

# Contents

<b>Introduction</b> .....	vi
<b>Part 1: Tutorials on Vector Quantization</b> .....	1
Vector Quantization: A Pattern-Matching Technique for Speech Coding, <i>A. Gersho and V. Cuperman (IEEE Communications Magazine, December 1983)</i> .....	2
Vector Quantization, <i>R. M. Gray (IEEE Acoustics, Speech, and Signal Processing Magazine, April 1984)</i> .....	9
Vector Quantization in Speech Coding, <i>J. Makhoul, S. Roucos, and H. Gish (Proceedings of the IEEE, November 1985)</i> .....	34
Image Coding Using Vector Quantization: A Review, <i>N. M. Nasrabadi and R. A. King, (IEEE Transactions on Communications, August 1988)</i> .....	72
<b>Part 2: Theoretical Studies and Algorithms</b> .....	87
An Algorithm for Vector Quantizer Design, <i>Y. Linde, A. Buzo, and R. M. Gray (IEEE Transactions on Communications, January 1980)</i> .....	88
Asymptotically Optimal Block Quantization, <i>A. Gersho (IEEE Transactions on Information Theory, July 1979)</i> .....	100
On the Structure of Vector Quantizers, <i>A. Gersho (IEEE Transactions on Information Theory, March 1982)</i> .....	108
Voronoi Regions of Lattices, Second Moments of Polytopes, and Quantization, <i>J. H. Conway and N. J. A. Sloane (IEEE Transactions on Information Theory, March 1982)</i> .....	118
Fast Quantizing and Decoding Algorithms for Lattice Quantizers and Codes, <i>J. H. Conway and N. J. A. Sloane (IEEE Transactions on Information Theory, March 1982)</i> .....	134
Finite-State Vector Quantization for Waveform Coding, <i>J. Foster, R. M. Gray, and M. O. Dunham (IEEE Transactions on Information Theory, March 1985)</i> .....	140
Using Simulated Annealing to Design Good Codes, <i>A. A. El Gamal, L. A. Hemachandra, I. Shperling, and V. K. Wei (IEEE Transactions on Information Theory, January 1987)</i> .....	152
An Algorithm for Uniform Vector Quantizer Design, <i>K. Sayood, J. D. Gibson, and M. C. Rost (IEEE Transactions on Information Theory, November 1984)</i> .....	160
Vector Quantizer Design for Memoryless Gaussian, Gamma, and Laplacian Sources, <i>T. R. Fischer and R. M. Dicharry (IEEE Transactions on Communications, September 1984)</i> .....	170
A Pyramid Vector Quantizer, <i>T. R. Fischer (IEEE Transactions on Information Theory, July 1986)</i> .....	175
Asymptotic Performance of Unrestricted Polar Quantizers, <i>P. F. Swaszek and T. Ku (IEEE Transactions on Information Theory, March 1986)</i> .....	191
Entropy-Constrained Vector Quantization, <i>P. A. Chou, T. Lookabaugh, and R. M. Gray (IEEE Transactions on Acoustics, Speech, and Signal Processing, January 1989)</i> .....	195
<b>Part 3: Speech Coding</b> .....	207
Rate Distortion Speech Coding with a Minimum Discrimination Information Distortion Measure, <i>R. M. Gray, A. H. Gray, Jr., G. Rebolledo, and J. E. Shore (IEEE Transactions on Information Theory, November 1981)</i> .....	208
An 800 bit/s Vector Quantization LPC Vocoder, <i>D. Y. Wong, B.-H. Juang, and A. H. Gray, Jr. (IEEE Transactions on Acoustics, Speech, and Signal Processing, October 1982)</i> .....	222
Very Low Data Rate Speech Compression with LPC Vector and Matrix Quantization, <i>D. Y. Wong, B.-H. Juang, and D. Y. Cheng (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1983)</i> .....	233
Matrix Quantizer Design for LPC Speech Using the Generalized Lloyd Algorithm, <i>C. Tsao and R. M. Gray (IEEE Transactions on Acoustics, Speech, and Signal Processing, June 1985)</i> .....	237
A Segment Vocoder at 150 B/S, <i>S. Roucos, R. M. Schwartz, and J. Makhoul (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1983)</i> .....	246
LPC Speech Coding Based on Variable-Length Segment Quantization, <i>Y. Shiraki and M. Honda (IEEE Transactions on Acoustics, Speech, and Signal Processing, September 1988)</i> .....	250
Vector Quantization of Speech and Speech-Like Waveforms, <i>H. Abut, R. M. Gray, and G. Rebolledo (IEEE Transactions on Acoustics, Speech, and Signal Processing, June 1982)</i> .....	258
Speech and Speaker Independent Codebook Design in VQ Coding Schemes, <i>H. Reininger and D. Wolf (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i> .....	271
