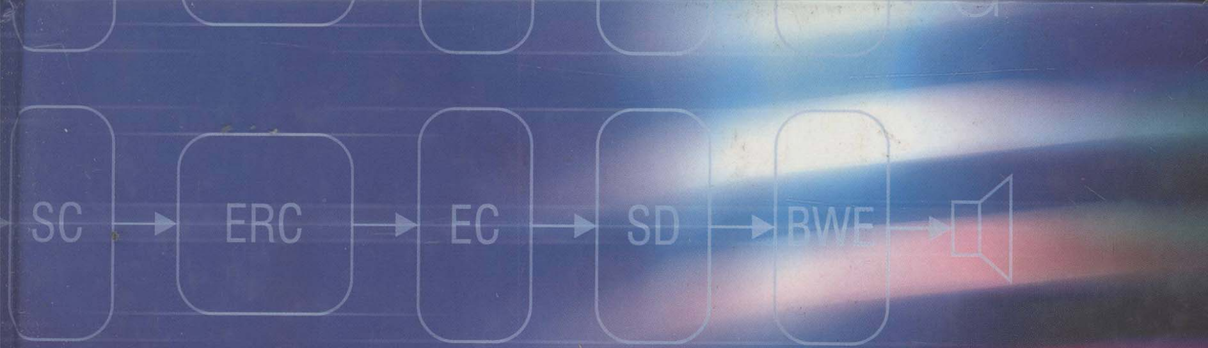

PETER VARY RAINER MARTIN

Digital Speech Transmission

Enhancement, Coding and Error Concealment

WILEY

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Enhancement, Coding and Error Concealment

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Digital Speech Transmission

Preface

The digital processing, storage, and transmission of speech signals have gained great practical importance. The main application areas are digital mobile radio, acoustic human–machine communication, and digital hearing aids. In fact, these applications are the driving force behind many scientific and technological developments in this field. A specific characteristic of these application areas is that theory and practice are closely linked; there is a seamless transition from theory to system simulations using general-purpose computers and to system realizations with programmable processors.

This book has been written for electrical engineers, information technology engineers, as well as for engineering students. It summarizes recent developments in the broad field of digital speech transmission and is based to a large extent on joint research of the authors. This book is used in courses at RWTH Aachen University and Ruhr-Universität Bochum. Portions of this volume are translated and revised from the German edition of *Digitale Sprachsignalverarbeitung*, by P. Vary, U. Heute, and W. Hess, with kind permission of Teubner Verlag. The reader will find supplementary information, publications, programs, and audio samples on the following web sites:

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The scope of the individual subjects treated in the book often exceeds that of the lectures; recent research results, standards, problems of realization, and applications have been included, as well as many suggestions for further reading. To gain maximum benefit from the text, the reader should be familiar with the fundamentals of digital signal processing and statistical signal and system description. A summary of spectral analysis, digital filter banks, as well as stochastic signals and estimation is provided.

The authors are grateful to all members of staff and students who contributed to the book through research results, discussions, and editorial work. We thank Dr.-Ing. Tim Fingscheidt, Dr.-Ing. Peter Jax, and Dr.-Ing. Marc Adrat for contributions to Chapters 9 and 10. Horst Krott prepared most of the diagrams. Dipl.-Ing. David Bauer and Dipl.-Ing. Laurent Schmalen helped us with LaTeX editing, and Diplom-Anglistin Heike Hagena and Christina Storms, MA, supported us in translating the texts. These contributions are gratefully acknowledged.

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Aachen and Bochum, January, 2006

Peter Vary and Rainer Martin

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Contents

1

Introduction

Language is the most essential means of human communication. It is used in two modes: as spoken language (*speech communication*) and as written language (*textual communication*). In our modern information society both modes are greatly enhanced by technical systems and devices. E-mail, short-messaging, and the world-wide web have revolutionized textual communication while

- digital mobile radio systems,
- acoustic human–machine communication, and
- digital hearing aids

have significantly expanded the possibilities and convenience of speech communication.

Digital processing of speech signals for the purpose of transmission (or storage) is a branch of information technology and an engineering science which draws on various other disciplines such as physiology, phonetics, linguistics, acoustics, and psychoacoustics. It is this multidisciplinary aspect which makes digital speech processing a challenging as well as rewarding task.

The goal of this book is a comprehensive discussion of fundamental issues, standards, and recent trends in speech communication technology. Speech communi-

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