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EDITORIAL

Editorial introduction to the special issue on developmental systems

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As computer scientists wrestle with trying to create computer-automated design systems that can produce ever more sophisticated designs, it is not surprising that those of us in the field of Evolutionary Computation (EC) turn to Nature for further inspiration. Just as the different types of Evolutionary Algorithms were inspired by natural evolution, so to do we look to biological development for inspiration on how to increase the complexity of what we can evolve. In this special issue, we present a handful of papers in the area of Developmental Systems.

Today it is not very controversial to point out that a synergy between evolutionary biology and developmental biology does exist. However, despite the mutual benefit to both evolutionary biology and developmental biology of taking the others' perspective, traditionally within evolutionary biology, development had been ''black-boxed'' and ignored [1]. This is most clearly seen in the Modern Synthesis, which combined Darwinian evolution by natural selection, Mendel's theory of genetics, and mathematical population genetics. Pivotal to Modern Synthesis was T. H. Morgan, for whom Bolkor notes ''genes mattered as vehicles of

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heredity, not as participants in the generation of phenotypes.'' Unfortunately, this was an all too common thought. The recognition of the importance of development within evolutionary biology, however, really did not occur until perhaps thirty years ago [2]. Although general principles of development are still over-looked in the evolutionary literature today, the inclusion of developmental perspectives is very much on the increase, and has given rise to a sort of Cambrian explosion evidenced by ever increasing nomenclature, new technologies, and new methods. In addition, new subjects are emerging all around such as evo-devo (evolutionary developmental biology), systems biology, bioinformatics, and computational biology, to name but a few.

Just as evolutionary biologists long ignored developmental biology, computer scientists working in Evolutionary Computation have also tended to ignore development. Since EAs traditionally have made no explicit difference between genotype and phenotype, there has generally been little need for any form of development. Yet, over the past quarter of a century or so—and as the types of problems EC'ers face get tougher as well as with an increase in the desired sophistication of the solutions—EC has seen a surge of research that not only acknowledges the distinction between genotype and phenotype, but that also augments the evolutionary process with an explicit model of development (whether biologically faithful or not).

Recognition that the process of development is itself evolved has led to a growing interest in augmenting models of evolution with models of development to evolve solutions for open-ended design problems. In so doing, EC has seen the birth of Developmental Systems, which essentially either model biological development or use mechanisms and processes from biological development as inspiration for approaching engineering problems. The common theme, regardless of which aspect of development is chosen to be modeled, is that the underlying problem has something to do with construction, which lies at the very heart of biological development.

In this special issue we are pleased to present four papers that investigate different aspects of developmental systems and take us a step closer to evolving systems of the complexity produced in Nature. For an organism to have a developmental process it must consist of more than one cell, and Cristian Solari, John Kessler and Raymond Goldstein present an investigation into the transition from unicellular to multicellular organisms. Rather than trying to re-implement Nature, Ken Stanley's article asks the intriguing question of whether ''development'' can be achieved in a far more mathematical and procedural manner than the biological approaches. In Una-May O'Reilly and Maartin Hemberg's paper they present Genr8, a design tool for architects which uses a developmental system for producing diverse and organic-looking shapes. Finally, Garnett Wilson and Malcolm Heywood describe a developmental process for Genetic Programming in which a population of genotypes is co-evolved along with a population of mappings for interpreting the genotypes.

We hope you enjoy reading this special issue of the GPEM journal on Developmental Systems as much as we've enjoyed compiling it!

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