Product Code Vector Quantizers for Waveform and Voice Coding, <i>M. J. Sabin and R. M. Gray (IEEE Transactions on Acoustics, Speech, and Signal Processing, June 1984)</i> .....	274



Efficient Bit Allocation for an Arbitrary Set of Quantizers, <i>Y. Shoham and A. Gersho (IEEE Transactions on Acoustics, Speech, and Signal Processing, September 1988)</i> .....	289
Embedded Coding of Speech: A Vector Quantization Approach, <i>A. Haoui and D. G. Messerschmitt (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i> .....	297
Vector Predictive Coding of Speech at 16 kbits/s, <i>V. Cuperman and A. Gersho (IEEE Transactions on Communications, July 1985)</i> .....	300
Low-Rate Speech Encoding Using Vector Quantization and Subband Coding, <i>H. Abut and S. Ergezinger (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1986)</i> .....	312
A High Quality Subband Speech Coder with Backward Adaptive Predictor and Optimal Time-Frequency Bit Assignment, <i>F. K. Soong, R. V. Cox, and N. S. Jayant (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1986)</i> .....	316
Quantization Procedures for the Excitation in CELP Coders, <i>P. Kroon and B. S. Atal (Proceedings of IEEE International Acoustics, Speech, and Signal Processing Conference, April 1987)</i> .....	320
CELP Coding for High Quality Speech at 8 kbits/s, <i>M. Copperi and D. Sereno (Proceedings of IEEE International Acoustics, Speech, and Signal Processing Conference, April 1986)</i> .....	324
An Expandable Error-Protected 4800 BPS CELP Coder (U.S. Federal Standard 4800 BPS Voice Coder), <i>J. P. Campbell, Jr., V. C. Welch, and T. E. Tremain (Proceedings of IEEE International Acoustics, Speech, and Signal Processing Conference, May 1983)</i> .....	328
<b>Part 4: Image Coding</b> .....	332
Image Compression Using Non-Adaptive Spatial Vector Quantization, <i>R. L. Baker and R. M. Gray (Record of the Sixteenth Asilomar Conference on Circuits, Systems, and Computers, October 1982)</i> .....	333
Image Coding Using Vector Quantization, <i>A. Gersho and B. Ramamurthi (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, May 1982)</i> .....	338
Vector Quantiser of Video Signals, <i>T. Murakami, K. Asai, and E. Yamazaki (Electronics Letters, vol. 7, November 1982)</i> .....	342
Image Vector Quantization with a Perceptually-Based Cell Classifier, <i>B. Ramamurthi and A. Gersho (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1984)</i> .....	344
A Matrix Quantizer Incorporating the Human Visual Model, <i>K. S. Thyagarajan, S. Parthasarathy, and H. Abut (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i> .....	348
High Quality Image Coding with a Model-Testing Vector Quantizer and a Human Visual System Model, <i>V. Ramamoorthy and N. S. Jayant (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1988)</i> .....	352
A New Vector Quantization Clustering Algorithm, <i>W. H. Equitz (IEEE Transactions on Acoustics, Speech, and Signal Processing, October 1989)</i> .....	356
Vector Quantization of Color Images, <i>T. Murakami, K. Asai, and A. Itoh (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1986)</i> .....	364
Image Compression Using Adaptive Vector Quantization, <i>M. Goldberg, P. R. Boucher, and S. Shlien (IEEE Transactions on Communications, February 1986)</i> .....	368
Variable Block Vector DPCM: Vector Predictive Coding of Color Images, <i>C. W. Rutledge (Proceedings of the IEEE International Communications Conference, June 1987)</i> .....	376
Linear Block Prediction with Source Classification for Image Encoding Applications, <i>K. S. Thyagarajan and S. Bhatt (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1988)</i> .....	382
Adaptive Discrete Cosine Transform Coding with Vector Quantization for Color Images, <i>K. Aizawa, H. Harashima, and H. Miyakawa (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1986)</i> .....	386
Image Sequence Coding Using Vector Quantization, <i>M. Goldberg and H. Sun (IEEE Transactions on Communications, July 1986)</i> .....	390
