Engineering Emergence: an occam-π Adventure

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Abstract. Future systems will be too complex to design and implement explicitly. Instead, we will have to learn to engineer complex behaviours indirectly: through the discovery and application of local rules of behaviour, applied to simple process components, from which desired behaviours predictably emerge through dynamic interactions between massive numbers of instances.

This talk considers such indirect engineering of emergence using a process-oriented architecture. Different varieties of behaviour may emerge within a single application, with interactions between them provoking ever-richer patterns – almost social systems. We will illustrate with a study based on Reynolds' *boids*: emergent behaviours include *flocking* (of course), directional *migration* (with waves), *fear* and *panic* (of hawks), *orbiting* (points of interest), *feeding frenzy* (when in a large enough flock), *turbulent flow* and *maze solving*. With this kind of engineering, a new problem shows up: the suppression of the emergence of undesired behaviours. The panic reaction within a flock to the sudden appearance of a hawk is a case in point. With our present rules, the flock loses cohesion and scatters too quickly, making individuals more vulnerable. What are the rules that will make the flock turn almost-as-one and maintain most of its cohesion? There are only the *boids* to which these rules may apply (there being, of course, no design or programming entity corresponding to a flock). More importantly, how do we set about finding such rules in the first place?

Our architecture and models are written in occam-π, whose processes are sufficiently lightweight to enable a sufficiently large mass to run and be interacted with for real-time experiments on emergent behaviour.

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