Index

Numbers and Symbols	aggregation, 112
632 bootstrap, 371	bootstrap, 379
δ-bicluster algorithm, 517–518	complex data types and, 166
δ-pCluster, 518–519	cube computation and, 193
	data cube, 110–111
A	at multiple granularities, 230-231
absolute-error criterion, 455	multiway array, 195–199
absolute support, 246	simultaneous, 193, 195
abstraction levels, 281	AGNES. See Agglomerative Nesting
accuracy	algebraic measures, 145
attribute construction and, 105	algorithms. See specific algorithms
boosting, 382	all_confidence measure, 268, 272
with bootstrap, 371	all-versus-all (AVA), 430-431
classification, 377-385	analysis of variance (ANOVA), 600
classifier, 330, 366	analytical processing, 153
with cross-validation, 370-371	ancestor cells, 189
data, 84	angle-based outlier detection (ABOD), 580
with holdout method, 370	angle-based outlier factor (ABOF), 580
measures, 369	anomalies. See outliers
random forests, 383	anomaly mining. See outlier analysis
with random subsampling, 370	anomaly-based detection, 614
rule selection based on, 361	antimonotonic constraints, 298, 301
activation function, 402	antimonotonic measures, 194
active learning, 25, 430, 437	antimonotonicity, 249
ad hoc data mining, 31	apex cuboids, 111, 138, 158
AdaBoost, 380–382	application domain-specific semantics, 282
algorithm illustration, 382	applications, 33, 607-618
TrAdaBoost, 436	business intelligence, 27
adaptive probabilistic networks, 397	computer science, 613
advanced data analysis, 3, 4	domain-specific, 625
advanced database systems, 4	engineering, 613, 624
affinity matrix, 520, 521	exploration, 623
agglomerative hierarchical method, 459	financial data analysis, 607-609
AGNES, 459, 460	intrusion detection/prevention, 614-615
divisive hierarchical clustering versus,	recommender systems, 615–618
459–460	retail industry, 609–611
Agglomerative Nesting (AGNES), 459, 460	science, 611–613
aggregate cells, 189	social science and social studies, 613

applications (Continued)	single-dimensional, 17, 287
targeted, 27–28	spatial, 595
telecommunications industry, 611	strong, 264–265, 272
Web search engines, 28	support, 21, 245, 246, 417
application-specific outlier detection, 548–549	top- <i>k</i> , 281
approximate patterns, 281	types of values in, 281
mining, 307–312	associative classification, 415, 416–419, 437
Apriori algorithm, 248–253, 272	CBA, 417
dynamic itemset counting, 256	CMAR, 417–418
efficiency, improving, 254–256	CPAR, 418–419
example, 250–252	rule confidence, 416
hash-based technique, 255	rule support, 417
join step, 249	steps, 417
partitioning, 255–256	asymmetric binary dissimilarity, 71
prune step, 249–250	asymmetric binary similarity, 71
pseudocde, 253	attribute construction, 112
sampling, 256	accuracy and, 105
transaction reduction, 255	multivariate splits, 344
Apriori property, 194, 201, 249	attribute selection measures, 331, 336–344
antimonotonicity, 249	CHAID, 343
in Apriori algorithm, 298	gain ratio, 340–341
Apriori pruning method, 194	Gini index, 341–343
arrays	information gain, 336–340
3-D for dimensions, 196	Minimum Description Length (MDL),
sparse compression, 198–199	343–344
association analysis, 17–18	multivariate splits, 343–344
association rules, 245	attribute subset selection, 100, 103–105
approximate, 281	decision tree induction, 105
Boolean, 281	forward selection/backward elimination
compressed, 281	combination, 105
confidence, 21, 245, 246, 416	greedy methods, 104–105
constraint-based, 281	stepwise backward elimination, 105
constraints, 296–297	stepwise forward selection, 105
correlation, 265, 272	attribute vectors, 40, 328
discarded, 17	attribute-oriented induction (AOI), 166–178, 180
fittest, 426	algorithm, 173
frequent patterns and, 280	for class comparisons, 175–178
generation from frequent itemsets, 253, 254	for data characterization, 167–172
hybrid-dimensional, 288	data generalization by, 166–178
interdimensional, 288	generalized relation, 172
intradimensional, 287	implementation of, 172–174
metarule-guided mining of, 295–296	attributes, 9, 40
minimum confidence threshold, 18, 245	abstraction level differences, 99
minimum support threshold, 245	behavioral, 546, 573
mining, 272	binary, 41–42, 79
multidimensional, 17, 287–289, 320	Boolean, 41
multilevel, 281, 283–287, 320	categorical, 41
near-match, 281	class label, 328
objective measures, 21	contextual, 546, 573
offspring, 426	continuous, 44
quantitative, 281, 289, 320	correlated, 54–56
redundancy-aware top- <i>k</i> , 281	dimension correspondence, 10
· · · · · · · · · · · · · · · · · · ·	

discrete, 44	sample learning calculations, 404–406
generalization, 169-170	sensitivity analysis, 408
generalization control, 170	sigmoid function, 402
generalization threshold control, 170	squashing function, 403
grouping, 231	terminating conditions, 404
interval-scaled, 43, 79	unknown tuple classification, 406
of mixed type, 75–77	weights initialization, 401
nominal, 41, 79	See also classification
numeric, 43–44, 79	bagging, 379–380
ordered, 103	algorithm illustration, 380
ordinal, 41, 79	boosting versus, 381–382
qualitative, 41	in building random forests, 383
ratio-scaled, 43–44, 79	bar charts, 54
reducts of, 427	base cells, 189
removal, 169	base cuboids, 111, 137–138, 158
repetition, 346 set of, 118	Basic Local Alignment Search Tool (BLAST), 591
	Baum-Welch algorithm, 591
splitting, 333	Bayes' theorem, 350–351
terminology for, 40	Bayesian belief networks, 393–397, 436
type determination, 41	algorithms, 396
types of, 39	components of, 394
unordered, 103	conditional probability table (CPT),
audio data mining, 604–607, 624	394, 395
automatic classification, 445	directed acyclic graph, 394–395
AVA. See all-versus-all	gradient descent strategy, 396-397
AVC-group, 347	illustrated, 394
AVC-set, 347	mechanisms, 394–396
average(), 215	problem modeling, 395–396
_	topology, 396
В	training, 396–397
background knowledge, 30-31	See also classification
backpropagation, 393, 398-408, 437	Bayesian classification
activation function, 402	basis, 350
algorithm illustration, 401	Bayes' theorem, 350-351
biases, 402, 404	class conditional independence, 350
case updating, 404	naive, 351-355, 385
efficiency, 404	posterior probability, 351
epoch updating, 404	prior probability, 351
error, 403	BCubed precision metric, 488, 489
functioning of, 400–403	BCubed recall metric, 489
hidden layers, 399	behavioral attributes, 546, 573
input layers, 399	believability, data, 85
input propagation, 401–402	BI (business intelligence), 27
interpretability and, 406–408	biases, 402, 404
learning, 400	biclustering, 512–519, 538
learning rate, 403–404	application examples, 512–515
logistic function, 402	enumeration methods, 517, 518–519
· ·	
multilayer feed-forward neural network, 398–399	gene expression example, 513–514 methods, 517–518
network pruning, 406–407	optimization-based methods, 517–518
neural network topology definition, 400	recommender system example, 514–515
output layers, 399	types of, 538

biclusters, 511	AdaBoost, 380–382
with coherent values, 516	bagging versus, 381–382
with coherent values on rows, 516	weight assignment, 381
with constant values, 515	bootstrap method, 371, 386
with constant values on columns, 515	bottom-up design approach, 133, 151-152
with constant values on rows, 515	bottom-up subspace search, 510-511
as submatrix, 515	boxplots, 49
types of, 515–516	computation, 50
bimodal, 47	example, 50
bin boundaries, 89	five-number summary, 49
binary attributes, 41, 79	illustrated, 50
asymmetric, 42, 70	in outlier visualization, 555
as Boolean, 41	BUC, 200-204, 235
contingency table for, 70	for 3-D data cube computation, 200
dissimilarity between, 71–72	algorithm, 202
example, 41–42	Apriori property, 201
proximity measures, 70–72	bottom-up construction, 201
symmetric, 42, 70–71	iceberg cube construction, 201
See also attributes	partitioning snapshot, 203
binning	performance, 204
discretization by, 115	top-down processing order, 200, 201
equal-frequency, 89	business intelligence (BI), 27
smoothing by bin boundaries, 89	business metadata, 135
smoothing by bin means, 89	business query view, 151
smoothing by bin medians, 89	- 1
biological sequences, 586, 624	
alignment of, 590–591	С
analysis, 590	C4.5, 332, 385
BLAST, 590	class-based ordering, 358
hidden Markov model, 591	gain ratio use, 340
as mining trend, 624	greedy approach, 332
multiple sequence alignment, 590	pessimistic pruning, 345
pairwise alignment, 590	rule extraction, 358
phylogenetic tree, 590	See also decision tree induction
substitution matrices, 590	cannot-link constraints, 533
bipartite graphs, 523	CART, 332, 385
BIRCH, 458, 462–466	cost complexity pruning algorithm, 345
CF-trees, 462-463, 464, 465-466	Gini index use, 341
clustering feature, 462, 463, 464	greedy approach, 332
effectiveness, 465	See also decision tree induction
multiphase clustering technique, 464-465	case updating, 404
See also hierarchical methods	case-based reasoning (CBR), 425–426
bitmap indexing, 160-161, 179	challenges, 426
bitmapped join indexing, 163, 179	categorical attributes, 41
bivariate distribution, 40	CBA. See Classification Based on Associations
BLAST. See Basic Local Alignment Search Tool	CBLOF. See cluster-based local outlier factor
BOAT. See Bootstrapped Optimistic Algorithm for	CELL method, 562, 563
Tree construction	cells, 10–11
Boolean association rules, 281	aggregate, 189
Boolean attributes, 41	ancestor, 189
boosting, 380	base, 189
accuracy, 382	descendant, 189

