

Index

- action, 11
- action space, 21, 38, 78, 80, 93, 111, 117, 121
 - mixed, 33, 97
 - pure, 33
- advertising campaign game, 11–13, 17, 32
- alternate play, 13, 23, 67
- battle of the sexes game, 96, 100, 103, 105
- behavioral policy, 79
- best-response equivalent games, 98, 99, 119
- bilateral symmetric game, 129
- bimatrix game, 94
 - mixed, 97
- Brouwer's fixed-point Theorem, 98, 114
- budget balanced utility, 133
- chicken game, 13–15, 18
- closed-loop game, 16
- closed-loop policy, 13
- computational complexity, 27, 160
- congestion game, 130
- conservative force, 124
- convex
 - combination, 46
 - hull, 46
 - set, 46, 55
- cooperative solution, 6
- cost-to-go
 - continuous time, 166, 170
 - discrete time, 156, 176
- crime deterrence game, 32
- CVX, 56
- decoupled game, 128
- difference Riccati equation, 162
- differential game, 151
 - one player, 165–173
 - pursuit evasion, 192–193
 - variable termination time, 154, 170–171, 191
 - zero sum, 187–193
- differential Riccati equation, 170
- directionally-local minimum, 117, 119
- discount factor, 14
- distributed resource allocation, 132
- distributed welfare games, 132
 - budget balanced, 133
- distribution rule, 133
- dominant saddle-point equilibrium, 58
- dominating policy
 - strictly, 57
 - weakly, 58
- dummy game, 121, 127
- dynamic game
 - continuous time, 151
 - one player, 165–173
 - zero sum, 187–193
 - discrete time, 149
 - one player, 155–164
 - zero sum, 175
- dynamic programming, 73, 82, 160
 - continuous time
 - one player, 166–168
 - zero sum, 187–189
 - discrete time
 - one player, 156
 - zero sum, 176
- exercise
 - best-response equivalence, 101–102
 - chess, 75
 - convex set, 61
 - CVX, 60–61, 85–89
 - extensive form, 75
 - behavioral policies, 85–90
 - behavioral saddle-point equilibrium, 85–90
 - feedback game, 70, 75
 - mixed saddle-point equilibria, 83–85
 - perfect information, 75
 - recursive computation, 75
 - fictitious play, 143–144
 - linear quadratic game, 163
 - MATLAB, 60–61, 85–89, 108–110, 141–145
 - mixed Nash equilibrium computation, 108–110

- mixed saddle-point equilibrium, 50–51, 61
- mixed saddle-point equilibrium computation
 - graphical method, 59–60
 - linear program, 60–61
- Nash equilibrium, 102
 - completely mixed, 110
 - multi-stage games, 18
 - multiple, 17–18
 - order interchangeability, 100–102
- potential game, 124–126, 139–145
 - bilateral symmetric game, 140–141
 - bimatrix game, 124–126
 - congestion game, 145
 - decoupled game, 139, 145
 - dummy game, 145
 - mixed policies, 125–126
 - prisoners' dilemma game, 124–126
 - pure policies, 124–125
 - Sudoku, 139–143, 145
 - sum game, 126
 - wonderful life utility, 141
- quadratic game
 - zero sum, 44, 180, 189
- resistive circuit design game, 40–42
- robust design, 40–42
- rock-paper-scissors game, 50
- saddle-point equilibria, 9, 28–29, 40–44
 - alternate play, 29
 - graphical method, 83–85
 - mixed policies, 40–42, 79
 - policy domination, 83–85
- saddle-point value, 44
- security level, 28–29, 102
- security policies, 40–43
- state-feedback policy
 - continuous time, 171–173
 - discrete time, 163–164
- symmetric games, 50–51
- tic-tac-toe game, 182–185
- extensive form game representation, 12, 63–75
 - multi stage, 149
- feedback behavioral saddle-point equilibrium, 81, 82
- feedback multi-stage game, 70, 82, 83
- feedback pure saddle-point equilibrium, 70, 72, 73
- fictitious play, 136
 - belief, 136
 - best response, 137
- full information, 3
- game-over state, 154, 170
- global minimum, 117–119
- global welfare cost, 132
 - separable, 132
- H-infinity norm
 - continuous time, 191
 - discrete time, 181
- half space, 47
- Hamilton-Jacobi-Bellman-Isaac equation, 187, 189–191, 193
- Hamilton-Jacobi-Bellman equation, 167, 169, 170
- hyperplane, 47
 - inwards-pointing normal, 47
 - normal, 47
- identical interests game, 95, 117, 119, 121, 127
- induced norm
 - continuous time, 190
 - discrete time, 181
- infimum, 38, 94, 112
- infinite horizon game, 150, 152
- information
 - set, 64, 73, 74, 79, 81, 82
 - structure, 3, 12, 64, 150, 156, 159, 160, 166–168, 171, 178, 181, 188, 189, 191, 192
 - state feedback, 175, 187
- integral quadratic cost, 169, 189
- lady in the lake game, 17
- large population paradigm, 32
- linear program, 55
- linear quadratic differential game
 - one player, 169–170
 - zero sum, 189–191
- linear quadratic dynamic game
 - continuous time
 - one player, 169–170
 - zero sum, 189–191
 - discrete time
 - one player, 162–163
 - zero sum, 179–185
- marginal contribution utility, 132
- MATLAB
 - linprog, 55
 - max, 23
 - min, 23
 - quadprog, 106
 - fictitious play, 137–139, 143–144
 - improvement path, 135–136, 141–143, 145
 - solving one-player finite game, 161–162

