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General Architecture for Perception-Action Information Flow Control

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Abstract
The perception-action (P-A) cycle is the process of receiving information about sensory events taking place in the environment through sensory systems, processing this information and triggering motor systems to initiate corresponding action events back into the environment. This information processing along the P-A pathway requires defining a certain level of dependency between the sensory events and their corresponding action events. This dependency is what determines the behavior of the system and its ability to implement its goals and to react to its environment. Information processing within the P-A process is based on the transmission of signals between the sensory and motor systems. This transmission is subject to noise. Noise leads to errors in the transmitted signals and reduces the amount of useful information carried by the signals, thus impacting the sensory-action dependency that can be defined by the organism. According to communication theory, managing information transmission along a channel is achieved by matching the messages to be transmitted with the specifics of that channel according to the statistical characteristics of the messages. The current paper argues that managing information transmission within the P-A process requires the brain to have dedicated information transmission control processes and structures. It is argued that one such control process is based on managing the mapping of the events involved in the P-A process to the signals used by the P-A process. The paper suggests the required structure that should enable the brain to access the required variables for managing the information transmission and examines the approach of the Theory of Event Coding.

Keywords: Perception-Action, Theory of event coding, information transmission

1 Introduction

The P-A process starts with the brain receiving information from the environment about sensory events. This information is processed to trigger corresponding action events. The process can also start via the brain triggering some action events in the environment to elicit some intended input, which is then captured back by the sensory systems. In either case, the P-A process is based upon the transmission of signals between sensory and motor events. Those signals travel over an extensive neural network comprising a vast number of nodes and connections. The conditions associated with these transmissions are not ideal, and the signal transmission within the neural network is therefore subject to a certain level of noise. Due to this noise, sensory and motor signals include a certain degree of er-

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ror. As indicated by communication theory (Shannon 1949), transmission error reduces the actual information available to the system for managing its behavior.

Transmission error can conceal the difference between two sensory events or patterns, which impacts the system's ability to recognize the need for a differentiated reaction. The same argument applies for motor events: error can impact the execution of selected motor signals, which may result in a different action event than originally intended.

Communication theory also indicates that reliable and efficient information processing with respect to meaning and effectiveness needs to be based on managing the signals transmitting this information. Managing the signal transmission means the ability of the system to provide sufficient capacity to capture and transmit the information it requires for its activity in the presence of noise.

Based on communication theory, the current paper develops an architecture that should enable the control of information transmission along the P-A process. This approach is explained in more detail as an example of the theory of Event Coding (TEC).

2 Information Transmission along the P-A Process

Figure 1 is a representation of the P-A process, with the main elements involved in the transmission of information between the sensory and action events. The process starts with sensory systems capturing sensory events from the environment and ends with motor systems implementing selected responses as action events. The evaluation of the sensory events and the planning for appropriate action events is thought to be performed by the information management component.

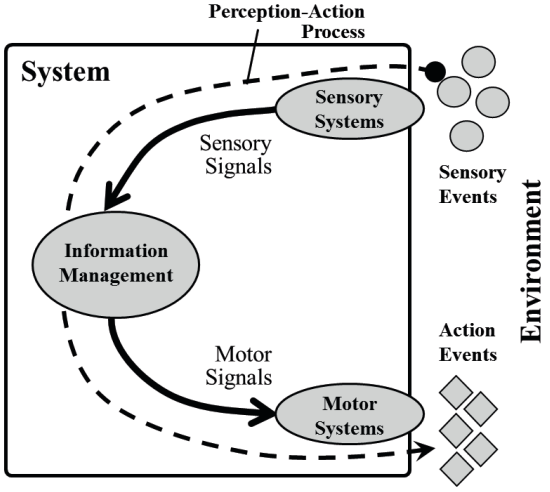

Figure 1: P-A process main elements for information transmission.
The "system" refers to the organism executing the P-A process.

Information processing along the P-A process ends up defining some level of dependency between sensory events and action events. If we consider a communication channel as "a system in which the output depends probabilistically on the input" (Cover 1991), then the P-A process can be considered to be a process of communication as shown in Figure 2.