dimensional, 189	equivalence, 427
exceptions, 231	target, 15
residual value, 234	classification, 18, 327–328, 385
central tendency measures, 39, 44, 45–47	accuracy, 330
mean, 45–46	accuracy improvement techniques, 377–385
median, 46–47	active learning, 433–434
midrange, 47	advanced methods, 393–442
for missing values, 88	applications, 327
models, 47	associative, 415, 416–419, 437
centroid distance, 108	automatic, 445
CF-trees, 462–463, 464	backpropagation, 393, 398-408, 437
nodes, 465	bagging, 379–380
parameters, 464	basic concepts, 327–330
structure illustration, 464	Bayes methods, 350–355
CHAID, 343	Bayesian belief networks, 393–397, 436
Chameleon, 459, 466–467	boosting, 380–382
clustering illustration, 466	case-based reasoning, 425–426
relative closeness, 467	of class-imbalanced data, 383–385
relative interconnectivity, 466-467	confusion matrix, 365-366, 386
See also hierarchical methods	costs and benefits, 373-374
Chernoff faces, 60	decision tree induction, 330-350
asymmetrical, 61	discriminative frequent pattern-based, 437
illustrated, 62	document, 430
ChiMerge, 117	ensemble methods, 378-379
chi-square test, 95	evaluation metrics, 364–370
chunking, 195	example, 19
chunks, 195	frequent pattern-based, 393, 415-422, 437
2-D, 197	fuzzy set approaches, 428-429, 437
3-D, 197	general approach to, 328
computation of, 198	genetic algorithms, 426-427, 437
scanning order, 197	heterogeneous networks, 593
CLARA. See Clustering Large Applications	homogeneous networks, 593
CLARANS. See Clustering Large Applications	IF-THEN rules for, 355–357
based upon Randomized Search	interpretability, 369
class comparisons, 166, 175, 180	k-nearest-neighbor, 423–425
attribute-oriented induction for,	lazy learners, 393, 422–426
175–178	learning step, 328
mining, 176	model representation, 18
presentation of, 175–176	model selection, 364, 370-377
procedure, 175–176	multiclass, 430-432, 437
class conditional independence, 350	in multimedia data mining, 596
class imbalance problem, 384-385, 386	neural networks for, 19, 398-408
ensemble methods for, 385	pattern-based, 282, 318
on multiclass tasks, 385	perception-based, 348–350
oversampling, 384–385, 386	precision measure, 368–369
threshold-moving approach, 385	as prediction problem, 328
undersampling, 384–385, 386	process, 328
class label attributes, 328	process illustration, 329
class-based ordering, 357	random forests, 382–383
class/concept descriptions, 15	recall measure, 368–369
classes, 15, 166	robustness, 369
contrasting, 15	rough set approach, 427–428, 437

classification (Continued)	cluster analysis, 19-20, 443-495
rule-based, 355-363, 386	advanced, 497-541
scalability, 369	agglomerative hierarchical clustering,
semi-supervised, 432-433, 437	459–461
sentiment, 434	applications, 444, 490
spatial, 595	attribute types and, 446
speed, 369	as automatic classification, 445
support vector machines (SVMs), 393,	biclustering, 511, 512–519
408-415, 437	BIRCH, 458, 462–466
transfer learning, 434–436	Chameleon, 458, 466-467
tree pruning, 344–347, 385	CLIQUE, 481–483
web-document, 435	clustering quality measurement, 484, 487-490
Classification Based on Associations (CBA), 417	clustering tendency assessment, 484-486
Classification based on Multiple Association Rules	constraint-based, 447, 497, 532-538
(CMAR), 417–418	correlation-based, 511
Classification based on Predictive Association Rules	as data redundancy technique, 108
(CPAR), 418–419	as data segmentation, 445
classification-based outlier detection, 571-573, 582	DBSCAN, 471–473
one-class model, 571–572	DENCLUE, 476–479
semi-supervised learning, 572	density-based methods, 449, 471-479, 491
See also outlier detection	in derived space, 519–520
classifiers, 328	dimensionality reduction methods, 519–522
accuracy, 330, 366	discretization by, 116
bagged, 379-380	distance measures, 461–462
Bayesian, 350, 353	distance-based, 445
case-based reasoning, 425–426	divisive hierarchical clustering, 459–461
comparing with ROC curves, 373–377	evaluation, 483–490, 491
comparison aspects, 369	example, 20
decision tree, 331	expectation-maximization (EM) algorithm,
error rate, 367	505–508
k-nearest-neighbor, 423–425	graph and network data, 497, 522-532
Naive Bayesian, 351–352	grid-based methods, 450, 479–483, 491
overfitting data, 330	heterogeneous networks, 593
performance evaluation metrics, 364–370	hierarchical methods, 449, 457–470, 491
recognition rate, 366–367	high-dimensional data, 447, 497, 508-522
rule-based, 355	homogeneous networks, 593
Clementine, 603, 606	in image recognition, 444
CLIQUE, 481–483	incremental, 446
clustering steps, 481–482	interpretability, 447
effectiveness, 483	k-means, 451–454
strategy, 481	k-medoids, 454–457
See also cluster analysis; grid-based methods	k-modes, 454
closed data cubes, 192	in large databases, 445
closed frequent itemsets, 247, 308	as learning by observation, 445
example, 248	low-dimensional, 509
mining, 262–264	methods, 448–451
shortcomings for compression, 308–309	multiple-phase, 458–459
closed graphs, 591	number of clusters determination, 484, 486–487
closed patterns, 280	OPTICS, 473–476
top-k most frequent, 307	orthogonal aspects, 491
closure checking, 263–264	for outlier detection, 445
cloud computing, 31	outlier detection and, 543
1 0	, · ·

partitioning methods, 448, 451–457, 491	in small clusters, 570–571
pattern, 282, 308–310	weakness of, 571
probabilistic hierarchical clustering, 467–470	clustering-based quantitative associations, 290–291
probability model-based, 497–508	clusters, 66, 443, 444, 490
PROCLUS, 511	arbitrary shape, discovery of, 446
requirements, 445–448, 490–491	assignment rule, 497–498
scalability, 446	completeness, 488
in search results organization, 444	constraints on, 533
spatial, 595	cuts and, 529–530
spectral, 519–522	density-based, 472
as standalone tool, 445	determining number of, 484, 486–487
STING, 479–481	discovery of, 318
subspace, 318–319, 448	fuzzy, 499–501
subspace search methods, 510–511	graph clusters, finding, 528–529
taxonomy formation, 20	on high-dimensional data, 509
techniques, 443, 444	homogeneity, 487–488
as unsupervised learning, 445	merging, 469, 470
usability, 447	ordering, 474–475, 477
use of, 444	pattern-based, 516
cluster computing, 31	probabilistic, 502–503
cluster samples, 108–109	separation of, 447
cluster-based local outlier factor (CBLOF), 569–570	shapes, 471
clustering. See cluster analysis	small, preservation, 488
clustering features, 462, 463, 464	CMAR. See Classification based on Multiple
Clustering Large Applications based upon	Association Rules
Randomized Search (CLARANS), 457	CN2, 359, 363
Clustering Large Applications (CLARA), 456–457	collaborative recommender systems, 610, 617, 618
clustering quality measurement, 484t, 487–490	collective outlier detection, 548, 582
cluster completeness, 488	categories of, 576
cluster homogeneity, 487–488	contextual outlier detection versus, 575
extrinsic methods, 487–489	on graph data, 576
intrinsic methods, 487, 489-490	structure discovery, 575
rag bag, 488	collective outliers, 575, 581
silhouette coefficient, 489-490	mining, 575–576
small cluster preservation, 488	co-location patterns, 319, 595
clustering space, 448	colossal patterns, 302, 320
clustering tendency assessment, 484-486	core descendants, 305, 306
homogeneous hypothesis, 486	core patterns, 304–305
Hopkins statistic, 484–485	illustrated, 303
nonhomogeneous hypothesis, 486	mining challenge, 302–303
nonuniform distribution of data, 484	Pattern-Fusion mining, 302–307
See also cluster analysis	combined significance, 312
clustering with obstacles problem, 537	complete-linkage algorithm, 462
clustering-based methods, 552, 567–571	completeness
example, 553	data, 84–85
See also outlier detection	data mining algorithm, 22
clustering-based outlier detection, 567–571, 582	complex data types, 166
approaches, 567	biological sequence data, 586, 590–591
distance to closest cluster, 568–569	graph patterns, 591–592
fixed-width clustering, 570	mining, 585–598, 625
intrusion detection by, 569–570	networks, 591–592
objects not belonging to a cluster, 568	in science applications, 612

complex data types (Continued)	constraint-based mining, 294-301, 320
summary, 586	interactive exploratory mining/analysis, 295
symbolic sequence data, 586, 588-590	as mining trend, 623
time-series data, 586, 587–588	constraint-based patterns/rules, 281
composite join indices, 162	constraint-based sequential pattern mining, 589
compressed patterns, 281	constraint-guided mining, 30
mining, 307–312	constraints
mining by pattern clustering, 308-310	antimonotonic, 298, 301
compression, 100, 120	association rule, 296–297
lossless, 100	cannot-link, 533
lossy, 100	on clusters, 533
theory, 601	coherence, 535
computer science applications, 613	conflicting, 535
concept characterization, 180	convertible, 299–300
concept comparison, 180	data, 294
concept description, 166, 180	data-antimonotonic, 300
concept hierarchies, 142, 179	data-pruning, 300-301, 320
for generalizing data, 150	data-succinct, 300
illustrated, 143, 144	dimension/level, 294, 297
implicit, 143	hard, 534, 535–536, 539
manual provision, 144	inconvertible, 300
multilevel association rule mining with, 285	on instances, 533, 539
multiple, 144	interestingness, 294, 297
for nominal attributes, 284	knowledge type, 294
for specializing data, 150	monotonic, 298
concept hierarchy generation, 112, 113, 120	must-link, 533, 536
based on number of distinct values, 118	pattern-pruning, 297–300, 320
illustrated, 112	rules for, 294
methods, 117–119	on similarity measures, 533–534
for nominal data, 117–119	soft, 534, 536–537, 539
with prespecified semantic connections, 119	succinct, 298–299
schema, 119	content-based retrieval, 596
conditional probability table (CPT), 394, 395–396	context indicators, 314
confidence, 21	context modeling, 316
association rule, 21	context units, 314
interval, 219–220	contextual attributes, 546, 573
limits, 373	contextual outlier detection, 546–547, 582
rule, 245, 246	with identified context, 574
conflict resolution strategy, 356	normal behavior modeling, 574–575
confusion matrix, 365–366, 386	structures as contexts, 575
illustrated, 366	summary, 575
connectionist learning, 398	transformation to conventional outlier
consecutive rules, 92	detection, 573–574
Constrained Vector Quantization Error (CVQE)	contextual outliers, 545–547, 573, 581
algorithm, 536	example, 546, 573
constraint-based clustering, 447, 497, 532–538, 539	mining, 573–575
categorization of constraints and, 533–535	contingency tables, 95
hard constraints, 535–536	continuous attributes, 44
methods, 535–538	contrasting classes, 15, 180
soft constraints, 536–537	initial working relations, 177
speeding up, 537–538	prime relation, 175, 177
See also cluster analysis	convertible constraints, 299–300

