

# Index

- Action
  - aggregated fuzzy control, 145
  - broader interpretation of, 128
  - in control, 128, 137
  - suggestion for, xiii
- Active cells, 137
- Activity completion cost, 84
- Activity completion time, 80, 81, 83
  - shortening of, 87
- Aggregation
  - in control (conflicting resolution), 138
  - in forecasting models, 61
  - of control outputs, 143
  - of experts opinions, xiv, 81, 115, 116, 118
  - of independent outputs, 182
  - of trapezoidal numbers, 68, 69
  - of triangular numbers, 68, 69
- $\alpha$ -cut ( $\alpha$ -level interval), 14, 15, 89
- Allocation
  - of investment (asset allocation), 157
  - of resources, 83
    - to activities, 84
- Ambiguous, ambiguity, 34, 35
- Antecedent (premise), 39
- Approximate reasoning, 44
- Arbitrary, 80
- Aristotle, 57
- Asai, K., 35, 215
- Aspects (objectives) of a problem, 93, 103
- Assilian, S., 155
- Average (mean) or crisp average, 61, 71, 82
  - weighted, 62, 80, 81
  - weights of, 62
- Baldwin, J. F., 58
- Bandwidth, 20
- Base variable, 45, 47
- Beck, N., 100, 125
- Bellman, R. E., 91–93, 95
- Black, M., 34
- Bojadziev, G., 35, 90
- Bojadziev, M., 35, 90
- Boole, G., 56
- Boolean algebra, 56
- Boyce, R. F., 189
- Budget
  - allocation, 91, 121

- crisp, 123
- cummulative, 121
- fuzzy, 121
- planning, 119
- selection, 121
  
- Cantor, G., 32, 33
- Cartesian plane, 5
- Cartesian product (cross product), 5, 6, 7, 53
- Chamberlin, D. D., 189
- Characteristic (membership) function of a set, 7, 9
- Classical control, 127
- Classical (two-valued) logic, xiii, 37, 42, 44, 50, 52, 56, 57
- Classical PERT, 78, 79, 81, 84, 86
- Client asset allocation model, xv, 158
- Client financial risk tolerance model, xiv, 127, 134, 135, 140–142
- Codd, E. F., 215
- Coding the inputs, 136
- Common-sense reasoning, xiii, 37, 44, 128
- Common stocks, 206
- Complex phenomena, 127
- Complex systems, 127
- Competition, 104
  - price, 104
- Composition rules for fuzzy propositions, 50
  - conjunction, 51, 134
  - disjunction, 52
  - implication, 52, 134
- Confidence, 46
  - level of, 14
- Conflicting linguistic values, 105
- Conflict resolution of experts opinions (see aggregation), 115
- Consequent, 39
- Contradiction (fallacy), in classical logic, 39
  - law of, 40, 42
- Control, xiii
  - action, 37
  - output, 139
    - of rules, 139
  - rules, 133
- Correspondence
  - between classical logic and sets, 40, 41, 43, 44
  - between infinite-valued logic and fuzzy sets, 43, 44
- Cost, 85
  - crash, 84, 86
  - normal, 84–86
- Cost-driven pricing, 126
- Cost slope, 86, 87
- Cox, E. D., 115, 125, 170, 185, 199
- Critical path, 79, 83, 84, 85
  - time for completion, 84
- Critical Path Method (CPM), 78, 79
- Crossover points, 20
  
- Database, 1, 187
  - fuzzy, xv

- standard, 187
  - relational, xv, 187, 188
- Decision, 14, 95
  - aggregated, 118
  - analysis, 37
  - maximizing, 93–96, 106, 108, 110, 112–114, 118
  - multiple, 92
  - table(s), 133
    - induced, 137
- Decision making, xiv, xv, 61, 91, 92, 119
  - by averaging, 110, 119
  - by intersection, xiv, 92, 104, 110, 112, 114, 119
  - fuzzy averaging for, xiv, 61, 91, 110
- Defuzzification, 69, 93, 144, 145
  - center of area (or gravity) method, 145, 147
  - height defuzzification method, 146, 148
  - mean of maximum method, 146
  - of fuzzy average, 69, 70, 81, 82, 116
  - maximizing value (formula), 69, 75, 77, 81, 84, 123
- Degree (grade) of membership, 9, 26, 35, 58
- Delphi method in forecasting, xiv, 71
- Demand, 87
  - annual, for a new product, 88
  - dependent, 88
  - independent, 88
  - on the market, 170
- Direct max product, 32, 52, 54
- Direct min product, 31, 52
- Distance between triangular numbers, 74, 90
- Dividend distribution, 95, 111, 112
- Drucker, P., 109, 126
- Dubois, D., 35
- DuPont, 79
- Earl, E., 89
- Employee performance, 104
- Entailment principle, entails, 56, 123
- Estimation, 84
- Evaluation, 96
  - from point of view of goals and constraints, 97
  - of learning performance, 102
- Excluded middle, law of, 17–19, 33
  - in logic, 40, 42
  - in sets, 17
- Experts, 80
  - experience of, 80
  - groups of, 85
  - opinions, 61, 76, 115
    - close, 115, 117
    - conflicting, 115, 117, 118
  - ranking of, 116, 117, 118
  - weights assign to, 76
- False, falsity
  - in classical logic, 37
  - in fuzzy logic, 58, 59

