Artificial Life and Society: Philosophies and Tools for Experiencing, Interacting with and Managing Real World Complex Adaptive Systems

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Abstract

Many of the grand challenges that society faces are concerned with understanding, managing and indeed creating complex living, lifelike or hybrid systems at multiple scales. Conventional approaches have often been unsuccessful in dealing with the inherent non-linearity, adaptability and self-organised behaviours of these systems. In fact the underlying technologies often transform the involved organizations and society as a whole. New paradigms are clearly required and the ALife community can play a key role. Artificial Life offers both tools and philosophical approaches which are well matched to the nature of these systems and can provide important perspectives on how to move forward.

Many of the most important challenges which now face our societies involve the management of interlinked complex adaptive systems (CAS): coupled socio-economic and ecological systems composed of many interacting elements which have been created or partially created by human actions. As we explicitly wish to manage and transform these systems, engineering and design approaches have much to offer us, however they must be fundamentally modified to deal with CAS (see e.g. Penn *et al.*, 2010, Frei and Di Marzo Serugendo, 2012). These systems are not static artifacts, but dynamic, evolving and reflexive *processes* the behaviour of which is not straightforwardly predicable and which may respond in unexpected ways in response to our interventions. Additionally many of the complex systems which we would most like to influence have significant social components. Objective choices about design goals cannot be made and the integration of participatory or political processes may be required. In parallel, new technologies that exploit or emulate the unique properties of living systems from the cellular to the digital realm have great potential, but create new engineering challenges and social dilemmas which must be addressed before they can become broadly utilized.

Conventional approaches to working with both living and life-like complex adaptive systems are, for the most part, "brute force", attempting to effect control in an input- and effort-intensive manner and are often insufficient when dealing with their inherent non-linearity and complexity. Much human management of complex adaptive systems/living systems has involved simplifying their dynamics or functions via large inputs of energy or work. Ecosystems, for example, are commonly constrained and managed for a minimum set of ecosystem functions, e.g. arable agricultural systems, fisheries and flood risk management in wetlands. Doing so may involve forcing systems into states that are far from natural equilibria and hence inherently unstable and requiring significant energy to maintain. System management of this type is ineffective in low energy/resource regimes and may be vulnerable to sudden state change. It offers an illusion of predictability and control, but is vulnerable when external drivers change (Deffuant, and Gilbert, 2011). Evidently, by their very nature, CASs are dynamic, adaptive and resilient and require management tools that interact with dynamic processes rather than inert artefacts. Particularly when as now, systems face increased perturbation and change. By using "steering" strategies which recognize their dynamical nature, we can attempt to manipulate these systems to move between attractors, allowing them to remain stable in a preferable state without significant energy needed to retain it.

However, a dynamical systems perspective is not sufficient for real world problem solving. On the ground in complex adaptive systems with human components or influence, key drivers are often social, political or economic (Gilbert and Bullock 2014). Our range of possible interventions is limited. Not only do we need different ways to manage our systems which embrace their complexity, we need broadly accepted narratives of systems as complex and adaptive to help us to shape policy and management and we must be prepared to take action without full system understanding. We must accept, explicitly recognize and be able to make decisions with incomplete knowledge, and require tools and methodologies for steering, monitoring and gathering knowledge which will allow us to adapt as systems respond to our intervention in complex adaptive systems which we for the most part experience and intuit rather than measure (Rowley et al. 1997, Kay *et al.* 1999, Waltner-Toews and Kay, 2005)

Artificial Life provides unique perspectives, tools and philosophies, which can offer both technical and methodological approaches to understanding and intervening in complex systems subject to "wicked" problems. And with our creation of new living, life-like and intelligent technologies, it plays a part in constructing the complex systems of the future (See e.g.Braha *et al*., 2006, Bedau *et al*., 2010). The time is ripe therefore, for the Artificial Life community to collate ideas on our technologies and approaches and their possible societal contributions and impact.

I will give an overview of the potential contribution that I believe that Alife can make and the need to connect productively with many different disciplines. In particular how ALife's focus on interaction, embodiment, dynamics, enactivism and phenomenological approaches, combined with its inherent creativity, focus on synthetic methods and "philosophy with a screwdriver" provide what I believe is the perfect basis for engaging with real world complex systems.

To illustrate these connections I will discuss numerous examples. Including some from my own work in developing participatory complexity science tools for use by policy makers and system stakeholders in both regional industrial economies ("industrial ecosystems") and water catchment management in the UK (Penn *et al.*, 2013, 2014, 2016). In particular, using a "steering complex adaptive systems" approach; a continuous process involving interacting with, monitoring and learning from the system in question which combines tools from complexity science and participatory methods with whole systems design philosophy and adaptive management (Penn, *Forthcoming*). In this particular context I will describe some of the experiences and challenges of combining mathematical modelling and analysis with participatory work in the context of rapidly changing real world systems and how an Alife perspective has informed the work. I will further discuss the potential role of experiential complex systems and ask what an interactive "natural history" approach to complex adaptive systems can offer in combination with mathematical and computational tools.

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