Additive synergy In qualitative probabilistic networks, 125 Additivity In evidence theory, 39, 56 In possibility theory, 49, 50 In probability theory, 39, 41 Ancestor node, 189 Anytime algorithm For propagating probabilities, 77 ARCO, 77 Argumentation And defeasible reasoning, 150-155 And handling uncertainty, 152, 153 And logic programming, 154 And probability, 133 Relationship with qualitative certainty networks, 323, 324 ATMS, 101, 165 Autoepistemic logic, 138, 139, 162, 163 Base rate fallacy, 21, 22, 27 Base rate neglect, 27 Bayes' rule In evidence theory, 58, 59 In possibility theory, 50 In probability theory, 42 Naïve, 42, 43 Bayesian belief function In evidence theory, 56 Bayesian multinets, 93, 94 Belief function Definition of, 54 Biases in human reasoning Base rate fallacy, 21, 22, 27 Base rate neglect, 27 Conservatism, 20, 21 Extension law, 23, 24 Gambler's fallacy, 23, 25 Overconfidence, 22, 28 Callibration Of human subjects, 22 Capacities, 118, 119 Causal networks And logic, 133 Dynamic construction of, 85-89 For evidence theory, 79 For possibility theory, 79, 80 For probability theory, 74-78 Causal reasoning In certainty networks, 188, 189 In qualitative certainty networks, 247-255 Certainty factors Birth of, 3 In qualitative certainty networks, 395, 396 Relation to rules, 66

Certainty networks Causal reasoning, 188, 189 Definition of, 186, 187 Evidential reasoning, 188, 189 Intercausal reasoning, 189 Certainty value Definition of, 185, 186 Child node, 189 Circumscription, 137, 138, 162, 163 Clique-tree, 76 CNETS, 78 Combination, 331-337 Role in valuation networks, 81 Compatibility Of qualitative values, 260, 261 Conditional cognitive independence Definition of, 59 Relation to d-separation, 79 Conditional independence In evidence theory, 59 In possibility theory, 50-53 In probability theory, 40 Relation to d-separation, 79 Conditional possibility Definition of, 49 Conditional probability Definition of, 40 Conservatism bias, 20, 21 Consonant belief function In evidence theory, 56 Context model As a solution to the translation problem, 175 To compare quantitative measures, 160 Contradiction In evidence theory, 54 Convex sets of probabilities, 119 CONVINCE, 77 Cox's axioms Critique by Shafer, 30 Definition of, 29, 30 To compare quantitative measures, 156, 158 d-separation Definition of, 191 In evidence theory, 79 In possibility theory, 79 In probability theory, 79 DAVID, 90 Decision making Coverage in this book, xiv Influence diagrams, 89 With kappa values, 132 Default logic, 135-137, 162-164 Defeasible reasoning And qualitative probabilistic networks, 145, 146 Circumscription, 137, 138

Default logic, 135-137 Definition of, 134, 135 Modal approaches, 138, 139 Nonmonotonic consequence relations, 140, 141 Nonmonotonic logic, 135–143 Numerical approaches, 143-150 Preferential models, 139, 140 Using evidence theory, 148 Using kappa values, 146-148 Using possibility theory, 148–150 Using probability theory, 140-148 Delief, 83 Dempster's rule Definition of, 57 Dempster-Shafer theory, See Evidence theory Descartes The ideally rational man, 8 Descendant node, 189 Direct link, 339 Disbelief functions, See Kappa values Disjunctive rule Definition of, 58 Divisible experiments And probability theory, 31 Driving value, 262, 263, 348-350 DRUMS, xiii Dutch book Against evidence theory, 61 Eclectic position And types of uncertainty, 35 Emergence of, 4 In decision making, 65 Issues arising from, 4, 5 Leading to the integration problem, 174 Manifesto for, xiv Probability and evidence theories, 59 Promotion as aim of book, 391 Relationship to qualitative methods, 394, 395 Solution to the incompleteness problem, 182 Statement of, xi, 172-174 Eco Umberto, xiii Empirical evaluation Of quantitative measures, 155, 156 Of qualitative measures, 358 EMYCIN, 176 ENAMORA, 160, 161 Endorsements, 151 Engineering out Of imperfect information, 2, 18 Entropy In thermodynamics, 18 Of information, 19, 20

