

# Index

- 2-pass compression, 969
- Abelson, Harold, 936
- ACB, 947
  - adaptive frequency encoding, 964
  - adaptive Huffman coding, 947, 962, 964
  - additive colors, 892–895
  - Aesop, 973
  - ALGOL60, 935
  - alphabet (definition of), 947
  - alphabet, Greek, 940
  - analog data, 969
  - ARC, 947, 948
  - archive, 947
  - arg (of a complex number), 929
  - Argand diagram, 929
  - Argand, Jean Robert (1768–1822), 929
  - ARIES, 908
  - arithmetic coding, 948, 960, 965, 970
    - in JPEG, 967
    - QM coder, 833, 967
  - ARJ, 948
  - array (data structure), 854–855, 954
  - ASCII, 948, 951, 972
    - code table, 823
  - audio compression
    - LZ, 963
  - AVL tree, 858
  - B-tree, 859
  - Babbage, Charles, 878
  - background pixel (white), 948
  - Backus, John, 935
  - Baeyer, Hans Christian von, 836, 978
  - Bark (unit of critical band rate), 948
  - Barkhausen, Heinrich Georg, 948
  - barycentric functions, 942, 943
  - basis matrix, 943
  - Baum, L. Frank, 918
  - Bayes, Thomas, 831, 833, 834, 952
  - Bayesian statistics, 831–834, 952
  - Bellard, Fabrice, 956
  - bi-level image, 948, 958–960
  - bicubic interpolation, 944
  - bicubic polynomial, 944
  - bicubic surface, 944
    - algebraic representation of, 944
    - geometric representation of, 945
  - Bierce, Ambrose, 881
  - binary search
    - tree, 858, 964
  - binary tree
    - complete, 857
    - empty, 859
    - height balanced, 859
    - implementing, 858
    - skewed, 857
    - traversal, 857
  - BinHex, 948
  - binomial distribution, 838
  - bintrees, 948, 951
  - bisection, 968
  - bitplane, 949
  - bitrate (definition of), 949
  - bits/char (bpc), 949
  - bits/symbol, 949

- Blelloch, Guy, 981  
blending functions, 942  
Blinn, James F., 920  
block coding, 949  
block decomposition, 949  
block matching (image compression), 949  
block truncation coding, 949  
Bloom, Charles R., 964  
BNF (Backus Naur Form), 935  
Boltzman, Ludwig Eduard, 978  
bpc (bits per character), 949  
Buchan, John (1875–1940), 1047  
Burrows-Wheeler method, 950  
Buyanova, George (Georgii) Mechislavovich, 947
- C (arrays in), 854  
Calgary Corpus, 883  
CALIC, 950  
Canterbury Corpus, 883  
Cartesian product, 944  
CCITT, 950, 960, 961  
cell encoding (image compression), 950  
Chambord (Château), 835  
Chomsky, Noam, 935  
chrominance, 897–901  
CIE, 887, 950
  - color diagram, 904–906
circular queue, 855, 950  
CMYK color model, 889, 894, 906, 913  
codec, 950  
codes
  - ASCII, 951
  - definition of, 951
  - EBCDIC, 951
  - error-correcting, 867–878, 956
  - error-detecting, 867–878
  - Hamming, 874, 875
  - Hamming distance, 872–874
  - overhead of, 871
  - prefix
    - and Fibonacci numbers, 979
  - SEC-DED, 876
  - Unicode, 951
  - variable-size, 968, 982
    - unambiguous, 962
  - voting, 869
color, 887–906
  - adding, 892
  - additive, 892–895
  - as wavelength, 888
  - complementary, 895–896
  - cool, 896
  - gamut, 890, 892, 906
  - model, 889
  - primary, 890
  - pure, 889
  - secondary, 890
  - spectral density, 901–904
  - subtracting, 892
  - subtractive, 892–895
  - warm, 896
color lookup table, 892, 912  
color printing, 894
  - and dithering, 913
complementary colors, 895–896  
complete binary tree, 857  
complex numbers, 928–929  
composite values for progressive images, 951  
compression factor, 951  
compression gain, 951  
compression ratio, 951  
Compuserve Information Services, 958  
conditional image RLE, 952  
conditional probability, 831–834, 952  
cones (in the retina), 895  
constrained average dithering, 908, 911–912  
context, 952  
context-free grammars, 952  
context-tree weighting, 952  
continuous wavelet transform (CWT), 953  
continuous-tone image, 883, 953, 958, 961  
convolution, 930–934, 953  
cool colors, 896  
correlation, 953
  - definition of, 830
covariance (definition of), 829  
CRC, 878, 953  
cross product, 926  
CRT, 953
  - and RGB, 890
  - gamma, 897
curves
  - Hilbert, 841
  - Peano, 848, 850
  - Sierpiński, 842
  - space-filling, 841–850
da Vinci, Leonardo, 835  
data compression

