Preface

Field-programmable gate arrays (FPGAs) were invented in 1984 by Ross Freeman. Basically, it is a semiconductor consisting of programmable logic blocks that can be used to reproduce simple functions up to a complex system on a chip (SoC). The main advantages of the FPGAs are: they can be reprogrammed, have low development and acquisition costs, and their application is a good option if the product is not in high numbers. That way, FPGAs are gaining the attention of researches for the development of applications in a wide variety of fields, for example, medicine, communications, signal processing, avionics, space, finance, military, electronics, and other areas that exploit their flexibility and capability of being reprogrammed/configured.

Configurability for engineering applications makes FPGA very crucial in initial stages for any embedded project. Some analog circuits and any digital circuit can be implemented using FPGA, so the possibilities are endless. However, applications found on recent articles and books did not detail the realizations from the model to the physical synthesis. That way, this book details engineering applications of FPGAs from mathematical models descriptions to VHDL programming issues and hardware implementation of applications involving chaos theory.

The reader can find insights on FPGA-based implementations for chaos generators, artificial neural networks (ANNs), random number generators (RNGs), and master–slave synchronization of chaotic oscillators to implement a secure communication system for image transmission. The plus of this book is focused on providing VHDL programming guidelines and issues, along with co-simulation examples with Active-HDL and Simulink. In addition, we list some challenges on applying different kinds of numerical methods, problems on optimizing chaotic systems, selection of an ANN topology, its training, improvements on designing activation functions, data supply using serial communication with a computer, generation of random number generators from chaos theory, realization of chaotic secure communication systems, and other open problems for future research.

In summary, this book details FPGA realizations for:

- Chaos generators, which are described from their mathematical models, are characterized by their maximum Lyapunov exponent, and are implemented using minimal FPGA resources.
- Artificial neural networks (ANNs), discussing some topologies, different learning techniques, kinds of activation functions, and issues on choosing the length of the digital words being processed. One ANN topology is applied to chaotic time series prediction.
- Random number generators (RNGs), which are designed using different chaos generators, in the continuous-time and discrete-time domains. The RNGs are characterized by their maximum Lyapunov exponent and entropy, and are evaluated through NIST tests.
- Optimized chaotic oscillators are synchronized in a master–slave topology that is used to implement a secure communication system to process black and white, and grayscale images.

Some chapters discuss computer arithmetic issues to minimize hardware resources and to reduce errors, before synthesizing the FPGA realization. At the end, the reader can infer open lines for future research not only in areas where chaos generators, ANNs, random number generators, and secure communications are required, but also to extend the presented material to other problems in engineering.

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