Beyond Fitness: Visualising Evolution - Workshop overview

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Evolving populations are high-dimensional, time-varying systems that exhibit complex and often counterintuitive dynamics across a variety of time-scales and at many different levels of organisation. Understanding how and why such systems behave in the way that they do is crucial if Alife practitioners are to harness the creative and design potential of evolutionary algorithms, use them as models of analogous natural systems, or even claim living status for the individuals being evolved.

Finding efficient and intuitive ways of visualising the behaviour of these systems can lead to insight into the way they work. Surprisingly, until recently there has been relatively little attention paid to this line of research within the Alife scientific community. While individual researchers have developed idiosyncratic (and often shortlived) graphing techniques and other representations with which to display the behaviour of particular systems, overall there has been a reliance on rather simplistic plots of population summary statistics over time - visualisations that by their nature disguise much of the system complexity.

Within the Alife community, practitioners who use evolutionary techniques as a means of producing works of art have had to grapple with the different ways in which exhibiting an evolutionary system engenders intuitions, impressions and understandings in an audience. In doing so they have tackled many of the same issues that are central to the visualisation problems facing their scientific colleagues: Presentation, interactivity, ease of use and understanding, and so on. This workshop aims at bringing Alife artists and scientists together to discuss these issues, in order to more clearly describe the challenges and move towards some solutions.

Paper abstracts

Mining Evolution Through Visualization. Michael Barlow, John Galloway, and Hussein A. Abbass.

Abstract: Evolutionary computation works in high-dimensional search spaces. Understanding how evolution acts on these spaces is a key step not only to understanding how the system functions, but also to give us an insight into validating and improving evolutionary computation techniques. In this paper, we present a discussion of the field of visualization and an evaluation of this technology from an evolutionary computation's perspective. We then summarize a number of methods to visualize evolutionary systems, some of them are traditional and have been used for the last decade or two while others are new.

Explorations in Evolutionary Visualisation. Lionel Barnett.

Abstract: A real-valued evolutionary optimisation scenario affords a unique opportunity to render visually explicit the "landscape" metaphor in the concept of *fitness landscape*.

Visualizing Adaptive Evolutionary Activity of Allele Tokens and of Phenotypic Equivalence Classes of Alleles. Mark A. Bedau and Michael J. Raven.

Abstract: We present a method for visualizing the important adaptive dynamics in evolving systems. The method consists of measuring evolutionary activity, (as conceived by Bedau and Packard) of components of evolving systems and then plotting this as a function of time. This method has already been applied to individual alleles and whole genotypes. We extend the method to phenotypically equivalent types of alleles and apply it to data generated by Packard's Bugs model, a simple artificial system that consists of agents with sensorimotor genes competing for resources in a two-dimensional world. One novelty of the Packard model studied here

is that it allows the evolution of sensory thresholds—a simple form of the evolution of evolvability. Plotting the evolutionary activity of phenotypically equivalent types of alleles provides an especially vivid empirical quantitative picture of the significant adaptive phenomena in an evolving system.

Prospects for Computational Steering of Evolutionary Computation. Seth Bullock, John Cartlidge and Martin Thompson.

Abstract: Currently, evolutionary computation (EC) typically takes place in batch mode: algorithms are run autonomously, with the user providing little or no intervention or guidance. Although it is rarely possible to specify in advance, on the basis of EC theory, the optimal evolutionary algorithm for a particular problem, it seems likely that experienced EC practitioners possess considerable tacit knowledge of how evolutionary algorithms work. In situations such as this, computational steering (ongoing, informed user intervention in the execution of an otherwise autonomous computational process) has been profitably exploited to improve performance and generate insights into computational processes. In this short paper, prospects for the computational steering of evolutionary computation are assessed, and a prototype example of computational steering applied to a coevolutionary algorithm is presented.

Visualizing Search-Spaces for Evolved Hybrid Auction Mechanisms. Dave Cliff.

