Is evolution fundamentally creative?

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Abstract

Categorizing, defining, and observing open-endedness are among the most important open research challenges in artificial life. As a step towards addressing these challenges, this paper highlights parallels between open-ended evolution (OEE) and the theory of computational creativity. Exposing this relationship may allow existing empirical tools for quantifying creativity to more clearly illuminate the hallmarks of OEE in artificial life systems.

Introduction

In recent years, the open-ended evolution (OEE) community has embraced a pluralistic view of open-endedness, recognizing that there may in fact exist *multiple* kinds of open-endedness. Taylor et al. (2016) recently suggested two primary categories of hallmarks of open-endedness: (1) ongoing adaptive novelty and (2) ongoing growth of complexity. This classification scheme thereby offers a viable pluralistic working definition of OEE. At the same time, it is worthwhile to ask what if any alternative frameworks exist, as categorizing, defining, and observing OEE are still among the most important open research challenges in the field (Taylor et al., 2016). The insight explored in this paper is that, interestingly, the primary categories of open-endedness seem to align with the well-established concepts of *exploratory* and *transformational* creativity (Boden, 1990). Highlighting this connection raises the intriguing question of whether ideas from computational creativity offer potential empirical methods and/or metrics suitable for measuring OEE, perhaps even avoiding unnecessarily reinventing any wheels.

Kinds of creativity

In her canonical text on the subject, Boden (1990) describes creativity as “the ability to come up with ideas or artefacts that are new, surprising, and valuable”. Creativity can also describe ways of traversing a *conceptual space*. Conceptual spaces contain all possible ideas or artefacts adhering to a particular stylistic structure. For instance, one might consider the conceptual spaces of chess moves (an idea-based space) or of Impressionistic paintings (an artefact-based space). Conceptual spaces are to creativity as genotype spaces are to evolutionary algorithms.

According to Boden (1990), the evolution of the conceptual space determines how creativity should be categorized. **Exploratory creativity** is the discovery of new points in a fixed conceptual space. In contrast, **transformational creativity** occurs when the bounds of the conceptual space are expanded and redefined as a result of the creative process. Boden considers “true” creativity to be distinct from mere novelty, with Bundy (2004) adding that an increase in complexity is what differentiates the two concepts. These ideas about transformational creativity echo for example the idea in the NEAT evolutionary algorithm (Stanley and Miikkulainen, 2002) of adding new connections (i.e. new genes) to the evolving structure, which in effect thereby add new dimensions to the conceptual (search) space, showing how specific algorithmic mechanisms can in principle relate to broader notions of creative search.

Discussion

Gabora and Kaufman (2010) claim that human creativity is distinctive because of the “adaptive and open-ended manner in which change accumulates”. Biological evolution seems intuitively to be a similarly creative process, generating myriad new ways of being an organism on Earth. In fact, Skusa and Bedau (2002) posit that “a key question of evolving systems [in general] is to explain the source of their adaptive creativity”. Yet, somewhat surprisingly, few if any published OEE studies contemplate the connection to computational creativity.

On the other hand, studies of creative cultural change have benefited from the relationship between creativity and evolution. For example, Skusa and Bedau (2002) demonstrate how evolutionary activity statistics (designed to measure OEE) could be applied to creative domains undergoing cultural evolution. Furthermore, multiple researchers have claimed that Darwinian terms can be used to describe cultural phenomena (Aunger, 2000; Blackmore, 1999; Boyd and Richerson, 1985; Sforza and Feldman, 1981; Dawkins, 1975; Durham, 1991; Gabora and Kaufman, 2010). By sharing language between fields, it has become possible to identify cultural drift and cultural niching. Perhaps more interestingly, OEE has been observed in the domains of technical innovation and social media tags (Taylor et al., 2016).

The empirical study of OEE has been inhibited by a lack of consensus on quantitative methods. Evolutionary activity statistics (Bedau et al., 1998; Channon, 2003) have long been offered as a metric for evaluating the open-endedness of a system, but it would be beneficial to take a pluralistic approach to metrics, as advocated by Dolson et al. (2015), among others. Boden (1990) advocates a similar approach to creativity and suggests developing methods for determining "just how creative [an artefact] is, and in just which way(s)".

If insights about evolution have informed the study of creativity, then it is worth seeing whether computational creativity can shed some light on OEE. In both fields the primary hallmarks of interest are increasing novelty and increasing complexity. Both fields have thus had to grapple with quantifying similar intangible concepts. In fact, both fields seek to answer parallel big questions: Ritchie (2006) asks what mechanisms lead to creativity, just as Waddington (1969), Taylor (2015), and Soros and Stanley (2014) ask what conditions enable open-ended evolution. If ideas from computational creativity can be applied to OEE, then we can avoid unnecessarily duplicating existing research. For instance, Ritchie (2006) suggests some formal models of creativity that might inform a specification of OEE and additionally suggests using connectionist models to determine when a fundamental transition has occurred.

Open questions

Though the connection between OEE and creativity may not be surprising, the lack of its discussion in the OEE community suggests a potentially untapped resource. Three questions offer a starting point for continued dialogue:

1. **Are there nontrivial differences between creativity and OEE or are they fundamentally the same concept?**

2. **Is there any utility in formally pursuing the nature of the relationship between evolution and creativity?**

3. **Do there exist metrics and practices for studying computational creativity (or creativity in general) that could help identify and quantify hallmarks of open-ended evolution?**

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