## Index

Activation function, 29-32, 37, 60 Active learning, 173-174 Ada. Boost. M1 algorithm, 166-167 Area under curve (AUC), 13-14, 118 - 119Artificial intelligence (AI), 1, 2 Artificial neural network (ANN), 26 Augmented reality (AR), 53 Automatic interaction detection method (AID method), 139–143 Automatic relevance detection (ARD), 49 Average linkage, 157–158 Backpropagation cost functions and training of neural networks using, 38-40 equations, 62 Bagging, 158-159, 161-165, 169 regularization through, 78 Basis expansion, 58-59 Basis function(s), 58-59 regression, 28, 31 Batch gradient descent, 8–9 size, 8–9 Bayesian approach, 26 Bayesian neural networks, 49 Bias, 2, 69 bias-variance tradeoff, 68–70 Binary choice targeting model, 72 Binary classification, 3 Boosting, 158-159, 165-169 Bootstrap(ping), 158-161 aggregation, 159 Business-to-business setting (B2B setting), 118-119

Caravan insurance, 176 Chain-rule of calculus, 39, 63 Chaotic time series, 119 Chi Squared automatic interaction detection method (CHAID method), 139–143 Chi-squared statistic, 140 Choice rules, 121-122 Choice-based conjoint analysis (CBC analysis), 122 Churn modeling, 118–119 prediction, 54-57 Classification models. 2-3 NN for, 37–38 performance assessment for classification tasks, 9-19 trees. 150-155 Classification and regression trees (CART), 143-155, 175-176 Classifier, 93 Clustering models, 156 Coefficients, 2 Collaborative-based recommendation system, 116-117 Complete linkage, 157–158 Composite functions, 36 Computational learning theory, 85–86 Confusion matrix, 12-13 Conjoint analysis, 124-125 methodology, 116 Connection weights, feature importance based on, 45 - 47

Business-to-customer setting

(B2C setting), 118-119

Consumer choice modeling, 121 Content-based recommendation system, 116-117 Convolutional neural networks (CNN), 2 Cosine similarity kernel, 130 Cost complexity criterion, 181 pruning, 149-150 Cost function, 9 and training of machine learning models, 3-4 Cross-entropy cost, 4, 6, 19–20, 38, 41, 151-152 Cross-validation, 70-72, 80 Cumulative response curve, 15-17 "Customer-focused" approach of marketing, 116 Decision trees, 155 applications in marketing and sales, 171 - 176bootstrapping, bagging, and boosting, 158-169 case studies, 176-179 decision tree-based methods, 139 - 140early evolution of, 139-143 random forest, 169-171 and segmentation, 155-158 Default classification rule, 12-13 Dendrograms, 156, 158 Dependent variable, 2 Depth of network, 36 Descent, 9 Direct Marketing Educational Foundation (DMEF), 117-118. 173-174 Directional derivatives, 8 Distance to city center (DCC), 58 Dot product, 59, 91, 128

"Earnings before tax-to-equity ratio", 173–174 Empirical distribution, 5 Ensemble methods, regularization through, 78 Ensemble random forest approach, 175–176 Euclidean distance, 156–157 Euclidean norm, 91–92 Evolutionary local selection algorithm (ELSA), 52 Example-dependent costs, 175–176 Expectation, 69 Expected test error, 71–72 Explanatory variable, 2

Feature importance based on connection weights, 45–47 based on partial derivatives, 49 measurement, 42–49 Feature selection, 75 Feature space, 94, 129, 143 First Order Conditions (FOCs), 132 Fivefold cross-validation, 71 Forward stagewise additive modeling process, 165–166

Gainsight and Survey Monkey company, 54 Gaussian distribution, 62 Gaussian errors, 38 Generalizability, 73 Generalization error, 9-10, 68 Gini coefficient, 17-19 Gini index, 151-152 Goodness-of-fit measure, 149-150 Gradient, 61 boosting, 168 with cross-entropy, 63 descent, 9, 61 gradient-based learning, 6-9 Gram matrix, 130 Greedy algorithm, 147-149, 155

Hard choices, 116–117 Hidden nodes, 31–32, 59–60 Hierarchical Bayesian method (HB method), 116 Hierarchical clustering, 156 Hit rate, 11–12 Hyperparameters, 66, 167 Hyperplanes, 88 margin between classes, 99–100 maximal margin classification, 101–106 optimal separating hyperplane, 99–106 separating, 88–89

Independent variable, 2 Inner product, 59, 91, 128 Intel's RealSense Vision Processor, 53 Internet Movie Database (IMDB), 116–117 "Inverted U" shape, 33–34 Irreducible error, 69

K-fold cross validation, 71 Karush–Kuhn–Tucker conditions, 132 Kernel(s), 94–98 kernel-based nonlinear classifier, 114 in machine learning, 90–99 matrix, 130 as measures of similarity, 91–94 trick, 98–99 k<sup>th</sup> degree polynomial kernel, 130

L<sub>1</sub> regularization, 74–75 as constrained optimization problems, 75–76 weight decay in, 81 L<sub>2</sub> regularization, 73–74 as constrained optimization problems, 75–76 weight decay in, 80–81 Lagrange multipliers, 131–132 Lasso, 73 Latitude of acceptance rule (LOA rule), 52, 121–122 Law of parsimony, 72 Lead qualification and scoring models, 52 Learning rate, 66 with cross-entropy function, 63 parameter, 7-8 Learning slowdown, 63 Leave-out-one cross-validation (LOOCV), 71 Lift chart, 15–17 Linear activation function for continuous regression outputs, 40, 62-63 Linear regression model, 2–3 Log odds, 86, 127 ratio. 3 Log-likelihood, 19 Logistic regression, 3, 86 Logit leaf model (LLM), 175-176 Machine learning, 1-2 implementation, 1 industry applications, 1 kernels in, 90-99 Margin, 104, 130 width, 107 Maximal margin classification, 101-106 Maximum likelihood estimation (MLE), 4-6, 38 Maximum likelihood estimator, 19, 60-61 Mean squared error (MSE), 10, 58 Mini-batch gradient descent, 8-9 Misclassification costs, 175-176 Model distribution, 5 Monocentric land value model, 26-27 Multi-class classification, 37 Multicentric land value model, 27 Multilayer NNs, 36-37, 53 Multilayer perceptron (MLP), 175-176 Multinomial logit (MNL), 50-51

