Modeling the Dynamic Nonlinear Nature of Emotional Phenomena

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Abstract. The study of emotional phenomena, particularly the development of emotion models for intelligent agent implementation, has been mainly based on a perspective of emotion as a human phenomenon and on the assumption that emotions can be divided into discrete and independent categories. We propose an alternative model that emphasizes the continuous nonlinear nature of emotion processes, where emotional phenomena are rooted not on high level cognitive or even nervous structures, but on biophysical principles that are pervasive among biological organisms.

1 Introduction

In the evolutionary continuum there is no evidence of a discontinuity in what regards the existence of emotional phenomena. On the contrary, it is well known that some simple organisms, even unicellular organisms, can present remarkable behaviors for organisms without nervous system, which from an observer point of view are easily classified as emotional [1]. Although almost unexplored, these observations give rise to the possibility that emotional phenomena are rooted not on cognitive or even on nervous structures, but on biophysical principles that are pervasive among biological organisms. In our work we explore this line of research by defining an emotion model that is inspired on the view that "basic biological organization is brought about by a complex web of energy flows" [2]. In our model, called *flow model of emotion*, an agent is modeled as a dissipative structure [3], i.e. an open system governed by the interchange of energy with the environment and able to maintain itself in a state far from equilibrium, yet keeping an internally stable overall structure.

2 The Flow Model of Emotion

In a dissipative structure, the maintenance of an internal stability in spite of environmental changes is done through feedback networks that motivate the system to act. The maintenance of a basic life support energy flow can be seen as a base motivation. However motivations can take various forms according to the cognitive

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context (e.g. drives, desires). In any case, to achieve its motivations an agent must apply an internal potential to be able to produce the adequate change in the environment. However the concretization of the intended change depends on the characteristics of the current environmental situation that, from a thermodynamic point of view, can be modeled as an agent-environment coupling conductance. Therefore, the agent-environment relation can be modeled as a relation between an agent's internal potential, its *achievement potential*, and the agent-environment coupling conductance, the *achievement conductance*. The achievement potential represents the potential of change that the agent is able to produce in the environment to achieve the intended state-of-affairs. The achievement conductance represents the degree of the environment's conduciveness or resistance to that change, which can also mean the degree of environment change that is conducive, or not, to the agent intended state-of-affairs.

From a thermodynamic point of view, the achievement potential can be viewed as a force (P) and the achievement conductance as a transport property (C). The behavioral dynamics of an agent can therefore be characterized as a relation corresponding to a flow, called *achievement flow* (F), which results from the application of a potential P over a conductance C. The forces that arise from this relation between achievement potential and achievement conductance, expressed as energy flows, generate behavioral dynamics that underlie the cognitive activity of an agent. In our model we consider emotional phenomena as the expression of those dynamics [4].

Although inspired by biophysical analogies, the main aim of the proposed model is to support the development and implementation of agents, independent of their kind or level of complexity. Therefore the base notions of the model are concretized in a computationally tractable way, namely the notion of energy. In thermodynamics, energy is usually defined as the capacity to produce work. In the context of the proposed model, energy is defined as the capacity of an agent to act or, in a wide sense, to produce change. Considering an agent as a dissipative structure, that change is oriented towards the achievement of motivations driven by internal potentials and expressed through energy flows. That is, both the agent and the environment can be modeled as a composition of multiple energetic potentials with different characteristics. This notion of energetic potential serve as a unifying support to explore the existence of specific emotional patterns and, at the same time, to explain the continuous nonlinear nature of emotion processes.

References

1. Staddon, J.: Adaptive Dynamics: The Theoretical Analysis of Behavior. MIT Press, Redmond, Washington (2001)
2. Bergareche, A., Ruiz-Mirazo, K.: Metabolism and the Problem of its Universalization, Biosystems, vol. 49 (1999)
3. Morgado, L., Gaspar, G.: Emotion Based Adaptive Reasoning for Resource Bounded Agents. In: Proceedings of the 4th International Joint Conference on Autonomous Agents and Multi-Agent Systems (2005)
4. Morgado, L., Gaspar, G.: Adaptation and Decision-Making Driven by Emotional Memories. In: Bento, C., Cardoso, A., Dias, G. (eds.) EPIA 2005. LNCS (LNAI), vol. 3808, Springer, Heidelberg (2005)