COP k-means algorithm, 536	subset selection, 160
core descendants, 305	See also data cubes
colossal patterns, 306	curse of dimensionality, 158, 179
merging of core patterns, 306	customer relationship management (CRM),
core patterns, 304–305	619
core ratio, 305	customer retention analysis, 610
correlation analysis, 94	CVQE. See Constrained Vector Quantization Error
discretization by, 117	algorithm
interestingness measures, 264	cyber-physical systems (CPS), 596, 623–624
with lift, 266–267	
nominal data, 95–96	D
numeric data, 96–97	data
redundancy and, 94–98	antimonotonicity, 300
correlation coefficient, 94, 96	archeology, 6
numeric data, 96–97	biological sequence, 586, 590–591
correlation rules, 265, 272	complexity, 32
correlation-based clustering methods, 511	conversion to knowledge, 2
correlations, 18	cyber-physical system, 596
cosine measure, 268	for data mining, 8
cosine similarity, 77	data warehouse, 13–15
between two term-frequency vectors, 78	database, 9–10
cost complexity pruning algorithm, 345	discrimination, 16
cotraining, 432–433	dredging, 6
covariance, 94, 97	generalizing, 150
numeric data, 97–98	graph, 14
CPAR. See Classification based on Predictive	growth, 2
Association Rules	linearly inseparable, 413–415
credit policy analysis, 608–609	linearly separated, 409
CRM. See customer relationship management	multimedia, 14, 596
crossover operation, 426	multiple sources, 15, 32
cross-validation, 370–371, 386	multivariate, 556
k-fold, 370	networked, 14
leave-one-out, 371	overfitting, 330
in number of clusters determination, 487	relational, 10
stratified, 371	sample, 219
cube gradient analysis, 321	•
cube shells, 192, 211	similarity and dissimilarity measures, 65–78 skewed, 47, 271
computing, 211	spatial, 14, 595
cube space	spatiotemporal, 595–596
discovery-driven exploration, 231–234	specializing, 150
multidimensional data analysis in, 227–234	statistical descriptions, 44–56
prediction mining in, 227	streams, 598
subspaces, 228–229	symbolic sequence, 586, 588–589
cuboid trees, 205	temporal, 14
cuboids, 137	text, 14, 596–597
apex, 111, 138, 158	time-series, 586, 587
base, 111, 137–138, 158	"tombs," 5
child, 193	training, 18
individual, 190	transactional, 13–14
lattice of, 139, 156, 179, 188–189,	types of, 33
234, 290	web, 597–598
sparse, 190	data auditing tools, 92

data characterization, 15, 166	full, 189–190, 196–197
attribute-oriented induction, 167-172	gradient analysis, 321
data mining query, 167–168	iceberg, 160, 190–191, 201, 235
example, 16	lattice of cuboids, 157, 234, 290
methods, 16	materialization, 159-160, 179, 234
output, 16	measures, 145
data classification. See classification	multidimensional, 12, 136-139
data cleaning, 6, 85, 88–93, 120	multidimensional data mining and, 26
in back-end tools/utilities, 134	multifeature, 227, 230–231, 235
binning, 89–90	multimedia, 596
discrepancy detection, 91–93	prediction, 227–230, 235
by information network analysis, 592–593	qualitative association mining, 289–290
missing values, 88–89	queries, 230
noisy data, 89	query processing, 218–227
outlier analysis, 90	ranking, 225–227, 235
pattern mining for, 318	sampling, 218–220, 235
as process, 91–93	shell, 160, 211
regression, 90	shell fragments, 192, 210-218, 235
See also data preprocessing	sparse, 190
data constraints, 294	spatial, 595
antimonotonic, 300	technology, 187–242
pruning data space with, 300-301	data discretization. See discretization
succinct, 300	data dispersion, 44, 48-51
See also constraints	boxplots, 49–50
data cube aggregation, 110-111	five-number summary, 49
data cube computation, 156–160, 214–215	quartiles, 48–49
aggregation and, 193	standard deviation, 50–51
average(), 215	variance, 50-51
BUC, 200–204, 235	data extraction, in back-end tools/utilities, 134
cube operator, 157–159	data focusing, 168
cube shells, 211	data generalization, 179-180
full, 189–190, 195–199	by attribute-oriented induction, 166-178
general strategies for, 192-194	data integration, 6, 85-86, 93-99, 120
iceberg, 160, 193–194	correlation analysis, 94–98
memory allocation, 199	detection/resolution of data value conflicts
methods, 194-218, 235	99
multiway array aggregation, 195-199	entity identification problem, 94
one-pass, 198	by information network analysis, 592-593
preliminary concepts, 188-194	object matching, 94
shell fragments, 210-218, 235	redundancy and, 94-98
Star-Cubing, 204–210, 235	schema, 94
data cubes, 10, 136, 178, 188	tuple duplication, 98–99
3-D, 138	See also data preprocessing
4-D, 138, 139	data marts, 132, 142
apex cuboid, 111, 138, 158	data warehouses versus, 142
base cuboid, 111, 137-138, 158	dependent, 132
closed, 192	distributed, 134
cube shell, 192	implementation, 132
cuboids, 137	independent, 132
curse of dimensionality, 158	data matrix, 67–68
discovery-driven exploration, 231-234	dissimilarity matrix versus, 67-68
example, 11–13	relational table, 67–68

rows and columns, 68 as two-mode matrix, 68 data migration tools, 93 data mining, 5–8, 33, 598, 623 ad hoc, 31 applications, 607–618 biological data, 624 complex data types, 585–598, 625 cyber-physical system data, 596 data at serams, 598 data types for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–2025, 626 ubiquitous, 618–620, 625	rows and columns, 68	user interaction and 20, 21
data migration tools, 93 data mining, 5–8, 33, 598, 623 ad hoc, 31 applications, 607–618 biological data, 624 complex data types, 585–598, 625 cyber-physical system data, 596 data streams, 598 data types for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 tata models entity-relationship (ER), 9, 139 multidimensional, 135–146 data objects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 tomeliness, 85 interpretability, 85 tomeliness, 85 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 data models entity-relationship (ER), 9, 139 multidimensional, 135–146 data objects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–9 overview, 84–87 transformation to, 87 integration, 93–9		
data mining, 5–8, 33, 598, 623 ad hoc, 31 applications, 607–618 biological data, 624 complex data types, 585–598, 625 cyber-physical system data, 596 data streams, 598 data types for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 tata mining systems, 10 data models entity-relationship (ER), 9, 139 multidimensional, 135–146 data objects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 timeliness, 85 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data ascurity-enhancing techniques, 621 data tarmsional, 135–146 data objects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 33–124 cleaning, 88–3 forms illustration, 87 integration, 92–9 overview, 84–87 quality, 84–120 accuracy, 84 believability, 85 tonsistency, 89 conspersion, 100,	•	
ad hoc, 31 applications, 607–618 biological data, 624 complex data types, 585–598, 625 cyber-physical system data, 596 data streams, 598 data types for, 8 data types for, 8 data base types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 the data objects, 40, 79 similarity, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 93–11 in science applications, 612 summary, 87 tatask in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 consistency, 85 interpretability, 85 timeliness, 85 data reduction, 91 data cube view, 91 data reduction, 93–99 overview, 84–87 quality, 84–87 reduction, 93–99 overview, 84–87 quality, 84–85 reduction, 93–99 overview, 84–87 quality, 84–85 reduction, 93–99 incremental, 31 in science applications, 612 summary, 87 tasks in, 85–87 tatas quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 consistency, 85 interpretability, 85 compression, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategicular on, 93–9 incremen		
applications, 607–618 biological data, 624 complex data types, 585–598, 625 cyber-physical system data, 596 data streams, 598 data types for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 135–146 data objects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 completeness, 84–85 comsistency, 85 interpretability, 85 timeliness, 85 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 sumerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data objects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 reduction, 93–99 overview, 84–87 quality, 84–85 reduction, 93–99 overview, 84–87 quality, 84–85 reduction, 89–99 overview, 84–87 quality, 84–85 reduction, 89–99 overview, 84–87 quality, 84–85 reduction, 89–99 overview, 84–87 quality, 84–85 reduction, 89–101 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 interpretability, 85 interpreta		· .
biological data, 624 complex data types, 585–598, 625 cyber-physical system data, 596 data streams, 598 data types for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 111–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 598 corial impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 50, 79, 624 trends, 622–625, 626 tata segmentation, 445 data abjects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 interpretability, 85 itmeliness, 85 data reduction, 99–111 dimensional, 110–111 dimensional, 110–111 diata objects, 40, 79 similarity, 40 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–85 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 interpretability, 85 interpretability, 85 interpretability, 85 interpretability, 86, 100–102 data reduction, 90–111 dimensional, 110–110 data quality, 84–120 accuracy, 84 believability, 81 believability, 81 c		
complex data types, 585–598, 625 cyber-physical system data, 596 data tyres for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 theory for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 timeliness, 85 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data trich but information, 87 integration, 87 integration, 87 integration, 86 completion, 9–11 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 timeliness, 85 data reduction, 9–9 integration, 86, 99–110	11	
cyber-physical system data, 596 data streams, 598 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interactive, 30 as interactive, 30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596-597, 624 trends, 622–625, 626 the object of the correction of the	e e e e e e e e e e e e e e e e e e e	
data streams, 598 data types for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 text data, 598 text data, 596–597, 624 trends, 622–625, 626 text data, 598 text data, 596–597, 624 trends, 622–625, 626 trends, 622–625, 626 terminology for, 40 data preprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 timeliness, 85 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data scruity-enhancing techniques, 621 data streams, 14, 598, 624 data transformation, 87 interactive, 9–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quali	* '*	•
data types for, 8 data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 data reprocessing, 83–124 cleaning, 88–93 forms illustration, 87 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 task sin, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 consistency, 85 interpretability, 85 timeliness, 85 data reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 consistency, 85 interpretability, 85 completeness, 84–85 consistency, 85 interpretability, 85 completeness, 84–85 consistency, 86 interpretability, 85 completeness, 84–85 consistency, 86 interpretability, 85 interpretability, 85 interpretability, 85 completeness, 84–85 consistency, 86 interpretability, 85 pedictive, 19 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 principle components analysis, 102–103 sampling, 108 strategics, 99–100 theory, 601 wavelet transfor	· · · · ·	•
data warehouses for, 154 database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 599-59, 624 trends, 622–625, 626 data transformation, 87 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 timeliness, 85 interpretability, 85 timeliness, 85 data reduction, 96, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		0.
database types and, 32 descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge discovery, 7 and knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 distributed, 615, 624 data reduction, 93–99 overview, 84–87 reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 consistency, 85 interpretability, 85 timeliness, 85 data reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 consistency, 85 interpretability, 85 completeness, 86-85 data reduction, 99–111 in science applications, 612 summary, 87 tasks in, 85–87 transformation, 0111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 86-85 data reduction, 99–101, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security	• =	
descriptive, 15 distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OIAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596 total data as formation, 8, 87, 111–119, 120 integration, 93–99 overview, 84–87 quality, 84–85 reduction, 99–111 in science applications, 612 summary, 87 transformation, 111–119 data quality, 84, 120 accuracy, 84 believability, 85 completeness, 84–85 consistency, 85 interpretability, 85 timeliness, 85 data reduction, 96, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transformation, 91-11 in science applications, 612 summary, 87 transformation, 612 summary, 87 transformation, 91-11 in science applications, 612 summary, 87 transformatio		· ·
distributed, 615, 624 efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596 text data, 5		
efficiency, 31 foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626	± .	
foundations, views on, 600–601 functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multiidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626		
functionalities, 15–23, 34 graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626	•	· ·
graphs and networks, 591–594 incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626		
incremental, 31 as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596-597, 624 trends, 622–625, 626		
as information technology evolution, 2–5 integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626	÷ .	•
integration, 623 interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626		
interactive, 30 as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626		
as interdisciplinary effort, 29–30 invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626		
invisible, 33, 618–620, 625 issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626		•
issues in, 29–33, 34 in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multidimensional, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentiation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 methodologies, 29–30, 585–607 timeliness, 85 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data selection, 8 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data segmentation, 845 data selection, 8 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data cube aggregation, 110–111 dimensionality, 86, 90–		
in knowledge discovery, 7 as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156,		•
as knowledge search through data, 6 machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 methodologies, 29–30, 585–607 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data reduction, 86, 99–111, 120		**
machine learning similarities, 26 methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 data reduction, 86, 99–111, 120 attribute subset selection, 103–105 clustering, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		• •
methodologies, 29–30, 585–607 motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156,	e e	
motivation for, 1–5 multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 data cube aggregation, 110–111 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		
multidimensional, 11–13, 26, 33–34, 155–156, 179, 227–230 data cube aggregation, 110–111 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 compression, 100, 120 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		
data cube aggregation, 110–111 multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data cube aggregation, 110–111 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		
multimedia data, 596 OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 trends, 622–625, 626 dimensionality, 86, 99–100, 120 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data security-enhancing techniques, 621 data segmentation, 445 data segmentation, 8, 87, 111–119, 120		<u>*</u>
OLAP and, 154 as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 histograms, 106–108 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data scrubbing tools, 92 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		66 6
as pattern/knowledge discovery process, 8 predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 numerosity, 86, 100, 120 parametric, 105–106 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data scrubbing tools, 92 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		•
predictive, 15 presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data scrubbing tools, 92 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
presentation/visualization of results, 31 privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 principle components analysis, 102–103 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data scrubbing tools, 92 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
privacy-preserving, 32, 621–622, 624–625, 626 query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 sampling, 108 strategies, 99–100 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data scrubbing tools, 92 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120	•	•
query languages, 31 relational databases, 10 scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 statistical at statistical statistica	<u>*</u>	
relational databases, 10 scalability, 31 sequence data, 586 See also data preprocessing social impacts, 32 data rich but information poor, 5 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 theory, 601 wavelet transforms, 100–102 See also data preprocessing data rich but information poor, 5 data scrubbing tools, 92 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
scalability, 31 sequence data, 586 social impacts, 32 society and, 618–622 spatial data, 595 spatiotemporal data and moving objects, 595–596, 623–624 statistical, 598 text data, 596–597, 624 trends, 622–625, 626 sequence data, 586 See also data preprocessing data rich but information poor, 5 data scrubbing tools, 92 data security-enhancing techniques, 621 data segmentation, 445 data selection, 8 data source view, 151 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120	1 , 6 6 .	
sequence data, 586 See also data preprocessing data rich but information poor, 5 society and, 618–622 spatial data, 595 data scrubbing tools, 92 spatiotemporal data and moving objects, 595–596, 623–624 data segmentation, 445 data selection, 8 statistical, 598 data source view, 151 text data, 596–597, 624 trends, 622–625, 626 data streams, 14, 598, 624 data transformation, 8, 87, 111–119, 120		•
social impacts, 32 data rich but information poor, 5 society and, 618–622 data scrubbing tools, 92 spatial data, 595 data security-enhancing techniques, 621 spatiotemporal data and moving objects, 595–596, 623–624 data selection, 8 statistical, 598 data source view, 151 text data, 596–597, 624 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
society and, 618–622 data scrubbing tools, 92 spatial data, 595 data security-enhancing techniques, 621 spatiotemporal data and moving objects, 595–596, 623–624 data selection, 8 statistical, 598 data source view, 151 text data, 596–597, 624 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120	=	
spatial data, 595 data security-enhancing techniques, 621 spatiotemporal data and moving objects, 595–596, 623–624 data selection, 8 statistical, 598 data source view, 151 text data, 596–597, 624 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
spatiotemporal data and moving objects, data segmentation, 445 595–596, 623–624 data selection, 8 statistical, 598 data source view, 151 text data, 596–597, 624 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120	• .	
595–596, 623–624 data selection, 8 statistical, 598 data source view, 151 text data, 596–597, 624 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
statistical, 598 data source view, 151 text data, 596–597, 624 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
text data, 596–597, 624 data streams, 14, 598, 624 trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
trends, 622–625, 626 data transformation, 8, 87, 111–119, 120		
uoiquitous, 618–620, 625 aggregation, 112		
	ubiquitous, 016–020, 625	aggregation, 112

