

Handbook of Signal Processing Systems

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Editors

Handbook of Signal Processing Systems

Third Edition

Foreword by S.Y. Kung

 Springer

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*To Milu
Shuvra Bhattacharyya*

*To Deirdre
Ed Deprettere*

*To Bettina
Rainer Leupers*

*To Auli
Jarmo Takala*

Foreword

It gives me immense pleasure to reintroduce this handbook to the research/development communities in the field of signal processing systems (SPS). The handbook represents the first of its kind to provide a comprehensive coverage on state of the arts of this field. The fact that it is already now the third edition is a clear attestation of the high demand from all the related professional communities. It is truly an influential and timely contribution to the field of SPS.

The driving force behind information technologies (IT) hinges critically upon the major advances in both component integration and system integration. The major breakthrough for the former is undoubtedly the invention of IC in the 1950s by Jack S. Kilby, the Nobel Prize Laureate in Physics in 2000. In an integrated circuit, all components were made of the same semiconductor material. Beginning with the pocket calculator in 1964, there have been many increasingly complex applications followed. In fact, processing gates and memory storage on a chip have since then grown at an exponential rate, following Moore's Law. (Moore himself admitted that Moore's Law had turned out to be more accurate, longer lasting, and deeper in impact than he ever imagined.) With greater device integration, various signal processing systems have been realized for many killer IT applications. Further breakthroughs in computer sciences and Internet technologies have also catalyzed large-scale system integration. All these have led to today's IT revolution which has profound impacts on our lifestyle and overall prospect of humanity. (It is hard to imagine life today without mobiles or the Internet!)

The success of SPS requires a well-concerted integrated approach from multiple disciplines, such as device, design, and application. It is important to recognize that system integration means much more than simply squeezing components onto a chip and, more specifically, there is a symbiotic relationship between applications and technologies. Emerging applications, e.g., 5G communication, big data analysis, machine learning, and the trendy AI, will prompt modern system requirements on performance and power consumption, thus inspiring new intellectual challenges. Therefore, the new paradigm of SPS architectures must be amenable to various design facets such as overall system performance, flexibility, and scalability, power/thermal management, hardware-software partition, and algorithm developments.

With greater integration, system designs become more complex and there exists a huge gap between what can be theoretically designed and what can be practically implemented. It is critical to consider, for instance, how to deploy in concert an ever increasing number of transistors with acceptable power consumption and how to make hardware effective for applications and yet friendly to the users (easy to program). Therefore, major advances in SPS must arise from close collaboration between application, hardware/architecture, algorithm, CAD, and system design.

It is only fitting for Springer/Nature to produce this timely handbook. Springer/Nature has long played a major role in academic publication on SPS, many of them have been in close cooperation with IEEE's signal processing, circuits and systems, and computer societies. For nearly 30 years, I have been the editor-in-chief of Springer's *Journal of Signal Processing Systems*, considered by many as a major forum for the SPS researchers. Nevertheless, the idea has been around for years that a single-volume reference book would very effectively complement the journal in serving this technical community. Then, during the 2008 IEEE Workshop on Signal Processing Systems, Washington D.C., Jennifer Evans from Springer and the editorial team led by Prof. Shuvra Bhattacharyya met to brainstorm implementation of such idea. The result was this series of right-on-time handbooks. Especially, this edition has collected a vast pool of leaders/pioneers to cover architectures; compilers, programming and simulation tools; and design tools and methodologies.

Indeed, the handbook offers a comprehensive and up-to-date treatment of the driving forces behind SPS, current architectures, and new design trends. It provides a solid foundation for several imminent technical areas, for instance, scalable, reusable, and reliable system architectures, energy-efficient high-performance architectures, IP deployment and integration, system-on-chip, memory hierarchies, and future cloud computing. Moreover, it covers a wide spectrum of applications, including wireless/radio signal processing, image/video/multimedia processing, control and communication, video coding, stereo vision, computer vision, data mining, and machine learning.

Looking into the (near) future, we note that modern AI tools have become heavily data-driven and data-intensive. As of now, on the daily basis, as many as 1 billion photos and 10 billion messages are being handled by a single Internet company and, moreover, such dazzling numbers are rapidly growing on par with Moore's law. In order to unravel useful information hidden in big data, it will require novel (and possibly parallel processing) algorithmic designs which in turn will call for special hardware/software technologies advocated here. In this sense, the handbook is actually well positioned to support the increasingly data-driven AI technologies.

With the utmost enthusiasm, my sincere congratulations go to the authors and editors for putting together such an outstanding contribution.

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Preface

In this new edition of the *Handbook of Signal Processing Systems*, many of the chapters from the previous editions have been updated, and several new chapters have been added. The new contributions include chapters on signal processing methods for light field displays, throughput analysis of dataflow graphs, modeling for reconfigurable signal processing systems, fast Fourier transform architectures, deep neural networks, programmable architectures for histogram of oriented gradients processing, high dynamic range video coding, system-on-chip architectures for data analytics, analysis of finite word-length effects in fixed-point systems, and models of architecture.

We hope that this updated edition of the handbook will continue to serve as a useful reference to engineering practitioners, graduate students, and researchers working in the broad area of signal processing systems. Selected chapters from the book can be used as core readings for seminar- or project-oriented graduate courses in signal processing systems. Given the wide range of topics covered in the book, instructors have significant flexibility to orient such a course towards particular themes or levels of abstraction that they would like to emphasize.

This new edition of the handbook is organized in three parts. Part I motivates representative applications that drive and apply state-of-the-art methods for design and implementation of signal processing systems; Part II discusses architectures for implementing these applications; and Part III focuses on compilers, as well as models of computation and their associated design tools and methodologies. The chapters are ordered alphabetically by the first author's last name in Parts I and III, while they are ordered in Part II starting with chapters that cover more general topics, and followed by chapters that are more application-specific.

We are very grateful to all of the authors for their valuable contributions, and for the time and effort they have devoted to preparing the chapters. We would also like

to thank Courtney Clark, Caroline Flanagan, and Jennifer Evans for their support and patience throughout the entire development process of the handbook.

College Park, MD, USA
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