- and redundancy, 868  
and reliability, 867  
bintrees, 948, 951  
bisection, 968  
block decomposition, 949  
block truncation coding, 949  
Burrows-Wheeler, 950  
conference, 953  
dictionary-based methods, 954, 966  
differential encoding, 955  
differential image, 954  
DjVu, 955  
edgebreaker, 971  
EIDAC, 969  
fax, 957  
FELICS, 957  
fingerprints, 973  
fractal, 960  
IFS, 960  
image  
    block matching, 949  
    differential, 954  
    progressive, 967  
    resolution independent, 968  
JBIG, 960  
JBIG2, 960  
JPEG-LS, 961  
lossless, 963  
lossy, 963  
LZ & RLE, 963  
LZ & statistical methods, 963  
LZ77, 949, 969  
LZAP, 963  
LZFG, 963  
LZMW, 964  
LZW, 964  
    patented, 966  
LZY, 964  
MLP, 964  
MNP5, 964  
MNP7, 964  
model, 964  
move-to-front, 963, 965  
octasection, 968  
patents, 966  
progressive FELICS, 966  
progressive image, 967  
quadrisection, 968  
quadtrees, 968  
run length encoding, 964  
semiadaptive, 969  
sequitur, 952, 969  
small numbers, 1035  
space filling, 969  
sparse strings, 970  
statistical methods, 970  
subsampling, 970  
two-pass, 969  
vector quantization, 972  
video, 972  
data structures, 853–865, 950, 954  
    arrays, 854–855, 954  
    definition of, 853  
    graphs, 860, 954  
    hashing, 861–865, 954  
    lists, 855, 954  
    queues, 855, 954  
    stacks, 855, 954  
    trees, 856–860, 954  
decibel (dB), 954  
decoder, 954  
decorrelated values (and covariance), 830  
deflation, 958, 973  
DeMoivre’s theorem, 923, 1044  
determinants, 920–923  
    and cross-product, 926  
    row interchange, 927  
Deutsch, David, 893  
diagonal matrix, 920  
dictionary-based methods, 954, 966  
difference values for progressive images, 951  
differencing, 968  
differential encoding, 955  
differential image compression, 954  
differential pulse code modulation, 955  
    and sound, 955  
diffusion dither, 908, 912–915  
digital camera, 896  
digital video, 954  
digitally sampled analog data, 972  
digram, 954  
direction cosines, 925  
directory (of a disk), 859  
Dirichlet tessellations, *see* Voronoi diagrams  
discrete cosine transform, 954  
discrete random variable (definition of), 827  
discrete wavelet transform (DWT), 955  
discrete-tone image, 883, 884, 949, 955  
disk (directory of), 859  
dithering, 908–918, 955