ENVISION, 109 Epistemic belief, See kappa values Evidence theory #P-completeness of Dempster's rule, 94 And ATMS, 165 And default logic, 164, 165 And defeasible reasoning, 148 And logic, 101, 102 As a variant of probability theory, 38 As upper and lower probabilities, 60 Bayes' rule, 58, 59 Bayesian belief function, 56 Belief function, 54 Birth of, 3 Causal networks, 79 Commonality function, 55 Computational problems with, 74 Consistency with possibility theory, 181 Consistency with probability theory, 181 Consonant belief function, 56 Contradiction, 54 Credal level, 61, 64 d-separation, 79 Decision making in, 63-65 Dempster's rule, 57, 58, 62 Disjunctive rule, 58 Efficient computation, 95, 96 Focal elements, 55 Frame of discernment, 53 In protein topology prediction, 380-383 Jeffrey's rule, 58 Linguistic values, 121 Mass distribution, 53 Normalisation, 58, 62 NP-completeness of Dempster's rule, 94 Pignistic level, 61, 64 Pignistic transformation, 65 Plausibility, 54 Principle of minimum commitment, 55 Probability of provability, 60, 61, 133 Relation to possibility theory, 56 Relation to probability theory, 56 Relation to upper and lower probabilities, 47 Relationship to possibility theory, 158, 159 Relationship with rough sets, 162 Simple support function, 55, 56 Transferable belief model, 61 Vacuous belief function, 54 Varieties of belief, 59-63 Why studied, 38 Evidential reasoning In certainty networks, 188, 189 In qualitative certainty networks, 263-271 Evidenzia, 134

Index

Explaining away In qualitative certainty networks, 311-317 In qualitative probabilistic networks, 125, 314 Focal elements Definition of, 55 FOG, 113, 114 FOLIO, 151 Frame of discernment In evidence theory, 53 Fuzzy sets And logic, 102-104 Birth of, 3 Fuzzy probability, 69, 70 Introduction to, 66 Linguistic quantifier, 69 Membership functions, 67-69 Relation to possibility theory, 47, 68, 69 Relationship with rough sets, 161, 162 Triangular norms, 68, 70 Gambler's fallacy, 23, 25 Head-to-head node, 190 Heuristics in human reasoning Anchoring and adjustment, 24, 26 Availability, 24, 25 Representativeness, 24, 25 Hidden variables Relation to uncertainty, 18 Hooptedoodle Explanation of, 7 HUGIN, 78 IDEAL, 78, 86, 90, 329, 330, 337, 338, 350, 351 Ignorant induction, 129 Imperfect information Engineering it out, 2, 18 Fundamental nature of, 2, 7-9 Hidden variable interpretation, 18 Numerical measures of, 2, 3 Qualitative measures of, 5 Quantitative measures of, 2, 3 Relation to measurement, 15-18 Taxonomy by Bonissone and Tong, 12, 13 Taxonomy by Bosc and Prade, 13 Taxonomy by Smets, 11, 12 Taxonomy by Smithson, 10, 11 Taxonomy for this book, 14, 15 Incompleteness problem An example, 196-199 Definition of, 169, 170 Example solved by Q2, 229, 230 Example solved by Q3, 231–233 Example solved by qualitative certainty networks, 273-275

