Evolving Emotional Behaviour

The Agent

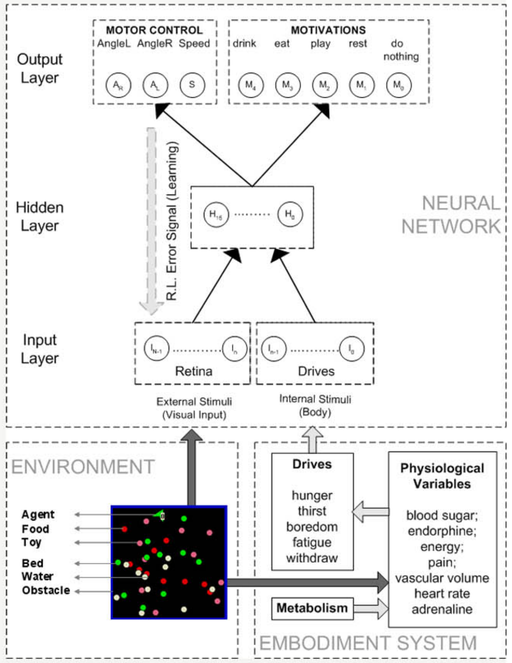
Perceptual System : retina.
Motor System : linear and angular speed signals.
Nervous System : feed-forward neural network.

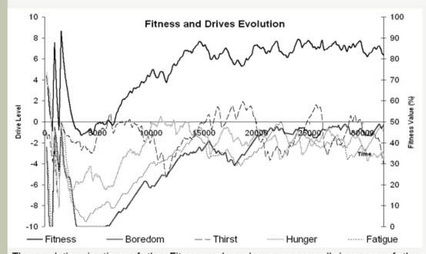
Embodied Emotional Process

Physiological Variables: define the body state;
Drives: translate physiological changes into specific alarms or urges to action (e.g. hunger if blood sugar is low);
Motivations: the level of willingness to adopt a certain behaviour (Eat, Drink, etc.); the desire to act in the environment.

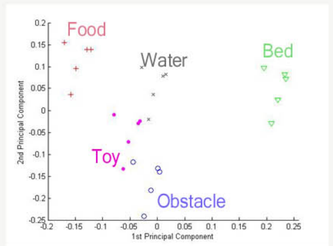
Reward and Punishment: "feeling" the interaction

Learning: Reinforcement Learning algorithm.
Rewards : dependent on the agent's actions - proportional to their effect on the agent's well-being, and their valence (positive or negative). Rewards depend on the pleasantness of the new body state.

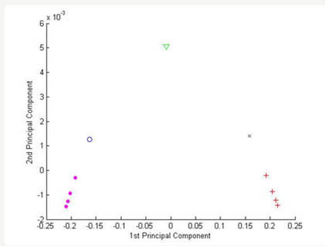




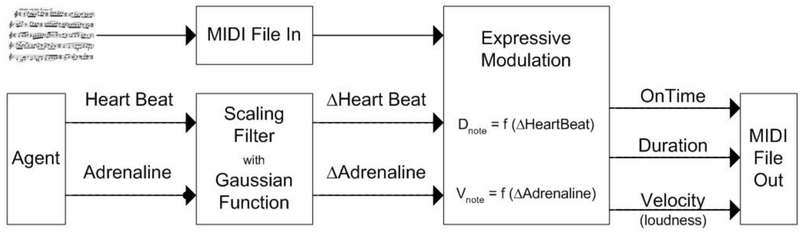
The evolution in time of the Fitness value shows an overall increase of the agent's ability to regulate its body state by interacting with the world. The Drives variation is maintained within a range of values near the optimal value. The agent mantains an "healthy behaviour". Extreme body states are avoided, showing the agent's ability to regulate its own body status, by coping with its metabolism, and managing competitive internal stimuli.

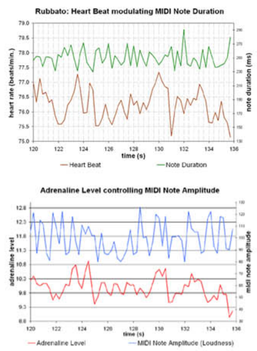


The agent is introduced to one object at a time. For each object we've activated all Drives to their maximum level (e. g. in a state of Hunger, all five objects in the environment were perceived individually). The agent is able to categorize the world so that, in fact, identical external stimuli (objects) are represented internally in a specific and dedicated way.