data transformation (Continued)	metadata, 134–135
attribute construction, 112	modeling, 10, 135-150
in back-end tools/utilities, 134	models, 132–134
concept hierarchy generation, 112, 120	multitier, 134
discretization, 111, 112, 120	multitiered architecture, 130-132
normalization, 112, 113-115, 120	nonvolatile, 127
smoothing, 112	OLAP server, 132
strategies, 112–113	operational database systems versus, 128-129
See also data preprocessing	planning and analysis tools, 153
data types	retail industry, 609–610
complex, 166	in science applications, 612
complex, mining, 585–598	snowflake schema, 140–141
for data mining, 8	star schema, 139–140
data validation, 592–593	subject-oriented, 126
data visualization, 56-65, 79, 602-603	three-tier architecture, 131, 178
complex data and relations, 64-65	time-variant, 127
geometric projection techniques, 58-60	tools, 11
hierarchical techniques, 63–64	top-down design approach, 133, 151
icon-based techniques, 60–63	top-down view, 151
mining process, 603	update-driven approach, 128
mining result, 603, 605	usage for information processing, 153
pixel-oriented techniques, 57–58	view, 151
in science applications, 613	virtual, 133
summary, 65	warehouse database server, 131
tag clouds, 64, 66	database management systems (DBMSs), 9
techniques, 39–40	database queries. See queries
data warehouses, 10-13, 26, 33, 125-185	databases, 9
analytical processing, 153	inductive, 601
back-end tools/utilities, 134, 178	relational. See relational databases
basic concepts, 125-135	research, 26
bottom-up design approach, 133, 151-152	statistical, 148–149
business analysis framework for, 150	technology evolution, 3
business query view, 151	transactional, 13–15
combined design approach, 152	types of, 32
data mart, 132, 142	web-based, 4
data mining, 154	data/pattern analysis. See data mining
data source view, 151	DBSCAN, 471–473
design process, 151	algorithm illustration, 474
development approach, 133	core objects, 472
development tools, 153	density estimation, 477
dimensions, 10	density-based cluster, 472
enterprise, 132	density-connected, 472, 473
extractors, 151	density-reachable, 472, 473
fact constellation, 141–142	directly density-reachable, 472
for financial data, 608	neighborhood density, 471
framework illustration, 11	See also cluster analysis; density-based methods
front-end client layer, 132	DDPMine, 422
gateways, 131	decimal scaling, normalization by, 115
geographic, 595	decision tree analysis, discretization by, 116
implementation, 156–165	decision tree induction, 330-350, 385
information processing, 153	algorithm differences, 336
integrated, 126	algorithm illustration, 333

attribute selection measures, 336-344	descendant cells, 189
attribute subset selection, 105	descriptive mining tasks, 15
C4.5, 332	DIANA (Divisive Analysis), 459, 460
CART, 332	dice operation, 148
CHAID, 343	differential privacy, 622
gain ratio, 340–341	dimension tables, 136
Gini index, 332, 341–343	dimensional cells, 189
ID3, 332	dimensionality reduction, 86, 99-100, 120
incremental versions, 336	dimensionality reduction methods, 510,
information gain, 336-340	519–522, 538
multivariate splits, 344	list of, 587
parameters, 332	spectral clustering, 520–522
scalability and, 347–348	dimension/level
splitting criterion, 333	application of, 297
from training tuples, 332–333	constraints, 294
tree pruning, 344–347, 385	dimensions, 10, 136
visual mining for, 348–350	association rule, 281
decision trees, 18, 330	cardinality of, 159
branches, 330	concept hierarchies and, 142-144
illustrated, 331	in multidimensional view, 33
internal nodes, 330	ordering of, 210
leaf nodes, 330	pattern, 281
pruning, 331, 344–347	ranking, 225
root node, 330	relevance analysis, 175
rule extraction from, 357–359	selection, 225
deep web, 597	shared, 204
default rules, 357	See also data warehouses
DENCLUE, 476–479	direct discriminative pattern mining, 422
advantages, 479	directed acyclic graphs, 394–395
clusters, 478	discernibility matrix, 427
density attractor, 478	discovery-driven exploration, 231–234, 235
density estimation, 476	discrepancy detection, 91–93
kernel density estimation, 477–478	discrete attributes, 44
kernels, 478	discrete Fourier transform (DFT), 101, 587
See also cluster analysis; density-based methods	discrete wavelet transform (DWT), 100-102,
dendrograms, 460	587
densification power law, 592	discretization, 112, 120
density estimation, 476	by binning, 115
DENCLUE, 477–478	by clustering, 116
kernel function, 477–478	by correlation analysis, 117
density-based methods, 449, 471-479, 491	by decision tree analysis, 116
DBSCAN, 471–473	by histogram analysis, 115–116
DENCLUE, 476–479	techniques, 113
object division, 449	discriminant analysis, 600
OPTICS, 473–476	discriminant rules, 16
STING as, 480	discriminative frequent pattern-based classification,
See also cluster analysis	416, 419–422, 437
density-based outlier detection, 564–567	basis for, 419
local outlier factor, 566–567	feature generation, 420
local proximity, 564	feature selection, 420–421
local reachability density, 566	framework, 420–421
relative density, 565	learning of classification model, 421
,,	

dispersion of data, 44, 48–51	efficiency
dissimilarity	Apriori algorithm, 255–256
asymmetric binary, 71	backpropagation, 404
between attributes of mixed type, 76–77	data mining algorithms, 31
between binary attributes, 71–72	elbow method, 486
measuring, 65–78, 79	email spam filtering, 435
between nominal attributes, 69	engineering applications, 613
on numeric data, 72–74	ensemble methods, 378–379, 386
between ordinal attributes, 75	bagging, 379-380
symmetric binary, 70–71	boosting, 380–382
dissimilarity matrix, 67, 68	for class imbalance problem, 385
data matrix versus, 67–68	random forests, 382–383
<i>n</i> -by- <i>n</i> table representation, 68	types of, 378, 386
as one-mode matrix, 68	enterprise warehouses, 132
distance measures, 461–462	entity identification problem, 94
Euclidean, 72–73	entity-relationship (ER) data model, 9, 139
Manhattan, 72-73	epoch updating, 404
Minkowski, 73	equal-frequency histograms, 107, 116
supremum, 73–74	equal-width histograms, 107, 116
types of, 72	equivalence classes, 427
distance-based cluster analysis, 445	error rates, 367
distance-based outlier detection, 561-562	error-correcting codes, 431-432
nested loop algorithm, 561, 562	Euclidean distance, 72
See also outlier detection	mathematical properties, 72-73
distributed data mining, 615, 624	weighted, 74
distributed privacy preservation, 622	See also distance measures
distributions	evaluation metrics, 364-370
boxplots for visualizing, 49-50	evolution, of database system technology, 3-5
five-number summary, 49	evolutionary searches, 579
distributive measures, 145	exception-based, discovery-driven exploration,
Divisive Analysis (DIANA), 459, 460	231–234, 235
divisive hierarchical method, 459	exceptions, 231
agglomerative hierarchical clustering versus,	exhaustive rules, 358
459–460	expectation-maximization (EM) algorithm,
DIANA, 459, 460	505–508, 538
DNA chips, 512	expectation step (E-step), 505
document classification, 430	fuzzy clustering with, 505–507
documents	maximization step (M-step), 505
language model, 26	for mixture models, 507–508
topic model, 26–27	for probabilistic model-based clustering,
drill-across operation, 148	507–508
drill-down operation, 11, 146–147	steps, 505
drill-through operation, 148	See also probabilistic model-based clustering
dynamic itemset counting, 256	expected values, 97
	cell, 234
E	exploratory data mining. See multidimensional data
_	mining
eager learners, 423, 437	extraction
Eclat (Equivalence Class Transformation) algorithm,	data, 134
260, 272	rule, from decision tree, 357–359
e-commerce, 609	extraction/transformation/loading (ETL) tools, 93
editing method, 425	extractors, 151

