Action Selection for an Artificial Life Model of Social Behavior in Non-Human Primates

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Introduction

This abstract reflects research into modeling primate social interactions which is only in its very early stages. Our interest is in understanding complex non-linguistic behavior, and demonstrating that understanding through models. In particular, we are interested in modeling the relationship between social intercession behaviors for damping or terminating conflict in a colony, and the social structure of that colony. At this stage in our research, however, we are only beginning to model the interplay of varying motivations, both social and selfish.

The Domain: Primate Conflict Management

We are interested in how individuals negotiate their social relationships: how conflict among lower level units (individual group members) is regulated in the formation of higher level units (societies). Although research on non-human primate societies indicates that there are a variety of mechanisms — such as aggression, social tolerance, and avoidance — by which conflict is managed or resolved (de Waal, 2000), it is not well understood how and why the expression of these mechanisms varies across and even within social systems. For example, there is tremendous variation across the macaque genus in terms of how conflict is managed despite similar patterns of social organization(Thierry, 2000; Preuschoft & van Schaik, 2000). Aggression in some species is common and severe while in others, it is extremely frequent but rarely escalates to levels that produce injuries (de Waal & Luttrell, 1989; Thierry, 2000). Corresponding to this variation in the degree to which aggression is employed to settle conflicts of interest is variation in the degree of social tolerance by dominant individuals of subordinate ones, particularly in the context of resource acquisition, and variation in the degree to which relationships damaged by aggression are repaired via reconciliation (de Waal & Luttrell, 1989). Although it appears that this co-variation in conflict management mechanisms varies in predictable ways across species, it does not appear that the co-variation can be explained by ecological factors. Rather, the variation seems to be emergent from patterns of social interaction among individuals, and self-reinforced through social learning.

The importance of social learning on styles of interaction was made clear by the results of a cross-fostering study of two macaque species the individuals of which have drastically different proclivities for aggression and reconciliation (de Waal & Johanowicz, 1993). In this study, juvenile rhesus macaques, which typically live in social systems characterized by high levels of severe aggression and low levels of reconciliation, were cross-fostered with slightly older “tutor” stumptailed macaques, which live typically in social systems characterized by high levels of mild aggression and high levels of reconciliation. Over the course of the study, the rhesus monkeys learned to reconcile more frequently and adopted the stumptailed style of interaction, and even retained this pattern after all stumptail tutors were removed.

Contemporary Models of Action Selection

When modeling behavior of any sort in a complex, at least partially embodied agent (e.g. artificial life or virtual reality), one must consider the problem of action selection. Action selection is the ongoing problem for an autonomous agent of deciding what to do next. Early research in artificial intelligence (AI) attempted to solve this problem via *constructive planning* — taking time to create reasoned plans. This proved combinatorially intractable and fragile. These problems brought focus to distributed, modular approaches to solving action selection: societies of agents (Minsky, 1985), behavior-based AI (Brooks, 1991), and plan networks (e.g. Maes, 1991; Tyrrell, 1993).

The advantage of modular theories of intelligence is that each element of the module is relatively simple, making it more plausible to evolve or engineer. The disadvantage is that they make it harder to explain the amount of coherence that *does* exist in an animal, or must exist in an animat.

In AI, the problem has been addressed by ‘hybrid architectures’ which reduce the role of behavior modules to simple primitives which are controlled by reactive planning systems. *Reactive* planning systems do not construct plans in real time, but rather rely on pre-programmed plans. Although reactive planning is implicit in earlier architectures (Brooks, 1991; Tyrrell, 1993, e.g.), AI programmers have found it easier to use explicit plan structures(e.g. Bonasso *et al.*, 1997; Bryson, 2000a).

There is converging neuro- and behavioral-science evidence that animals also use some structured systems of action selection for coherence, as well as emotional strategies (Bryson, 2000b; Prescott *et al.*, to appear, for reviews). Nevertheless, these hybrid architectures eliminate much of the utility of modularity by reducing the modules remit from perceiving, learning and acting (Brooks, 1991) to simply responding to control.

Behavior Oriented Design

We are using a modification of the hybrid approach for our modeling which puts more emphasis on the autonomy of the constituent behavioral modules. Behavior Oriented Design (BOD) (Bryson & Stein, 2001) is a modular architecture with explicit reactive plans. However, the modules are not the primitives of the plans, but rather are the primary structures of the intelligence. The modules support the plan primitives. Where arbitration is necessary, a plan determines *when* an action happens, but a behavior determines *how*.

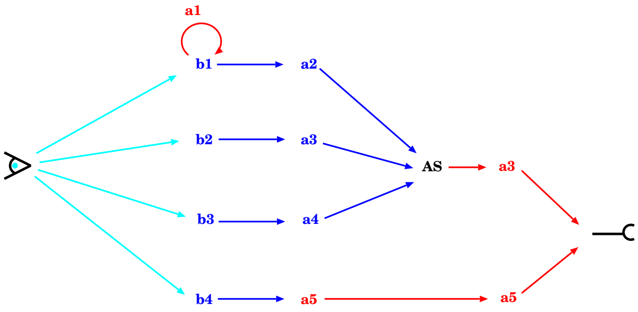

Figure 1: BOD *behaviors* ($b_1 \ldots$) generate *actions* ($a_1 \ldots$) based on their own perception. Actions which affect state external to their behavior (*expressed acts*, the hand icon), may be subject to arbitration by *action selection* (AS).

The central observation of behavior-oriented design is that mere sensing is seldom sufficient for either detecting context or controlling action. Rather, both of these abilities require memory. Perception exploits experience and expectation to perform discriminations more reliably than would otherwise be possible. Action also exploits experience, expectation and feedback. Behavior modules support diverse memory forms, including structured long-term representations, such as learned maps of an environment; short-term sensory memory, for disambiguating sensory stimuli; and internal drive or emotion levels (e.g. hunger, anger), for providing behavioral coherence (Damasio, 1999).

Progress to Date

Our modeling efforts are only in their earliest stages, though we have been able to make a simple pilot study (Figure 2). This shows time spent on productive goals (grooming) and unproductive ones (attempting to groom, attempting to disengage from another agent) as a function of whether each agent ignores other agents attempting to groom it, or facilitates them by either waiting while being groomed, or waiting when being approached *or* groomed. The target percentage time spent grooming is set to 14%, so we see that the social advantage in terms of reduced approach time has some cost in terms of time available to devote to productive goals.

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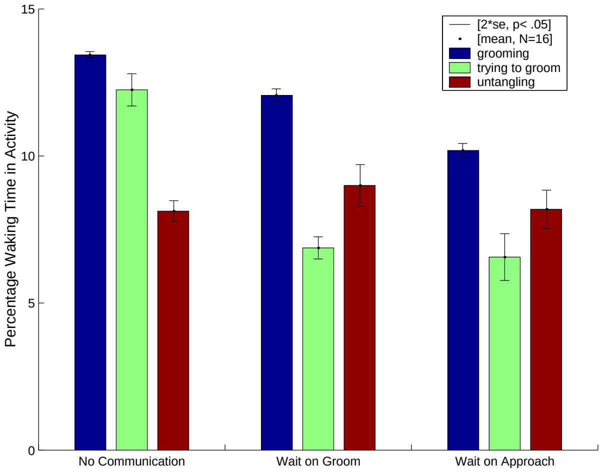

Figure 2: The effect of very basic facilitating behavior.

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