

Index

- A-current, 48
- action potential, 5, 36
 - channel dynamics, 37
 - Hodgkin–Huxley model, 37
- activity, *see* population activity
- adaptation, 19, 52, 136, 347
 - biophysical origin, 149, 151
 - spike-triggered, 136, 149, 151
 - subthreshold, 136, 149, 152
- adaptive integrate-and-fire, 136
 - parameter space, 148
 - piecewise linear, 145
- AdEx, *see* adaptive integrate-and-fire
- afterpotential, 8, 157
- all-to-all coupling, 302
- AMPA receptor, 61
- Arrhenius & Current model, 237
- Arrhenius formula, 237
- assembly, neuronal 444
- asynchronous firing, 310
 - stability, 371
- asynchronous irregular, 338
- attractor network, 454
- autocorrelation function, 179
- autocorrelation-renewal, 186
- axon, 4, 72
 - myelinated, 74
 - unmyelinated, 72
- balanced excitation and inhibition, 211, 304, 316, 319
- Bayesian decoding, 279
- Bayesian parameter estimation, 250
- Bayesian regularization, 252
- BCM rule, 499
- bifurcation, 96
 - Hopf, 101
 - saddle-node, 97
- biophysical neuron model, 43
- blobs of activity, 484
- Brunel network, 316, 338
- bump attractors, 484
- bursting, *see* firing pattern
- cable equation, 61
- calcium current
 - low-threshold, 50
- calcium spike, 55
- calcium-dependent potassium current, 48
- close-loop stimulus design, 263
- cluster states, 374
- coding, 190
 - correlation code, 195
 - firing rate, 190
 - phase code, 194, 530
 - rate code, 172, 196, 197
 - timing-based, 192
- coefficient of variation, 179
- compartmental model, 75
- competition, 427
 - decision making, 428
 - of populations, 428
 - of synapses, 499
 - through common inhibition, 426
 - through shared inhibition, 427
 - winner-take-all, 431
- competitive network, 430
- conductance input, 349
- conductance-based neuron model, 32
- connectivity
 - Mexican hat, 470, 475, 480
 - sparse random, 314
- conservation equation, 363
- continuity equation, 327
- continuum model, 468
 - of population activity, 470
- contrast enhancement, 476
- correlation
 - code, 195
 - matrix, 513
 - reverse, 195
- cortex, 7, 284, 293, 295, 472
 - barrel, 295
- coupling
 - full, 302
 - random, 303

574

covariance matrix, 513
 covariance rule, 498
 current
 pulse, 82
 rheobase, 96, 123
 step, 84
 cut-off frequency, 207
 Dale's law, 462
 decision making, 421
 drift-diffusion model, 435
 energy picture, 433
 perceptual, 423
 decoding, 278
 for neuroprosthetics, 283
 in vision, 283
 deep brain stimulation (DBS), 541
 dendrite, 4, 22, 64, 152, 161
 compartmental model, 75, 76
 dendritic spike, 22, 76
 density equation
 for membrane potential, 330
 for refractory variable, 382
 relation with integral equations, 381
 depression of synapses, 63
 diffusion model, 215, 332
 diffusive noise, 404
 drift-diffusion model, 435
 echo state network, 524
 encoding models, 268
 escape model, 224
 for population, 381
 escape noise, 224, 402
 escape rate, 224, 225
 event-based moment expansion, 388
 excitable system, 103
 exponential integrate-and-fire, 124
 fit to data, 126
 f-I plot, 38
 facilitation of synapses, 63
 field equation, 470
 blob/bump solution, 484
 for hyper column, 479
 homogeneous solution, 472
 input driven regime, 472
 field model, 468
 finite-size effects, 391
 firing intensity, 225
 firing pattern, 136, 137, 140
 adapting, 141
 bursting, 143, 151, 153, 160
 classification, 140
 facilitating, 141
 tonic, 141
 transient spike, 148
 firing rate, 172, 178, 196

Index

firing regime
 asynchronous irregular, 338
 synchronous regular, 338
 first passage time, 219
 first principal component, 512, 513
 FitzHugh–Nagumo model, 88, 103
 nullclines, 95
 fixed point, 93
 ghost, 98
 of activity, 368
 flow field, 92
 flux, 327
 probability current, 329
 drift, 329
 jump, 329
 refractory, 382
 Fokker–Planck equation, 216, 332, 333
 linearized, 343
 Fourier transform, 17
 frequency–current relation, 38
 full coupling, 302
 gain frequency-dependent, 377, 406, 408
 gain function
 and population activity, 312
 of Hodgkin–Huxley model, 38
 of integrate-and-fire model
 with noise, 336
 type I, 96
 type I/II, 38
 type II, 96
 Gamma distribution, 201
 gating variable, 33
 Generalized Linear Model (GLM), 248
 generative model, 231
 ghost of fixed point, 98
 GLM (Generalized Linear Model), 248
 Green's function, 68
 h-current, 52
 hazard, 182
 Hebb's postulate, 492
 Hodgkin–Huxley model, 31
 channel opening, 37
 gain function, 38
 reduction, 149, 151
 reduction to two dimensions, 84
 refractoriness, 40
 Hopf bifurcation, 101
 subcritical, 103
 supercritical, 103
 Hopfield model, 446
 energy picture, 456
 hyper column, 478
 illusion, 469, 476
 impulse response, 157

