

## Index

- Active perception, 94
- Adaptive Behavior, 11, 12, 91
- Agent
  - active, 10, 12
  - autonomous, 16, 25, 49, 66, 67, 117, 148, 215
  - embodied, 5
  - passive, 10, 96
  - reactive, 93, 113
  - simulated, 5, 105, 155, 160
  - situated, 11
- Animat,
  - See* Agent, simulated
- Artificial intelligence, 93, 215
- Artificial life, 5, 25, 60
- Beer's insect model, 235, 243
- Behavior
  - basic, 1, 6, 7, 9, 11, 18, 116–118, 121, 124, 130, 172, 259
  - behavioral attractor, 103, 107
  - coordination, 1, 7, 115, 116
  - decomposition, 1, 7, 8, 115, 117, 134, 150, 246
  - distal description, 7, 8, 118, 127, 134
  - emergent, 6, 77, 117, 148, 168
  - global, 1, 8, 9, 122, 124, 134, 137
  - integration, 7, 115, 134
  - proximal description, 7, 118, 130
  - shaping, 14, 172
- Behavior-based robotics, 1, 7, 115, 241
- Bootstrap problem, 13, 27, 149, 190, 212
- Braitenberg's vehicles, 11, 69, 71, 76
- Cockroaches, 245
- Competitive co-evolution,
  - See* Evolution, co-evolution
- Connectionism, 10, 153, 182, 185, 231, 232
- Cricket, 269
- Cybernetics, 11, 39
- Design method
  - design the fitness function, 64, 73, 148
  - handcrafting, 69, 117, 270
- Development, 153, 223, 230
  - adaptive neural architectures, 228
  - cellular duplication and differentiation, 233
  - cellular migration, 233
  - neural maturation, 153
  - neurites growth, 233
  - regulatory genes, 223
- Development and evolution, 224
- Developmental biology, 17, 18, 223, 224, 247
- Drosophila, 95
- Dynamic state machine, 265
- Dynamical systems, 5, 103, 171
- Embodied cognition, 10, 93, 182
- Engineering, 6, 67, 110, 115, 148, 261
- Ethology/Neuro-ethology, 10, 49, 139, 247
- Evolution
  - adaptive power, 184, 204, 210, 224, 261
  - binary coding, 19
  - building blocks, 23
  - challenges of increasing complexity, 189
  - co-evolution, 15, 25, 56, 189
  - co-evolving body and brain, 270, 273
  - co-evolving sensory morphology, 91
  - crossover operator, 1, 22, 23, 25, 27, 40
  - current individual vs. ancestral opponents analysis, 194
  - cycling between the same strategies, 190, 214, 218
  - duplication operator, 1
  - elitism, 22, 204
  - evolutionary algorithms, 23, 25, 27, 80
  - evolutionary stable strategy, 205
  - genetic algorithms, 19, 23, 25, 27
  - genetic encoding,
    - See* Genetic encoding
  - genetic programming, 44, 234, 237
  - genetic drift, 21, 194
  - grey coding, 20, 247
  - growing encoding, 26, 228
  - hall of fame, 195, 204–206, 209
  - master tournament analysis, 194
  - mutation operator, 1, 22, 24, 27
  - neutral evolution, 26
  - oscillatory dynamic, 191
  - pleiotropy, 226
  - predisposition to change in certain directions, 214, 216
  - rank based selection, 21
  - real valued coding, 20
  - roulette wheel selection, 20
  - species adaptation genetic algorithm, 27
  - tournament selection, 22
  - truncation selection, 21
- Evolutionary biology, 12, 13, 17, 190, 191
- Evolvability, 17, 65, 149, 223, 226, 261
- Evolvable hardware, 261
  - field programmable gate arrays, 263
  - programmable circuits, 262
  - self-repairing circuits, 264
- Fitness function, 1, 20, 25, 49
  - explicit-implicit dimension, 66
  - external-internal dimension, 66
  - for reactive navigation, 73
  - functional-behavioral dimension, 65
  - generality, 148, 150
  - subjective, 67, 252
- FPGA,
  - See* Evolvable hardware, field programmable gate arrays
- Gantry robot, 79
- Gazelles, 273
- Generality, 215
  - full general, 16, 216
  - plastic general, 16, 216

