

Index

- A-Law compressor, 93
- Algorithms
 - Arithmetic decoding, 54
 - Arithmetic encoding, 52
 - Bisection for rate target, 224
 - Bisection procedure for optimal bit allocation, 356
 - Bit-by-bit allocation, 226
 - Block-oriented SPIHT coding, 353
 - Decoding recursive block splitting, 273
 - ECVQ-training sequence version, 139
 - Entropy constrained vector quantization (ECVQ), 137
 - Golomb decoding, 63
 - Golomb encoding, 61
 - Huffman code, 44
 - Incremental rate allocation for arbitrary quantizers, 230
 - LBG (or generalized Lloyd), 132
 - LBG (or generalized Lloyd) with training sequence, 133
 - Lloyd Method I quantizer, 88
 - Lloyd–Max quantizer, 88
 - LZ77 coding, 70
 - LZW decoding, 68
 - LZW encoding, 67
 - M-algorithm, 156
 - Optimal bit allocation to independent blocks, 355
 - Optimal rate allocation for arbitrary quantizers, 228
 - Progressive-resolution wavelet transform coding, 321
 - Quadtree decoding by recursive block splitting, 273
 - Quadtree encoding by recursive block splitting, 272
 - Recursive set partitioning with adaptive thresholds, 283
 - Resolution scalable SPIHT, 351
 - Slepian–Wolf coding, 402
 - SOT encoding algorithm, 281
 - SPECK: embedded coding in subband blocks, 291
 - SPIHT algorithm: embedded coding in SOTs, 298
 - Tree-block encoding, 278
 - Tree-structured VQ design, 143
 - Tree-structured VQ encoding, 142
 - Value-progressive wavelet transform coding, 325
 - Value-progressive wavelet transform coding by set partitioning with adaptive thresholds, 330
 - Variable length VQ code tree design, 145
 - Viterbi algorithm, 159
 - Wavelet transform coding by set partitioning with adaptive thresholds, 330
 - Alphabet partitioning, 58, 287
 - Amplitude and group partitioning (AGP), 287
 - Arithmetic code, *see also* Entropy coding,
 - arithmetic code
 - decoding algorithm, 54
 - encoding algorithm, 52
 - Autocorrelation function, 118, 168
 - Markov-1, 119, 178, 246
 - Autocorrelation matrix, 118, 169, 178
 - Autoregressive (AR) source, 118
 - Average mutual information, 102, 124
 - Balanced tree, 147
 - Bennett’s formula, 94
 - BFOS algorithm, 146
 - Bias cancellation, 366
 - Binary entropy function, 25
 - Binary tree (bintree) code, 276
 - Binary tree code, 28
 - Bit allocation, *see* Rate allocation
 - Bit-embedded coding, 328
 - Bitplane, 269, *see also* Entropy coding, bitplane code
 - Block DCT of image, 252
 - Block quantization, *see* Quantization, vector
 - Block transform filterbank, 181
 - Breadth-first search, 280
 - CALIC, 368
 - Causal template, 363, 364

- Centroid, 86, 87
- Chrominance, 374
- Circulant matrix, 173
- Code properties
 - embedded code, 18, 286, 291, 326
 - random access, 314
- Codebook initialization, 135
- Codevector alphabet, 152
- Coding bounds
 - binary Huffman code, 35
 - entropy, 34
 - entropy-coded quantizer, 98
 - Gish–Pierce, 104–106
 - rate-distortion function, 103, 125
 - SFE code, 48
 - source coding, 27
 - upper bound, 104
 - Shannon lower bound, 104
 - Wyner–Ziv, 126
- Coding gain, 12
- DPCM, 121
- optimal, 172
- subband, 189, 190, 239–240
- transform, 170, 230–232
- Color image coding
 - JPEG, 379
 - JPEG2000, 380
 - SPECK, 381
 - SPIHT, 381
- Color space, 374