- in three-valued logic, 41
- Filev, D. P., 155
- Firing of rules, 138
- Fogarty, D. W., 79, 84, 170
- Folger, T. A., 35, 215
- Forecasting, xiii, xiv, 61, 71, 89
  - activity completion time, 84
  - by Fuzzy Delphi method, 72
  - fuzzy averaging for, 61, 72
  - in business, 89
  - in finance, 89
  - in management, 89
  - project completion time, 83
- Freiberger, P., 36
- Function, 6, 7
- Fuzzy, fuzziness, 21, 33–35, 80, 119, 127
- Fuzzy averaging (average), xiv, 61, 66, 71, 91, 95, 110, 111, 115, 119
- Fuzzy complex queries, 196, 197, 203
  - based on averaging, 198, 204
  - based on logical connectives, 196, 204
  - conclusion of, 197
  - truth value of, 198
  - for small manufacturing companies, 199
  - for stocks and funds, 206, 207
  - from 20 biggest mutual funds in Canada, 208, 212
- Fuzzy Delphi method, 61, 71, 72, 75, 76, 81, 84, 88, 119,
  - weighted, 76
- Fuzzy environment, 91, 165
- Fuzzy graph, 28
- Fuzzy logic, xiii–xv, 1, 35–37, 43, 50, 60, 61, 91, 115, 128, 178, 187
- Fuzzy logic control, xi, 127, 128, 151, 157, 183
  - for business, finance, and management, 127
  - for pest management, 164
  - for potential problem analysis, 189
  - for problem analysis, 179
- Fuzzy logic models, 127, 128
- Fuzzy number(s), xiv, 1, 19, 34, 35, 44, 71, 128
  - arithmetic operations with, 62, 89
  - bell-shaped, 20, 125, 170
  - describing large, 24–26
  - describing small, 24–26
  - piecewise-quadratic, 20
  - trapezoidal, 24, 25, 45
    - arithmetic operations with, 62, 66, 89
    - central, 24, 25, 62, 102
    - clipped, 140, 145
    - left, 24
    - right, 24
    - symmetrical, 24
  - triangular, 22–24, 45, 62, 71, 72, 81, 85, 119
    - arithmetic operations with, 62, 66, 89
    - central, 22, 23, 69, 83

- clipped, 140, 145
- left, 25
- right, 25
- symmetrical, 23
- Fuzzy outputs, 133
- Fuzzy PERT, 77, 81, 84
  - for project management, 77
  - for shortening project length, 84
  - for time forecasting, 81
- Fuzzy reading inputs, 136, 137
- Fuzzy relation(s), xiv, 1, 26, 27, 36, 52
  - complement of, 30
  - direct max product, 32
  - direct min product, 31
  - equality of, 30
  - inclusion of, 30
  - intersection of, 30
  - union of, 30
- Fuzzy set(s), xiii–xv, 1, 8–10, 18, 27, 33–36, 43, 44, 58, 69, 91, 92, 115, 128, 187
  - complement, complementation, of, 16, 17, 99
  - convex, 15, 19
  - discrete, 96
  - empty, 10
  - equality of, 15
  - inclusion of, 16, 54, 123
  - intersection of, 16, 18, 91, 93
  - nonconvex, 15
  - nonnormalized, 15
  - normalized, 15
  - proper subset of, 16
  - union of, 16, 18
- Fuzzy singleton, 10, 149, 150
- Fuzzy statistics, 69
- Fuzzy zero-based budgeting method, 119, 123
- Goals, 91, 93, 110
- Greece, paradox from, 33
- Greek oracles of Delphi, 71
- Greek philosophy, 57
- Graham, I. G., 185, 215
- Grant, R. M., 126
- Gupta, M. M., 35, 71, 74, 90, 119
- Hellendoorn, H., 155
- Herbert, B., 126
- Heuristic, xiii, 128
- Hoffmann, T. R., 79, 84, 170
- Housing policy, 99
- If ... then rules, xiii, xiv, 127, 128, 133, 155
- Imprecise, imprecision, xiii, 34, 35
  - environment of, 128
- Income, 46
- Individual investment planning policy, 115–117
  - aggressive, 115, 117, 118
  - conservative, 115, 117
- Induced decision table, 137
- Inferential rules, 44, 127
- Infinite-valued logic, 43, 44
- Inflation, 46
- Information, xi

