

Chapter 7.6

Emotions, Diffusive Emotional Control and the Motivational Problem for Autonomous Cognitive Systems

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ABSTRACT

All self-active living beings need to solve the motivational problem—the question of what to do at any moment of their life. For humans and non-human animals at least two distinct layers of motivational drives are known, the primary needs for survival and the emotional drives leading to a wide range of sophisticated strategies, such as explorative learning and socializing. Part of the emotional layer of drives has universal facets, being beneficial in an extended range of environmental settings. Emotions are triggered in the brain by the release of neuromodulators, which are, at the same time, are the agents for meta-learning. This intrinsic relation between emotions, meta-learning and universal action strategies suggests a central importance for emotional control for the design

of artificial intelligences and synthetic cognitive systems. An implementation of this concept is proposed in terms of a dense and homogeneous associative network (dHan).

INTRODUCTION

Is it a coincidence, a caprice of nature, that the species living presently on our planet with the most developed intellectual and cognitive capabilities, humanity, is also thoroughly infused with emotions? Or is it a *conditio sine qua non*: Are higher cognitive powers intrinsically dependent on a functioning and solid emotional grounding? This question is centrally relevant for our scientific and philosophical self-understanding, posing at the same time a paradigmatic challenge for the development of synthetic cognitive systems and artificial intelligences (AI).

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A wide range of different notions are connected with the term emotion and with the personal experience of emotions (Barrett, Mesquita, Ochsner, Gross, 2007). Social interactions and emotional involvements, to give an example, take-up a good share of our daily life and the social aspects of emotional expressions are being widely discussed (Blakemore, Winston & Frith, 2004; Lieberman, 2007). They constitute an important aspect in human-robot interactions (Breazeal, 2003) and may even play a role in human phylogenesis (Parr, Waller & Fugate, 2005), having a high adaptive value (Rolls, 2005). The study of synthetic emotions (Picard, 2000) constitutes therefore a field of growing importance, dealing, beside others, with the role of emotions in artificial intelligences in general (Minsky, 2007), social robots (Duffy, 2003; Fong, Nourbakhsh & Dautenhahn, 2003), emotional expression in speech and language (Murray & Arnott, 2008) and social synthetic computer characters (Tomlinson & Blumberg, 2002).

It is well known, that emotions are triggered by neuromodulators like dopamine, serotonin and opioids, and that the very same neuromodulators can be found all over the animal kingdom, and not just in mammals (Arbib & Fellous, 2004). It is therefore reasonable to assume, that the neurobiological foundations of emotion-like functionalities, being present to a varying extend in all animals having a central or distributed nervous system, preceded phylogenetically higher cognitive capabilities, like sophisticated social interactions or logical reasoning. This observation suggests an underlying functional role of emotions, or emotion-like regulative processes, for both simple and highly developed cognitive systems in general. Neurobiological studies have found indeed close relations between emotions and the internal reward system (Aron *et. Al*, 2005; Kringelbach, 2005; Burgdorf & Panksepp, 2006), indicating that there is a close relation between emotions and decision making (Damasio, 1994; Naqvi, Shiv & Bechara, 2006; Coricelli, Dolan & Sirigu, 2007) quite in general. In the following we

will describe, from the functional perspective of dynamical system theory, the role of emotions in cognitive systems. Taking into account the established results from experimental neurobiology and experimental psychology, a theory for emotions will emerge that can be translated algorithmically precisely into formulas and code lines, a prerequisite for the realization of synthetic emotions in artificial intelligences and robots.

MOTIVATIONS

In order to elucidate the general functional purposes of emotions we start by considering the motivational problem of self-determined living creatures, whether biological or artificial. We use here and in the following the general term 'cognitive system' for such an autonomous and self-determined being. The question then regards the general motivational drives for cognitive systems.

The basic motivational drive of all living organisms is the 'instinct for survival' and it is sometimes assumed, indeed this is the general folklore in the larger public, that the survival instinct would be the sole driving force. In this context the desire to survive would determine in ultima ratio all activities of non-human animals, as well as the ones of humans, e.g. the decision to attend a violin concert instead of a cello performance.

Cognitive systems are instances of complex and adaptive dynamical systems (Gros, 2008) and the survival instinct can be defined algorithmically in a very precise manner, as we will do further below, in terms of a set of survival variables representing the health-status of their respective bodies. Nevertheless, the separate motivational layer, the network of emotions, has several stand-alone features. Emotions might indeed be triggered by the processes representing the survival instinct, but generally they constitute an independent dynamical component. The evolutionary fitness of an animal is increased both by a functioning survival instinct and by a suitable emotional framework

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