Abstract: A sequence of previous papers has demonstrated that a genetic algorithm (GA) can be used to automatically discover new optimal auction mechanisms for automated electronic marketplaces populated by software-agent traders. Significantly, the new auction mechanisms are often unlike traditional mechanisms designed by humans for human traders; rather, they are peculiar hybrid mixtures of established styles of mechanism. Qualitatively similar results (i.e., non-standard hybrid mechanism designs being evolved) have been demonstrated for Cliff's ZIP trader algorithm and also for Gode and Sunder's ZI-C traders, provoking the possibility that such hybrid markets may be optimal for any marketplace populated entirely by artificial trader-agents. The financial implications of this work could potentially be measured in billions of dollars. In an attempt to elucidate why these evolved hybrid markets outperform traditional human-designed mechanisms, this paper presents results from thousands of repetitions of the GA experiments. These data allow 2-d projections of the 10-d real-space fitness landscape to be made, which inter alia illustrate a surprisingly high sensitivity in the relationship between the fitness evaluation function and the resulting landscape.

Visualising Evolutionary Pathways in Real-World Search Spaces. Paul Layzell.

Abstract: A new method of visualising search spaces on a two-dimensional surface is presented, and applied to real search spaces created by the artificial evolution of electronic circuits. The visualisation method is inspired by work on search space neutrality, and its links with evolvability, both of which are discussed. The search space is transformed into a connected graph. Vertices on the graph are connected if their Hamming distance from each other is one, and a clustering algorithm reveals important inter-cluster pathways that can be reached by single mutations.

Ways of Seeing: Visualization of Artificial Life Environments. Jon McCormack and Alan Dorin.

Abstract: This paper investigates the significance of cultural assumptions associated with the methodology and epistemology of visualization in simulations. Starting with ideas from art theory on ways of seeing in the context of painting, we look at the concepts of truth and representation in the visual image. Example images on the subject of evolution and artificial life are examined to reveal the assumptions and implicit knowledge used by the creators and viewers. We use examples of visualization from other cultures to clarify the means by which knowledge influences conventions in representation, and how alternate modes of visual representation may offer new insights for visualization of artificial life systems.

Evolutionary Dynamics Discovered via Visualization in the BREVE Simulation Environment. Lee Spector and Jon Klein.

Abstract: We report how BREVE, a simulation environment with rich 3D graphics, was used to discover significant patterns in the dynamics of a system that evolves controllers for swarms of goal-directed agents. These patterns were *discovered* via visualization in the sense that we had not considered their relevance or thought to look for them initially, but they became obvious upon visually observing the behavior of the system. In this paper we briefly describe BREVE and the system of evolving swarms that we implemented within it. We then describe two discovered properties of the evolutionary dynamics of the system: transitions to/from genetic drift regimes and the emergence of collective or multicellular organization. We comment more generally on the utility of 3D visualization for the discovery of biologically significant phenomena and briefly describe our ongoing work in this area. Pointers are provided to on-line resources including source code and animations that demonstrate several of the described effects.

Visualising Tierra's tree of life using Netmap.

Russell K. Standish and John Galloway.

Abstract: We report on some preliminary results of a project using Netmap to visualise the network of genotypes generated in an evolutionary run of Tierra (the *tree of life*). Netmap is a sophisticated tool for visualising and analysing any dataset containing a network of graph structure. It has been successfully used for fraud detection in a number of commercial datamining projects, in the insurance and retail sector. It has the potential for detecting unusual relationships in the wide varieties of networks generated in Complex Systems.

Hyperspace Graph Paper: Visualising interactions between search algorithms and landscapes. Janet Wiles and Bradley Tonkes.

Abstract: Hyperspace graph paper (HSGP) is a technique for visualising surfaces defined over moderate dimensional binary spaces. The key to this technique is in unfolding the hypercube using recursive steps so that the topology of the high dimensional space is reflected in a recursive structure in the two-dimensional unfolding. In this paper, we describe the original studies that tested the ease of using of this layout technique, and then describe a preliminary case study of its application to understanding the interaction between search algorithms and landscape structures.

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