A Finite State/Frame Difference Interpolative Vector Quantizer for Low Rate Image Sequence Coding, <i>H.-H. Shen and R. L. Baker (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1988)</i> .....	398
Image Coding Based on Segmentation Using Region Growing, <i>K. S. Thyagarajan, H. Bohlmann, and H. Abut (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1987)</i> .....	402
<b>Part 5: Segmentation, Classification, and Recognition</b> .....	406
Vector Quantization and Markov Source Models Applied to Speech Recognition, <i>R. Billi (Proceedings of the IEEE Acoustics, Speech, and Signal Processing Conference, May 1982)</i> .....	407



Discrete Utterance Recognition Based upon Source Coding Techniques, <i>A. Buzo, H. Martinez, and C. Rivera (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, May 1982)</i>	411
Discrete Utterance Speech Recognition without Time Alignment, <i>J. E. Shore and D. K. Burton (IEEE Transactions on Information Theory, July 1983)</i>	415
Network-Based Connected Digit Recognition Using Vector Quantization, <i>M. A. Bush and G. E. Kopec (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i>	434
Recent Developments in the Application of Hidden Markov Models to Speaker-Independent Isolated Word Recognition, <i>B.-H. Juang, L. R. Rabiner, S. E. Levinson, and M. M. Sondhi (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i>	438
A Vector-Quantization-Based Preprocessor for Speaker-Independent Isolated Word Recognition, <i>K.-C. Pan, F. K. Soong, and L. R. Rabiner (IEEE Transactions on Acoustics, Speech, and Signal Processing, June 1985)</i>	442
Connected Digit Recognition Using Vector Quantization, <i>H. Bourlard, C. J. Wellekens, and H. Ney (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1984)</i>	457
BYBLOS: The BBN Continuous Speech Recognition System, <i>Y.-L. Chow, M. O. Dunham, O. A. Kimball, M. A. Krasner, G. F. Kubula, J. Makhoul, P. J. Price, S. Roucos, and R. M. Schwartz (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1987)</i>	461
A VQ-Based Preprocessor Using Cepstral Dynamic Features for Large Vocabulary Word Recognition, <i>S. Furui (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1987)</i>	465
A Vector Quantization Approach to Speaker Recognition, <i>F. K. Soong, A. E. Rosenberg, L. R. Rabiner, and B.-H. Juang (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i>	469
Text-Dependent Speaker Verification Using Vector Quantization Source Coding, <i>D. K. Burton (IEEE Transactions on Acoustics, Speech, and Signal Processing, February 1987)</i>	473
<b>Part 6: Real-Time Implementation</b>	484
Hardware Realization of Waveform Vector Quantizers, <i>B. P. M. Tao, H. Abut, and R. M. Gray (IEEE Journal of Selected Areas in Communications, March 1984)</i>	485
Real-Time Speech Compression with a VLSI Vector Quantization Processor, <i>G. Davidson, T. Stanhope, R. Aravind, and A. Gersho (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i>	495
Systolic Architectures for Vector Quantization, <i>G. A. Davidson, P. R. Cappello, and A. Gersho (IEEE Transactions on Acoustics, Speech, and Signal Processing, October 1988)</i>	499
Vector Quantizer Architectures for Speech and Image Encoding, <i>H. Abut, B. P. M. Tao, and J. L. Smith (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1987)</i>	513
Real-Time Vector APC Speech Coding at 4800 bps with Adaptive Postfiltering, <i>J. H. Chen and A. Gersho (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, April 1987)</i>	517
A Multiple Rate Low Rate Voice Codec, <i>J. Rothweiler and J. Carmody (Proceedings of the IEEE International Acoustics, Speech, and Signal Processing Conference, March 1985)</i>	521
A VLSI Chip Set for Real-Time Vector Quantization of Image Sequences, <i>R. Dianysian and R. L. Baker (Proceedings of the International Symposium on Circuits and Systems, May 1987)</i>	525
<b>Bibliography</b>	529
<b>Author's Index to Bibliography</b>	553
<b>Author Index</b>	559
<b>Subject Index</b>	561
<b>Editor's Biography</b>	566