

Preface

This book originates from a nice discussion among colleagues with different engineering backgrounds and skills. We had so far worked in apparently distant fields, such as ultrasonics, sensing for nondestructive evaluation (NDE) of manufactured goods, signal processing for telecommunications, signal processing for earth exploration and geophysical engineering, and more. We had been involved in these areas in various capacities, for different applications and with different goals. During our exchanges, it clearly emerged that some of the difficulties encountered in the industrial implementation of ultrasonic testing techniques could be better addressed by pursuing a closer interaction among sibling working areas. Specifically, we realized that there were advantages in importing and adapting results or points of view originally developed in areas different from ultrasonic testing, such as telecommunications, radar, or geophysics.

The most immediate result of that conversation was a strong desire to cooperate to translate that intuition into action. This led to the conception of a research project, targeting “*nondestructive ultrasound test based on pseudoorthogonal sequences for imaging and automatic classification of industrial products*.” The work plan was then funded by the Italian Ministry of Education, University and Research, in the framework of the Italian Research Programs of Relevant National Interest (PRIN).

In the 3-year activity of this research project, a stable network of academic cooperation grew, including working with research groups from different countries and gaining strength from close collaboration with leading industrial groups. In this period, we all gained experience by the opportunity to directly apply our techniques to the production line. We all benefited from a uniquely short path from conception, development through theoretical analysis and discussion, preliminary verification by simple laboratory tests, and real-world on-field validation.

This book aims at disseminating the body of coordinated knowledge developed in this context. With this monograph, our desire is to add a small tile to the extensive and thorough mosaic of scientific literature existing on this subject. Our aim is to offer a contribution based on a strongly interdisciplinary perspective and linked to real-world working examples of ultrasonic nondestructive testing (NDT) techniques for industrial applications. We would like to offer a view on some of the

challenging problems that we encountered in our investigation; spark the readers'—and particularly the student readers'—curiosity on them and their many facets; and hint at approaches to tackle them when applying advanced techniques for signal and information processing in a systematic way.

As a consequence of these choices, the book lies at a somehow higher abstraction level than typical texts on the topic. While it certainly cannot ignore some technological aspects, it gives much space to “what happens after the probe,” including signal processing and the extraction of useful information out of the collected data. To avoid appearing too abstract, speculative, or theoretic, we have striven to include a large number of practical applications and examples. Furthermore, we hope that this setup can be an opportunity to avoid overlap and enhance complementarity with other publications.

The book is primarily addressed at advanced technicians, engineers, and experienced teachers already involved in ultrasonic NDE and NDT inspection techniques. We expect the reader to be open to the use of advanced signal processing methodologies. For this reason, the book only summarizes the fundamentals of current diagnostic techniques in an introductory chapter. The interested readers who would like more details on fundamental or technological aspects are encouraged to refer to the excellent texts already available in the technical literature, including *Ultrasonic Nondestructive Evaluation Systems, Models and Measurements* from our same publisher.

Although the book is not meant to have a strictly educational purpose, we believe that our approach, always very practical, can have a significant educational value. Student readers can certainly get insight from our attempt at always tying theoretical considerations to implementation and the practice of production systems. That is why all chapters include a significant number of examples. In addition, we have dedicated the entire Part IV to examples of industrial application where the techniques proposed in the previous chapters are put to work.

The book is organized by growing abstraction levels, starting from the physics of ultrasonic NDE, going up to signal processing, information processing, and applications. This is reflected in a structure made of four parts, devoted to:

Part I: A description of the ultrasonic system at the physical level. How to analytically model and numerically simulate the system;

Part II: A description of how to improve system performance by the application of signal processing tools;

Part III: Considerations on how to deal with the collected data by means of high level information processing techniques;

Part IV: Real-world applications of processing techniques in the context of industrial ultrasonic NDE systems.

We chose to include a wide range of application examples to show how the great flexibility of the ultrasonic technique, well known to all who already work in this sector, can further broaden the horizons of this technique by suggesting new applications, thus helping push its limits. We believe that ultrasonics can be applied in industrial evaluation on an even wider scale as long as it sees widespread adoption of advanced signal processing, and information extraction and classification techniques.

We are confident that the research that we carried out with enthusiasm, the intuition of Springer who proposed us to write this text, and our work of publishers and authors can give a small contribution in a field, which is already very important today, but whose full potential remains to be explored.

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