# Preface

It was 1986 when John Tanner and Carver Mead published an article describing one of the first analog VLSI visual motion sensors. The chip proposed a novel way of solving a computational problem by a collective parallel effort amongst identical units in a homogeneous network. Each unit contributed to the solution according to its own interests and the final outcome of the system was a collective, overall optimal, solution. When I read the article for the first time ten years later, this concept did not lose any of its appeal. I was immediately intrigued by the novel approach and was fascinated enough to spend the next few years trying to understand and improve this way of computation - despite being told that the original circuit never really worked, and in general, this form of computation was not suited for aVLSI implementations.

Luckily, those people were wrong. Working on this concept of collective computation did not only lead to extensions of the original circuit that actually work robustly under real-world conditions, it also provided me with the intuition and motivation to address fundamental questions in understanding biological neural computation. Constraint satisfaction provides a clear way of solving a computational problem with a complex dynamical network. It provides a motivation for the behavior of such systems by defining the optimal solution and dynamics for a given task. This is of fundamental importance for the understanding of complex systems such as the brain. Addressing the question *what* the system is doing is often not sufficient because of its complexity. Rather, we must also address the functional motivation of the system: *why* is the system doing what it does?

Now, another ten years later, this book summarizes some of my personal development in understanding physical computation in networks, either electronic or neural. This book is intended for physicists, engineers and computational biologists who have a keen interest in the computational question in physical systems. And if this book finally inspires a young graduate student to try to understand complex computational systems and the building of computationally efficient devices then I am very content – even if it takes another ten years for this to happen.

**Acknowledgments**

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go to all members of the institute at that time, and in particular to the late Jörg Kramer who introduced me to analog circuits design. I also want to thank the Swiss government, the Körber foundation, and the Howard Hughes Medical Institute for their support during the development and writing of this book.

Many colleagues and collaborators had a direct influence on the final form of this book by either working with me on topics addressed in this book or by providing invaluable suggestions and comments on the manuscript. I am very thankful to know and interact with such excellent and critical minds. These are, in alphabetical order: Vlatko Becanovic, Tobias Delbrück, Rodney Douglas, Ralph Etienne-Cummings, Jakob Heinzle, Patrik Hoyer, Giacomo Indiveri, Jörg Kramer, Nicole Rust, Bertram Shi, and Eero Simoncelli.

Writing a book is a hard optimization problem. There are a large number of constraints that have to be satisfied optimally, many of which are not directly related to work or the book itself. And many of these constraints are contradicting. I am very grateful to my friends and my family who always supported me and helped to solve this optimization problem to the greatest possible satisfaction.

### Website to the book

There is a dedicated on-line website accompanying this book where the reader will find supplementary material, such as additional illustrations, video-clips showing the real-time output of the different visual motion sensor and so forth. The address is http://wiley.com/go/analog

The website will also contain updated links to related research projects, conferences and other on-line resources.