- Companding, *see* Quantization, scalar
 - compressor function, 92
 - expander function, 92
 - minimum distortion, 94
- Compression standards
 - audio
 - AAC, 1
 - MP3, 1, 262
 - WMA, 1
 - image
 - JPEG, 1, 251, 379
 - JPEG-LS, 364
 - JPEG2000, 19, 336
 - Lossless JPEG, 362
 - video
 - H.264/AVC, 1, 18
 - MPEG-2, 1
 - MPEG-4, 1
- Constraint length, 150
- Context, 335, 337, 340, 364, 365
- Coset, 152, 401, 406
- Counter identity matrix, 176
- Covariance function, 168
 - AR(1) source, 119
- Covariance matrix, 126, 127
 - eigenvalues, eigenvectors, 127, 171
- Cumulative distribution function (CDF), 47
- DCT matrix, 174
- Dead-zone quantizer, *see* Quantization, null-zone quantizer
- Decimation, *see* Downsampling, 184
 - integer-band, 184
- Decision thresholds, 79
- Delta modulation, 163
- Depth-first search, 280
- DFT matrix, 173
- Dictionary codes, 63
 - LZ77, 67–72
 - LZ78, 64–65
 - LZSS, 71
 - LZW, 65–67
- Differential entropy, 104, 105
 - Gaussian, 106
- Differential pulse code modulation, *see* Predictive coding, DPCM
- Distortion
 - absolute error, 78
 - average, 79
 - granular, 80
 - mean squared error (MSE), 83
 - measure, 78
 - overload, 80
 - squared error, 83
 - subband, 188, 234, 237, 238
 - transform, 219
- Distortion-rate function, 124
- Distortion-rate theorem, 125
- Distributed source coding, 20, 398
 - additive noise model, 409
 - correlated Gaussian model, 407
 - probability of failure, 403
 - probability of success, 404, 407
 - Slepian–Wolf coding, 398
 - Wyner–Ziv coding, 404
- Downsampling, 180, *see also* Decimation and subsampling
- EBCOT (embedded block coding with optimized truncation), *see* Transform coding, wavelet
- Eigenvalues, eigenvectors, 171
- Embedded code, 286, 324
- Entropy
 - binary entropy function, 25
 - bounds, 25, 26
 - conditional entropy, 36
 - definition, 24
 - Markov source, 36
 - scalar, 25
- Entropy coding, 11
 - arithmetic code, 50–54
 - arithmetic coding, 11

- bitplane code, 285
- CABAC, 260, 336
- CAVLC, 260
 - context-based code, 335, 338
 - exp-Golomb code, 260
 - Golomb code, 60–63, 366
 - Huffman coding, 11, 41–46
 - modified Huffman code, 57
 - run-length code, 55–56
 - SFE (Shannon–Fano–Elias) code, 47–49
 - unary code, 60, 334, 366
- Entropy-coded quantizer, 95
- Entropy-constrained scalar quantization (ECSQ), 141
- Entropy-constrained vector quantization (ECVQ),
 - see* Quantization, vector
- Error propagation, 7
- Error resiliency, 7
- Error-correcting (channel) code, 400
 - correctable regions, 401
 - cosets, 401
 - Golay, 404
 - Hamming weight, 403
 - syndrome, 402
- EZBC (embedded zero block coder), *see* Transform coding, wavelet
- Filterbank
 - analysis, 184
 - synthesis, 185
- Filters
 - biorthogonal, 194
 - linear phase FIR, 193
 - orthonormal, 241
 - perfect reconstruction, 193, 194
 - power complementarity, 193
 - quadrature mirror (qmf), 193
 - wavelet, 194, 210, *see also* Wavelet transform
 - (spline) 5/3, 204, 207
 - biorthogonal, 199
 - CDF 9/7, 204, 208
 - Haar, 198
 - lifting scheme, 205–208
 - orthogonal, 198
 - perfect reconstruction, 202
 - two-dimensional analysis, 314
 - two-dimensional synthesis, 314
- Finite-state machine, 148
- Fractional bitplane coding, 337
- Gish–Pierce bound, 105