- Genetic encoding, 224
  - automatic definition of neural sub-network, 235
  - automatically defined functions, 47, 234
  - cellular encoding, 233, 234
  - compactness, 225
  - direct encoding, 224
  - encoding repeat structures, 225
  - evolvability,
    - See* Evolvability
  - expressive power, 225
  - geometry oriented cellular encoding, 237
  - growing neural network, 228
  - modular, 227
- Genotype, 153, 223
- Genotype-to-phenotype mapping, 17, 40, 223, 224, 227
- Geometric separability index, 101
- Hexapod robot, 242, 247
- Incremental evolution, 13, 27, 55, 81, 189, 245, 248
- Input-output mapping,
  - See* sensory-motor mapping
- Insect, 245
- Internal unit,
  - See* Neural network, hidden unit
- Khepera robot, 50
  - ambient light sensors, 50
  - batteries, 51
  - battery charger, 135
  - cable with rotating contacts, 53
  - gripper module, 52
  - infrared sensors, 50
  - laser-beam emitting device, 54
  - processor, 282
  - serial port, 51
  - touch sensor, 196
  - twin cable with rotating contacts, 195
  - vision turret, 52
  - wheels, 50
- Koala robot, 55
- Lamprey, 253
- Learning, 153
  - adapting to fast changes, 154, 173, 175, 218
  - adaptive changes, 153
  - directional learning, 159, 185
  - dynamical stability, 172
  - enhancing perceived differences, 183
  - environmental constraints, 173
  - extracting information from the environment, 154, 160
  - genetically encoded initial behavior, 172
  - plasticity, 153
  - prediction learning, 160
  - random search, 159
  - reaching a stable state, 154, 169, 172
  - synaptic plasticity, 153
  - the role of the sequence of training patterns, 181
- Learning algorithm
  - adaptive mixture of local experts, 232
  - auto-teaching, 16, 177
  - back-propagation, 3, 33, 36, 41, 96, 164, 232
  - cascade correlation, 232
  - classifier systems, 3, 14
  - complimentary reinforcement back-propagation, 37
  - delta rule, 32
  - dynamic node creation, 232
  - evolutionary reinforcement learning, 175
  - hebbian, 30, 168
  - reinforcement learning, 3, 16, 30, 36, 153, 174, 175, 243
  - self-organized maps, 3
  - supervised learning, 25, 30, 32
  - unsupervised learning, 30
  - weight decay method, 232
- Learning and evolution
  - Baldwin's effect, 154, 156, 175
  - canalization effect, 156
  - correlation of the fitness surfaces, 164
  - dynamical correlation of the fitness surfaces, 163
  - evolving the learning task, 173
  - extracting supervision from the environment, 160
  - genetic assimilation of learned traits, 155, 156, 164, 175
  - Harvey's effect, 165
  - learning help and guide evolution, 154, 156
  - predisposition to learn, 180
  - predisposition to select useful learning experiences, 182
  - selecting good starting conditions, 185
  - selecting useful learning experiences, 185
  - the influence of evolution on learning, 164
  - the influence of learning on evolution, 164
- Legged robot, 242
  - dynamic gait, 242
  - pace, 242
  - static gait, 242
  - tripod gait, 245
  - trotting, 242
- Lobster, 249
- Local minimum, 23, 190, 220
- Lotka-Volterra equations, 191
- Maturation, 228
- Memory, 153
- Model based on line evolution, 267
- Neural network, 27, 39
  - adaptive architecture, 230, 231
  - architecture, 29, 42, 231
  - bias unit, 29

