Emotion, Adaptation, and Consequence Driven Systems

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Abstract

This is a short report of a research which considers emotion as internal evaluation of the encountered situation. Here we introduce the concept of emotion learning automata.

Adaptation and consequence driven systems

There are several views toward adaptation and one of them is adaptation as *consequence optimization process* (Bozinovski 1990).

Consequence driven systems (CDS) are systems that behave taking into consideration the consequences of their previous behavior. The CDS theory (Bozinovski 1995) so far considers three classes of agents: 1) consequence driven teachers, 2) external reinforcement learners and 3) self-reinforcement learners.

CDS theory includes the reinforcement learning (RL) theory (e.g. Barto 1997) in which mainly systems with external reinforcement (class 2) are considered. Such systems usually assume two inputs: situation X and external reinforcement R. We are more interested in class 3 systems: those systems have only one input, situation X. A typical and classical example of class 2 system is the Actor/Critic (A/C) architecture (Barto et. al. 1983) while a typical example of the class 3 agents is the Crossbar Adaptive Array (CAA) architecture (Bozinovski 1982). It is interesting that both architectures were designed to solve the delayed reinforcement learning problem (e.g. Bozinovski 1982). Both the architectures compute internal reinforcement, but with different philosophy: A/C architecture uses the concept of prediction, while CAA architecture uses the concept of desirability (emotion) of being in a state (situation). A/C architecture uses two memory structures and four memory equations, while CAA uses only one memory structure in *crossbar mode*, and only one memory equation, its crossbar learning rule:

$$w_{ax} = w_{ax} + v_{x'}$$

where w is the connectionist learning variable, x' is a situation encountered as a consequence of performing action (or behavior) a in a previous situation x, and v_x' is the emotional value of the consequence situation x'.

Emotion Learning

Basing on the CAA, we can define *emotion learning automaton* as pair of (parallel computing) equations

$$w_{ax}\,(t\text{-}k) = L(w_{ax}\,(t\text{-}k),\, E(x(t))$$
$$a(t) = B(w_{*x}(t), x(t))$$

where

$x(t)$ is a situation presented by the environment,
$a(t)$ is action, reaction to $x(t)$
$E(x(t))$ is the agent's emotional value of $x(t)$
$w_{ax}\,(t\text{-}k)$ is the learning variable associated with the behavioral element $(x(t\text{-}k), a(t\text{-}k))$ which is the cause of being in situation $x(t)$
w_{*x} is the set of all possible actions from the situation x
$L(.,.)$ is the learning (memory updating) rule
$B(.)$ is the action (behavior) choosing rule

Here t is a discrete time, and t-k is a time k steps behind t. The simplest case is k=1 in which the agent should memorize only one step behind (example is CAA). In more general case, the agent should memorize several steps behind in order to deal with the emotional value backpropagation problem.

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Since I did not receive the reviewer's comments I assume I should sent you a one page position report.

Please find it as enclosed.

I also sent it to you as postscript file by ftp and by email,.

See you in Zurich,

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