F	closed, 247, 248, 262–264, 308
fact constellation, 141	finding, 247
example, 141–142	finding by confined candidate generation,
illustrated, 142	248–253
fact tables, 136	maximal, 247, 248, 262-264, 308
summary, 165	subsets, 309
factor analysis, 600	frequent pattern mining, 279
facts, 136	advanced forms of patterns, 320
false negatives, 365	application domain-specific semantics, 282
false positives, 365	applications, 317–319, 321
farthest-neighbor clustering algorithm, 462	approximate patterns, 307–312
field overloading, 92	classification criteria, 280–283
financial data analysis, 607–609	colossal patterns, 301–307
credit policy analysis, 608-609	compressed patterns, 307–312
crimes detection, 609	constraint-based, 294-301, 320
data warehouses, 608	data analysis usages, 282
loan payment prediction, 608-609	for data cleaning, 318
targeted marketing, 609	direct discriminative, 422
FindCBLOF algorithm, 569-570	high-dimensional data, 301-307
five-number summary, 49	in high-dimensional space, 320
fixed-width clustering, 570	in image data analysis, 319
FOIL, 359, 363, 418	for indexing structures, 319
Forest-RC, 383	kinds of data and features, 282
forward algorithm, 591	multidimensional associations, 287-289
FP-growth, 257–259, 272	in multilevel, multidimensional space, 283-294
algorithm illustration, 260	multilevel associations, 283-294
example, 257–258	in multimedia data analysis, 319
performance, 259	negative patterns, 291–294
FP-trees, 257	for noise filtering, 318
condition pattern base, 258	Pattern-Fusion, 302–307
construction, 257–258	quantitative association rules, 289–291
main memory-based, 259	rare patterns, 291–294
mining, 258, 259	in recommender systems, 319
Frag-Shells, 212, 213	road map, 279–283
fraudulent analysis, 610-611	scalable computation and, 319
frequency patterns	scope of, 319–320
approximate, 281, 307–312	in sequence or structural data analysis, 319
compressed, 281, 307–312	in spatiotemporal data analysis, 319
constraint-based, 281	for structure and cluster discovery, 318
near-match, 281	for subspace clustering, 318–319
redundancy-aware top- <i>k</i> , 281	in time-series data analysis, 319
top-k, 281	top-k, 310
frequent itemset mining, 18, 272, 282	in video data analysis, 319
Apriori algorithm, 248–253	See also frequent patterns
closed patterns, 262–264	frequent pattern-based classification, 415–422, 437
market basket analysis, 244–246	associative, 415, 416–419
max patterns, 262–264	discriminative, 416, 419–422
methods, 248–264	framework, 422
pattern-growth approach, 257–259	frequent patterns, 17, 243
with vertical data format, 259–262, 272	abstraction levels, 281
frequent itemsets, 243, 246, 272	association rule mapping, 280
association rule generation from, 253, 254	basic, 280

frequent nottorns (Continued)	presentation of 174
frequent patterns (<i>Continued</i>) closed, 262–264, 280	presentation of, 174 threshold control, 170
	ŕ
concepts, 243–244 constraint-based, 281	generative model, 467–469 genetic algorithms, 426–427, 437
dimensions, 281 diversity, 280	genomes, 15
,	geodesic distance, 525–526, 539
exploration, 313–319	diameter, 525
growth, 257–259, 272	eccentricity, 525
max, 262–264, 280	measurements based on, 526
mining, 243–244, 279–325	peripheral vertex, 525
mining constraints or criteria, 281	radius, 525
number of dimensions involved in, 281	geographic data warehouses, 595
semantic annotation of, 313–317	geometric projection visualization, 58–60
sequential, 243	Gini index, 341
strong associations, 437	binary enforcement, 332
structured, 243	binary indexes, 341
trees, 257–259	CART use of, 341
types of values in, 281	decision tree induction using,
frequent subgraphs, 591	342–343
front-end client layer, 132	minimum, 342
full materialization, 159, 179, 234	partitioning and, 342
fuzzy clustering, 499–501, 538	global constants, for missing values, 88
data set for, 506	global outliers, 545, 581
with EM algorithm, 505–507	detection, 545
example, 500	example, 545
expectation step (E-step), 505	Google
flexibility, 501	Flu Trends, 2
maximization step (M-step), 506-507	popularity of, 619–620
partition matrix, 499	gradient descent strategy, 396-397
as soft clusters, 501	algorithms, 397
fuzzy logic, 428	greedy hill-climbing, 397
fuzzy sets, 428–429, 437, 499	as iterative, 396–397
evaluation, 500–501	graph and network data clustering, 497,
example, 499	522–532, 539
	applications, 523–525
G	bipartite graph, 523
gain ratio, 340	challenges, 523-525, 530
C4.5 use of, 340	cuts and clusters, 529-530
formula, 341	generic method, 530-531
maximum, 341	geodesic distance, 525-526
gateways, 131	methods, 528-532
gene expression, 513–514	similarity measures, 525-528
generalization	SimRank, 526-528
attribute, 169–170	social network, 524-525
attribute, control, 170	web search engines, 523-524
attribute, threshold control, 170	See also cluster analysis
in multimedia data mining, 596	graph cuts, 539
process, 172	graph data, 14
results presentation, 174	graph index structures, 591
synchronous, 175	graph pattern mining, 591-592, 612-613
generalized linear models, 599–600	graphic displays
generalized relations	data presentation software, 44-45
attribute-oriented induction, 172	histogram, 54, 55

quantile plot, 51–52	data distribution of, 560
quantile-quantile plot, 52–54	frequent pattern mining, 301–307
scatter plot, 54–56	outlier detection in, 576–580, 582
greedy hill-climbing, 397	row enumeration, 302
greedy methods, attribute subset selection, 104–105	high-dimensional data clustering, 497, 508–522 538, 553
grid-based methods, 450, 479-483, 491	biclustering, 512-519
CLIQUE, 481–483	dimensionality reduction methods, 510,
STING, 479–481	519–522
See also cluster analysis	example, 508–509
grid-based outlier detection, 562-564	problems, challenges, and methodologies,
CELL method, 562, 563	508–510
cell properties, 562	subspace clustering methods, 509,
cell pruning rules, 563	510–511
See also outlier detection	See also cluster analysis
group-based support, 286	HilOut algorithm, 577–578
group-by clause, 231	histograms, 54, 106-108, 116
grouping attributes, 231	analysis by discretization, 115-116
grouping variables, 231	attributes, 106
Grubb's test, 555	binning, 106
	construction, 559
Н	equal-frequency, 107
hamming distance, 431	equal-width, 107
hard constraints, 534, 539	example, 54
example, 534	illustrated, 55, 107
handling, 535–536	multidimensional, 108
harmonic mean, 369	as nonparametric model, 559
hash-based technique, 255	outlier detection using, 558-560
heterogeneous networks, 592	holdout method, 370, 386
classification of, 593	holistic measures, 145
clustering of, 593	homogeneous networks, 592
ranking of, 593	classification of, 593
heterogeneous transfer learning, 436	clustering of, 593
hidden Markov model (HMM), 590, 591	Hopkins statistic, 484–485
hierarchical methods, 449, 457-470, 491	horizontal data format, 259
agglomerative, 459–461	hybrid OLAP (HOLAP), 164–165, 179
algorithmic, 459, 461-462	hybrid-dimensional association rules,
Bayesian, 459	288
BIRCH, 458, 462–466	_
Chameleon, 458, 466-467	
complete linkages, 462, 463	IBM Intelligent Miner, 603, 606
distance measures, 461–462	iceberg condition, 191
divisive, 459–461	iceberg cubes, 160, 179, 190, 235
drawbacks, 449	BUC construction, 201
merge or split points and, 458	computation, 160, 193-194, 319
probabilistic, 459, 467-470	computation and storage, 210-211
single linkages, 462, 463	computation with Star-Cubing algorithm,
See also cluster analysis	204–210
hierarchical visualization, 63	materialization, 319
treemaps, 63, 65	specification of, 190-191
Worlds-with-Worlds, 63, 64	See also data cubes
high-dimensional data, 301	icon-based visualization, 60
clustering, 447	Chernoff faces, 60-61

icon-based visualization (Continued)	OLAP in, 594
stick figure technique, 61–63	role discovery in, 593–594
See also data visualization	similarity search in, 594
ID3, 332, 385	information processing, 153
greedy approach, 332	information retrieval (IR), 26–27
information gain, 336	challenges, 27
See also decision tree induction	language model, 26
IF-THEN rules, 355–357	topic model, 26–27
accuracy, 356	informativeness model, 535
conflict resolution strategy, 356	initial working relations, 168, 169, 177
coverage, 356	instance-based learners. See lazy learners
default rule, 357	instances, constraints on, 533, 539
extracting from decision tree, 357	integrated data warehouses, 126
form, 355	integrators, 127
rule antecedent, 355	intelligent query answering, 618
rule consequent, 355	interactive data mining, 604, 607
rule ordering, 357	interactive mining, 30
satisfied, 356	intercuboid query expansion, 221
triggered, 356	example, 224–225
illustrated, 149	method, 223–224
image data analysis, 319	interdimensional association rules, 288
imbalance problem, 367	interestingness, 21–23
imbalance ratio (IR), 270	assessment methods, 23
skewness, 271	components of, 21
inconvertible constraints, 300	expected, 22
incremental data mining, 31	objective measures, 21–22
indexes	strong association rules, 264–265
bitmapped join, 163	subjective measures, 22
composite join, 162	threshold, 21–22
Gini, 332, 341–343	unexpected, 22
inverted, 212, 213	interestingness constraints, 294
indexing	application of, 297
bitmap, 160–161, 179	interpretability
bitmapped join, 179	backpropagation and, 406–408
frequent pattern mining for, 319	classification, 369
join, 161–163, 179	cluster analysis, 447
OLAP, 160–163	data, 85
inductive databases, 601	data quality and, 85
inferential statistics, 24	probabilistic hierarchical clustering,
information age, moving toward, 1–2	469
information extraction systems, 430	interquartile range (IQR), 49, 555
information gain, 336–340 decision tree induction using, 338–339	interval-scaled attributes, 43, 79
ID3 use of, 336	intracuboid query expansion, 221 example, 223
pattern frequency support versus, 421	method, 221–223
single feature plot, 420	value usage, 222
split-point, 340	intradimensional association rules, 287
information networks	intrusion detection, 569–570
analysis, 592–593	anomaly-based, 614
evolution of, 594	data mining algorithms, 614–615
link prediction in, 593–594	discriminative classifiers, 615
mining, 623	distributed data mining, 615