- ambiguous, 119
- imprecise, 19, 61, 71, 119
- incomplete, 19, 91
- Input(s) (in control), 129
- Interest rates, 115
  - falling, 115, 125
  - rising, 115, 125
- Internal reallocation, 82
- Interval, 2
  - number, 2
- Inventory action, 174
- Inventory control models, xv, 170, 173
  - adjustment factor, 177
  - classical, 170
  - fuzzy, 170
  - if ... and ... then rules for, 171–173
  - inputs: demand and quantity-on-hand, 170, 171, 173
  - output: inventory action, 170, 171, 173
- Investment advisory models, 157
- Japanese, 126
- Job hiring policy, 96–98
- Job selection strategy, 100
- Jones, P. L., 185, 215
- Kandel, A., 35
- Kaufmann, A., 35, 71, 74, 90, 119
- Kepner, C. H., 177, 178, 182, 183, 185
- Klir, G., 35, 215
- Knowledge base, 128
- Knowledge of human experts, 80, 128
- Knowledge workers, xiii
- Kosko, B., 36
- Kunii, T. L., 215
- Li, H. X., 125
- Linguistic modifiers, xiv, 44, 46, 47, 49
  - fairly, 46, 49, 105
  - not, 46
  - very, 46, 49, 105
- Linguistic relations, in set theory, 27
- Linguistic variable(s), xv, 37, 44, 46, 190
  - age (human), 44, 45, 192
  - age (company), 200
  - annual income, 128, 131
  - annual revenues, 200
  - change (of fund asset), 209, 210
  - demand (for a product), 170
  - dividend, 96
  - earning per share, 202
  - employee count, 201
  - false, 58
  - growth potential, 179
  - parasite population, 164, 165
  - pest population, 164, 165
  - priority of deviation, 179, 180
  - product count, 201
  - profit (or loss), 201
  - return, 210
  - risk tolerance, 131

- salary, 192
- serious, 178, 180
- terms (labels, values) of, 44, 45
- total networth, 131
- truth, true, 58, 59
  - modifications of, 58, 59
- Loan scoring model, 46–48, 53
- Logical connectives, 38, 41, 196
  - conjunction (and), 38, 40, 41, 196
  - disjunction (or), 38, 40, 41, 196
  - implication, 39–41
  - negation (not), 38, 40, 41
- Lukasiewicz, J., 41, 43, 52, 57
- Makridakis, S., 89
- Mamdani, E. H., 155
- Management Intelligenter Techno-  
gien GmbH, 216
- Mandelman, A., 207, 208
- Many-valued logic, 37, 41, 50, 52, 57
- Material handling system de-  
sign, 79
- Mathematical models, 127, 128
- McNeill, D., 36
- Membership degree (see degree  
of membership)
- Membership function
  - of fuzzy relations, 26
  - of fuzzy sets, 9, 17, 51
- Mintzberg, H., 89
- Mizumoto, M., 52
- Modifiers (see linguistic modi-  
fiers), 37
- Money supply, 38
- Multi-experts decision making,  
xiv, 115
- Multi-experts forecasting, 72
- Mutual funds, 206
- Nahmias, S., 35
- Network planning model, 79
  - for material handling sys-  
tem, 79
  - improved by using fuzzy PERT,  
83
- Novák, V., 35, 95
- $n$ -valued logic, 43
- One-input–one-output control model,  
152, 179
- Ordered pair, 4, 5, 26
- Ordered triple, 26
- Orlicky, J., 88
- Output(s) (in control), 129
- Overpricing, 104
- Peirce, C. S., 57
- PERT (see Classical PERT)
- Pest management, xv
  - fuzzy logic control for, 164
- Poper, K., 34
- Possibility theory, 58
- Post, E. L., 57
- Potential problem analysis, xv,  
182
  - fuzzy logic control for, 184
- Prade, H., 35
- Precondition, 133
- Predicate, 40