Solution by monotonicity assumption, 392, 393 Solution through degrading, 182-184, 392 Solution using Q2, 208 Solution using Q3, 219 INFERNO, 46 Infinitesimal probabilities, 129-132 Influence diagrams, 89-91 Information Relation to uncertainty, 19 Information node, 338 Information theory, 18 Information trail, 339 Integration problem An example, 191-196 Definition of, 171, 172 Example solved by Q2, 221-224 Example solved by Q3, 225–228 Example solved by qualitative certainty networks, 276-280 Solution through degrading, 177-179 Solved by qualitative certainty networks, 238 Stemming from the eclectic position, 174 Intelligence Definition of, 1 Intercausal link, 339 Intercausal reasoning In certainty networks, 189 In qualitative certainty networks, 311-319 In qualitative probabilistic networks, 125 Jack Dulouz And Cody's poetry, 271-273 And the letter, 257-260 And the telephone call, 320, 321 And the weekend, 293-296 On the mountain, 214-217 With the Subterraneans, 309-311 Jeffrey's rule In evidence theory, 58 In possibility theory, 50 In probability theory, 41, 42 Join tree, 76, 121 Kappa values And decision making, 132 And local computation, 130 As linguistic probabilities, 131 As possibility values, 73 As probability values, 72, 73, 129-132 Combination of, 73 Comparison with probability values, 131, 132 Known node, 338

Law of small numbers, 23 Leaf node, 190

Linguistic probabilities As kappa values, 131 Human fondness for, 33 Linguistic quantifier In fuzzy sets, 69 Linguistic values In evidence theory, 120 In probability theory, 120, 121 Local computation For *Q2* and *Q3*, 333–335 In Pulcinella, 83, 84, 331, 332 In valuation networks, 80-84 With kappa values, 130 Logic And evidence theory, 101, 102, 133, 134 And fuzzy sets, 102-104 And possibility theory, 100, 101 And probability theory, 97-100, 133 And qualitative probabilistic networks, 133 And rough sets, 104 Lower previsions, 120 LTMS, 165 MacEvidence, 83 Marginalisation, 331-337 Role in valuation networks, 81 Markov blanket, 340 Markov-tree, 76 Membership functions Of fuzzy sets, 67-69 MILORD, 176 Monotonicity assumption Consistency with consistency principles, 181 Definition of, 179, 180 Follows from degrading, 392 Foundation of the qualitative approach, 391 In protein topology prediction, 387 In qualitative certainty networks, 278, 280 Leads to principle of degrading, 393 Solution to the incompleteness problem, 392, 393 Solution to the translation problem, 392 Multi-valued mapping Inducing upper and lower possibilities, 53 Inducing upper and lower probabilities, 47 Multiple-observations In qualitative certainty networks, 348 In qualitative probabilistic networks, 127, 128, 319, 342 Multiply-connected Definition of, 76 Qualitative certainty networks, 296-305 Mummu, xii And IDEAL, 350, 351 And Pulcinella, 335, 336

For handling qualitative algebras, 333-336 For handling qualitative change, 342-351 In protein topology prediction, 362, 363 Origin of the name, 329 Relation to IDEAL and Pulcinella, 330 MUNIN, 77, 78 **MYCIN**, 176 Myth of Zu, 329 Natural conditional functions, See kappa values Naïve Bayes rule, 42, 43 Naïve physics Manifesto, 109 Qualitative reasoning, 109-112 Relationship with qualitative certainty networks, 322, 323 Negative influence In qualitative certainty networks, 240 Non-interactivity Definition of, 52, 53 Non-zero change at a node In qualitative certainty networks, 246 Non-zero change in value In qualitative certainty networks, 242 Non-zero influence In qualitative certainty networks, 241 Normalisation In evidence theory, 58, 62 In possibility theory, 48 Normativeness Of human reasoning, 24, 26, 29, 34 Versus irrationality, 24 Why formality helps, 37 Numerical measures For handling imperfect information, 2, 3 Obtaining numerical values, 107 O[M], 114, 115 Objective probability As frequentist, 44 As opposed to subjective, 26 Ordinal conditional functions, See kappa values OSCAR, 154 Overall qualitative influence, 346 Overconfidence bias, 22, 28 Oxford System of Medicine, 191 Parent node, 189 Path Through a graph, 190 Perfect information Impossibility of, 7, 8 Pignistic transformation As a solution to the translation problem, 176

