

## CODE AND DATASETS

Rating	Easy?	AI?	Sys?	Thy?	Morning?
+2	y	y	n	y	n
+2	y	y	n	y	n
+2	n	y	n	n	n
+2	n	n	n	y	n
+2	n	y	y	n	У
+1	y	y	n	n	n
+1	y	y	n	y	n
+1	n	y	n	y	n
0	n	n	n	n	У
0	y	n	n	y	У
0	n	y	n	y	n
0	y	y	y	y	У
-1	y	y	y	n	У
-1	n	n	y	y	n
-1	n	n	y	n	У
-1	y	n	y	n	У
-2	n	n	y	y	n
-2	n	y	y	n	У
-2	y	n	y	n	n
-2	y	n	y	n	y

## NOTATION

## **BIBLIOGRAPHY**

Sergey Brin. Near neighbor search in large metric spaces. In *Conference on Very Large Databases (VLDB)*, 1995.

Tom M. Mitchell. Machine Learning. McGraw Hill, 1997.

Frank Rosenblatt. The perceptron: A probabilistic model for information storage and organization in the brain. *Psychological Review*, 65:386–408, 1958. Reprinted in *Neurocomputing* (MIT Press, 1998).

## INDEX

K-nearest neighbors, 56	circuit complexity, 125	example normalization, 57, 58
$\epsilon$ -ball, 37	• •	
r-norms, 91 clustering quality, 166		examples, 9 expectation maximization, 175
0/1 loss, 87	collective classification, 83	expected loss, 15, 16
	complexity, 31	exponential loss, 89, 157
absolute loss, 14	concave, 89	•
activation function, 117	ation function, 117 concavity, 179	
activations, 39	concept, 144	feature combinations, 51
active learning, 181	confidence intervals, 66	feature mapping, 51
AdaBoost, 154	constrained optimization problem, 98	feature normalization, 57
algorithm, 86	contour, 91	feature scale, 30
all pairs, 76	convergence rate, 94	feature space, 28
all versus all, 76	convex, 86, 88	feature values, 11, 26
architecture selection, 126	cross validation, 62, 66	feature vector, 26, 28
area under the curve, 62, 81	cubic feature map, 131	features, 11, 26
AUC, 62, 80, 81	curvature, 94	forward-propagation, 124
AVA, 76		fractional assignments, 176
averaged perceptron, 49	data covariance matrix, 172	furthest-first heuristic, 168
	data generating distribution, 15	
back-propagation, 121, 124	decision boundary, 31	Gaussian distribution, 109
bag of words, 54	decision stump, 156	Gaussian kernel, 134
bagging, 153	decision tree, 8, 10	Gaussian Mixture Models, 177
base learner, 152	decision trees, 55	generalize, 9, 16
batch, 161	development data, 24	generative story, 110
batch learning, 184	dimensionality reduction, 166	geometric view, 26
Bayes error rate, 104, 150	discrete distribution, 109	global minimum, 92
Bayes optimal classifier, 103, 150	distance, 28	GMM, 177
Bayes optimal error rate, 104	dominates, 61	gradient, 92
Bernouilli distribution, 108	dot product, 43	gradient ascent, 92
bias, 40	dual problem, 138	gradient descent, 92
binary features, 27	dual variables, 138	graph, 83
bipartite ranking problems, 79		
boosting, 142, 152	early stopping, 51, 120	hard-margin SVM, 99
bootstrap resampling, 153	embedding, 166	hash kernel, 165
bootstrapping, 65, 67	ensemble, 152	held-out data, 24
	error driven, 41	hidden units, 116
categorical features, 27	error rate, 87	hidden variables, 175
chain rule, 107	Euclidean distance, 28 hinge loss, 89	
chord, 89	evidence, 114	histogram, 12