 - Gaussian, squared error, 106
- Goblick and Holsinger, 98
- Golomb code, 60, 366
- Greedy tree growing, 145
- Hadamard matrix, 215
- Hadamard–Walsh matrix, 178
- Hermitian symmetry, 173
- Hessian matrix, 88
- Histogram
 - image, 266
 - wavelet transform, 266
- Huffman code, 44
- Index entropy, 96, 135
- Information theory, 3
 - differential entropy, 104, 105
 - entropy, 11, 24–27
 - mutual information, 102, 124
 - rate-distortion function, 125
 - Gaussian, 127
 - rate-distortion theorem, 125
 - rate-distortion theory, 10, 102–104, 124–126
 - test channel, 124
- Interpolation, *see* Upsampling, 185
- JPEG
 - (runlength, category) symbol, 255
 - AC triplets, 254
 - DC difference array, 253
 - Q-table, 252
 - Range categories, 253
- JPEG image compression
 - lossy, 252
- JPEG-LS
 - bias cancellation, 366
 - causal template, 363
 - context, 365
 - predictor, 364
- JPEG2000, *see* Transform coding, wavelet
 - Part 10, 384
 - Part II, 155, 383
- Kraft inequality, 30
- Kronecker delta function, 181, 194
- Lagrange minimization, 136, 220, 235
- Lagrange multiplier, 188, 221
- Lempel–Ziv, *see* Dictionary codes
- Linde–Buzo–Gray, *see* Quantization, vector, LBG algorithm
- Linear minimum mean squared estimation (LMMSE), 117
- List of insignificant pixels (LIP), 279, 280
- List of insignificant sets (LIS), 272, 280
- List of significant pixels (LSP), 285, 291
- Lossless coding, *see* Lossless compression
- Lossless compression, 2
 - image
 - CALIC, 368
 - HINT, 369

- JPEG, 362
- JPEG-LS, 364
- Lossless JPEG, 362
- Lossless predictive coding, 362
- Lossy coding, *see* Lossy compression
- Lossy compression, *see* Quantization and Transform coding
- LOT, *see* Transforms, Lapped Orthogonal Transform
- LOT matrix, 175
- Luminance, 374
- M-algorithm, 156
 - (M, L)-algorithm, 157
- Magnitude sets, 289
- Marginal returns algorithm, 225
- Maximum a priori probability (MAP) estimate, 117
- Mean squared error (MSE), 83
- Midrise quantizer, 79, 83
- Midtread quantizer, 79, 83
- Minimum prediction error, 118
- Modified Huffman code, *see* Entropy coding
- Motion-compensated predictive coding, *see* Video coding, MCPC
- Motion-compensated temporal filtering, *see* Video coding, MCTF
- μ -Law compressor, 93
- Multi-resolution
 - analysis, 185
 - synthesis, 186
- Multi-resolution coding, 368
- Near-lossless coding, 368
- Non-uniform quantizer, 87
- NTSC TV color format, 375
- Null-zone quantization, 99
- Octave band partitioning, 289, 326
- Orthonormal basis, 181
- PAL TV color format, 374
- Path map, 141, 151
- Positive definite matrix, 118
- Power spectral density, 238
- Predictive coding, 13
 - DPCM, 120
 - DPCM coding gain, 121
 - linear prediction, 117
 - motion-compensated, 390
 - prediction residual, 120, 362, 364
 - principle, 116–117
 - projection principle, 118
 - Yule–Walker equation, 118
- Prefix-free code
 - construction, 28, 31
 - definition, 28
- optimality, 32
- Probability distribution
 - autocorrelation function, 171
 - autocorrelation matrix, 168, 169
 - binomial, 403
 - conditional mean, 88
 - covariance matrix, 126
 - cumulative distribution function (CDF), 47
 - expectation, 80
 - Gaussian (normal), 103, 105, 126, 407
 - geometric, 60