Definition of, 65

Index

Plain belief Introduction to, 72 Positive influence In qualitative certainty networks, 240 Possibilistic ATMS, 101 Possibilistic logic, 100, 101 Possibility theory Alternative combination functions, 52 And default logic, 164 And logic, 100, 101 And upper and lower probabilities, 159 As a variant of probability theory, 38 Bayes' rule, 50 Causal networks, 79, 80 Computational problems with, 74 Conditional independence, 50-53 Conditional possibility, 49 Consistency with evidence theory, 181 Consistency with probability theory, 51 d-separation, 79 In protein topology prediction, 359-361, 377-380 Jeffrey's rule, 50 Necessity measure, 50 Non-interactivity, 52, 53 Normalisation, 48 Possibility distribution, 47 Possibility measure, 49 Principle of minimum specificity, 48, 49 Relation to evidence theory, 56, 158, 159 Relation to fuzzy sets, 47, 68, 69 Relation to kappa values, 73, 159, 160 Relation to probability theory, 159, 160 Specificity, 48 Subadditivity in, 49 Superadditivity in, 50 Upper and lower possibilities, 53 Varieties of, 52 Why studied, 38 POSSINFER, 80 Predecessor node, 189 Premature mathematization, 37 Principle of degrading Definition of, 177 Follows from monotonicity assumption, 393 Foundation of the qualitative approach, 391 Leads to monotonicity assumption, 392 Solution to the incompleteness problem, 182-184 Solution to the integration problem, 177-179 Solution to the translation problem, 392 Principle of maximum entropy And information theory, 20 Applied in diagnosis, 198 In evidence theory, 55 In possibility theory, 48, 49

In probability theory, 43, 44 Used in *Q3*, 213 Principle of minimum commitment In evidence theory, 55 Principle of minimum specificity And information theory, 20 Applied in diagnosis, 193, 195 In possibility theory, 48, 49 In qualitative certainty networks, 252, 280, 301 Probabilistic logic, 97-99 Probability of provability Interpretation of evidence theory, 60, 61 Probability theory Addition law, 40 Additivity in, 41 And argumentation, 133 And defeasible reasoning, 140-148 And divisible experiments, 31 And logic, 97-100 And seriable experiments, 31 And System P, 146 As a normative theory, 24 Bayes' rule, 42 Causal networks, 74-78 Computational problems with, 73, 74 Conditional independence, 40 Conditional probability, 40 Consistency with evidence theory, 181 Consistency with possibility theory, 51 Convex sets of probabilities, 119 Convexity law, 40 d-separation, 79 Fuzzy probability, 69, 70, 122 In protein topology prediction, 358, 359, 373-377 Infinitesimal probabilities, 129-132 Interval values, 117-123 Jeffrey's rule, 41, 42 Linguistic values, 120, 121 Lower previsions, 120 Multiplication law, 40 NP-hardness of propagation, 76 Odds-likelihood formulation, 45 Principle of maximum entropy, 43, 44 Probability distribution, 39 Probability measure, 39 Problems with, 3 Qualitative probabilistic networks, 123-129 Relation to evidence theory, 56 Relation to kappa values, 73 Relationship to possibility theory, 159, 160 Subjective and objective, 26 Symbolic values, 132 Total probability, 41 Upper and lower probabilities, 47, 118, 119

