Embodied Emergence: Distributed Computing Manipulatives

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Abstract

This paper discusses how a system comprised of simple tangible blocks can enable playful and creative experimentation with the concept of emergent behavior.

Introduction

Distributed systems and the emergent properties that can arise out of simple localized interactions have fascinated scientists and artists alike for the last century. They challenge the notions of control and creativity, producing outcomes that can be beautiful, engaging and surprising at the same time.

Emergence has been central to fields such as artificial life and its artistic derivatives. It implies something novel and unanticipated, and as such can be thought of as the reward which draws the artist to explore this bottom-up approach to creation.[1] Furthermore, systems based on emergence carry the promise to allow the creation of complex behaviour from simple elements. The notion of using emergence as a strategy to manage this complexity is very attractive in an era where technology is becoming ever more complicated.

Related Work

The last few decades have given rise to a rich body of software-based works in fields like artificial life and generative art, such as Brian Knepp's Healing Series[2] and the Emergence Engine.[3] Comparatively, their physically embodied counterparts are still in their infancy, in part due to the complexity of building and deploying such systems. Still, a number of artists have been exploring this conceptual space: for example, see Ken Rinaldo's Autotelematic Spider Bots,[4] Adam Brown and Andrew Fagg's Bions[5] or Ping Genius Loci by Aether Architecture.[6]

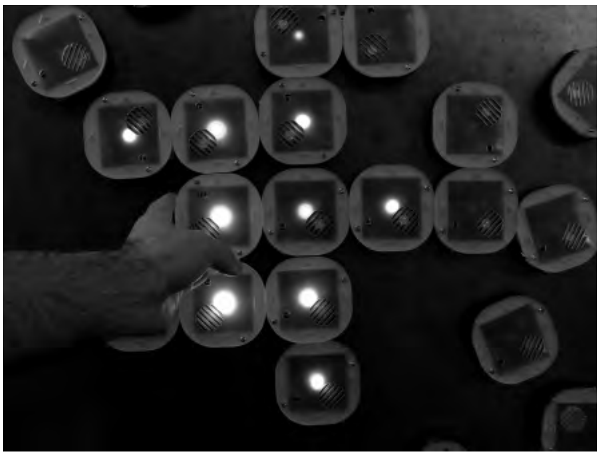
Educational tools also come to mind when discussing emergence, going back to software environments like StarLogo[7] to more recent, tangible interfaces such as Leah Buckley's Boda Blocks[8] or Vincent Leclerc's Senspectra.[9]

Motivation

The aforementioned educational platforms shine with their simplicity and intuitiveness: they can be manipulated by the user to enable a deeper understanding of the emergence mechanisms and therefore encourage experimentation. On the other hand, the artists' project designs push the limit of what can be accomplished using software simulations. However, the user's involvement is often limited to an observation role, with very little direct manipulation.

This paper attempts to address this shortcoming. We present a platform at the intersection of art and education, called *Sound Mites*, which enables a playful exploration of emergent phenomena through what we refer to as distributed computing manipulatives.

Sound Mites



Sound Mites are tangible blocks that communicate with one another in an asynchronous fashion. Each block generates light and sound according to the state of its immediate neighbors and a simple set of rules. They sense touch through a thin metal rim and can modify their state to reflect the interventions of users. The blocks are made out of acrylic and wood, and adhere to flat metallic surfaces by the way of built-in magnets on the bottom.

Each block is fully independent. Users can reconfigure the topology of the system in real-time by rearranging the blocks, creating an ever-changing sound texture with unique qualities that are revealed through a multitude of sound sources physically distributed in space.

Design Considerations

We set out to define a set of principles which have guided and informed the design process of the work. In this process, we identified some constituents of a playful, intuitive and engaging system exploring the notion of emergent behaviour:

Tangibility

The blocks embody the principles of distributed computing in a tangible way. In terms of intuitiveness and playfulness, tangibility offers advantages over software implementations because of affordances derived from an object's shape, material and texture. It enables a more direct manipulation of the system as well. For instance, it is easy to quickly make adjustments to the topology using both hands. Finally, projecting a simulation unto the physical objects also has the benefit of allowing multiple people to interact at the same time around a set of blocks.

Interactivity

In combination with their tangible nature, interactive blocks enable coincidental input and output, where feedback occurs on the interface itself, thus reducing the level of indirection. Interaction also fosters exploration. By allowing the blocks to sense user input, we have created a system which is responsive and gratifying to interact with. Action/reaction mechanisms also provide some grounding point for more abstract concepts, for example by allowing the user to control the placement and amount of "seeds" which are driving a distributed algorithm simulation.

Autonomy

In order to remain true to the spirit of decentralized control, the blocks were implemented in a fully distributed and autonomous fashion. This means that each block functions independently and does not rely on the presence of any particular neighbour block to perform its processing. To strengthen the user's perception of their autonomy, blocks communicate wirelessly via infrared. The use of physical connections would suggest a hidden clock or a centralized process running the show. We believe that making the blocks truly autonomous has a more powerful impact on the user's discovery and understanding of their decentralized behaviour.

Simplicity

There was an effort to make sure the blocks remained as simple as possible. One of the most appealing ideas about emergence is the notion that a simple model of local interactions can generate complex, higher-level behaviour. The blocks should reflect this in their architecture as well as in the complexity of the computation that they can carry out.

Simplicity also means that the blocks can be produced at a low cost. A high number of blocks are needed to make a tangible distributed simulation interesting; thus it is impractical if the cost of each individual block becomes too high, particularly in an independent art context.

Future Work

We are still in the process of understanding these types of networks and what possibilities they might have to offer. Sound Mites are a small step in that direction. Looking ahead, there is a need for platforms targeted at artists that would facilitate these kinds of aesthetic experimentation with emergence and distributed systems.

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5 Brown A. and Fagg A. 2006. "Is it alive? Sensor Networks and Art." In *SIGGRAPH '06: ACM SIGGRAPH 2006 Sketches.* New York: ACM Press, pp. 22.

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9 V. LeClerc, A. Parkes, and H. Ishii. 2007. "Senspectra: a computationally augmented physical modeling toolkit for sensing and visualization of structural strain." In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pp 801–804