 - Laplacian, 94, 100, 410
 - Markov, 24, 118
 - probability density function, 77
- Progressive bitplane coding, 285
- Progressive value coding, 324
- Pruned TSVQ, 145
- PSNR, 258, 320
- Pulse code modulation (PCM), 78
- Quadtree code, 273
- Quality scalable bitstream, 352
- Quantization, 11
 - conditional dequantization, 345
 - decision thresholds, 79
 - dequantization, 318, 345
 - distortion measure, 78
 - distortion-rate model, 106, 221, 230
 - entropy-coded, 95–99
 - implicit, 285
 - Lloyd algorithm, 88
 - Lloyd–Max algorithm, 88
 - non-uniform quantizer, 87–89
 - null-zone quantizer, 99–101, 318
 - quantization bins, 318
 - quantizer levels, 79
 - reconstruction point, 86
 - scalar, 78–80
 - Bennett's formula, 94
 - centroid condition, 87
 - companding, 91
 - entropy-constrained (ECSQ), 141
 - high rate approximation, 89
 - midrise, 79
 - midtread, 79
 - PCM, 78
 - uniform quantizer, 81–87
 - uniform threshold quantizer, 86
- vector, 129–141
 - centroid condition, 131
 - entropy-constrained (ECVQ), 135–141
 - generalized BFOS, 146
 - Generalized Lloyd algorithm (GLA), 131
 - LBG algorithm, 131
 - pruned TSVQ, 145
 - splitting method, 134

- tree-structured (TSVQ), 141–146
- TSVQ code, 143
- variable-length TSVQ, 145
- Voronoi region, 130
- Quantization table (Q-table), 252, 380
- Quantization tables, 107
- Quantizer function, 79
- Quantizer levels, 79
- Quantizer step size, 83
- Random access decoding, 352
- Random coding, 152
- Random process, 24
 - i.i.d., 24
 - Markov, 24
 - memoryless, 24
 - stationary, 24
- Random variables, 23
 - alphabet, 24
 - probability mass function, 24, *see also* Probability distribution
- Random vector, 23
- Rate allocation
 - arbitrary quantizer, 226–230
 - bisection procedure, 223, 356
 - embedded codestreams, 354
 - equal slope condition, 226
 - iterative procedure, 224
 - KLT optimal, 129
 - known quantizer, 220–223
 - optimal subband, 235, 237, 238
 - subband coding, 233–238
 - transform coding, 218–230
- Rate constraint
 - subband, 187, 234
 - transform, 220
- Rate control, *see* Rate allocation
- Rate-distortion function, 103, 125
 - Gaussian, 127
- Rate-distortion theorem, 103, 125
- Rate-distortion theory
 - see* Information theory, 124
- Refinement pass, 291
- Resolution scalable bitstream, 352
- Resolution scalable coding, 322
- Reversible color transform (RCT), 376
- Run-length code, *see* Entropy coding
- Scalability, 7
 - by quality or bit rate, 323, 349
 - by resolution, 18, 349
- Separable transform, 182
- Set partitioning embedded block (SPECK) algorithm, 291
- Set partition code, *see also* Transform coding, wavelet
 - adaptive thresholds, 283, 333
 - embedded SOT code, 298
 - quadtree, 272
 - SOT code, 281
 - tree-block code, 278, 331
- Set partition coding, 16
 - block-based
 - AGP, 19
 - progressive coding, 17
- Set partitioning
 - bisection, 274
 - group testing, 283
 - principles, 265–270
 - quadrisection, 270, 333
 - three-dimensional, 387
 - tree-blocks, 277
- Shannon lower bound, 104
- Shannon, Claude E., 23
- Shannon–Fano–Elias (SFE) code, 47
- Signal to quantization noise ratio, *see* SQNR
- Significance map, 297
- Significance test, 271, 280
- Slepian–Wolf theorem, 399
- Sorting pass, 291
