

Preface

This book has emerged as the result of the authors' research activity over the past six years. We started the journey as an Electronics Engineer and a Computer Scientist, both with working experience of sensing systems. The motivation for joint work was initially provided by the vision of a new world-changing technology put forward by vanguard researchers such as Kris Pister and Deborah Estrin. They foresaw systems composed of millions of MEMS sensors, collaborating in an 'intelligent' way to address many of the major problems of our age — environmental study and monitoring, pollution controls, transport safety and so on. These sensors would self-organise into networks, which in turn would be self-configuring, fully decentralised and would rely entirely on collaborative behaviour between sensors.

Like most researchers launching into a new venture, we started with simple theoretical and practical studies derived from our own sensing backgrounds and aimed at evolving the research towards full blown applications as above. Eventually it became clear that neither of our disciplines was sufficient to allow us to fully cover the scope of this research. Our vistas simply had to expand to allow us to make sensible choices as to direction and emphasis of research.

When approaching the detailed design of even quite small systems (in terms of sensor numbers), we found that the research questions posed required new science within our own respective disciplines, combined with a need for new science in other disciplines. To overcome the exposed hurdles, these findings had to be communicated to the scientists with the knowledge and skills to provide it. At this stage we became aware of how difficult it is for domain specialists to hold an overview of a topic as broad as that of large scale MEMS based sensing systems. As a simple example of the problem, a MEMS device designer may spend an enormous amount of effort optimising

a design for those last few decibels of noise margin, when, at a system level in an intelligent sensor, that same performance increase may be obtained very simply using a slightly more sophisticated signal processing algorithm. Without at least some knowledge of what is possible in each of the domains involved here (MEMS technology and smart sensor electronics), it is impossible to make sensor system design trade-offs in a sensible way. When one moves on to the possibility of sensors collaborating and operating advanced data fusion algorithms, the design choices become even more difficult and the breadth of knowledge required tenfold larger.

A study of the many new books and papers being published in the domain of intelligent MEMS systems and wireless sensor networks reveals that they mostly take a single discipline perspective. While several of these books are excellent, a researcher embarking on a top-down sensor system design venture (which we believe to be essential to achieving success in this field) is faced with assembling a library of books, each of which books assumes prior knowledge of domains that could easily be alien to our researcher.

The aim of this book is therefore to present the leading edge of this research and indeed set the research agenda in the field of MEMS based sensing. We hope to have been able to bring in a view from all of the participatory disciplines, in an integrated way. No assumption was made of *a priori* knowledge above the level which might be reasonably expected from, say, an electronic engineer about computer science or a computer scientist about MEMS. This has proved to be a much harder task than we initially envisaged, resolved however with the help of our distinguished contributors who have risen to the challenge of stepping out of their specialist domain and presenting deep knowledge of their own field in a way accessible to the non-specialist. Hence, we are very grateful to Dr. Andrew Flewitt for a complete and clear exposition of relevant MEMS micromachining technologies; to Dr. Michael Kraft for a detailed case study on inertial sensors which reveals the merits of integrated sensor signal processing and Dr. Davies William de Lima Monteiro for a fascinating insight into the practice and potential of active optical MEMS systems.

Overall, we have tried to pay particular attention to the level of each chapter. We have not allowed ourselves to work at elementary introduction level, but have always attempted to present leading edge work in each of the three areas covered, MEMS technology, electronic system design and

pervasive computer science, in a digestible fashion. The central element which facilitated this treatment was the concept of the “cogent” sensor, which we developed when it became clear how overused and overloaded the terms ‘smart’ and ‘intelligent’ are, when used to describe processor integrated sensing devices. We strongly believe that it is much more useful to define things by what they do, rather than how they are constructed, when working from a top-down systems perspective. Whereas Randy Frank proposed whimsically that “A rose with a microcontroller would be a smart rose” (*Understanding Smart Sensors*, pp1), we would say “a rose which provides the fragrance you need would be a cogent rose”. The theme of usefulness is the essence of the top-down approach.

It is widely held that smart MEMS technology will be world-changing, which presumes it will be of real use for activities which shape the world. Rather than promoting a solution waiting for a problem, we want to enable those with problems waiting for solutions to evaluate whether smart MEMS systems will rise to that challenge. If it proves to be so, we want also to enable them to begin the process of scoping that solution.

If we have achieved this goal, we believe that the book will be uniquely useful to those faced with understanding the breadth and wealth of the opportunities that combined MEMS and pervasive computing technologies offers.

Elena Gaura,
Robert Newman.
Coventry, 2006.