Emotion and Agent Interaction

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Abstract

The paper describes work-in-progress in extending a behavioural agent architecture to include a low-level emotional system and communication of emotions between agents using virtual odour for propagation.

1. Background

This paper discusses work-in-progress in emotion as a form of interaction *between* (pseudo-)embodied agents in a virtual environment (VE). It attempts to integrate emotions at the pseudo-physiological level into an existing behavioural architecture. It then seeks mechanisms for the transmission of emotion between agents, and for the perceived emotion of one agent to influence the emotion and thence the behaviour of another. The work discussed here confines itself to the behavioural level, taking sheep as exemplar agents.

Emotional interaction between agents clearly requires an internal emotional architecture but this has to be linked both to transmission and reception mechanisms. We do not include intentionality in this system – emotional interaction is being modelled as essentially involuntary. By analogy with the brain modelled as a layered control architecture [e.g. Prescott et al 99] we consider emotion at the level of the midbrain and not at the level of the frontal cortex [Damasio 94].

2. Behavioural architecture

Previous work had taken a behavioural architecture developed for multiple cooperating robots – the Behavioural Synthesis Architecture or BSA [Barnes et al 99] – and reapplied it to agents in a virtual environment (VE) in the Virtual Teletubbies project [Aylett et al 00). The BSA incorporated three structures at increasing levels of abstraction: behaviour patterns, behaviour packets, and behaviour scripts. At the most primitive level, a *behaviour pattern* (**bp**) was defined as a pair of functional mappings, one from incoming sensory stimulus to outgoing desired motor response, and the other from sensory stimulus to utility, a mapping defining the *importance* of the motor response for the given level of stimulus. An agent possesses a repertoire of behaviour patterns, with each active pattern at any given time proposing its desired motor response according to its current sensory input. These responses were weighted by their utility values and synthesised together to produce an emergent response, which was the actual behaviour of the agent. Thus second-to-second variation in emergent behaviour was dealt with via weighted synthesis on a continuous basis, unlike the time-sliced Brooksian architecture [Brooks 86].

A second, higher-level, mechanism supported action-selection between conflicting groups of behaviour patterns - the behaviour packet, a small data structure which includes a sensory pre-condition for activating the **bp**s it references, and a sensory post-condition which controls deactivation of the named **bp**s. A *behaviour script* was then a set of behaviour packets assembled sequentially for the achievement of a particular task, having something in common with Arkin's schemas [Arkin 92], but critically providing a flexible way of organising **bp**s rather than the hardwired FSM of the subsumption architecture. For task-based cooperating robots, behaviour scripts were generated dynamically using a reflective agent incorporating a symbolic AI planner, [Aylett 1996].

3. Incorporating emotion

Where virtual agents live in an environment which is not task-oriented, internal motivations replace external task-direction as behavioural determiners. Thus a sequencing engine linking behaviour to internal motivations was developed as seen in Figure 3 and applied in the Virtual Teletubbies project [Aylett et al 99]. A set of drives were developed for the virtual agents - hunger, excitability, happiness, curiosity, and sleep - comparable to the homeostatic variables found in work of Bruce Blumberg [Blumberg 1996]. These drives play the same role of contextually-driven behaviour switching that had previously been played by an AI planner. The framework developed contains four queues, one for each of the conceptual behavioural categories **self**, **species**, **environment** and **universe** (which we do not have space here to discuss). The entries in this queue consist of groups containing one or more behaviour packets, effectively small scripts known as *behaviour scriptlets*, each with an attached priority. The priority is generated automatically and is typically related to a predetermined threshold level of a drive, so the more hungry an agent becomes, the greater the priority. The scriptlet with the highest priority is then selected for packet execution.

Emotional mechanisms

We are currently examining how to incorporate the six basic emotions [Ekman 92], starting with fear and taking a virtual sheep as the exemplar. We aim to produce emergent behaviour similar to real sheep [Neary 01] under corresponding conditions and in particular similar collective behaviour. This requires the integration of emotion with the control architecture [Velasquez 97] but also the communication of emotion between virtual sheep.

In the architecture discussed, there are three ways in which low-level emotion can be modelled. Firstly, emotion can be modelled as a **bp** in its own right, with its motor response synthesised with that from other **bp**s. Secondly, it can act as an internal sensory pre-condition for a behaviour packet or for a scriplet, alone or in addition to an external sensory trigger. The sight of a supposed predator triggers fleeing behaviour and also fear which then maintains the behaviour when the predator is not seen, for a period related to its decay rate.

Thirdly, emotion can enter into the synthesis of **bp**s and modify the emergent behaviour. If it alters the shape of the functional mappings between stimulus and motor response and between stimulus and utility, then it could have effects such as increasing the translate speed in relation to the level of fear and reducing the normal obstacle avoidance sensitivity. These three views are not mutually exclusive and we will explore how they combine.

Collective behaviour

There is evidence in the real world that fear is propagated within flocks or herds so that not every individual has to directly perceive a threatening stimulus for the appropriate behaviour to be invoked. Thus we require a transmission mechanism for propagating basic emotions. The sensory modality we are choosing to investigate is smell since there is evidence that the olfactory lobe is closely connected to the limbic systems which handle basic emotions [Goleman 96]. Neary [Neary 01] points out that sheep, especially range sheep, usually move more readily into the wind than with the wind, allowing them to use their sense of smell.

In real animals chemoreceptors (exteroceptors and interocetors) are used to identify chemical substances and detect their concentration. We intend to model the exteroceptors which detect the presence of chemicals in the external environment. The virtual molecules must be distributed in the environment; this is modelled by setting the density of each of the molecules within the environment represented as a grid. To simplify the computation the current grid is 2D, but we plan to move to a voxel-based grid. The smell sensor and the virtual molecules can then be used to communicate emotions between agents through the environment. If a sheep panics it will exude a distinctive odour, or molecular signature, to the environment using a density function: through time the molecules would disperse depending on virtual factors like wind, rain, season and time of day. Other sheep will sense the panic smell and panic themselves, also exuding the distinctive odour which will propagate through the flock in

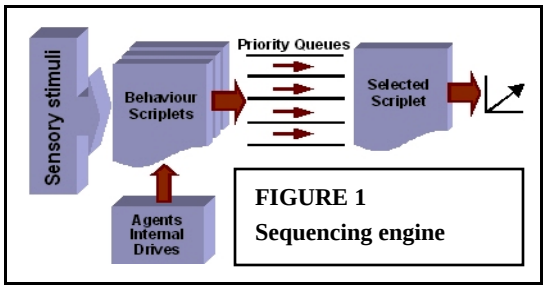

FIGURE 1
Sequencing engine

small simulation steps. A decay factor, as well as fatigue, is required to prevent permanent panic. Finally, *mood* will be modelled to account for the fact that sheep behave differently at different times of the day [Nearey 01]: they usually graze, drink and are more active in the morning and during the evening..

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