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What is In an Affective Architecture for Situated Agents?

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What is In an Affective Architecture for Situated Agents?

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Introduction and Characterisation of Approach

The uses of affective architectures are varied, and although different applications share common characteristics, they are founded on different—and not always complementary—conceptual assumptions. Our contribution is an attempt to provide a conceptualisation of the role of emotional processes in architectures for situated agents, focussing on the role for bridging the gap between 'higher-' and 'lower-level' aspects of behaviour coordination. This is the topic of investigations of element 3 of the exemplar proposed in [D7c], that targets human computer interaction involving agents that employ models of emotional processes for relating to their world which includes other agents and users.

In our contribution, to characterise our approach, we not only provide our working definitions on emotion, but also the defining characteristics of 'higher and lower levels' in architectures for situated agents, as well as the requirements for application scenarios that warrant the use of different levels in control mechanisms and the need for emotional processes as part of the architectures. Further terms to be analysed include decision-making; action selection; behaviour coordination; and behaviour arbitration; and their relation to other notions prominent in agent architectures. Our contribution thus presents a survey of different terminologies used to describe agent architectures and their relevance to behaviour coordination and related processes.

Emotion

Our approach views emotions as a crucial element for intelligent agents situated in complex social environments (for the important role of sociality see element 4 in [D7c]). Emotion, as described in cognitive appraisal theories [EllsworthScherer2003] [Scherer2001a] [Scherer2001b] [Ortony2003] [Frijda1986], is characterised as interplay of processes (rather than the descriptive characterisations of emotions in dimensional or categorical models). [D3c] provides a definition of an emotion episode taken from Scherer's appraisal theory. For the purposes of computational modelling, a concise working description of our approach to emotion could be:

> Emotions involve continuous processes that evaluate stimulus events according to subjective criteria, and, for events of subjective relevance, influence continuous activity in a synchronised fashion.

A stimulus event, in this context, is understood as an interaction between the agent and its world, possibly comprising environmental and internal changes.

A computational model needs to provide all of the infrastructure of a complete agent [PfeiferScheier1999] that is explicitly and implicitly implied by descriptions of the appraisal process. The involvement of multiple continuous processes points to this embedding in a complete agent architecture: it has to allow the synchronised recruitment of resources. Further, the definition of emotion in [D3c] delineates it from other affective phenomena, like moods and affective dispositions, that interact through said continuous processes in a complete agent.

In computational models of emotion, such processes are relevant in 'higher' and 'lower levels' of an architecture and especially to link them. The separation of higher and lower levels is a helpful simplification that needs to be re-evaluated regularly; cf. that some theories of human competencies distinguish two separate systems (planning and control) even for seemingly low-level motor processes [Glover2004]. Characteristics that can be used to differentiate levels in an agent architecture are the time-scale of operations at different levels [Gat1997], the temporal regularities of representations used, and the independence from the outside world (as reflected with the reification of the notion of duration at higher levels). Operations at a lower or reactive level involve more direct coupling to an agent's environment, the time-scale of operations corresponds directly to the temporal resolution of the agent's interface to its world, and no symbolic representations need to be involved. Examples of processes on higher levels include planning, that uses a representation of possible actions, or counterfactual reasoning, that can detach representations from the current state of the world. The notion of representation has stirred many controversies in behaviour-based AI [Brooks1991] and cognitive science [Clark1997]. Relevant properties of higher- and lower-level representations are the rate of change and if they refer to internal or environmental conditions.

Having distinguished higher- and lower-levels, the different influences of emotional processes on these interacting levels, with different scopes of competence, involve mechanisms for evaluating interactions on lower levels to provide meaningful information for higher levels and vice-versa. Further capabilities are the regulation of the information flow between the levels and the recruitment of already existing abilities on the different levels to effect internal and external changes.

Scenarios for Behaviour Coordination

Distinctions between higher- and lower-levels only make sense in the context of a specific agent and the relation to its world. We try to capture this context for the description of affective agent architectures as "scenario descriptions". A scenario for the application of an agent architecture includes the purpose of the envisioned system as a whole, the kinds, number, and tasks of agents, the possible interactions between agents and their world, including the social interaction between agents (possibly mediated through the environment). Scenarios for the use of agent control architectures can range from simple virtual worlds with one task and a very restricted set of interactions to very complex virtual worlds and robot scenarios that target human-like competencies. We argue that the complexity of a scenario is an indicator for the existence of higher and lower levels on the one hand and emotional processes on the other. For the purpose of this paper we want to point out some requirements for scenarios that warrant different architectural levels and emotional processes and are relevant to behaviour coordination: situatedness (including temporal criteria for task achievement), possibly ambiguous and unreliable sensing and acting, multiple conflicting tasks, variability of resources and resource usage.

Classical definitions of decision-making are anchored in a symbolic conceptualisation of intelligent action:

> "Decision making is the process of choosing a preferred option or course of action from among a set of alternatives." [WilsonKeil1999]

Affect has varied influences on behaviour coordinaton in humans [LoewensteinLerner2003], ranging from the role of expected emotions in evaluating options, to the influence of immediate emotions, i.e., the emotions experienced at the time of decision making. But human, and in general situated, activity involves different processes of control that do not necessarily need conscious decisions between alternatives. A related problem is action selection [Tyrrell1993] or behaviour selection [Gadanho2003]. The latter term stresses the fact that what is selected is not a single and atomic action but the collection of current continuously running situated activities. In [Tyrrell1993] action selection is defined as the problem of "choosing at each moment in time the most appropriate action out or a repertoire of possible actions". In order to stress our conviction that for situated activity there is no selection at "each moment in time", we prefer to use the term behaviour coordination (used e.g. in [AlthausChristensen2003]) to denote the management of ongoing activities of an entity at different levels (which subsumes decision making and action selection).

The full contribution presents our terminology for the concepts involved in behaviour coordination starting form the fundamental notion of situatedness, and the related concepts concern and motivation. The terms operation, behaviour, goal, task, and activity target the area of an agent's executive. The concept of an agent's lifeworld is fundamental for the analysis of an agent's abilities in a specific scenario. Finally the crucial notions appraisal, relational action tendency, and coping are related to their origin in emotion theories and possible use in affective agent architectures.

Conclusion

Further steps of our endeavour to clarify architectural terminology will include the enlargement of the list of reviewed systems and the refinement of conceptual clarification regarding higher and lower levels of cognition and action, environment, and scenario. A special interest is the relation of a scenario, especially its potential for emotional interactions, to the needs in terms of agent architectures and virtual world simulations.

By presenting different systems in terms of the terminology used to describe their take on the problem of behaviour coordination, we aim at addressing fundamental issues of a comparative approach towards design, development and evaluation of affective architectures in emotion-oriented systems. A further result of this effort is the instigation of discussions in workpackage 7 of the Network of Excellence HUMAINE about theoretical foundations and practical issues of matching theory and practice in order to approach a given scenario of behaviour coordination

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