approaches on a humanoid robot interacting with multiple objects in physically distant spaces [4]. In either case, to solve the behavioral task, the robot has to learn both appropriate parameter values for binocular distance estimation [2] and a policy for solving the behavioral task. The experimental results show that updating the robot's perceptual parameter values while learning the behavior results in more accurate perceptual judgments and better behavior than determining perceptual parameter values prior to learning the behavioral task. This result provides support for the plausibility of a perception-action cycle for improving both perceptual judgments and action.**

***Index Terms*—Sensory invariance driven action (SIDA), action-perception learning cycle, autonomous robot, binocular distance estimation, reinforcement learning**

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