- ARIES, 908
- color printing, 913
- constrained average, 911–912
- diffusion dither, 912–915
- dot diffusion, 915–917
- minimized average error, 913
- ordered dither, 908–911
- DjVu document compression, 955
- dot diffusion, 908, 915–917
- dot product, 925
- dynamic Markov coding, 881
- Dyson, George B., 835
- EBCDIC, 951
- edgebreaker, 971
- EIDAC, simple image compression, 969
- eigenvalues of a matrix, 923
- eigenvectors of a matrix, 923
- Einstein, Albert, 919
- electromagnetic spectrum, 888
- embedded coding in image compression, 956
- embedded coding using zerotrees (EZW), 956
- encoder, 956
- entropy
  - definition of, 956
- Erdős-Kac theorem, 835
- error-correcting codes, 867–878, 956
- error-detecting codes, 867–878
- Euler, Leonhard, 929, 1045
- Euler's formula, 929
- EXE compressors, 956
- eye
  - and spatial integration, 890, 906, 913
  - resolution of, 896
- facsimile compression, 957
- factor of compression, 951
- FBI fingerprint compression standard, 973
- FELICS, 957
- Feynman, Richard Phillips, 980
- FHM compression, 957
- Fiala, Edward R., 963
- Fibonacci numbers, 957
  - and FHM compression, 1036, 1037
  - and prefix codes, 979
- FIFO (first-in first-out), 855
- file directory (of a disk), 859
- fingerprint compression, 973
- finite automata, 879–881
  - nondeterministic, 880
  - regular expressions, 881
- finite-state machines, 879–881
  - nondeterministic, 880
- Floyd-Steinberg filter, 912
- foreground pixel (black), 948
- Fortran (arrays in), 854
- Foster, Jodie, 925
- four-color process, 894
- Fourier transform, 954, 957, 971
- Fourier, Jean Baptiste Joseph, 957
- fractal image compression, 960
- Freed, Robert A., 947
- frequencies
  - of symbols, 965
- functions
  - barycentric, 942, 943
  - blending, 942
- gain of compression, 951
- Galois fields, 877
- gamma correction, 898–899
- gas molecules (and normal distribution), 835
- Gaussian distribution, 829, 835–838, 957, 962, 965
  - Gaussian random numbers, 837
- Gell-Mann, Murray, 980
- generalized finite automata, 957
- generating polynomials, 877, 956
- GIF, 958
  - and LZW patent, 966
- Gogh, Vincent Van, 897
- golden ratio, 957, 1029
- Golomb code, 957, 958
  - and JPEG-LS, 961
- grammars, context-free, 952
- graphs (data structure), 860, 954
- grayscale image, 958, 961, 964, 967
- Greek alphabet, 940
- Greene, Daniel H., 963
- group 3 fax compression, 957
- group 4 fax compression, 957
- growth geometry coding, 958
- gzip, 958
- H.261 video compression, 958
- Hadamard, Jacques, 929
- halftones, 894, 906–908
- halftoning, 959
- Halmos, Paul, 923