- central pattern generator, 253
- connection weights, 29
- Elman's architecture, 38, 136
- emergent modular architecture, 124, 126
- evaluation module, 173
- feedforward architecture, 29
- hidden unit, 27, 126
- Jordan's architecture, 38
- learning rate, 30
- modular architecture, 121, 124
- neuron, 27
- oscillator circuit, 248
- output function, 28
- passive, 98
- place cells, 147
- postsynaptic neuron, 31
- presynaptic neuron, 31
- recurrent architecture, 29, 37
- recurrent connections, 37, 76, 135, 153
- self-teaching architecture, 173
- sigmoid function, 28
- specialization of internal units, 142
- synapsy, 27
- teaching unit, 177
- time delay networks, 37
- Neutral networks, 26
- Octopod robot, 237, 249
- One-to-one mapping,
  - See Genetic encoding, direct encoding
- Open ended evolution, 27, 67, 80, 91, 148, 261
- Parasite, 191, 194
- Path planning, 142
- Perceptual aliasing, 94
- Phenotype, 153, 223
- Predator, 195
- Prey, 195
- Principal component analysis, 171
- Progress, 25, 194
- Random morphology robot, 273
- Rat, 110, 147
- Re-adaptation, 84, 145
  - cross platform adaptation, 85
  - from simulation to reality, 87
- Receptive field, 81, 197
- Red Queen effect, 193, 194
- Representation
  - euclidean map of the environment, 111
  - fitness landscape, 26, 157, 158
  - genetic, 17, 19, 22, 40, 46, 192, 223
  - grounded, 6
  - internal, 93, 96, 111, 143, 146, 147
  - map of the environment, 110
  - topographical map, 135, 143
- Robot-environment interaction, 1, 2, 6–8, 10–12, 18, 25, 27, 54, 69, 76, 90, 93, 113, 261, 268
- Salamander, 254
- Selection criterion,
  - See Fitness function
- Self-organization, 4, 25
  - behavior coordination, 7, 116
  - behavioral modules, 7, 116
  - decomposition of behavior, 9, 116, 236
  - emergence of complex behavior, 25, 121, 148, 150
  - exploiting constraints, 110, 269
  - genotype to phenotype mapping, 225
  - neural architecture, 230, 232
  - robot morphology, 230
  - self-generation of the teaching inputs, 185
  - self-organized incremental evolution, 189
- Sensory-motor coordination, 11, 93, 115, 182
  - selecting useful learning experiences, 182
  - self-select favourable patterns, 134
  - simplifying hard problems, 95
  - simplifying type-2 problems, 96
  - solving perceptual aliasing, 94
- Sensory-motor mapping, 3, 7, 96
  - type-1 problems, 96
  - type-2 problems, 96
- Sims' creatures, 272
- Simulation, 57
  - adding noise, 60, 88
  - base set aspects, 62
  - conservative noise, 88
  - friction, 6
  - grid world, 60, 160
  - idiosyncratic characteristics of sensors and motors, 59
  - implementation aspects, 62
  - inertia, 6
  - minimal simulation, 62, 250
  - sampling technique, 59
  - sensors and motors are inaccurate, 60
  - time problem, 57, 58
- Situated cognition, 93
- Sony dog robot, 256
- State space analysis, 74, 171
- Subsumption architecture, 1, 9
- Task
  - catching prey, 195
  - clustering behavior, 269
  - escaping predators, 195
  - exploring the environment, 175, 230
  - garbage collecting, 122
  - homing navigation, 135
  - landmark navigation, 110
  - navigation with obstacle avoidance, 69, 70, 87, 168, 238, 267, 273

- object discrimination, 96
  - swimming, 253
  - tic tac toe game, 194
  - visually guided navigation, 79
  - walking, 235
- Vision, 79, 84, 195, 272
- active vision, 95
  - classical approach, 79
  - ecological approach, 79