signature-based, 614	editing method, 425
stream data analysis, 615	missing values and, 424
visualization and query tools, 615	number of neighbors, 424-425
inverted indexes, 212, 213	partial distance method, 425
invisible data mining, 33, 618-620, 625	speed, 425
IQR. See Interquartile range	knowledge
IR. See information retrieval	background, 30–31
item merging, 263	mining, 29
item skipping, 263	presentation, 8
items, 13	representation, 33
itemsets, 246	transfer, 434
candidate, 251, 252	knowledge bases, 5, 8
dependent, 266	knowledge discovery
dynamic counting, 256	data mining in, 7
imbalance ratio (IR), 270, 271	process, 8
negatively correlated, 292	knowledge discovery from data (KDD), 6
occurrence independence, 266	knowledge extraction. See data mining
strongly negatively correlated, 292	knowledge mining. See data mining
See also frequent itemsets	knowledge type constraints, 294
iterative Pattern-Fusion, 306	k-predicate sets, 289
iterative relocation techniques, 448	Kulczynski measure, 268, 272
nerative relocation techniques, 110	negatively correlated pattern based on, 293–294
J	negatively correlated pattern based on, 255 254
Jaccard coefficient, 71	L
join indexing, 161–163, 179	language model, 26
join muching, 101 100, 17,	Laplacian correction, 355
K	lattice of cuboids, 139, 156, 179, 188–189, 234
k-anonymity method, 621–622	lazy learners, 393, 422–426, 437
Karush-Kuhn-Tucker (KKT) conditions, 412	case-based reasoning classifiers, 425–426
<i>k</i> -distance neighborhoods, 565	<i>k</i> -nearest-neighbor classifiers, 423–425
kernel density estimation, 477–478	<i>l</i> -diversity method, 622
kernel function, 415	learning
k-fold cross-validation, 370–371	
k-means, 451–454	active, 433–434, 437
	backpropagation, 400
algorithm, 452	as classification step, 328
application of, 454	connectionist, 398
CLARANS, 457	by examples, 445
within-cluster variation, 451, 452	by observation, 445
clustering by, 453	rate, 397
drawback of, 454–455	semi-supervised, 572
functioning of, 452	supervised, 330
scalability, 454	transfer, 430, 434–436, 438
time complexity, 453	unsupervised, 330, 445, 490
variants, 453–454	learning rates, 403–404
k-means clustering, 536	leave-one-out, 371
k-medoids, 454–457	lift, 266, 272
absolute-error criterion, 455	correlation analysis with, 266–267
cost function for, 456	likelihood ratio statistic, 363
PAM, 455–457	linear regression, 90, 105
k-nearest-neighbor classification, 423	multiple, 106
closeness, 423	linearly, 412–413
distance-based comparisons, 425	linearly inseparable data, 413–415

link mining, 594	all_confidence, 272
link prediction, 594	antimonotonic, 194
load, in back-end tools/utilities, 134	attribute selection, 331
loan payment prediction, 608-609	categories of, 145
local outlier factor, 566–567	of central tendency, 39, 44, 45-47
local proximity-based outliers, 564-565	correlation, 266
logistic function, 402	data cube, 145
log-linear models, 106	dispersion, 48–51
lossless compression, 100	distance, 72-74, 461-462
lossy compression, 100	distributive, 145
lower approximation, 427	holistic, 145
••	Kulczynski, 272
M	max_confidence, 272
machine learning, 24–26	of multidimensional databases, 146
active, 25	null-invariant, 272
data mining similarities, 26	pattern evaluation, 267–271
semi-supervised, 25	precision, 368–369
supervised, 24	proximity, 67, 68–72
unsupervised, 25	recall, 368–369
Mahalanobis distance, 556	sensitivity, 367
majority voting, 335	significance, 312
Manhattan distance, 72–73	similarity/dissimilarity, 65–78
MaPle, 519	specificity, 367
margin, 410	median, 39, 46
market basket analysis, 244–246, 271–272	bin, smoothing by, 89
example, 244	example, 46
illustrated, 244	formula, 46–47
Markov chains, 591	for missing values, 88
materialization	metadata, 92, 134, 178
full, 159, 179, 234	business, 135
iceberg cubes, 319	importance, 135
no, 159	operational, 135
partial, 159–160, 192, 234	repositories, 134–135
semi-offline, 226	metarule-guided mining
max patterns, 280	of association rules, 295–296
max_confidence measure, 268, 272	example, 295–296
maximal frequent itemsets, 247, 308	metrics, 73
example, 248	classification evaluation, 364–370
mining, 262–264	microeconomic view, 601
shortcomings for compression, 308–309	midrange, 47
maximum marginal hyperplane (MMH), 409	MineSet, 603, 605
SVM finding, 412	minimal interval size, 116
maximum normed residual test, 555	minimal spanning tree algorithm, 462
mean, 39, 45	minimum confidence threshold, 18, 245
bin, smoothing by, 89	Minimum Description Length (MDL), 343–344
example, 45	minimum support threshold, 18, 190
for missing values, 88	association rules, 245
trimmed, 46	count, 246
weighted arithmetic, 45	Minkowski distance, 73
measures, 145	min-max normalization, 114
accuracy-based, 369	missing values, 88–89
algebraic, 145	mixed-effect models, 600

mixture models, 503, 538	multifeature cubes, 227, 230, 235
EM algorithm for, 507–508	complex query support, 231
univariate Gaussian, 504	examples, 230–231
mode, 39, 47	multilayer feed-forward neural networks,
example, 47	398–399
model selection, 364	example, 405
with statistical tests of significance, 372–373	illustrated, 399
models, 18	layers, 399
modularity	units, 399
of clustering, 530	multilevel association rules, 281, 283, 284, 320
use of, 539	ancestors, 287
MOLAP. See multidimensional OLAP	concept hierarchies, 285
monotonic constraints, 298	dimensions, 281
motifs, 587	group-based support, 286
moving-object data mining, 595-596, 623-624	mining, 283–287
multiclass classification, 430–432, 437	reduced support, 285, 286
all-versus-all (AVA), 430-431	redundancy, checking, 287
error-correcting codes, 431–432	uniform support, 285–286
one-versus-all (OVA), 430	multimedia data, 14
multidimensional association rules, 17, 283,	multimedia data analysis, 319
288, 320	multimedia data mining, 596
hybrid-dimensional, 288	multimodal, 47
interdimensional, 288	multiple linear regression, 90, 106
mining, 287–289	multiple sequence alignment, 590
mining with static discretization of quantitative	multiple-phase clustering, 458–459
attributes, 288	multitier data warehouses, 134
with no repeated predicates, 288	multivariate outlier detection, 556
See also association rules	with Mahalanobis distance, 556
multidimensional data analysis	with multiple clusters, 557
in cube space, 227–234	with multiple parametric distributions, 557
in multimedia data mining, 596	with χ^2 -static, 556
spatial, 595	multiway array aggregation, 195, 235
•	
of top-k results, 226	for full cube computation, 195–199
multidimensional data mining, 11–13, 34 155–156,	minimum memory requirements, 198 must-link constraints, 533, 536
179, 187, 227, 235	
data cube promotion of, 26	mutation operator, 426
dimensions, 33	mutual information, 315–316
example, 228–229	mutually exclusive rules, 358
retail industry, 610	N
multidimensional data model, 135–146, 178	- •
data cube as, 136–139	naive Bayesian classification, 351
dimension table, 136	class label prediction with, 353–355
dimensions, 142–144	functioning of, 351–352
fact constellation, 141–142	nearest-neighbor clustering algorithm, 461
fact table, 136	near-match patterns/rules, 281
snowflake schema, 140–141	negative correlation, 55, 56
star schema, 139–140	negative patterns, 280, 283, 320
multidimensional databases	example, 291–292
measures of, 146	mining, 291–294
querying with starnet model, 149–150	negative transfer, 436
multidimensional histograms, 108	negative tuples, 364
multidimensional OLAP (MOLAP), 132, 164, 179	negatively skewed data, 47

neighborhoods	null-transactions, 270, 272
density, 471	number of, 270
distance-based outlier detection, 560	problem, 292–293
k-distance, 565	numeric attributes, 43-44, 79
nested loop algorithm, 561, 562	covariance analysis, 98
networked data, 14	interval-scaled, 43, 79
networks, 592	ratio-scaled, 43-44, 79
heterogeneous, 592, 593	numeric data, dissimilarity on, 72-74
homogeneous, 592, 593	numeric prediction, 328, 385
information, 592–594	classification, 328
mining in science applications, 612-613	support vector machines (SVMs) for, 408
social, 592	numerosity reduction, 86, 100, 120
statistical modeling of, 592-594	techniques, 100
neural networks, 19, 398	
backpropagation, 398-408	0
as black boxes, 406	object matching, 94
for classification, 19, 398	objective interestingness measures, 21–22
disadvantages, 406	one-class model, 571–572
fully connected, 399, 406-407	one-pass cube computation, 198
learning, 398	one-versus-all (OVA), 430
multilayer feed-forward, 398-399	online analytical mining (OLAM), 155, 227
pruning, 406–407	online analytical processing (OLAP), 4, 33, 128,
rule extraction algorithms, 406, 407	179
sensitivity analysis, 408	access patterns, 129
three-layer, 399	data contents, 128
topology definition, 400	database design, 129
two-layer, 399	dice operation, 148
neurodes, 399	drill-across operation, 148
Ng-Jordan-Weiss algorithm, 521, 522	drill-down operation, 11, 135–136, 146
no materialization, 159	drill-through operation, 148
noise filtering, 318	example operations, 147
noisy data, 89-91	functionalities of, 154
nominal attributes, 41	hybrid OLAP, 164-165, 179
concept hierarchies for, 284	indexing, 125, 160-163
correlation analysis, 95–96	in information networks, 594
dissimilarity between, 69	in knowledge discovery process, 125
example, 41	market orientation, 128
proximity measures, 68–70	multidimensional (MOLAP), 132, 164, 179
similarity computation, 70	OLTP versus, 128–129, 130
values of, 79, 288	operation integration, 125
See also attributes	operations, 146–148
nonlinear SVMs, 413–415	pivot (rotate) operation, 148
nonparametric statistical methods,	queries, 129, 130, 163–164
553–558	query processing, 125, 163–164
nonvolatile data warehouses, 127	relational OLAP, 132, 164, 165, 179
normalization, 112, 120	roll-up operation, 11, 135–136, 146
data transformation by, 113–115	sample data effectiveness, 219
by decimal scaling, 115	server architectures, 164-165
min-max, 114	servers, 132
z-score, 114–115	slice operation, 148
null rules, 92	spatial, 595
null-invariant measures, 270–271, 272	statistical databases versus, 148-149

