Preface

Evolution has probably been the driving force behind most things that we think of as remarkable, unbelievable and admire. For example, the complexity of a beehive, of a coral reef, of a brain. For example, the beauty of tropical lilies, of flocks of swifts at sunset, of the multitude of patterns on moth wings. For example, the ability of salamanders to recover from injury, the ability of immune systems to protect against unknown and previously unseen invaders, the colour-changing ability of chameleons. All of these examples and so much more have been achieved through millions of years of evolutionary battles. These remarkable achievements, if we can call them achievements, have been accomplished in quite a different way to how we as engineers, scientists, inventors, create our designs. The theme of this book is to take inspiration from the remarkable process we know as evolution and use this inspiration to help create engineering systems, in the majority of the cases outlined in the book, electronic systems.

As mentioned this book is mainly about electronic engineering as an application for artificial evolution, as such the drive and development of the subject has been linked very strongly to innovations and growth in the underlying technology that supports electronics. The developments in this technology over the last 20 years have enabled ideas and metaphors from natural sciences to become reality on electronic hardware. However, the hardware is not so useful on its own and requires programming, configuring, structuring by some form of software mechanisms. We can abstract evolutionary processes understood in nature to form sets of artificial evolutionary processes that we can use in tandem with technology to form what is generally known as Evolvable Hardware—the theme of this book.

While evolutionary computing, or the ideas that we now know of as evolutionary computing, have been around for much longer than 20 years, both von Neumann and Turing, for example, toyed with the ideas of inspiration from nature for the design of computational engines (and da Vinci 600 years ago with flying machines based on bird anatomy), the field of Evolvable Hardware is much newer (or at least the realisation of the field onto electronic hardware). It has required the underlying technology to "catch up" with the ideas behind evolutionary computation and pro-

vide the structures and mechanisms essential for the field to achieve outcomes that are worth pursuing.

As might be imagined, the field of Evolvable Hardware is full of technical details, of hardware subtleties, of hardware-software mappings and of compromises. So while you should not be put off by the fact that you will have to understand something about hardware, you should realise that you will have to expend some effort to achieve the results you dream of. But don't fear, help is at hand, Part I of this book focuses on these technical issues to help you get started.

Part I will introduce you to Evolvable Hardware, starting by abstracting away from these technical issues and giving an overview of the field and much of the terminology used. The book then gets technical! We consider in more detail the different types of hardware substrates and software mechanisms that are used within the field of Evolvable Hardware. Ranging from analogue to digital substrates, from commercial to research hardware, from binary bit-strings to genetic programming. Finally in Part I we will highlight issues learnt through experience related to actually implementing Evolvable Hardware on hardware.

Part II of the book gives a rather higher-level view of Evolvable Hardware and focuses on applications. In this part of the book we have invited a number of leading researchers throughout the world to give an insight into how they used various types of Evolvable Hardware to solve their problems. These applications range from VLSI design to image processing, from medical engineering to robotics. Each gives their own particular take on applying Evolvable Hardware to their application, some of the issues that were overcome and a view on how they see Evolvable Hardware developing, for their field, in the coming years.

You will also find in the Appendix of this book a number of documents related to undergraduate and postgraduate laboratory experiments we have undertaken at the University of York over a number of years. We provide these to assist those new to the subject and wishing to get started quickly with real hardware experiments.

Our motivation for writing this book is that we consider Evolvable Hardware to have a place in the design of engineering systems. We believe that as systems get more and more complex, as substrates start to move from homogeneous media to heterogeneous media, techniques and mechanisms inherent in Evolvable Hardware will be fundamental to help produce working systems.

We hope you enjoy reading this book and that we can both enlighten you on this exciting field and enthuse you to join the field if you have not already. Happy evolving!

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January 2015   *Andy M. Tyrrell*

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