- inhibition
 - dominating, 341
 - effective, 429
 - shunting, 21
- inhibition-stabilized network, 482
- inhibitory plasticity, 527
- inhibitory rebound, 19, 84
- integral equation, 360
 - adaptive neurons, 413
 - finite size, 391
 - for adaptive neurons, 386
 - linearized, 375
 - numerical methods, 365
 - quasi-renewal, 364
 - relation with density equations, 381
 - several populations, 367, 410
 - stationary state, 368
 - Wilson–Cowan, 363, 408
- integral-equation approach, 357
- integrate-and-fire model, 10
 - as a reduction of Hodgkin–Huxley, 129
 - exponential IF, 124, 126
 - nonlinear IF, 121
 - quadratic IF, 130, 131
 - refractory exponential IF, 127
 - multi-compartment, 161
 - relation to SRM, 163
 - noisy, 204
 - nonlinear, 120
 - quadratic, 129
 - relation to SRM, 158
 - two-compartment, 163
- interspike interval, 178
- interval distribution, 182, 358
 - for periodic input, 234
 - input-dependent, 190
- ion channel, 31, 42
 - I_A , 48
 - I_M , 48
 - I_h , 52
 - $I_{K|Ca}$, 48
 - I_{NaP} , 51
 - I_{NaS} , 53
- Kramers–Moyal expansion, 216
- Langevin equation, 204, 217
- leaky integrate-and-fire model, 10
- learning window, 495
- Liapunov function, 434, 456
- Libet experiment, 438
- likelihood of spike train, 229
- limit cycle, 96
- linear regression, 246
- linear-nonlinear Poisson, 411
- linear-nonlinear Poisson Model (LNP), 273
- liquid computing, 524
- LNP model, *see* linear-nonlinear Poisson
- locking, 532
- locking theorem, 532
- log-likelihood of a spike train, 230
- long-term depression, 491
- long-term potentiation, 491, 493
 - heterosynaptic, 506
 - homosynaptic, 506
- low-connectivity network, 314
- LTD, *see* long-term depression
- LTP, *see* long-term potentiation
- M-current, 48
- MAP, *see* maximum *a posteriori*
- Markov Process, 216
- matrix random, 527
- maximum *a posteriori*, 280
- membrane potential, 7
 - density, 215, 218, 327
 - stationary distribution, 334
- memory, 442
 - associative, 442
 - Hopfield model, 446
 - retrieval, 451
 - working memory, 446
- Mexican hat, 470
- Mexican hat connectivity, 475, 480
- Morris–Lecar model, 87, 99
- motor cortex, 518
- MT neuron, 423
- Nernst potential, 29
- network, *see* population
- neural mass models, 297
- neuron, 3
 - bursting, 19
 - postsynaptic, 4
 - presynaptic, 4
- neurotransmitter, 6
- NMDA receptor, 61
- noise, 168
 - channel, 171
 - colored, 206, 351
 - escape, 224
 - Gaussian white, 204
 - Johnson, 170
 - slow, 400
 - synaptic, 171
 - thermal, 170
 - white, 203
- noise model
 - diffusive noise, 203
 - escape noise, 224
 - noisy integration, 203
 - noisy threshold, 224
 - random connectivity, 314
 - stochastic spike arrival, 207

noise spectrum, 180
 nullclines, 92
 Oja's rule, 499
 orientation selectivity, model of, 478
 Ornstein–Uhlenbeck process, 204, 217
 oscillation, 338, 371, 541
 as an instability, 371
 cluster states, 374
 experimental, 529
 subthreshold, 40
 synchronous locked, 532
 overlap, 451
 pairing experiment, 494
 parameter estimation
 Bayesian, 250
 decoding, 280
 maximum *a posteriori* (MAP), 280
 Parkinson's disease, 541
 pattern recognition, 451
 with spiking neurons, 458
 peri-stimulus-time histogram (PSTH), 175
 persistent sodium current, 51
 phase code, 194, 530
 phase plane, 143, 148
 of decision making, 430
 phase plane analysis, 91
 phase portrait, 92
 phase response curve, 537
 plasticity
 hard bound, 497
 of inhibition, 527
 soft bound, 498
 synaptic short-term, 63
 plasticity synaptic, 491
 point process, 181
 Poisson neuron, 188
 Poisson process
 absolute refractoriness, 179, 189
 autocorrelation, 188
 homogeneous, 175
 inhomogeneous, 176, 240
 population, 177, 295
 coupled, 305
 fully connected, 302
 homogeneous, 298
 inhibition dominated, 318
 multiple, 336
 population activity, 177, 330, 358
 asynchronous firing, 310
 blobs/bumps of, 484
 definition, 177, 297
 field equation, 470
 linearized, 343
 linearized equation, 375, 378
 stationary state, 341
 time scale, 397

