Preface

Measurement plays a fundamental role in both physical and behavioural sciences, as well as in engineering and technology, in that it acts as a link between abstract models and empirical reality and is a privileged method of gathering information from the real world.

This poses a challenge, therefore: is it possible to develop a single theory of measurement for the various domains of science and technology in which measurement is involved? One such theory is presented in this book, which addresses three main issues:

- what is the meaning of measurement?
- how do we measure? and
- what can be measured?

Since uncertainty plays an essential role, the theory is expressed in probabilistic terms. Some key applications are also addressed.

In writing this book, three major goals were pursued.

First of all, I set out to develop a theoretical framework that could truly be shared by scientists in different fields, ranging from physics and engineering to psychology. In the past, measurement was a controversial issue between these communities and a division took place during the last century, the consequences of which can still be felt today. Now it is time for a change: in the future it will be necessary to find new and creative methods of ensuring that human activities respect the environment and manage energy sources in a different way. This will require greater collaboration between science and technology and between different sciences. Measurement, which played a key role in the birth of modern science, can act as an essential interdisciplinary tool and language for this new scenario.

The second goal was to provide a sound theoretical basis for addressing key problems in measurement. These include perceptual measurements, the evaluation of uncertainty, the evaluation of inter-comparisons, the analysis of risks in decision-making, and the characterisation of dynamical measurements. Currently, increasing attention is paid to these issues due to their scientific, technical, economical and social impact. The book proposes a unified probabilistic approach to them which may allow more rational and effective solutions to be reached.

Lastly, I would like to reach as broad a readership as possible, including, as mentioned, people from different fields who may have different mathematical backgrounds and different understandings of measurement. For this purpose, great care was taken over language usage by giving preference to as interdisciplinary a terminology as possible and carefully defining and discussing all key terms. Concerning mathematics, all the main results are preceded by intuitive discussions and illustrated by simple examples. Moreover, precise proofs are always included in order to enable the more demanding readers to make conscious and creative use of these ideas, and also to develop new ones.

Attempts at developing a general theory of measurement have been made in the past, especially the so-called representational theory. These include some classics works, as the excellent books by Krantz, Luce, Suppes and Tversky (three volumes, 1971–1990) and by Roberts (1979), to mention just a few, that have all been recently reprinted. With respect to these, this book features two main new developments.

Firstly, it includes a general model of the measurement process which, in physics and engineering, provides a sound basis for instrument science, and, in psychology, makes it possible to consider people as 'measuring instruments'. Secondly, it uses a fully probabilistic approach which allows uncertainty to be treated as an inherent feature of measurement and helps in the systematic development of effective data processing procedures.

Finally, the book demonstrates that measurement, which is commonly understood to be a merely experimental matter, poses theoretical questions which are no less challenging than those arising in other, apparently more theoretical, disciplines.

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