hyperbolic tangent, 117	log-likelihood ratio, 109	polynomial kernels, 133
hypercube, 35	logarithmic transformation, 59	positive semi-definite, 133
hyperparameter, 23, 42, 88	logistic loss, 89	posterior, 114
hyperplane, 39	logistic regression, 113	precision, 60
hyperspheres, 35	LOO cross validation, 63	precision/recall curves, 60
hypothesis, 144	loss function, 14	predict, 9
hypothesis class, 147	•	preference function, 78
hypothesis testing, 65	margin, 46, 98	primal variables, 138
71 O, 3	margin of a data set, 46	principle components analysis, 172
i.i.d. assumption, 105	marginal likelihood, 114	prior, 114
imbalanced data, 70	maximum a posteriori, 114	probabilistic modeling, 103
importance weight, 71	maximum depth, 23	Probably Approximately Correct, 14
independently, 104	maximum likelihood estimation, 105	projected gradient, 138
independently and identically dis-	Mercer's condition, 133	psd, 133
tributed, 105	model, 86	Pou, 199
indicator function, 87		1: 11
	modeling, 22	radial basis function, 126
induce, 15	multi-layer network, 116	random forests, 157
induced distribution, 72		RBF kernel, 134
induction, 9	naive Bayes assumption, 107	RBF network, 126
inductive bias, 18, 28, 30, 90, 109	nearest neighbor, 26, 28	recall, 60
iteration, 32	neural network, 157	receiver operating characteristic, 62
	neural networks, 52, 116	reconstruction error, 172
jack-knifing, 67	neurons, 39	reductions, 72
Jensen's inequality, 179	noise, 19	redundant features, 54
joint, 111	non-convex, 122	regularized objective, 88
	non-linear, 116	regularizer, 87, 90
K-nearest neighbors, 29	Normal distribution, 109	representer theorem, 130, 132
Karush-Kuhn-Tucker conditions, 139	normalize, 44, 57	ROC curve, 62
kernel, 128, 132	null hypothesis, 65	
kernel trick, 133		sample complexity, 144, 145, 147
kernels, 52	objective function, 87	semi-supervised learning, 181
KKT conditions, 139	one versus all, 75	sensitivity, 62
, 37	one versus rest, 75	separating hyperplane, 86
label, 11	online, 41	SGD, 161
Lagrange multipliers, 106	online learning, 184	shallow decision tree, 18, 156
Lagrange variable, 106	optimization problem, 87	shape representation, 54
Lagrangian, 106	output unit, 116	sigmoid, 117
	OVA, 75	sigmoid function, 113
layer-wise, 126 leave-one-out cross validation, 63	overfitting, 21	sigmoid network, 126
level-set, 91	oversample, 73	9
license, 2	oversample, 75	sign, 117
likelihood, 114	n value 6=	single-layer network, 116
•	p-value, 65	slack, 135
linear classifier, 157	PAC, 143, 154	slack parameters, 99
linear classifiers, 157	paired t-test, 65	smoothed analysis, 168
linear decision boundary, 39	parametric test, 65	soft assignments, 176
linear regression, 96	parity function, 125	soft-margin SVM, 99
linearly separable, 45	patch representation, 54	span, 130
link function, 117	PCA, 172	sparse, 91
log likelihood, 106	perceptron, 39, 40, 56	specificity, 62
log posterior, 114	perpendicular, 43	squared loss, 14, 89
log probability 106	pixel representation 54	stacking 84

StackTest, 84	t-test, 65	validation data, 24	
statistical inference, 103	test data, 22	Vapnik-Chernovenkis dimension, 149	
statistically significant, 65	test error, 22	variance, 153	
stochastic gradient descent, 161	test set, 9	VC dimension, 149	
stochastic optimization, 160	text categorization, 54	vector, 28	
strong learner, 154	the curse of dimensionality, 34	visualize, 166	
strong learning algorithm, 154	threshold, 40	vote, 29	
strongly convex, 94	Tikhonov regularization, 86	voted perceptron, 49	
structural risk minimization, 86	training data, 9, 15, 22	voting, 49	
sub-sampling, 72	training error, 16		
subderivative, 95	trucated gradients, 163	weak learner, 154	
subgradient, 95	two-layer network, 116		
subgradient descent, 96		weak learning algorithm, 154	
support vector machine, 98	unbiased, 45	weighted nearest neighbors, 37	
support vectors, 140	underfitting, 21	weights, 39	
surrogate loss, 89	unit hypercube, 36		
symmetric modes, 122	unsupervised learning, 32	zero/one loss, 14	