

Index

- Accumulation, 55
- Activation, 54
- Adaptation gain, 119
- Adaptive controller
 - convergence, 121
 - defined, 117
- Adjoint, 184
- Adjustment mechanism, 118
- Aggregation, 54
- Anti-windup, 90
- Argument
 - modus ponens, 35
- Array-based logic example, 29
- Array-based modus ponens, 36
- Automatic controller, 1

- Baseball example
 - three-valued logic, 31
 - two-valued logic, 28
- Bilinear interpolation
 - example, 63
- Bisector of area, 56
- BOA, 56
- Buying a house example, 21

- Cart–ball
 - data, 177
 - nonlinear equations, 189
- Cart–ball system, 173
 - linear model, 176
 - positive feedback, 179
- Cartesian product
 - classical, defined, 24
 - fuzzy, defined, 24
- Centre of gravity, 56
- Centre of gravity for singletons, 56

- Centre point, 95
- Characteristic equation, 183
- Classical sets, 13
- Classical sets example, 14
- COG, 56
- COGS, 56
- Composition of relations, 26
 - max–min, 26
 - max–star, 26
- Connectives, 27, 51
 - classical, 27
 - fuzzy, 30
- Control surface, 62, 100
- Control tasks, 193
- Controllability, 185
- Controller type
 - FLS, 59
 - linear, 64
 - Mamdani, 57
 - Sugeno, 59
 - table-based, 62
- Crisp sets, 15
- Critical point, 85
- Cylindrical extension, 43

- Defuzzification, 55
 - bisector of area, BOA, 56
 - centre of gravity for singletons, COGS, 56
 - centre of gravity, COG, 56
 - leftmost maximum, LM, 56
 - mean of maxima, MOM, 56
 - rightmost maximum, RM, 56
- Derivative time, 73

- Describing function
 - deadzone surface, 165
 - defined, 141
 - FPD, 146
 - FPD+I, 151
 - linear FPD example, 146
 - quantizer surface, 168
 - saturation surface, 162
- Design choices
 - list, 69
- Direct control, 47
- Disjunction, 31
- Double integrator
 - example, 97
 - FPD control, 104
 - FPD+I control, 108
 - proportional control, 98
- Dynamic nonlinearity, 145
- Egg-eating example, 19
- Eigenvalues and poles, 184
- Empty set, 14
- Engineering units, 57
- Equilibrium point, 94
 - centre point, 95
 - focus, 95
 - node, 95
 - saddle point, 95
- Equivalence, 33
- Family of terms, 52
- Family resemblance example, 25
- Filtered derivative, 89
- Filtering hypothesis, 142
- FLnc controller, 77
- Fine-tuning, 109
- FLS controller, 59
- Focus, 95
- Four rule FPD, 71
- Fourier integrals, 143
- FP controller, 73
- FPD controller, 74, 99
- FPD+I control, 107
- FPD+I controller, 76
- Frequency response, 84, 141
 - FPD, 146
 - FPD+I, 151
 - linear FPD example, 147
 - nonlinear FPD example, 149
- Friction, 188
- Fundamental frequency, 143
- Fuzzification, 49
- Fuzzy connectives, 30
- Fuzzy controller, 1
- Fuzzy implication, 32
- Fuzzy logic, 1, 26
- Fuzzy reasoning, 13
- Fuzzy set, 13
 - defined, 15
 - examples, 16
- Fuzzy sets
 - equality defined, 20
 - inclusion defined, 20
- Gödel implication, 33
- Gains
 - fuzzy vs PID table, 78
 - transfer in other situations, 83
- Generalized modus ponens, 37
 - defined, 39
 - example, 39
- Hand-tuning, 81
 - table, 81
- Harmonics, 143
- Hedges, 22
- High-level control, 193
 - configurations, 195
 - FLS design procedure, 196
 - objective module, 197
- High-level control
 - performance, 194
- Ideal PID controller, 72
- Ideal saturation, 144
- Implication
 - fuzzy, 32
 - Gödel, 33
 - material, 29, 32
- In-phase component, 143
- Inference
 - defined, 35
 - modus ponens, 35
- Inference engine, 54