Varieties of, 44, 45 Why studied, 38 Product synergy In qualitative probabilistic networks, 125 Protein topology prediction Introduction to, 354-357 Using Q3, 358-373 Using qualitative certainty networks, 376-387 Psychology Human reasoning under uncertainty, 20-29 Pulcinella And Mummu, 335, 336 As an implementation of valuation networks, 83, 84 Local computation mechanism, 331, 332 Q1, 114, 202 Q2 Definition of, 202-204 Example solution to the incompleteness problem, 229, 230 Example solution to the integration problem, 221-224 Handling evidence theory, 205, 206 Handling possibility theory, 205, 206 Handling probability theory, 205, 206 Solution to the incompleteness problem, 208 Solution to the translation problem, 207, 208 The role of semantics, 396 Valuation-based systems, 333-335 Q_3 And qualitative certainty networks, 398 Comparing intervals, 213, 214 Definition of, 209, 210 Example solution to the incompleteness problem, 231-233 Example solution to the integration problem, 225-228 Handling certainty factors, 396 Handling evidence theory, 212 Handling possibility theory, 211, 212 Handling probability theory, 211, 212 In protein topology prediction, 358-373 Solution to the incompleteness problem, 219 Solution to the translation problem, 217-219 The role of semantics, 396 Valuation-based systems, 333-335 QCN, See Qualitative certainty networks QPN, See Qualitative probabilistic networks QSIM, 109, 111, 113 Qualitative algebra For qualitative influences, 220, 221 Qualitative algebras For certainty values, 202 For qualitative reasoning, 114-117

The role of semantics, 396 Qualitative certainty networks And causality, 398 And Q3, 398 Causal reasoning, 247-255 Complexity of propagation, 350 Conditions on certainty factor influences, 395, 396 Conditions on evidential influences, 253-255, 266, 268, 269, 287, 288, 306-308, 316, 317 Conditions on possibilistic influences, 251, 252, 265, 290, 291, 300, 301, 303, 304, 315, 316 Conditions on probabilistic influences, 249, 250, 254, 267-269, 286, 297-299, 302-304, 313-315 Driving value, 262, 263, 348-350 Evidential reasoning, 263-271 Example solution to the incompleteness problem, 273-275 Example solution to the integration problem, 276-280 Explaining away, 311-317 In protein topology prediction, 376-387 Intercausal reasoning, 311-319 Introduced, 237 Monotonicity assumptions in, 278, 280 Multiple observations, 348 Multiply-connected, 296-305 Negative influence, 240 Non-zero change at a node, 246 Non-zero change in value, 242 Non-zero influence, 241 Positive influence, 240 Possible futures, 399 Principle of minimum specificity, 252, 279 Propagation algorithm, 342-350 Qualitative derivative, 242-244 Qualitative independence, 240 Qualitative influence, 239 Qualitative influence along a trail, 256, 257 Relationship to argumentation, 323, 324 Relationship to naïve physics, 322, 323 Relationship to qualitative physics, 322, 323 Relationship to qualitative probabilistic networks, 314, 324-327, 395 Separable derivative, 245 Sets of propositions, 305-309 Solution to the integration problem, 238 Synergy, 283-293 Zero change at a node, 246 Zero change in value, 242 Zero influence, 240 Qualitative certainty values Solution to the robustness problem, 237 Qualitative derivative

And synergy, 284, 285 In qualitative certainty networks, 242-244 Qualitative differential equations In qualitative physics, 110 Qualitative independence In qualitative certainty networks, 240 Qualitative influence Along a trail, 256, 257 As a qualitative algebra, 220, 221 In qualitative certainty networks, 239 In qualitative probabilistic networks, 123-125 Overall between two nodes, 346 **Oualitative** measures Compatibility of, 260, 261 Definition of, 38, 108 For handling imperfect information, 5 OPNs, 123-129 Qualitative probabilistic networks, 123-129 Types of abstraction, 123 Qualitative physics Order of magnitude reasoning, 112-114 Qualitative differential equations, 110 Qualitative reasoning, 109-112 Relationship to qualitative certainty networks, 322, 323 Qualitative probabilistic networks Additive synergy, 125 And defeasible reasoning, 145, 146 Complexity of propagation, 342 Explaining away, 125, 314 For constructing probabilistic networks, 128 Intercausal reasoning, 126 Multiple observations, 127, 128, 319, 342 Product synergy, 125 Propagation algorithms, 126, 127, 338-343 Qualitative influence, 123-125 Qualitative synergy, 125 Relationship to qualitative certainty networks, 314, 324-327, 395 Relationship to monotonic influence diagrams, 128 Relationship to qualitative certainty networks, 314, 324-327 Relationship to qualitative probability, 129 Resolving trade-offs, 127 Qualitative probability Relationship to qualitative probabilistic networks, 129 Qualitative reasoning In qualitative physics, 109-112 Problems with, 112 Qualitative differential equations, 110 Semigualitative reasoning, 115 With numerical information, 114