Natural language processing (NLP), 2, 53 "Net profit margin", 173–174 Neural interpretation diagrams (NID), 43-44 Neural networks (NN), 2, 25–26, 53 applications to sales and marketing, 49 - 54case studies, 54-58 for classification, 37-38 cost functions and training of neural networks using backpropagation, 38-40 early evolution, 25-26 feature importance measurement and visualization, 42-49 model, 26-38 output nodes, 40-42 for regression, 28-37 Next Product To Buy (NPTB), 54 Non-compensatory choice rules, 52, 121 Non-convex region, 146 Non-parametric methods, 139–140 Nonlinear maps and kernels, 94–98 Norm, 91–92, 128 Online learning, 8-9 Optimal classifier, 114 Ordinary least squares regression (OLS regression), 101 Out-of-bag observations, 163 Output nodes, 40-42 Overfitting, 66-68 Parameter norm penalty methods, 73-74 Partial derivatives, feature importance based on, 49 Percent correctly classified (PCC), 11-12, 124, 176 Perceptrons, 89 Permutation importance measure, 164

Pessimistic active learning (PAL), 173 - 174Polynomial kernel, 114 Predicted mean squared error (PMSE), 126 Predicted MSE (PMSE), 10 Prediction rule, 143 Profile method for sensitivity analysis, 44-45 Propensity scoring model, 12-13 Prototypes, 173–174 Quadratic cost, 63 function, 76, 83 Radial basis function kernel (RBF kernel), 99, 130, 175-176 Radial basis kernel, 126 Radial kernel, 123 Random forest, 2, 139-140, 169-171 applications in marketing and sales, 171 - 176Randomization approach for weight and input variable significance, 48-49 Receiver operating characteristics curve (ROC curve), 13-14 Recency, frequency, monetary value analysis (RFM analysis), 173-174 Rectified Linear Units (ReLU), 33 Recurrent neural networks (RNN), 2 Recursive binary partitioning, 145 Regression cost complexity pruning, 149-150 greedy algorithm, 147-149 models, 2–3 NN for, 28-37 performance assessment for, 9-19 trees, 147-150 Regularization, 66, 72-78 through bagging and ensemble methods, 78 through early stopping, 77

through input noise, 76 through sparse representations, 77 - 78Rent value location vs., 125 prediction, 57-58 Response variables, 1–3 Ridge regression, 73 "Root" node, 149-150 Sales and marketing applications of NN to, 49-54 SVM applications in, 114-120 Sampling variability, 69 Satisficing rule, 52 Segmentation, 155-158 Segmentation, targeting and positioning (STP), 50, 155-156 Self-organizing feature maps (SOFM), 115 Separability, 109-110 Separating hyperplanes, 88-89, 127 Sequential binary programming (SBP), 173 - 174Shannon's entropy, 151–152 Sigmoid activation function, 33 for binary outputs, 40-41, 63 Sigmoid function, 33, 36 Sigmoid kernel, 130 Similarity, kernels as measures of, 91-94 Slack variable, 107–109 Soft margins, 107 Softmax activation function for multiclass outputs, 42, 64 Softmax function, 37 Sparse representations, regularization

through, 77–78 Sparsity, 75, 81–82

Stochastic gradient boosting algorithm, 169 Stochastic gradient descent (SCD), 8, 0

Stochastic gradient descent (SGD), 8–9 Stopping rule, 148–149

Streaming data, 8–9 Sum of squares (SS), 147, 150, 181 cost, 4, 19 error cost, 38 Supervised learning models, 1 Supervised segmentation, 155-156 Support vector classifier, 106–114 Support vector clustering (SVC), 115 Support vector machine (SVM), 2, 85-86, 175-176 applications in marketing and sales, 114 - 120case studies, 120-127 early evolution, 85–86 hyperplanes, 88-89 kernels in machine learning, 90-99 nonlinear classification using, 86-88 optimal separating hyperplane, 99-106 support vector classifier and, 106-114 Support vectors, 102 SVMauc technique, 118–119

Taiwan Ratings Corporation, 118–119 Target variables, 1-3 Test data, 9-10, 71 Test error, 9-10, 66, 68 Text analysis, 119-120 Text classification, 120 THAID, 139–143 Top decile lift, 17 Training error, 9-10, 66 Training of machine learning models, 1 - 9cost functions and training of machine learning models, 3 - 4gradient-based learning, 6-9 MLE, 5-6 regression and classification models, 2 - 3Tree size, 149-150 Tree-based model, 175-176

"Trial-and-repeat" purchase models, 2 Weight decay, 72-78 True data distribution, 5, 71-72 in L1 regularization, 81 in L<sub>2</sub> regularization, 80-81 parameter, 74, 80, 150 Underfitting, 69 Units, 25-26 Weight(s), 2 Universal approximation theorem, vectors, 31 weight-based input importance 33-34 Unsupervised segmentation models, weighted additive rule, 52 156 Wine quality, 178 Wolfe Dual program, 106, 133 Vapnik–Chervonenkis theory, 85–86

XOR problem, 113

method, 45

Variance, 69 Virtual reality (VR), 53 Visualization, 42-49