- Inner product, 26
 - example, 26
- Integral action
 - example, 82
- Integral time, 73
- Interpolation, 63
 - bilinear, 63
 - rule-based, 60
- Laboratory rig, 173
- Law of involution, 31
- Law of the excluded middle, 15, 32
- Leftmost maximum, 56
- Limit cycle, 112, 153
 - example, 159
- Linear fuzzy controller, 64
 - design choices, 86
- Linguistic rules, 1
- Linguistic term, 47
- Linguistic variable, 22
- LM, 56
- Long deadtime example, 127
- Lookup table, 62, 63
- Mamdani controller, 57
- Mamdani implication, 34
- Mamdani inference, 57
 - defined, 42
 - example, 43
- Material implication, 29, 32
- Max–min composition, 26
- Max–star composition, 26
- Mean of maxima, 56
- Member, 13
- Membership function, 7, 17
 - bell, 54
 - defined, 15
 - example, 18
 - FLS, 54
 - Gauss, 54
 - smooth trapezoid, 17
 - trapezoidal, 17
 - triangular, 17
- Membership grade, 7, 15
- MIT rule, 119
- Model reference adaptive system, 117
- Modus ponens
 - argument, 35
 - array based, 36
 - generalized, 37
- MOM, 56
- Nand, 31
- negation, 30
- Node, 95
- Noise, 114
- Non-minimum phase, 185
- Nyquist criterion, 151
- Nyquist plot, 85
- Or-projection, 43
- Ordered pair
 - defined, 15
- Perfect model-following, 118
- Performance table, 123
- Phase plane, 100
- Phase plane analysis, 93
- Phase plot, 93
- Phase trajectory, 94
- Pole assignability, 185
- Pole placement, 185
- Possibility distribution, 19
 - example, 19
- Post-processing, 57
- Pre-processing, 48
- Predicate, 14
- Primary terms, 24
- Procedure
 - design fuzzy PID, 72
 - fuzzy controller design, 114
 - fuzzy controller design, especially steps 1 and 2, 90
 - hand-tuning, 81
 - Ziegler–Nichols, 79
- Proportional gain, 73
- Proposition, 14, 28
- Prototype response poles, 188
- Quadrature component, 143
- Quantization, 112
- Quantizer, 49

- Relation, 24
 - binary, 24
 - fuzzy, 24
- Return difference, 153
- Rightmost maximum, 56
- RM, 56
- Rule base
 - four rules, 66
 - nine rules, 50, 67
- Rule-based interpolation example, 60
- Rule format
 - graphical, 51
 - if-then, 50
 - relational, 50
 - tabular, 51
- Rule of inference
 - compositional, 42
 - disjunctive syllogism, 35
 - examples, 35
 - hypothetical syllogism, 35
 - modus ponens, 35
 - modus tollens, 35
- Saddle point, 95
- Saturation in the universes, 112
- Scaling
 - alpha-scaling, 83
 - nonlinear, 49
- Self-organizing controller, 117
- Sensitivity derivative, 119
- Set defined
 - classical, 13
 - fuzzy, 15
- Set operations defined
 - classical, 20
 - fuzzy, 20
- Setpoint weighting, 88
- Signal flow graph, 177
- Singleton, 16
- Singleton conclusion, 53
- Sliding mode control, 140
- Smooth trapezoidal membership
 - function, 17
- SOC, 122
 - tuning, 131
- SOC adjustment mechanism
 - adaptation gain, 127
 - defined, 124
 - desired time constant, 127
 - example, 126
 - time lock, 132
- Stability
 - deadzone surface, 165
 - double integrator example, 156
 - linear, 95
 - oscillatory modes example, 158
 - quantizer surface, 168
 - third-order plant example, 155
 - time delay example, 157
- Stability margin, 153
- Standard universe, 51
 - examples, 52
- Static nonlinearity, 143
- Stopping a car example, 3
 - PD control, 99
- Student John
 - example, 38
- Subset
 - classical, 14
- Sugeno controller, 59
- Supervisory control, 191
- Supervisory system, 191
- Surface shaping, 103
- Surfaces
 - deadzone, 103
 - linear, 103
 - quantizer, 103
 - saturation, 103
- t-conorm, 41
- t-norm, 41
- Table-based controller, 62
- Target value deviation TVD, 194
- Tautology
 - defined, 32
 - proof, 33
- Term set, 52
 - age example, 22
- Time lock, 132
- Transfer function from state space,
 - 183
- Trapezoidal membership function,
 - 17
- Triangular membership function, 17

Triangular norms, 41

Truth table

classical, 28

fuzzy, 30

Truth-value, 27

Tuning

defined, 73

map, 85

Ziegler–Nichols,
79

Ziegler–Nichols example,
80

Universe, 7, 16, 54

example, 16

Universes, 51

Venn diagrams, 20

Very

example, 23