- solving potential game, 135–139, 141–145
 - solving zero-sum finite game, 179
 - tic-tac-toe game, 182–185
- matrix form game representation, 66
- maximally reduced game, 58
- maximum, 39
- minimax
 - pair, 94
 - policy tuple, 112
- Minimax Theorem, 36, 45–51, 82
- minimum, 38
- mixed Nash equilibrium
 - computation using linear equation, 105
 - computation using quadratic program, 106
- mixed policy, 31, 33, 77, 97, 113, 114
- mixed saddle-point equilibrium computation
 - graphical method, 53
 - linear program, 54
- mixed value, 50, 78
- monotone function, 100
- multi-stage game, 13, 64, 70
- multiplayer game, 111
- Nash equilibrium, 5, 6, 9, 94, 112, 113, 117, 119
 - admissible, 96, 112, 118
 - completely mixed, 104, 105, 114
 - computation for potential games, 134–139
 - inner point, 104, 114
 - mixed, 98, 114
 - pure, 95
- Nash outcome, 94, 112
 - mixed, 98
- network routing game, 8–10, 36
- non-feedback game, 83
- non-zero-sum game, 5
- noncooperative game, 4, 95
- open-loop game, 16, 150, 152
- open-loop policy, 12, 155
 - continuous time, 165, 166, 170
 - one player, 167
 - discrete time, 156
 - one player, 157, 159
- optimization of linear functions over simplexes, 35
- order interchangeability property, 27, 39, 78, 81, 83, 97, 98, 118
- Pareto-optimal solution, 7
- partially known matrix game, 28
- partial information, 3
- path
 - improvement, 134, 135
 - mixed, 136
 - pure, 134
- perfect information game, 68, 74
- perfect state-feedback game, 151, 152
- policy, 11
- potential, 121, 124
 - exact, 119, 122
 - ordinal, 119
- potential game, 121
 - bimatrix, 120
 - exact, 119, 120, 122
 - interval action spaces, 122
 - mixed, 120
 - ordinal, 119
 - pure, 120
- price of anarchy, 134
- prisoners' dilemma game, 95, 100
- probability simplex, 33, 35
- proofs
 - direct, 26
 - equivalence, 26, 123
- pure game in normal form, 113
- pure policy, 64, 77
- pursuit-evasion game, 16, 192–193
- quadratic program, 106
 - indefinite, 106
- rationality, 3
- regret, 23, 24, 94, 95, 112
- repeated games, 13
- repeated game paradigm, 32
- resistive circuit design game, 39–42
- risk averse solution, 22
- robust design, 7–8, 39
- rock-paper-scissors game, 31, 37, 40, 50–51, 105
- rope-pulling game, 4–7
- saddle-point equilibrium, 9, 38, 39, 94
 - behavioral, 80, 81
 - completely mixed, 104, 105
 - dominant, 58
 - inner point, 104
 - mixed, 34, 36, 50, 78
 - pure, 25, 26, 72
 - recursive computation, 68, 73, 82
 - state feedback, 177, 181, 187, 190, 191
- saddle-point value, 38
 - behavioral, 80, 81
 - mixed, 34, 36
 - pure, 25, 26
- secure solution, 22

- security level, 22, 38, 39, 94, 112
 - average, 33, 34, 36, 45, 98, 114
 - pure, 95
- security policy, 6, 9, 22, 38, 39, 94, 112
 - behavioral, 81
 - mixed, 33, 34, 36, 50, 78, 98
 - pure, 95
- Separating Hyperplane Theorem, 47
- Shapley value utility, 133
- simultaneous play, 12, 24
- single-stage game, 13, 68
- stage-additive cost, 150, 155, 175
 - quadratic, 162, 180
- state-feedback game, 151, 152
- state-feedback policy, 155
 - continuous time, 165, 171, 187, 190, 191
 - one player, 167
 - discrete time, 177, 181
 - one player, 158, 159
- state of the game, 149
- state space, 149
- Sudoku, 130
- sum game, 122
- supermodular cost, 134
- supremum, 38, 39, 94, 112
- symmetric game, 50–51
- tax-payers auditing game, 32
- tensor, 113
- terminal cost, 150
- Theorem of the Alternative for Matrices, 47
- tic-tac-toe game, 161, 182–185
- time-consistent policy, 158, 159, 162, 167, 171
- value function
 - continuous time, 166, 170
 - discrete time, 156
- vehicle routing game
 - heterogeneous, 132
 - homogeneous, 130
- war deterrence game, 32
- war of attrition game, 13–15, 18
- Weierstrass' Theorem, 34, 35
- wireless power control game, 128–129
- wonderful life utility, 132, 133
- zebra in the lake game, 16–17, 152, 154
- zero-sum game, 4, 93, 94
 - matrix, 21