user-control versus automation, 167	multivariate, 556
view, 129	novelty detection relationship, 545
online transaction processing (OLTP), 128	proximity-based methods, 552, 560–567, 581
access patterns, 129	semi-supervised methods, 551
customer orientation, 128	statistical methods, 552, 553–560, 581
data contents, 128	supervised methods, 549–550
database design, 129	understandability, 549
OLAP versus, 128–129, 130	univariate, 554
view, 129	unsupervised methods, 550
operational metadata, 135	outlier subgraphs, 576
OPTICS, 473–476	outliers
cluster ordering, 474–475, 477	angle-based, 20, 543, 544, 580
core-distance, 475	collective, 547–548, 581
density estimation, 477	contextual, 545–547, 573, 581
reachability-distance, 475	density-based, 564
structure, 476	distance-based, 561
terminology, 476	example, 544
See also cluster analysis; density-based methods	global, 545, 581
ordered attributes, 103	high-dimensional, modeling, 579–580
ordering	identifying, 49
class-based, 358	interpretation of, 577
dimensions, 210	local proximity-based, 564–565
rule, 357	modeling, 548
ordinal attributes, 42, 79	in small clusters, 571
dissimilarity between, 75	types of, 545–548, 581
example, 42	visualization with boxplot, 555
proximity measures, 74–75	oversampling, 384, 386
outlier analysis, 20–21	example, 384–385
clustering-based techniques, 66	example, 504 505
example, 21	Р
in noisy data, 90	pairwise alignment, 590
spatial, 595	pairwise comparison, 372
outlier detection, 543–584	PAM. See Partitioning Around Medoids algorithm
angle-based (ABOD), 580	parallel and distributed data-intensive mining
application-specific, 548–549	algorithms, 31
categories of, 581	parallel coordinates, 59, 62
CELL method, 562–563	parametric data reduction, 105–106
challenges, 548–549	parametric statistical methods, 553–558
clustering analysis and, 543	Pareto distribution, 592
clustering for, 445	partial distance method, 425
clustering-based methods, 552-553, 560-567	partial materialization, 159–160, 179, 234
collective, 548, 575–576	strategies, 192
contextual, 546-547, 573-575	partition matrix, 538
distance-based, 561–562	partitioning
extending, 577–578	algorithms, 451–457
global, 545	in Apriori efficiency, 255–256
handling noise in, 549	bootstrapping, 371, 386
in high-dimensional data, 576–580, 582	criteria, 447
with histograms, 558–560	cross-validation, 370–371, 386
intrusion detection, 569–570	Gini index and, 342
methods, 549–553	holdout method, 370, 386
mixture of parametric distributions, 556–558	random sampling, 370, 386

partitioning (Continued)	expressed, 309
recursive, 335	frequent, 17
tuples, 334	hidden meaning of, 314
Partitioning Around Medoids (PAM) algorithm,	interesting, 21–23, 33
455–457	metric space, 306–307
partitioning methods, 448, 451–457, 491	negative, 280, 291–294, 320
centroid-based, 451-454	negatively correlated, 292, 293
global optimality, 449	rare, 280, 291–294, 320
iterative relocation techniques, 448	redundancy between, 312
<i>k</i> -means, 451–454	relative significance, 312
k-medoids, 454–457	representative, 309
k-modes, 454	search space, 303
object-based, 454-457	strongly negatively correlated, 292
See also cluster analysis	structural, 282
path-based similarity, 594	type specification, 15–23
pattern analysis, in recommender systems,	unexpected, 22
282	See also frequent patterns
pattern clustering, 308-310	pattern-trees, 264
pattern constraints, 297-300	Pearson's correlation coefficient, 222
pattern discovery, 601	percentiles, 48
pattern evaluation, 8	perception-based classification (PBC), 348
pattern evaluation measures, 267-271	illustrated, 349
all_confidence, 268	as interactive visual approach, 607
comparison, 269–270	pixel-oriented approach, 348-349
cosine, 268	split screen, 349
Kulczynski, 268	tree comparison, 350
max_confidence, 268	phylogenetic trees, 590
null-invariant, 270–271	pivot (rotate) operation, 148
See also measures	pixel-oriented visualization, 57
pattern space pruning, 295	planning and analysis tools, 153
pattern-based classification, 282, 318	point queries, 216, 217, 220
pattern-based clustering, 282, 516	pool-based approach, 433
Pattern-Fusion, 302–307	positive correlation, 55, 56
characteristics, 304	positive tuples, 364
core pattern, 304–305	positively skewed data, 47
initial pool, 306	possibility theory, 428
iterative, 306	posterior probability, 351
merging subpatterns, 306	postpruning, 344–345, 346
shortcuts identification, 304	power law distribution, 592
See also colossal patterns	precision measure, 368–369
pattern-guided mining, 30	predicate sets
patterns	frequent, 288–289
actionable, 22	k, 289
co-location, 319	predicates
colossal, 301–307, 320	repeated, 288
combined significance, 312	variables, 295
constraint-based generation, 296-301	prediction, 19
context modeling of, 314-315	classification, 328
core, 304–305	link, 593–594
distance, 309	loan payment, 608–609
evaluation methods, 264-271	with naive Bayesian classification, 353-355
expected, 22	numeric, 328, 385

prediction cubes, 227–230, 235	for nominal attributes, 68–70
example, 228–229	for ordinal attributes, 74-75
Probability-Based Ensemble, 229–230	proximity-based methods, 552, 560-567, 581
predictive analysis, 18–19	density-based, 564-567
predictive mining tasks, 15	distance-based, 561-562
predictive statistics, 24	effectiveness, 552
predictors, 328	example, 552
prepruning, 344, 346	grid-based, 562–564
prime relations	types of, 552, 560
contrasting classes, 175, 177	See also outlier detection
deriving, 174	pruning
target classes, 175, 177	cost complexity algorithm, 345
principle components analysis (PCA), 100, 102-103	data space, 300-301
application of, 103	decision trees, 331, 344-347
correlation-based clustering with, 511	in k-nearest neighbor classification, 425
illustrated, 103	network, 406–407
in lower-dimensional space extraction, 578	pattern space, 295, 297-300
procedure, 102–103	pessimistic, 345
prior probability, 351	postpruning, 344-345, 346
privacy-preserving data mining, 33, 621, 626	prepruning, 344, 346
distributed, 622	rule, 363
k-anonymity method, 621–622	search space, 263, 301
<i>l</i> -diversity method, 622	sets, 345
as mining trend, 624–625	shared dimensions, 205
randomization methods, 621	sub-itemset, 263
results effectiveness, downgrading, 622	pyramid algorithm, 101
probabilistic clusters, 502-503	
probabilistic hierarchical clustering, 467–470	Q
agglomerative clustering framework, 467,	quality control, 600
469	quantile plots, 51–52
algorithm, 470	quantile-quantile plots, 52
drawbacks of using, 469-470	example, 53–54
generative model, 467–469	illustrated, 53
interpretability, 469	See also graphic displays
understanding, 469	quantitative association rules, 281, 283, 288,
See also hierarchical methods	320
probabilistic model-based clustering, 497-508, 538	clustering-based mining, 290-291
expectation-maximization algorithm, 505-508	data cube-based mining, 289-290
fuzzy clusters and, 499–501	exceptional behavior disclosure, 291
product reviews example, 498	mining, 289
user search intent example, 498	quartiles, 48
See also cluster analysis	first, 49
probability	third, 49
estimation techniques, 355	queries, 10
posterior, 351	intercuboid expansion, 223-225
prior, 351	intracuboid expansion, 221–223
probability and statistical theory, 601	language, 10
Probability-Based Ensemble (PBE), 229–230	OLAP, 129, 130
PROCLUS, 511	point, 216, 217, 220
profiles, 614	processing, 163-164, 218-227
proximity measures, 67	range, 220
for binary attributes, 70–72	relational operations, 10

quaries (Continued)	radundancy awara ton k nattorna 201 211 220
queries (Continued)	redundancy-aware top-k patterns, 281, 311, 320
subcube, 216, 217–218	extracting, 310–312
top- <i>k</i> , 225–227	finding, 312
query languages, 31	strategy comparison, 311–312
query models, 149–150	trade-offs, 312
query-driven approach, 128	refresh, in back-end tools/utilities, 134
querying function, 433	regression, 19, 90
	coefficients, 105–106
R	example, 19
rag bag criterion, 488	linear, 90, 105–106
RainForest, 347, 385	in statistical data mining, 599
random forests, 382–383	regression analysis, 19, 328
random sampling, 370, 386	in time-series data, 587–588
random subsampling, 370, 360	relational databases, 9
random walk, 526	components of, 9
similarity based on, 527	mining, 10
·	relational schema for, 10
randomization methods, 621	relational OLAP (ROLAP), 132, 164, 165, 179
range, 48	relative significance, 312
interquartile, 49	relevance analysis, 19
range queries, 220	repetition, 346
ranking	replication, 347
cubes, 225–227, 235	illustrated, 346
dimensions, 225	representative patterns, 309
function, 225	retail industry, 609–611
heterogeneous networks, 593	RIPPER, 359, 363
rare patterns, 280, 283, 320	robustness, classification, 369
example, 291–292	ROC curves, 374, 386
mining, 291–294	classification models, 377
ratio-scaled attributes, 43–44, 79	classifier comparison with, 373–377
reachability density, 566	illustrated, 376, 377
reachability distance, 565	plotting, 375
recall measure, 368–369	roll-up operation, 11, 146
recognition rate, 366–367	rough set approach, 428-429, 437
recommender systems, 282, 615	row enumeration, 302
advantages, 616	rule ordering, 357
biclustering for, 514–515	rule pruning, 363
challenges, 617	rule quality measures, 361-363
collaborative, 610, 615, 616, 617, 618	rule-based classification, 355-363, 386
content-based approach, 615, 616	IF-THEN rules, 355–357
data mining and, 615-618	rule extraction, 357–359
error types, 617–618	rule induction, 359-363
frequent pattern mining for, 319	rule pruning, 363
hybrid approaches, 618	rule quality measures, 361-363
intelligent query answering, 618	rules for constraints, 294
memory-based methods, 617	
use scenarios, 616	
recursive partitioning, 335	S
reduced support, 285, 286	sales campaign analysis, 610
redundancy	samples, 218
in data integration, 94	cluster, 108–109
detection by correlations analysis, 94-98	data, 219

