About this Series

The series “Studies in Computational Intelligence” (SCI) publishes new developments and advances in the various areas of computational intelligence—quickly and with a high quality. The intent is to cover the theory, applications, and design methods of computational intelligence, as embedded in the fields of engineering, computer science, physics and life sciences, as well as the methodologies behind them. The series contains monographs, lecture notes and edited volumes in computational intelligence spanning the areas of neural networks, connectionist systems, genetic algorithms, evolutionary computation, artificial intelligence, cellular automata, self-organizing systems, soft computing, fuzzy systems, and hybrid intelligent systems. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution, which enable both wide and rapid dissemination of research output.
Growing Adaptive Machines

Combining Development and Learning in Artificial Neural Networks
Preface

It is our conviction that the means of construction of artificial neural network topologies is an important area of research. The value of such models is potentially vast. From an applied viewpoint, identifying the appropriate design mechanisms would make it possible to address scalability and complexity issues, which are recognized as major concerns transversal to several communities. From a fundamental viewpoint, the important features behind complex network design are yet to be fully understood, even as partial knowledge becomes available, but scattered within different communities.

Unfortunately, this endeavour is split among different, often disparate domains. We started a workshop in the hope that there was significant room for sharing and collaboration between these researchers. Our response to this perceived need was to gather like-motivated researchers into one place to present both novel work and summaries of research portfolio.

It was under this banner that we originally organized the DevLeaNN workshop, which took place at the Complex Systems Institute in Paris in October 2011. We were fortunate enough to attract several notable speakers and co-authors: H. Berry, C. Dimitrakakis, S. Doncieux, A. Dutech, A. Fontana, B. Girard, Y. Jin, M. Joachimczak, J. F. Miller, J.-B. Mouret, C. Ollion, H. Paugam-Moisy, T. Pinville, S. Rebecchi, P. Tonelli, T. Trappenberg, J. Triesch, Y. Sandamirskaya, M. Sebag, B. Wróbel, and P. Zheng. The proceedings of the original workshop are available online, at http://www.devleann.iscpif.fr. To capitalize on this grouping of like-minded researchers, we moved to create an expanded book. In many (but not all) cases, the workshop contribution is subsumed by an expanded chapter in this book.

In an effort to produce a more complete volume, we invited several additional researchers to write chapters as well. These are: J. A. Bednar, Y. Bengio, D. B. D’Ambrosio, J. Gauci, and K. O. Stanley. The introduction chapter was also co-authored with us by S. Chevallier.
Our gratitude goes to our program committee, without whom the original workshop would not have been possible: W. Banzhaf, H. Berry, S. Doncieux, K. Downing, N. García-Pedrajas, Md. M. Islam, C. Linster, T. Menezes, J. F. Miller, J.-M. Montanier, J.-B. Mouret, C. E. Myers, C. Ollion, T. Pinville, S. Risi, D. Standage, P. Tonelli. Our further thanks to the ISC-PIF, the CNRS, and to M. Kowaliw for help with the editing process. Our workshop was made possible via a grant from the Région Île-de-France.

Enjoy!

Toronto, Canada, January 2014
Paris, France
Washington DC, USA

Taras Kowaliw
Nicolas Bredeche
René Doursat
Contents

1 Artificial Neurogenesis: An Introduction and Selective Review . . . 1
Taras Kowaliw, Nicolas Bredeche, Sylvain Chevallier
and René Doursat

2 A Brief Introduction to Probabilistic Machine Learning
and Its Relation to Neuroscience . . . . . . . . . . . . . . . . . . . 61
Thomas P. Trappenberg

3 Evolving Culture Versus Local Minima . . . . . . . . . . . . . . . . 109
Yoshua Bengio

4 Learning Sparse Features with an Auto-Associator . . . . . . . . . 139
Sébastien Rebecchi, Hélène Paugam-Moisy and Michèle Sebag

5 HyperNEAT: The First Five Years . . . . . . . . . . . . . . . . . . . 159
David B. D’Ambrosio, Jason Gauci and Kenneth O. Stanley

6 Using the Genetic Regulatory Evolving Artificial Networks
(GReaNs) Platform for Signal Processing, Animat Control,
and Artificial Multicellular Development . . . . . . . . . . . . . . . 187
Borys Wróbel and Michał Joachimczak

7 Constructing Complex Systems Via Activity-Driven
Unsupervised Hebbian Self-Organization . . . . . . . . . . . . . . 201
James A. Bednar

8 Neuro-Centric and Holocentric Approaches
to the Evolution of Developmental Neural Networks . . . . . . . 227
Julian F. Miller

9 Artificial Evolution of Plastic Neural Networks:
A Few Key Concepts . . . . . . . . . . . . . . . . . . . . . . . . . . 251
Jean-Baptiste Mouret and Paul Tonelli