EMOBOT: An approach to control an autonomous robot by means of "Drives and Emotions" with learning hierarchical action selection

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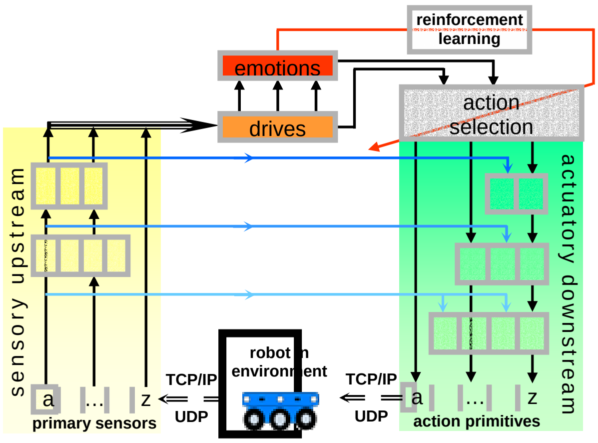
Controlling mobile robots in an efficient way is one of the greatest challenges in current research in robotics. Since Damasio's "Descartes' error" in 1994 the number of approaches to action selection that use internal values derived from psychological models of emotions or drives, has increased significantly.
We present an approach that realises a learning action selection mechanism in a hierarchy of sensory and actuatory layers. The sensory values yield the internal states which serve as a basis for the action selection. In addition the internal states are used to calculate the reinforcement signal that trains the action selection.

The **hierarchical structure** of the robot control system (EC-project SIGNAL, IST-2000-29225) is divided into five sections:

1. The robot in its environment (real robot or simulation)
2. A sensory upstream, with levels of increasing sensory complexity
3. An actuatory downstream, with levels of decreasing action or behaviour complexity
4. An internal value system (*"drives"*, *"emotions"*) based on sensory values to govern the action selection mechanism (input to AS, learning AS).
5. The action selection mechanism, designed as a neural network, activating action programs and behaviours of different complexity.

The **autonomous robot** is connected to the control architecture via robot-client and robot-server using TCP/IP and UDP. The robot is situated in a common office **environment**.
The **sensory upstream** and the **actuatory downstream** are designed to retrieve sensory information and to trigger action programs from arbitrary levels of the hierarchy. Furthermore every action program can directly retrieve the sensory information necessary for its execution.
The **internal value system** consists of two different sets of internal states. The primary one is called *"drives"*, representing states like *hunger*, *curiosity* or *fatigue*, depends on the sensory inputs. The secondary set of internal states , called *"emotions"* and including mechanisms like *fear*, *anger*, *surprise* or *boredom*, depends on the primary set. Both sets provide the input for the action selection neural network. We decided to use the secondary set of internal states, which do not directly depend on sensory input, as a basis for the reinforcement signals learning the action selection.
Based on the current internal states the **learning action selection** mechanism selects and triggers the appropriate action programs.



The proposed model is implemented in several stages: First, a static action selection with basic actions and basic pattern recognition is used. This implementation is then extended by adding the "drives" and later the "emotions". Successively more complex pattern recognition and action programs which are known to be learnable by the robot autonomously (F.Kintzler, EANN 2003). Each stage in this development is tested and evaluated by experiments using a simulation as well as a real robot (here a 2-motor, 6-wheeled robot platform with infrared and ultrasonic based distance sensors and bumpers).

The presented results obtained within the experiments and simulations demonstrate the effectiveness of the learning hierarchical action selection. Thus, the robot is able to adapt effectively to a wide variety of situations encountered in the selected dynamic office environment.