- Hamming codes, 874–876, 959  
  16 bits, 875
- Hamming distance, 872–874
- Hamming, Richard, 872, 874
- hashing, 861–865, 954
- HDTV  
  and MPEG-3, 965  
  standards used in, 959
- heap (data structure), 858
- Hempel, Carl G., ii
- Henderson, J. Robert, 834
- hierarchical image compression, 959
- Hilbert curve, 841–842  
  traversing of, 848–849
- Hilbert, David, 841
- HLS color model, 889–890
- HSV color model, 890
- HTML (as semi-structured text), 969
- hue, 889, 890  
  definition of, 889  
  primary, 890  
  secondary, 890
- Huffman coding, 958, 959, 969, 970, 973, 992  
  adaptive, 947, 962
- human vision, 895–896
- human visual system, 887–918
- identity matrix, 920, 921
- IFS compression, 960
- image  
  bi-level, 948, 958–960  
  bitplane, 949  
  continuous-tone, 883, 953, 961  
  discrete-tone, 883, 884, 949, 955  
  grayscale, 958, 961, 964, 967  
  simple, 969
- image compression, 968  
  bi-level, 960  
  block decomposition, 949  
  block matching, 949  
  block truncation coding, 949  
  conditional RLE, 952  
  differential, 954  
  DjVu, 955  
  embedded coding, 956  
  EZW, 956  
  fax, 957  
  fingerprints, 973  
  GFA, 957
- JPEG-LS, 961
- LZ, 963
- prefix compression, 967
- progressive, 967
- quadrisection, 968
- quadtrees  
  prefix compression, 967
- resolution independent, 968
- self similarity, 957, 973
- SPIHT, 956, 970
- subsampling, 970
- vector quantization, 972
- WFA, 881, 973
- WSQ, 973
- image transforms, 971
- images (standard), 883–886
- inequality (Kraft-MacMillan), 962
- information theory, 870, 959
- infrared, 888
- inkjet color printing, 906, 913
- interpolating polynomials, 940–946, 960
- inverse discrete cosine transform, 1005
- ISO, 960, 961, 965  
  recommendation CD 14495, 961
- iterated function systems, 960
- ITU, 950, 957, 960
- ITU-R  
  recommendation 709, 901  
  recommendation BT.601, 901
- ITU-T  
  and fax training documents, 883  
  and MPEG, 965  
  recommendation H.261, 958  
  recommendation T.6, 957  
  V.42bis, 972
- JBIG, 833, 960, 967
- JBIG2, 833, 960  
  and DjVu, 955
- JFIF, 961
- Jonson, Ben, 895
- JPEG, 833, 949, 960, 961, 967
- JPEG-LS, 961
- Jung, Robert K., 948
- Kaplansky, Irving, 923
- Katz, Philip, 966
- Koch snowflake curve, 935
- Kraft-MacMillan inequality, 962
- KT probability estimate, 962

- L Systems, 935–938, 962
- Laplace distribution, 838, 962, 964, 967
- Laplace, Pierre Simon de, 839
- Laplacian pyramid, 962
- large numbers (law of), 837
- Lau, Daniel Leo, 849
- law of large numbers, 837
- Lempel, Abraham, 963
- Lempereur, Yves, 948
- Lena (image), 883–884, 1024
  - blurred, 1025
- LHA, 962
- LHArc, 962
- Libri, Guglielmo, 840
- LIFO, 855
- lifting scheme, 963
- light, 887–889
  - visible, 888, 895
- lightness, 890
  - definition of, 889
- Lindenmayer, Aristid, 935, 962
- line
  - as a space-filling curve, 1039
  - vector equation of, 926
- linear systems, 930–934, 953
- list (data structure), 855, 954
- logarithm (and luminance), 899
- lossless compression, 963
- lossy compression, 963
- luminance, 897–901
  - definition of, 889
- LZ77, 949, 958, 963, 964, 969, 973
- LZ78, 963, 964
- LZAP, 963
- LZEXE, 956
- LZFG, 963
- LZMW, 964
- LZP, 964
- LZRW1, 861
- LZSS, 962, 964
- LZW, 963, 964, 972, 1035
  - patented, 966
- LZY, 964
- mandril (image), 883
- Markov model, 1012, 1037
- matrices
  - definition and operations, 920–923
  - eigenvalues, 923
  - eigenvectors, 923
- orthogonal, 922
- orthonormal, 922
  - rotation, 923
- Maugham, William Somerset, 864
- Microcom, Inc., 964
- minimized average error, 913
- MLP, 962, 964, 967
  - and Laplace distribution, 838
- MNP class 5, 964
- MNP class 7, 964
- model
  - Gaussian, 835
  - Markov, 1012, 1037
- modem, 964, 972
- Moivre, Abraham de (1667–1754), 836, 1044
- Morley, Christopher, 946
- move-to-front method, 950, 963, 965
- .mp3 audio files, 1032
- MPEG, 960, 965
- multiresolution decomposition, 965
- multiresolution image, 965
- NASA, 1013
- Naur, Peter, 935
- nondeterministic finite automata, 880
- normal distribution, 829, 835–838, 957, 965
- numerical history (mists of), 946
- octasection, 968
- Okumura, Haruhiko, 962
- ordered dither, 908–911
- orthogonal
  - matrix, 922
  - vectors, 925
- orthonormal matrix, 922
- painter's pigments, 894
- palette, 912
- panda (black and white image), 909
- PANTONE matching system, 895
- paper tape (punched), 824
- parametric cubic polynomial (PC), 941
- Pareto, Wilfredo, 878
- Pascal (arrays in), 854
- Pascal, Blaise, 831
- patents of algorithms, 966
- Peano curve, 848, 937
  - traversing, 850
- peppers (image), 883
- Perella, P. E., 930

