From Infotaxis to Boids-like Swarm Behaviour

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Abstract

The three rules of alignment, separation and cohesion, introduced by Reynolds (1987) to recreate flocking behaviour have become a well known standard to create swarm behaviour. We aim to demonstrate that those three rules can emerge from the principle of information maximisation. We begin with a single agent looking for a specific location (i.e. a food source), its actions governed by a modified version of the Infotaxis behaviour introduced by Vergassola et al. (2007). Every action is selected to maximise the expected gain in information in the coming step. In Salge and Polani (2009, 2010) we demonstrated that this leads, without an explicit intent to communicate, to a "concentration" of "Relevant Information"(Polani et al. (2001, 2006)) in the agents' actions. In a multi-agent scenario it therefore becomes interesting, from an information theoretic (Shannon (1948)) perspective, to look at another agent's actions. We further demonstrated, that Bayes' Formula can be used to update the internal probability mapping of the food source using the other agents' actions, leading to an increase in agent performance and information gain per time.

So far, we only used the other agents' information when we encountered them incidentally. But it seems reasonable, as our behaviour is motivated by maximising the expected information gain, to include the expected position of other agents, and the expected gain of information from observing them, into our decision making process. Looking now at a multi-agent, grid-world scenario where all agents act with this new policy we can observe the emergence of some coordinated behaviour via local decision making of the agents. A closer analysis shows not only a further increase in performance, but also an increase in local agent density around the agent and an alignment of the overall direction the agents move in. Also, even though the agents are interested in being close to other agents to gain information from them, there is also some force that still separates them, since we rarely observe all agents congregating on one single spot and staying there.

Those measurements suggest that we are observing a behaviour that could - in spirit - also be created by the well-known three rules of "Boids" behaviour introduced by Reynolds (1987). The *cohesion* that makes agents move towards the average position of the local flock mates is recreated by the agent's motivation to have as many agents as possible in its sensor range, so it can profit from the information in their actions. The *separation* on the other hand, the aversion of the agents to get too close to others, is motivated by the lack of new environmental information around observed agents. Even though an agent's action is rich in information, it mostly provides information of its immediate surroundings. So, while some agent at the end of an agent A's sensor range would provide it with further information, an agent that is close to A can mostly display information that A has already acquired. Finally, *alignment* can be explained by realising that if an agent moves in a given direction, the goal is more likely to be there, and all else being equal, another agent should have a tendency to move in that direction as well.

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