Unconventional Computing in the Built Environment

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ABSTRACT

The Synthetic Biology engineering based approach to living systems intersects with the new interdisciplinary field of unconventional computing and suggests a new method for design in architectural practice. Living systems possess unique properties that are not present in digital/mechanical systems - their sensors and effectors are intrinsically coupled, perform parallel forms of computation, are able to respond to unpredictable circumstances, respond in real time to environmental changes, and possess a robustness that can result in evolutionary change. This paper proposes how living technology, operating through the principles of unconventional computing could offer new environmentally remediating materials for architectural practice using a bottom-up approach to the construction of buildings and other human-made interventions.

Keywords: Architecture, Environment, Living Technology, Protocells, Synthetic Biology

INTRODUCTION

We’ve become familiar with the technology of computers being a particular kind of experience based on rational numbers (Chatelin, 2010) that translates these calculations into the actions of digitally operated machines. These devices have transformed the infrastructure of our lives, shaping the way we work and socialize in so many ways that it is almost impossible to imagine what everyday life would be like without them.

Our current notion of what constitutes digital technology (digital processor plus machine) has developed over the last century and its evolution is so rapid that, in keeping with Hook’s Law, no sooner is a device on the market it’s already out of date. Within this same period of technological evolution there have been no new major technological phyla evolving that are independent of digital technology and industrial combustion processes. We’re experiencing the technological equivalent of the Cambrian Explosion, which is a period in the history of life on earth where, according to the fossil record, there appears to have been a sudden diversity in the range of species. Yet, the computational potential of a new phylum of technology that is much older and well established than digital systems is gradually being understood. This kind of technology was responsible for the original Cambrian Explosion and is so seamlessly entwined with our existence that we’re part of it. This technology is life.

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LIFE AS A COMPUTATIONAL PROCESS

The precedent for considering life as a technology has already been established through the scientific disciplines of biotechnology and synthetic biology, owing to the development of theoretical and practical models describing how living systems work. These algorithmic evaluations of living processes offer an approach through which the engineering and modification of biology can be creatively applied to solve existing problems in new ways. Biology can be thought of as the spontaneous, sustained, self-assembling chemical system that has arisen on earth. Over the last few decades new perspectives and models in understanding cell organization have provided insights that enable biology to be designed to support human culture in an increasing variety of ways. This engineering based approach to biological organization intersects with the field of unconventional computing. This is a new interdisciplinary research area that aims to enrich or go beyond the standard models of computing, such as the von-Neumann information architecture and the Turing machine that have dominated computer science for more than half a century (Adamatzky et al., 2007; Cooper et al., 2008; Stepney et al., 2007). Over the last fifty years many analogies between biology and computing have been made. Notably, these manifest as shared terminology applied to digital technologies such as, genetic codes to describe organizational principles, or viruses referring to infectious information agents (Armstrong, n. d.).

“Computer viruses are an analogy -- it’s a very good analogy, because a computer virus is a piece of computer code written in computer language. It says, “Duplicate me and spread me around and maybe do some mischief on the way,” and it works because computers obey the instructions written in computer language. If you write a program that says “duplicate me, spread me around,” it will spread by the medium of floppy disks and so on” (Dawkins, n. d.).

However, there are fundamental differences between digital technology and organisms such as, the ability of biology to uniquely able to respond to unpredictability in a flexible, embodied way and establish an intimate connectedness to its surroundings that clearly distinguish living systems from digital technologies. Additionally, unlike digital systems that can be built from their component parts, biology has not been successfully constructed from an understanding of its fundamental units and arises as a spontaneous, complex system of networks under the ‘right’ conditions, which can be described using a combination of top-down and bottom up organizational relationships.

TOP DOWN BIOLOGICAL ORGANIZATION

Biological systems alter their developmental strategies when environmental conditions change so that the ‘living’ solution is always relevant in the context of the surroundings. This mutually dependent relationship between biology and its environment was described by Charles Darwin in his 1859 publication ‘On the Origins of Species’ set the theoretical landscape for the pioneering work of Watson and Crick (Watson & Crick, 1953) to position the chemical DNA as playing a central role in cell regulation. DNA is regarded as the fundamental information processing system of biology that influences the activity of cells (Armstrong, n. d.). It performs a top-down regulatory function orchestrating the production and behaviour of groups of molecules with downstream effects on the infrastructure of a cell. Whilst much research has been dedicated to understanding the mechanism of operation of the top-down control processes, through computer modeling with genetic algorithms, biotechnological interventions and even using DNA itself to solve complex tasks (Braich et al., 2002), bottom-up processes in the cell are not so well understood. This is partly due to difficulty in modeling these processes owing to their complexity as well as for cultural and historical reasons since the
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