simple random, 108	mutual information, 315–316
stratified, 109–110	task definition, 315
sampling	Semantic Web, 597
in Apriori efficiency, 256	semi-offline materialization, 226
as data redundancy technique, 108–110	semi-supervised classification, 432–433,
methods, 108–110	437
oversampling, 384–385	alternative approaches, 433
random, 386	cotraining, 432–433
with replacement, 380–381	self-training, 432
uncertainty, 433	semi-supervised learning, 25
undersampling, 384–385	outlier detection by, 572
sampling cubes, 218–220, 235	semi-supervised outlier detection, 551
confidence interval, 219–220	sensitivity analysis, 408
framework, 219–220	sensitivity measure, 367
query expansion with, 221	sentiment classification, 434
SAS Enterprise Miner, 603, 604	sequence data analysis, 319
scalability	sequences, 586
classification, 369	alignment, 590
cluster analysis, 446	biological, 586, 590-591
cluster methods, 445	classification of, 589-590
data mining algorithms, 31	similarity searches, 587
decision tree induction and, 347-348	symbolic, 586, 588-590
dimensionality and, 577	time-series, 586, 587-588
k-means, 454	sequential covering algorithm, 359
scalable computation, 319	general-to-specific search, 360
SCAN. See Structural Clustering Algorithm for	greedy search, 361
Networks	illustrated, 359
core vertex, 531	rule induction with, 359-361
illustrated, 532	sequential pattern mining, 589
scatter plots, 54	constraint-based, 589
2-D data set visualization with, 59	in symbolic sequences, 588-589
3-D data set visualization with, 60	shapelets method, 590
correlations between attributes, 54-56	shared dimensions, 204
illustrated, 55	pruning, 205
matrix, 56, 59	shared-sorts, 193
schemas	shared-partitions, 193
integration, 94	shell cubes, 160
snowflake, 140–141	shell fragments, 192, 235
star, 139–140	approach, 211–212
science applications, 611–613	computation algorithm, 212, 213
search engines, 28	computation example, 214-215
search space pruning, 263, 301	precomputing, 210
second guess heuristic, 369	shrinking diameter, 592
selection dimensions, 225	sigmoid function, 402
self-training, 432	signature-based detection, 614
semantic annotations	significance levels, 373
applications, 317, 313, 320-321	significance measure, 312
with context modeling, 316	significance tests, 372–373, 386
from DBLP data set, 316-317	silhouette coefficient, 489-490
effectiveness, 317	similarity
example, 314–315	asymmetric binary, 71
of frequent patterns, 313–317	cosine, 77–78

similarity (Continued)	sparse data cubes, 190
measuring, 65–78, 79	sparsest cuts, 539
nominal attributes, 70	sparsity coefficient, 579
similarity measures, 447–448, 525–528	spatial data, 14
constraints on, 533	spatial data mining, 595
geodesic distance, 525–526	spatiotemporal data analysis, 319
SimRank, 526–528	spatiotemporal data mining, 595, 623–624
similarity searches, 587	specialized SQL servers, 165
in information networks, 594	specificity measure, 367
in multimedia data mining, 596	spectral clustering, 520–522, 539
simple random sample with replacement	effectiveness, 522
(SRSWR), 108	framework, 521
simple random sample without replacement	steps, 520–522
(SRSWOR), 108	speech recognition, 430
SimRank, 526–528, 539	speed, classification, 369
computation, 527–528	spiral method, 152
random walk, 526–528	split-point, 333, 340, 342
structural context, 528	splitting attributes, 333
simultaneous aggregation, 195	splitting criterion, 333, 342
single-dimensional association rules, 17, 287	splitting triterion, 555, 542 splitting rules. See attribute selection measures
single-linkage algorithm, 460, 461	splitting rules. See attribute selection measures splitting subset, 333
singular value decomposition (SVD), 587	SQL, as relational query language, 10
skewed data	square-error function, 454
balanced, 271	squashing function, 403
	standard deviation, 51
negatively, 47	
positively, 47	example, 51
wavelet transforms on, 102	function of, 50
slice operation, 148	star schema, 139
small-world phenomenon, 592	example, 139–140
smoothing, 112	illustrated, 140
by bin boundaries, 89	snowflake schema versus, 140
by bin means, 89	Star-Cubing, 204–210, 235
by bin medians, 89	algorithm illustration, 209
for data discretization, 90	bottom-up computation, 205
snowflake schema, 140	example, 207
example, 141	for full cube computation, 210
illustrated, 141	ordering of dimensions and, 210
star schema versus, 140	performance, 210
social networks, 524–525, 526–528	shared dimensions, 204–205
densification power law, 592	starnet query model, 149
evolution of, 594	example, 149–150
mining, 623	star-nodes, 205
small-world phenomenon, 592	star-trees, 205
See also networks	compressed base table, 207
social science/social studies data mining,	construction, 205
613	statistical data mining, 598-600
soft clustering, 501	analysis of variance, 600
soft constraints, 534, 539	discriminant analysis, 600
example, 534	factor analysis, 600
handling, 536–537	generalized linear models, 599-600
space-filling curve, 58	mixed-effect models, 600
sparse data, 102	quality control, 600

regression, 599	subcube queries, 216, 217–218
survival analysis, 600	sub-itemset pruning, 263
statistical databases (SDBs), 148	subjective interestingness measures, 22
OLAP systems versus, 148–149	subject-oriented data warehouses, 126
statistical descriptions, 24, 79	subsequence, 589
graphic displays, 44–45, 51–56	matching, 587
measuring the dispersion, 48–51	subset checking, 263–264
statistical hypothesis test, 24	subset testing, 250
statistical models, 23-24	subspace clustering, 448
of networks, 592–594	frequent patterns for, 318–319
statistical outlier detection methods, 552, 553-560,	subspace clustering methods, 509, 510–511,
581	538
computational cost of, 560	biclustering, 511
for data analysis, 625	correlation-based, 511
effectiveness, 552	examples, 538
example, 552	subspace search methods, 510–511
nonparametric, 553, 558–560	subspaces
parametric, 553–558	bottom-up search, 510–511
See also outlier detection	cube space, 228–229
statistical theory, in exceptional behavior disclosure,	outliers in, 578–579
291	top-down search, 511
statistics, 23	substitution matrices, 590
inferential, 24	substructures, 243
predictive, 24	sum of the squared error (SSE), 501
StatSoft, 602, 603	summary fact tables, 165
stepwise backward elimination, 105	superset checking, 263
stepwise forward selection, 105	supervised learning, 24, 330
stick figure visualization, 61–63	supervised outlier detection, 549–550
STING, 479–481	challenges, 550
advantages, 480–481	support, 21
as density-based clustering method, 480	association rule, 21
hierarchical structure, 479, 480	group-based, 286
multiresolution approach, 481	reduced, 285, 286
See also cluster analysis; grid-based methods	uniform, 285–286
stratified cross-validation, 371	support, rule, 245, 246
stratified samples, 109–110	support vector machines (SVMs), 393, 408–415
stream data, 598, 624	437
strong association rules, 272	interest in, 408
interestingness and, 264–265	maximum marginal hyperplane, 409, 412
misleading, 265	nonlinear, 413–415
Structural Clustering Algorithm for Networks	for numeric prediction, 408
(SCAN), 531–532	with sigmoid kernel, 415
structural context-based similarity, 526	support vectors, 411
structural data analysis, 319	for test tuples, 412–413
structural patterns, 282	training/testing speed improvement, 415
structure similarity search, 592	support vectors, 411, 437
structures	illustrated, 411
as contexts, 575	SVM finding, 412
discovery of, 318	supremum distance, 73–74
indexing, 319	surface web, 597
substructures, 243	survival analysis, 600
Student's t-test, 372	SVMs. See support vector machines
- · · · · · · · · · · · · · · · · · · ·	T I

symbolic sequences, 586, 588	time-variant data warehouses, 127
applications, 589	top-down design approach, 133, 151
sequential pattern mining in, 588-589	top-down subspace search, 511
symmetric binary dissimilarity, 70	top-down view, 151
synchronous generalization, 175	topic model, 26-27
_	top-k patterns/rules, 281
Т	top-k queries, 225
tables, 9	example, 225–226
attributes, 9	ranking cubes to answer, 226-227
contingency, 95	results, 225
dimension, 136	user-specified preference components,
fact, 165	225
tuples, 9	top-k strategies
tag clouds, 64, 66	comparison illustration, 311
Tanimoto coefficient, 78	summarized pattern, 311
target classes, 15, 180	traditional, 311
initial working relations, 177	TrAdaBoost, 436
prime relation, 175, 177	training
targeted marketing, 609	Bayesian belief networks, 396-397
taxonomy formation, 20	data, 18
technologies, 23-27, 33, 34	sets, 328
telecommunications industry, 611	tuples, 332–333
temporal data, 14	transaction reduction, 255
term-frequency vectors, 77	transactional databases, 13
cosine similarity between, 78	example, 13-14
sparse, 77	transactions, components of, 13
table, 77	transfer learning, 430, 435, 434–436, 438
terminating conditions, 404	applications, 435
test sets, 330	approaches to, 436
test tuples, 330	heterogeneous, 436
text data, 14	negative transfer and, 436
text mining, 596-597, 624	target task, 435
theoretical foundations, 600-601, 625	traditional learning versus, 435
three-layer neural networks, 399	treemaps, 63, 65
threshold-moving approach, 385	trend analysis
tilted time windows, 598	spatial, 595
timeliness, data, 85	in time-series data, 588
time-series data, 586, 587	for time-series forecasting, 588
cyclic movements, 588	trends, data mining, 622-625, 626
discretization and, 590	triangle inequality, 73
illustrated, 588	trimmed mean, 46
random movements, 588	trimodal, 47
regression analysis, 587-588	true negatives, 365
seasonal variations, 588	true positives, 365
shapelets method, 590	t-test, 372
subsequence matching, 587	tuples, 9
transformation into aggregate approximations,	duplication, 98-99
587	negative, 364
trend analysis, 588	partitioning, 334, 337
trend or long-term movements, 588	positive, 364
time-series data analysis, 319	training, 332–333
time-series forecasting, 588	two sample t-test, 373

two-layer neural networks, 399	frequent itemset mining with, 259-262,
two-level hash index structure, 264	272
	video data analysis, 319
U	virtual warehouses, 133
ubiquitous data mining, 618-620, 625	visibility graphs, 537
uncertainty sampling, 433	visible points, 537
undersampling, 384, 386	visual data mining, 602-604, 625
example, 384–385	data mining process visualization, 603
uniform support, 285–286	data mining result visualization, 603
unimodal, 47	data visualization, 602-603
unique rules, 92	as discipline integration, 602
univariate distribution, 40	illustrations, 604–607
univariate Gaussian mixture model, 504	interactive, 604, 607
univariate outlier detection, 554-555	as mining trend, 624
unordered attributes, 103	Viterbi algorithm, 591
unordered rules, 358	
unsupervised learning, 25, 330, 445, 490	W
clustering as, 25, 445, 490	warehouse database servers, 131
example, 25	warehouse refresh software, 151
supervised learning versus, 330	waterfall method, 152
unsupervised outlier detection, 550	wavelet coefficients, 100
assumption, 550	wavelet transforms, 99, 100-102
clustering methods acting as, 551	discrete (DWT), 100-102
upper approximation, 427	for multidimensional data, 102
user interaction, 30–31	on sparse and skewed data, 102
	web directories, 28
V	web mining, 597, 624
values	content, 597
exception, 234	as mining trend, 624
expected, 97, 234	structure, 597–598
missing, 88-89	usage, 598
residual, 234	web search engines, 28, 523-524
in rules or patterns, 281	web-document classification, 435
variables	weight arithmetic mean, 46
grouping, 231	weighted Euclidean distance, 74
predicate, 295	Wikipedia, 597
predictor, 105	WordNet, 597
response, 105	working relations, 172
variance, 51, 98	initial, 168, 169
example, 51	World Wide Web (WWW), 1-2, 4, 14
function of, 50	Worlds-with-Worlds, 63, 64
variant graph patterns, 591	wrappers, 127
version space, 433	_
vertical data format, 260	Z
example, 260–262	z-score normalization, 114–115