- petri dish, 934, 973  
Petty, Lori, 906  
phrase, 966  
Picasso, Pablo, 897  
pixels  
  background, 948  
  definition of, 966  
  foreground, 948  
PKArc, 966  
PKlite, 966  
PKunzip, 966  
PKWare, 966  
PKzip, 966  
Poisson distribution, 839  
Poisson, Siméon Denis, 840  
polynomial  
  definition of, 940  
  parametric cubic, 941  
  parametric representation, 941  
polynomials (bicubic), 944  
polynomials (interpolating), 940–946, 960  
PPM, 967  
PPPM, 967  
prediction, 966  
preechoes (in MPEG audio), 1032  
prefix compression  
  images, 966, 967  
prefix property, 966, 972, 1041  
primary hue, 890  
prime factors (and normal distribution), 835  
printing in color, 913  
printing pigments, 894  
prisoners' problem, 833  
probability  
  concepts, 827–839  
  conditional, 831–834, 952  
  distributions, 834–839  
  model, 964  
  of joint and union, 830–831  
  three prisoners problem, 833  
process color, 894  
Prochnow, Jürgen, 904  
progressive FELICS, 966  
progressive image compression, 967  
psychoacoustic model (in MPEG audio), 967, 1032  
pure color, 889  
  
QIC-122, 967  
QM coder, 833, 967  
  
quadrisection, 968  
quadtrees, 948, 957, 966–968, 973  
  prefix compression, 967  
quantization  
  block truncation coding, 949  
  image transform, 971  
  scalar, 968  
  vector, 972  
quaternary (base-4 numbering), 968  
queue (data structure), 855, 950, 954  
  as a list, 855  
Quinton, R. E., 936  
  
radio waves, 888  
RAND Corp., 837  
random data, 972, 982  
random variable, 827  
ratio of compression, 951  
redundancy, 869  
  and data compression, 868  
  and error-correction, 867, 874  
  definition of, 1002  
  spatial, 972  
  temporal, 972  
reflected Gray code, 850, 958  
regular expressions, 881  
relative encoding, 955, 968  
reliability, 867  
renormalization (in the QM-coder), 992  
resolution of the eye, 896  
RGB  
  color model, 889–892  
  cube, 885, 892  
  reasons for using, 890, 895, 906  
right hand rule, 1043  
RLE, 968  
  and BW method, 950  
  QIC-122, 967  
rods (in the retina), 895  
rotation matrix (orthonormal), 923  
Rozenberg, Grzegorz, 851, 935  
run length encoding, 964  
  
Saravanan, Vijayakumaran, 1008  
saturation, 889, 890, 906  
  definition of, 889  
  full, 1041  
scalar quantization, 968  
Scott, Paul, 932  
SEC-DED code, 876