- Source coding theorem, 27, 28
- Spatial orientation tree (SOT), 19, 276
 - three-dimensional, 386
- SPIHT, *see also* Transform coding, wavelet
 - algorithm, 298, 351
 - block-oriented, 352
 - resolution scalable, 349
 - three-dimensional, 385–387
- SQNR, 91
- Subband block hierarchical partitioning (SBHP),
 - see* Transform coding, wavelet
- Subband coding gain, 190, 240
- Supersets in TCQ, 154
- Temporal subbands, 394
- Test channel, *see* Information theory, rate-distortion theory
- Threshold coding, 250
- Threshold quantizer, 83
- Transform coding
 - bio-medical signals, 262
 - H.264/AVC, 18, 259–262
 - JPEG, 18, 251–259
 - spectral model, 246
 - subband, 19
 - system, 13, 166
 - threshold coding, 250
 - wavelet
 - EBCOT, 19, 336
 - EZBC, 19, 343–347, 387
 - EZW, 19, 302–306
 - GTW, 20, 306

- JPEG2000, 19, 336–343
- SBHP, 19, 335–336, 388
- SPECK, 19, 290–297, 326, 387
- SPIHT, 19, 297–299
- SPIHT algorithm, 298, 351
- zigzag scan, 247
- zonal sampling, 249
- Transform coding gain, 232
- Transform matrix, 171
- Transforms, 13
 - basis, 167
 - block transform, 180, 245
 - color, 374
 - discrete cosine (DCT), 13, 173
 - discrete Fourier (DFT), 172
 - Hadamard matrix, 215
 - Hadamard–Walsh, 174
 - integer H.264/AVC, 260
 - Karhunen–Loève transform (KLT), 13, 127, 171, 377
 - lapped orthogonal transform (LOT), 175
 - linear, 167
 - multi-resolution, 185, *see also* Wavelet transform
 - principal components, 13, 172, 377
 - subband, 14, 184–187
 - analysis, 184
 - synthesis, 185
 - transform matrix, 168
 - two-dimensional, 181
 - unitary, 166
 - via filter banks, 179
- Tree code, 146
 - rate, 147
- Tree sets
 - grand-descendant, 276, 280
 - offspring, 276, 280
- Tree-structured vector quantizer (TSVQ), *see* Quantization, vector
- Trellis code, 148
 - parallel transition, 153
 - rate, 149
- Trellis coded quantization (TCQ), 152–155
- Trellis state, 148
- TSVQ code tree, 142
- Two-dimensional DCT, 183
- Unary code, 60, 366
- Uniform quantizer, 81
- Uniform threshold quantizer, 86
- Unique decodability, 28
- Unitary matrix, 169
- Universal code, 63
- Upsampling, 181, 185
- Value-progressive coding, 330
- Variable length codes, 28
 - prefix-free, 28
 - uniquely decodable, 28
- Variable length TSVQ, 144
- Variance, 168
- Variance estimation, 248
- Variance spectrum, 247
- Vector quantization, *see* Quantization, vector
 - centroid condition, 131
 - codebook, 122
 - system, 123
 - Voronoi region, 130
- Video coding
 - block matching, 391
 - MCPC, 390
 - MCTF, 394
 - motion compensation, 390
 - scalable, 394
 - standard formats, 389
- Viterbi algorithm, 158
- VQ, *see* Vector quantization
- Wavelet packet transform, 384
- Wavelet transform, *see also* Filters, wavelet
 - biorthogonal, 199
 - coding system, 317
 - data partitions, 268
 - dilation equation, 195, 200
 - dyadic, 385
 - Haar, 198
 - image, 314
 - integer, 208, 210
 - orthogonal, 198
 - packet, 384
 - ROI (region-of-interest), 315
 - S+P transform, 210
 - S-transform, 209
 - scaling function, 195, 199
 - three-dimensional, 384
 - wavelet function, 195, 199
- Wyner–Ziv Theorem, 405
- Yule–Walker equation, 118
- Zerotree, 19, 302
- Zigzag scan, 247
 - subband, 289
- Zonal sampling, 249