With qualitative algebras, 114-117

Qualitative synergy Additive synergy, 125 In qualitative certainty networks, 283-293 In qualitative probabilistic networks, 125 Product synergy, 125 **OUALOUANT**, 78 Quantitative measures Brief history of, 3, 4 Definition of, 38 Experimental comparisons, 155, 156 For handling imperfect information, 3 Obtaining numerical values, 107 Quantity space In naïve physics, 110 Robustness problem An example, 199 Definition of, 170, 171 Solved by qualitative certainty networks, 237 ROM[\R], 114 ROM[K], 114 Root node, 190 Rose By any other name, xiii Rough sets And indiscernability, 71 And logic, 102 Introduction to, 70 Relationship with evidence theory, 162 Relationship with fuzzy sets, 161, 162 Upper and lower approximations, 71, 72 RUM, 32, 70 Schrödinger And his cats, 18 Negentropy, 18 Semiqualitative measures, 38 Semiqualitative reasoning, 115 Semiquantitative reasoning, 115 Separable derivative In qualitative certainty networks, 245 Seriable experiments And probability theory, 31 Sign of a trail, 339 Similarity networks, 91, 92 Simple support function Definition of, 55, 56 Singly-connected Definition of, 75, 76 SOLOMON, 151 SR1, 115, 203 Strictly positive synergy, 285 Subadditivity

In evidence theory, 56

In possibility theory, 49

505

Index

Subjective probability As opposed to objective, 26 Bayesian view, 45 Personalist and necessarian, 44, 45 Superadditivity In evidence theory, 56 In possibility theory, 50 Synergy Additive, 125 In qualitative certainty networks, 283-293 In qualitative probabilistic networks, 125 Product, 125 System P And evidence theory, 102 And preferential models, 140 And probability theory, 146 System-Z, 147, 148 Theorist, 153 Track Through a graph, 190 Trade-offs In qualitative certainty networks, 397, 398 In qualitative probabilistic networks, 127 Trail Active, 190 Minimal, 190 Through a graph, 190 Transferable belief model Definition of, 61 Translation problem Definition of, 175, 176 In protein topology prediction, 364, 365, 384, 385, 387 Solution by monotonicity assumption, 392 Solution using Q2, 207, 208 Solution using Q3, 217-219 Some solutions suggested, 176 TresBel, 83, 84 Triangular norms For combining fuzzy sets, 68, 70 Uncertainty Dictionary definition of, 9, 10 Hidden variable interpretation, 18 Inevitability of, 7-9, 34 Irreducible, 8 Relation to information, 19 Relation to measurement, 15-18 Taxonomy by Bonissone and Tong, 12, 13 Taxonomy by Bosc and Prade, 13 Taxonomy by Smets, 11, 12 Taxonomy by Smithson, 10, 11 Taxonomy for this book, 14, 15

Upper and lower possibilities

From a multi-valued mapping, 53 Upper and lower probabilities And possibility theory, 159 From a multi-valued mapping, 47 Relation to evidence theory, 47 Vacuous belief function Definition of, 54 Valuation networks Combination and marginalisation, 81, 331-337 Dynamic construction of, 87 For quantitative measures, 80-84 Valuation-based systems, 81, 82 Valuation-based systems For Q2, 333-335 In Mummu, 327 In Pulcinella, 331 Valuation networks, 81, 82 VPROP, 77 VSBD, 83, 84 Weather reports, 2 Zero change at a node

Zero change in value In qualitative certainty networks, 242 Zero influence In qualitative certainty networks, 240

In qualitative certainty networks, 246