- Seckel, Albert, 980  
 secondary hue, 890  
 self similarity in images, 957, 973  
 semi-structured text, 969  
 semiadaptive compression, 969  
 sequitur, 952, 969  
 set partitioning in hierarchical trees (SPIHT), 956, 970  
 Shannon, Claude Elwood, 868, 956, 959  
 Shannon-Fano method, 959, 969, 970  
 shift invariance, 930–934, 953  
 Sierpiński  
     curve, 842–848  
     gasket, 1019, 1021  
     triangle, 1019  
 Sierpiński, Waclaw, 842  
 simple images, EIDAC, 969  
 skewed binary tree, 857  
 sliding window compression, 949, 969  
 small numbers (easy to compress), 1035  
 Smith, Alvy Ray, 935  
 Soderberg, Lena (of image fame), 884  
 space-filling curves, 841–850, 969  
     Hilbert, 841–842  
     Peano, 848, 937  
     Sierpiński, 842–848  
 sparse strings, 970  
 spatial redundancy, 972  
 spectral density, 901–904  
 stack (data structure), 855, 954  
 standard deviation  
     and normal distribution, 829, 836  
     definition of, 828  
 standard test images, 883–886  
 statistical methods, 970  
 statistical model, 965  
 Storer, James Andrew, 964  
 string compression, 970  
 subsampling, 970  
 subtractive colors, 892–895  
 sums (of series), 919–920  
 symbol ranking, 970  
 symmetric matrix, 920  
 Szilard, Andy, 936  
 Szymanski, T., 964  
 taps (wavelet filter coefficients), 971  
 TAR, 971  
 Tektronics (and the HLS model), 889  
 temporal redundancy, 972  
 ternary tree, 857, 1040  
 text  
     random, 982  
     semi-structured, 969  
 text compression  
     LZ, 963  
     QIC-122, 967  
 textual image compression, 971  
 thread (a pointer), 858  
 three prisoners problem, 833  
 TIFF  
     and JGIB2, 961  
 token (definition of), 971  
 training (in data compression), 883  
 transforms  
     discrete cosine, 954  
     images, 971  
     inverse discrete cosine, 1005  
     Walsh-Hadamard, 1005  
 tree  
     AVL, 858  
     B, 859  
     binary search, 858, 964  
     data structure, 856–860, 954  
     Huffman, 959, 984  
     lazy deletion, 857  
     threads, 858  
 triangle (Sierpiński), 1019  
 triangle mesh compression, edgebreaker, 971  
 trigonometric identities, 923–925  
 trit (ternary digit), 850, 970, 971, 977, 982  
 Twain, Mark, 865  
 two-pass compression, 969  
 ultraviolet, 888  
 unary code, 957, 958, 971, 979  
     general, 971, 1012  
 Unicode, 951, 972, 1012  
 UNIX  
     compress, 951, 966  
 V.32bis, 972  
 V.42bis, 972  
 variable-size codes, 966, 970, 972, 982, 1041  
     and reliability, 968  
     unambiguous, 962  
 variance (definition of), 828  
 vector quantization, 972  
 vectors, 925–928  
     absolute value, 925

- addition, 925
  - cross product, 926
    - direction of, 926, 1043
  - direction cosines, 925
  - dot product, 925
  - orthogonal, 925
  - projecting, 927–928
  - unit, 925
    - vector product, 926
  - video
    - digital, 954
  - video compression, 972
    - H.261, 958
    - MPEG-1, 965
  - Vinci, Leonardo da, 835
  - vision (human), 895–896
  - visual acuity, 906
  - Voronoi diagrams, 934, 973
  - voting codes, 869
  
  - Walsh-Hadamard transform, 1005
  - warm colors, 896
  - Warren, Robert Penn (1905–1989), 926
  - wavelet scalar quantization (WSQ), 973
  - wavelets
    - continuous transform, 953
  
  - Daubechies
    - D8, 1023, 1025
  - discrete transform, 955
  - fingerprint compression, 973
  - lifting scheme, 963
    - multiresolution decomposition, 965
  - weighted finite automata, 881, 973
  - Welch, Terry A., 964
  - Wing-Davey, Mark, 890
  - Wirth, Niklaus, 841
  - Wright, Amy, 863
  - www (web), 934, 961
  
  - X-rays, 888
  
  - Yoshizaki, Haruyasu, 962
  - Young, Daniel, 892
  - Young, Roland, 912
  
  - zero-probability problem, 973
  - zigzag sequence
    - in JPEG, 1008
    - in MPEG, 1030
  - Zip, 973
  - Ziv, Jacob, 963
- a transparent thing becomes invisible if it is put in any medium of almost the same refractive index
- H. G. Wells, *The Invisible Man* (1898)