In the presence of Food, we've varied the Hunger drive from its minimum to its maximum values, considering steps of 2 units (-10, -8, ..., 8, 10). The agent can identify its body needs and attribute dynamical meanings to objects with a complete separation of the different states of well-being (over-stimulated, homeostatic level, under-stimulated).





... for Expressive Performance of Music

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ABSTRACT

We are interested in developing A-Life-like models to study the evolution of emotional systems. We adopt an evolutionary perspective by modelling the agent based on biologically plausible principles, whereby emotions emerge from homeostatic mechanisms.

CONCEPT

We have created a conceptual A-Life-like model to implement artificial worlds inhabited by autonomous emotional agents. We've focused on the idea of having an embodiment (in the sense that an agent has a virtual physical body whose states can be sensed by the agent itself) so that low level tasks (e.g. satiate body needs) influence its overall performance, by affecting its behaviour. A neural network endows the agent with cognitive capabilities, processing information related with its body, and its environment (visual cues). The agent's emotional state is mirrored into a set of Background Emotions. This term is used by Damasio [1] to describe the responses caused by "...certain conditions or internal states engendered by ongoing physiological processes or by the organism's interactions with the environment or both".

HYPOTHESIS

The aim of this project is to design an embodied agent-based cognitive model, and establish how an emotional system can emerge from self-regulatory Homeostatic Processes by the interaction between a body and a brain. To meet this goal we propose a model of such biological mechanisms, implemented at this stage as a single-agent system. The objective is to understand the role and the importance of Emotions in self-survival tasks. We are also interested in studying how the regulation of the Homeostatic Processes can influence world categorization and decision making (currently at a low level and for single tasks). We also analyze how Emotions act as a system of internal rewards that preserve the system, and allow a continuous adaptation process in self-survival tasks, by signalling and scaling pleasant or unpleasant interactions.

RESULTS

We have addressed the notion of the emergence of a stable emotional system by means of self-regulatory Homeostatic Processes. We've demonstrated that (a) it is possible to model such phenomenon, and (b) that physical restrictions (even with a very simple artificial embodiment) can play an important role in the agent's adaptation to its environment. The emergence of a stable emotional system (albeit in low level tasks), potentiates dynamical categorization of objects based on the emotional context, proving to be effective and versatile enough to allow the agent to adapt to an unknown environment. The results are coherent with Damasio's convincing theories about the existence of a background emotional system [1]. We've demonstrated that phenomena such as body/world categorization, and existence of a body map can evolve from a simple principle: self-survival.

CASE STUDY

We are looking into the possibility of endowing computer music systems with emotions. We are addressing this problem from an A-Life perspective combined with recent discoveries in the neurosciences with respect to emotion. Two physiological variables, selected for their influence in actual human performances [2], Heart Rate and Adrenaline, control the rate of events (tempo) and loudness (velocity) in the performance of a piece of music [3], reflecting neural activity and emotions valence, mirroring the agent's emotional state. Heart Rate values modulate the on-times of events within each measure (one bar, in this case 4000 ms), with a maximum deviation of +/- 640 ms. Adrenaline values modulate MIDI events' velocity (loudness) between user chosen limits, in this case, 80 and 127. The system related Heart Rate onto music by mirroring stable or unstable situations, relaxation or anxiety with deviations from original rhythmic structure of each measure of music, and Adrenaline, by mirroring excitement, tension, intensity, or, in the other hand, boredom, low arousal, by changes in note-velocity (loudness).

REFERENCES

[1] **Damasio, A.**: *The Feeling of What Happens: Body, Emotion and the Making of Consciousness*. Vintage (2000).
[2] **Juslin, P.N., Sloboda, J.A.**, eds.: *Music and Emotion: Theory and Research*. Oxford University Press (2001).
[3] **Bach, J.S.**: Prelude I (C major). In: *The Well-Tempered Clavier, Book I* (BWV 846).

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