Index

N-way arrays, 41, 42 k-fold cross-validation, 145, 146, 148 k-means, 164, 165, 167, 191 k-nearest neighbors (kNN), 192	discrete empirical interpolation method (DEIM), 403, 423 discrete wavelet transform, 75, 77, 81 DMD eigenvalue, 238, 240
activation function, 199, 201, 207, 212, 213 actuator, 288, 289 adjoint, 292, 330–334, 337, 338, 343 Akaike information criterion (AIC), 151, 175, 256	DMD mode (also <i>dynamic mode</i>), 236, 237, 242 dynamic mode decomposition (DMD), 235, 241 dynamical system, 8, 47, 216, 229–236, 247, 251, 257, 276, 277, 297, 322, 404
alternating descent method, 128	eigensystem realization algorithm (ERA), 243, 270, 334, 336
backpropagation (backprop), 201, 202, 204, 205, 208 balanced input—output model, 336 Bayesian information criterion (BIC), 151, 152 boosting, 190, 192, 193	ensemble learning, 189, 190, 192, 193 expectation-maximization algorithm (EM), 172–174, 191
	extremum seeking control (ESC), 362, 364, 365, 369
classification, 25, 28, 72, 103, 105, 106, 190–192, 195, 196, 198, 200, 202, 203, 208, 215, 242, 367 classification trees, 185, 189 closed-loop control, 277, 280 clustering, 24, 25, 36, 186, 191, 192 coherent structure, 4, 85, 235, 242, 292, 322 compressed sensing, 17, 88–92, 95, 97, 236	fast Fourier transform, 3, 47, 56, 59, 85, 378 feature engineering, 154, 159, 212, 430 feedback control, 272, 276, 277, 279, 321 feedforward control, 277, 316 Fourier transform, 15, 47, 54, 55, 266, 310, 387, 405, 428
compressed sensing, 17, 86–92, 93, 97, 256 compression, 8, 10, 59, 75, 77, 80, 84, 85, 88, 95, 241 control, 7, 47, 56, 89, 155, 233, 242, 257, 266, 292, 293, 322, 323, 345	Gabor transform, 69, 70 Galerkin projection, 247, 250, 321, 378, 382, 423 gappy POD, 383, 403, 424
control theory, 89, 236, 276, 319, 322, 346, 349 controllability, 47, 287–291, 324–326, 329, 333 convex optimization, 92, 131, 250, 294, 357	Gaussian mixture models (GMM), 172–174 gradient descent, 117, 123, 125, 182, 198, 201, 206 gramian, 291, 292, 324, 325, 327, 329
convolutional neural network (CNN), 212 convolutional neural network (CNN), 191 cost function, 278, 294, 295, 297, 304, 318, 345, 353,	Hankel matrix, 270, 331, 333, 337 Hilbert space, 47, 257, 258, 260, 269
359, 367	incoherent measurements, 96, 97
CP tensor decomposition, 43–45 cross-validation, 101, 102, 142–145, 154, 163, 165, 173, 179, 202, 243, 268	information theory, 148, 149 inner product, 36, 42, 48, 96, 260, 266, 321, 325, 383, 384, 392, 404, 408
curve fitting, 117, 118, 123	Johnson-Lindenstrauss (JL), 98
data arrays, 41 data labels, 154, 160–162, 206, 214, 215 data matrix, 31, 35, 42, 44, 107, 167, 199, 237, 244, 348, 393 deep convolutional neural network (DCNN), 212–214	Kalman filter, 296, 297, 299, 305, 339, 341, 372 kernel methods, 183, 243, 267 Koopman eigenfunction, 268, 270 Koopman operator, 260, 261, 267
deep learning, 195, 196, 212 dendrogram, 168, 169 dimensionality reduction, 4, 7, 176, 235, 237, 238, 276, 347, 376, 380 discrete cosine transform (DCT), 94	LASSO, 100, 101, 138, 145, 199, 204 least square fit, 98, 118, 143 least-square fit, 119 linear discriminant, 176 linear quadratic regulator (LQR), 292–294, 349, 359

linear system, 15, 93, 122, 198, 233, 243, 252, 294,	randomized SVD, 37, 38
310, 316, 380	rank truncation, 155, 264
low-rank, 7, 108, 109, 154, 155, 321, 323, 382, 385,	reduced order model (ROM), 242, 396, 423
391, 396, 403, 404	reference tracking, 278, 280, 316, 358, 359
machine learning, 19, 24, 77, 119, 142, 156, 158, 165,	regression, 15, 17, 98, 117–119, 121, 160, 163, 204,
180, 183, 185, 190, 195, 206, 336	242, 246, 248, 251, 336
Markov parameters, 340	restricted isometry property (RIP), 91, 97
max pooling, 213	ridge regression, 138
mixture models, 172–174, 191	robust control, 300, 304, 308, 309, 317
model predictive control (MPC), 346, 347, 349	robust fit, 138
model reduction, 291, 321, 322, 426	robust principal component analysis (rPCA), 107
model selection, 117, 120, 137, 143, 148	robust statistics, 138
Moore's law, 89	sampling rate, 91, 94
multi-resolution analysis (MRA), 75	sensor, 244, 272, 302, 305, 306, 319, 336, 337, 353,
multiscale, 58, 244, 276	364, 370
manageare, 20, 211, 270	singular value decomposition (SVD), 3, 37, 39, 97,
naive Bayes, 190, 192	156, 235–237, 266, 322, 330, 381, 385,
neural networks, 125, 191, 195, 196, 209, 273	426, 427
noise, 92	snapshot, 41, 236, 252, 292, 330–333, 347, 382, 386,
absorpability 47 257 297 299 202 205 224 226	391, 424, 427
observability, 47, 257, 287, 288, 292, 305, 324–326,	sparse identification of nonlinear dynamics (SINDy),
329, 333	247
observable function, 257, 258, 266	sparse regression, 98, 247–249, 251, 256
open loop, 357	sparse representation, 84, 88, 103, 242
optimization	sparsity, 92
gradient descent, 125	spectrogram, 69–72
steepest descent, 125	state space, 269, 321, 334
outliers, 19, 98, 100, 107, 120, 138	stochastic gradient descent (SGD), 201, 202, 209
overdetermined system, 4, 16, 101, 117, 132, 248	supervised learning, 160, 161
pagerank, 190, 193	support vector machine (SVM), 180, 191
Pareto front, 140–142	system identification (System ID), 236, 243, 251, 270,
Perron-Frobenius operator, 235, 266	321, 322, 324, 336, 346, 354
polynomial basis functions, 183, 185	41 40
principal component, 21-23, 25, 108	tensors, 41, 42
principal component analysis (PCA), 3, 7, 21, 37, 97,	test data, 165, 167, 192
107, 195, 333	total least-squares, 244
proper orthogonal decomposition, 97, 245	training data, 176–178, 180, 212, 214
proper orthogonal decomposition (POD), 3, 235, 321,	uncertainty principle, 74, 75
323, 375, 380, 423	underdetermined system, 4, 16, 89, 92, 103, 117, 134,
pseudo-inverse, 4, 15, 17, 93, 143, 145, 199, 200, 237,	196
238, 341	unitary matrix, 14, 15
radial basis functions, 221	unsupervised learning, 154, 160, 190, 191
radial basis functions (RBF), 184	
random forest, 185, 189	wavelet, 75, 97
randomized algorithms, 37, 39	windowed FFT (Gabor transform), 69
randomized argonumis, 51, 57	withhold data, 176