- Predator (parasite)–prey (pest) system, 165  
 control of, 165
- Price  
 competition, 104, 105, 108, 109, 113, 126  
 initial, 104  
 of a product, 38  
 suggested, 107
- Price-led (driven) costing, 109, 126  
 model, 109
- Pricing models, xiv, 91, 104, 105, 110, 112  
 for new products, 104  
 requirements for, 104, 105  
 modified, 105, 107, 108
- Pricing policy, 105
- Probability, probabilistic, 35, 80  
 PERT, 80, 84
- Problem analysis, xv, 177, 182  
 fuzzy logic control for, 179
- Product of competition, 110
- Production rules (see control rules), 133
- Profit, 24, 46, 109, 126
- Project completion time, 79, 80, 83  
 estimation (forecasting), 80, 81
- Project management, 77  
 of a material handling system, 78, 79, 81
- Project reduction time, 87
- Proposition(s) (statement), 37, 40, 41  
 compound, 38, 39  
 truth value of, 39  
 imprecise, 44  
 simple, 38  
 truth value of, 39  
 expressing future events, 57
- Propositional fuzzy logic, 44
- Propositions of fuzzy logic, 50  
 canonical form of, 50  
 composition rules of, 50  
 conjunction, 51  
 disjunction, 52  
 implication, 52  
 conditional, 50  
 modified, 50  
 true to a degree, 50  
 truth value of, 51, 57
- Quasi-contradiction, 42
- Quasi-tautology, 42
- Queries, 187  
 crisp (standard), 187, 189, 190, 195, 199  
 fuzzy, xv, 187, 194, 195, 199
- Rand Corporation, 71
- Readings (measurements), 61, 135
- Relation(s), in set theory, 6, 7, 36
- Remington Rand, 79
- Risk, 24
- Rule evaluation, in fuzzy logic control, 136
- Rule of inference, in fuzzy logic control, 133  
 compositional, 155



- conjunction based, 155
- Rules strength table, 138
- Russell, B., 33, 57
- Schwartz, T. J., 208
- Selection for building construction, 98
- Semantic entailment, 54–56
- SEQUEL, 189, 190
- Set(s), classical, xiv, 1, 2, 9, 10, 32, 44
  - complement of, 3, 40
  - convex, 4
  - disjoint, 3
  - empty, 3
  - equal, 3
  - finite, 2
  - infinite, 2
  - intersection of, 3, 4, 40
  - listing method, to define, 2
  - members of, 1
  - membership rule, to define, 2
  - subset of, 3, 40
  - union of, 3, 4, 40
  - universal, 2, 7, 45
- Simon, H. A., 177
- Singleton, 2, 58
- Standard & Poor's 500 index, 216
- Standard relational databases, 187, 188
  - retrieval of data from, 189, 190, 207
- Statistics
  - classical, 61, 69, 71, 80
  - fuzzy, 69
- Stock market, 38, 126, 206, 207
  - crash, 206
- Storage cost, 170
- Strength of a rule, 138, 139
- Stress, 46
- Subjective, subjectivity, 71, 80, 91
  - judgement of experts, xi
- Sugeno, M., 35, 215
- Supporting interval, 19, 22, 23
- Systems, 128
  - business, 128
  - financial, 128
  - managerial, 128
- Tahani, V., 190
- Tautology, in classical logic, 39, 40
- Terano, T., 35, 215
- Terms of linguistic variables (see linguistic variables), 44, 45
- Thomas, C., 155
- Three-valued logic, 41
- Tidd, C., xv, 209
- Trapezoidal numbers (see Fuzzy numbers)
- Tregoe, B. B., 177, 178, 182, 183, 185
- Treshold, 14, 15, 194, 197
- Triangular numbers (see Fuzzy numbers)
- Trotsky, L., 89
- Truth, true, 46
  - degree (grade) of, 35

- in classical logic, 37
  - in fuzzy logic, 50
  - in three-valued logic, 41
- Truth tables, 39, 57
- Truth value set
- in classical logic, 37
  - in infinite-valued logic, 43
  - in many-valued logic, 43
  - in three-valued logic, 41, 42
- Tuning of FLC models, 150, 151
- Two-valued logic (see classical logic)
- Uncertain, uncertainty, xiii, 23, 35, 80
- environment of, 128
- U.S.A. Navy, 79
- Vague, vagueness, xiii, 8, 14, 19, 21, 33–35, 43, 44, 57
- Venn diagrams, 4, 17
- Wall Street, 126
- Whitehead, A. N., 57
- Wittgenstein, L., 57
- Words with opposite meaning, 99
- Yager, R. R., 155
- Yamaichi securities, 208
- Yen, V. C., 125
- Zadeh, L. A., xv, 9, 34–36, 43, 58, 59, 91–93, 95, 155
- Zero-based budgeting method, 119
- Zimmermann, H. J., 35, 95