population dynamics, 297
 population vector, 192
 postsynaptic potential, 8
 excitatory, 21
 inhibitory, 21
 power spectrum, 180
 prediction, 267
 of membrane potential, 268
 of spikes, 270, 272
 priming, 442
 principal component analysis, 512
 principal components, 513
 probability current, 329
 PSTH, *see* peri-stimulus-time histogram
 pyramidal cell, 76
 quasi-steady-state, 85
 quasi-renewal theory, 364, 386
 random connectivity, 303, 314
 random walk, 211
 random weight matrix, 527
 rate, 172
 code, 172
 mean firing rate, 173
 models, 408
 population activity, 177
 spike density, 175
 rebound spike, 41
 rebound, inhibitory, 19, 55, 84
 receptive field, 7, 273, 293
 of MT neurons, 423
 reconstruction kernel, 195
 refractoriness, 158
 refractory density, 381
 refractory period, 5
 absolute, 5
 Hodgkin–Huxley model, 40
 regression, linear, 246
 regularization, 252
 relaxation oscillation, 108
 renewal hypothesis, 184
 renewal process, 181
 renewal theory
 for adaptive neurons, 364
 time dependent, 232, 233, 358
 reservoir computing, 524
 resting potential, 7
 reversal potential, 21, 30
 reverse correlation, 195, 275
 rheobase current, 96
 ring model, 471, 479
 ruins of fixed point, 98
 saddle point, 93
 scaling behavior, 300
 self-averaging, 453

- separation of time scales, 85, 108
- shunting inhibition, 21
- signal-to-noise ratio, 180, 239
- similarity measure, 262
- singular perturbation, 108
- slow sodium current, 53
- soft threshold, 224
- soma, 4
- spectral radius, 527
- spike, dendritic, 22
- spike afterpotential, *see* afterpotential
- spike response model, 154
 - adaptation, 160
 - bursting, 160
 - definition, 155
 - interpretation, 157
 - relation to integrate-and-fire, 158
- spike train, 5
 - distance, 260
 - irregular, 168
 - metrics, 260
 - reliability, 262
 - variability, 262
 - vector, 260
- spike train decoding
 - linear, 281
 - nonlinear, 280
- spike-triggered average (STA), 252, 275
- spiking neuron model
 - SRM₀, 10
- spontaneous activity, 168, 169, 318
- STA, *see* spike-triggered average
- stability, 93
- stable manifold, 105
- stationary state, 368
- STDP, 495
 - protocol, 496
- Stein's model, 208
- stimulation sub-/suprathreshold, 213
- stimulus reconstruction
 - linear, 281
 - nonlinear, 280
- stochastic
 - differential equation, 204
 - intensity, 225
 - process, 203
 - resonance, 239
- STP, *see* plasticity, synaptic short-term
- Stroop effect, 443
- subthreshold oscillation, 148
- survivor function, 182
- synapse, 4, 6, 58
 - AMPA, 61
 - depression, 63
 - excitatory, 61
 - facilitation, 63
 - GABA_A, 61
 - GABA_B, 61
 - inhibitory, 60
 - NMDA, 61
 - postsynaptic neuron, 4, 6
 - postsynaptic potential, 8
 - presynaptic neuron, 4, 6
 - short-term plasticity, 63
- synaptic depression, 64
- synaptic plasticity, 491
 - anti-Hebbian, 495, 497
 - locality, 496
 - non-Hebbian, 497
 - spike-timing dependent, 495
- synaptic transmission failures, 171
- synchronous regular, 374
- synchronization, 541
- synchronous regular, 338
- synchrony, 195
- threshold, 8, 121
 - dynamics, 155, 156
 - of Hodgkin–Huxley model, 40, 81
 - of type I models, 105
 - of type II models, 108
 - soft, 224
- time-rescaling theorem, 258
- transfer function with escape noise, 377
- transient spike, 40
- type III model bifurcations, 96, 97
 - canonical type I, 106
 - Hopf bifurcation, 101
 - onset of oscillations, 96, 103
 - stable manifold, 105
 - threshold, 103
- visual illusion, 469, 476
- Vogels–Abbott network, 319
- volition, 438
- weight matrix, 527
- Wiener–Khinchin theorem, 180
- will, *see* volition
- Wilson–Cowan model, 410
 - field equation, 470
- winner-take-all, 431
- working memory, 446, 484