HANDBOOK OF NATURE-INSPIRED AND INNOVATIVE COMPUTING

Integrating Classical Models with Emerging Technologies

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Edited by

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To my family for their help,
support, and patience.
Albert Zomaya

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PREFACE

The proliferation of computing devices in every aspect of our lives increases the demand for better understanding of emerging computing paradigms. For the last fifty years most, if not all, computers in the world have been built based on the von Neumann model, which in turn was inspired by the theoretical model proposed by Alan Turing early in the twentieth century. A Turing machine is the most famous theoretical model of computation (A. Turing, On Computable Numbers, with an Application to the Entscheidungsproblem, *Proc. London Math. Soc*. (ser. 2), **42**, pp. 230–265, 1936. Corrections appeared in: ibid., **43** (1937), pp. 544–546.) that can be used to study a wide range of algorithms.

The von Neumann model has been used to build computers with great success. It has also been extended to the development of the early supercomputers and we can also see its influence on the design of some of the high performance computers of today. However, the principles espoused by the von Neumann model are not adequate for solving many of the problems that have great theoretical and practical importance. In general, a von Neumann model is required to execute a precise algorithm that can manipulate accurate data. In many problems such conditions cannot be met. For example, in many cases accurate data are not available or a "fixed" or "static" algorithm cannot capture the complexity of the problem under study.

Therefore, The Handbook of Nature-Inspired and Innovative Computing: Integrating Classical Models with Emerging Technologies seeks to provide an opportunity for researchers to explore the new computational paradigms and their impact on computing in the new millennium. The handbook is quite timely since the field of computing as a whole is undergoing many changes. Vast literature exists today on such new paradigms and their implications for a wide range of applications -a number of studies have reported on the success of such techniques in solving difficult problems in all key areas of computing.

The book is intended to be a Virtual Get Together of several researchers that one could invite to attend a conference on `futurism' dealing with the theme of Computing in the 21st Century. Of course, the list of topics that is explored here is by no means exhaustive but most of the conclusions provided can be extended to other research fields that are not covered here. There was a decision to limit the number of chapters while providing more pages for contributed authors to express their ideas, so that the handbook remains manageable within a single volume.

It is also hoped that the topics covered will get readers to think of the implications of such new ideas for developments in their own fields. Further, the enabling technologies and application areas are to be understood very broadly and include, but are not limited to, the areas included in the handbook.

The handbook endeavors to strike a balance between theoretical and practical coverage of a range of innovative computing paradigms and applications. The handbook is organized into three main sections: (I) Models, (II) Enabling Technologies and (III) Application Domains; and the titles of the different chapters are self-explanatory to what is covered. The handbook is intended to be a repository of paradigms, technologies, and applications that target the different facets of the process of computing.

The book brings together a combination of chapters that normally don't appear in the same space in the wide literature, such as bioinformatics, molecular computing, optics, quantum computing, and others. However, these new paradigms are changing the face of computing as we know it and they will be influencing and radically revolutionizing traditional computational paradigms. So, this volume catches the wave at the right time by allowing the contributors to explore with great freedom and elaborate on how their respective fields are contributing to re-shaping the field of computing.

The twenty-two chapters were carefully selected to provide a wide scope with minimal overlap between the chapters so as to reduce duplications. Each contributor was asked to cover review material as well as current developments. In addition, the choice of authors was made so as to select authors who are leaders in the respective disciplines.

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First and foremost we would like to thank and acknowledge the contributors to this volume for their support and patience, and the reviewers for their useful comments and suggestions that helped in improving the earlier outline of the handbook and presentation of the material. Also, I should extend my deepest thanks to Wayne Wheeler and his staff at Springer (USA) for their collaboration, guidance, and most importantly, patience in finalizing this handbook. Finally, I would like to acknowledge the efforts of the team from Springer's production department for their extensive efforts during the many phases of this project and the timely fashion in which the book was produced.

Albert Y. Zomaya