
Index

- 0_x , 55
- C^1 , 196
- C^∞ , 19
- ∇^2 , 109
- \mathfrak{F} , 33, 37
- GL, 23
- Grass(p, n), 32
- J_F , 71
- O_n , 27
- $P_{U,V}$, 122
- P_x , 47
- P_x^\perp , 47
- $\mathbb{R}^{n \times p}$, 189
- $\mathbb{R}_*^{n \times p}/\text{GL}_p$, 31
- $\mathbb{R}_*^{n \times p}$, 23
- \mathcal{S}_{sym} , 26
- S^{n-1} , 27
- $\mathcal{S}_{\text{skew}}$, 42
- $\text{St}(p, n)$, 26
- \mathfrak{X} , 37
- $\mathfrak{X}(\mathcal{M})$, 94
- ∂_i , 35
- p -plane, 31
- $\mathcal{S}_{\text{sym}+}$, 58
- $\mathcal{S}_{\text{upp}+}(n)$, 58
- \simeq , 30
- skew, 48, 81
- span, 30
- sym, 48, 81
- tr, 7
- vec, 23

- acceleration, 102
- accumulation point, 64, 192
- adjoint, 191
- algebraic multiplicity, 6
- arithmetic operation, 59
- Armijo point, 62
- asymptotically stable point, 67
- atlas, 19
 - compatible, 20
 - complete, 19
 - maximal, 19
- atlas topology, 20

- basis, 6
 - of a topology, 192
- bijection, 193
- blind source separation, 13
- bracket (Lie), 97
- BSS, 13

- Cauchy decrease, 142
- Cauchy point, 142
- Cayley transform, 59
- chain rule, 195
- characteristic polynomial, 6
- chart
 - around a point, 20
 - of a manifold, 20
 - of a set, 18
- Christoffel symbols, 94
- closed set, 192
- cocktail party problem, 13
- column space, 6
- commutator, 189
- compact, 27, 193
- complete, 56, 102
- conjugate directions, 180
- connected, 21
- connection
 - affine, 94
 - canonical, 94
 - Levi-Civita, 97
 - Riemannian, 97
 - symmetric, 97
- continuous, 194
- continuously differentiable, 196
- convergence, 63
 - cubic, 70
 - linear, 69
 - order of, 70
 - quadratic, 70
 - superlinear, 70
- convergent sequence, 192
- convex set, 198
- coordinate domain, 20
- coordinate neighborhood, 20
- coordinate representation, 24
- coordinate slice, 25
- coordinates, 18
- cotangent bundle, 108
- cotangent space, 108

- covariant derivative, 94
- covector, 108
- covector field, 108
- covering, 193
- critical point, 54
- curve, 33

- deflating subspace, 7
- derivation, 37
 - at a point, 37
- derivative, 38
 - directional, 32, 92
- descent mapping, 67
- determinant
 - derivative, 196
- diffeomorphism, 24
- differentiable, 24
 - Lipschitz continuously, 148
- differentiable structure, 19
- differential, 24, 38
 - qf, 173
- dimension
 - of subspace, 6
- directional derivative, 195
- distance
 - locally equivalent, 163
 - Riemannian, 46
- distribution, 101, 120

- Eckart-Young-Mirsky theorem, 11
- eigenpair, 6
 - leftmost, 7
- eigenspace, 6
 - extreme, 7
- eigenvalue, 6
 - leftmost, 7
- eigenvector, 5
- embedding space, 25
- epipolar constraint, 15
- equivalence class, 27
- equivalence relation, 27
- Euclidean gradient, 46
- Euclidean group, 14
- Euclidean space, 45, 190
- exponential, 112
- exponential map, 102
- exponential retraction, 103

- fiber, 194
- Finsler manifold, 53
- fixed point, 67
- flag manifold, 29
- foot, 34
- Fréchet differentiable, 195
- Frobenius norm, 11, 23
- function, 193
 - differentiable, 24
 - domain, 193
 - image, 193
 - inverse, 193
 - on, 193
 - onto, 193
 - projection, 29
 - range, 193
 - restriction, 26
 - smooth, 24, 97

- Gauss-Newton, 186
- generalized eigenvalue problem, 7
- geodesic, 102
 - minimizing, 103
- Givens rotation, 58
- gradient, 46, 74, 196
- gradient-related, 62
- Gram-Schmidt, 58
- graph, 28
- Grassmann manifold, 6, 32

- Hausdorff, 20, 192
- Heine-Borel, 193
- Hessian, 113
- Hessian operator, 197
- horizontal distribution, 43
- horizontal lift, 43, 50, 83
- horizontal space, 43, 48

- ICA, 13
- image, 191, 193
- immersed submanifold, 25
- immersion, 38
 - canonical, 24
- independent component analysis, 13
- injection, 193
- injectivity radius, 148
- inner iteration, 140
- inner product, 45
- interior eigenvalues, 75
- invariant, 29
- invariant subspace, 6, 7, 82, 85
 - leftmost, 7
 - rightmost, 7
 - simple, 133
 - spectral, 6, 128, 133
- inverse, 193

- Jacobi correction equation, 126
- Jacobi's formula, 196
- Jacobian, 111
- Jacobian matrix, 71
- JDCG, 167

- Kantorovich's theorem, 132
- kernel, 191
- Koszul formula, 97

- least squares, 11, 185

- Leibnizian, 37
- length of a curve, 46
- level set, 194
- Levenberg-Marquardt, 187
- Lie bracket, 96
- limit, 63
- limit point, 64, 192
- limit set, 64
- linear convergence factor, 69
- Lipschitz constant, 198
- Lipschitz-continuous, 198
- local rigidity, 55
- locally equivalent distances, 163
- locally optimal conjugate gradient, 89
- LOCG, 78
- Lojasiewicz's inequality, 67

- manifold, 19
 - dimension, 19
 - linear, 22
 - nonlinear, 22
 - quotient, 28
 - Riemannian, 69
 - topology, 21
- manifold structure, 20
- map, *see* function, 193
- mapping, *see* function, 193
- matrix
 - commutator, 82
 - identity, 189
 - inverse, 189
 - invertible, 23, 189
 - nonsingular, 189
 - orthogonal, 189
 - orthonormal, 189
 - singular, 189
 - skew-symmetric, 189
 - square, 189
 - symmetric, 189
- matrix quotient manifold, 29
- matrix manifold, 17, 29
- matrix representation, 31
- matrix submanifold, 25
- matrix-free, 10
- metric, 46
- module, 53
- Moore-Penrose inverse, 186, 191

- neighborhood, 192
- Newton equation, 111
- Newton vector, 111
- norm, 190
 - consistent, 190
 - Frobenius, 191
 - induced, 190
 - mutually consistent, 190
 - operator, 190
 - spectral, 191
 - submultiplicative, 190
 - normal coordinates, 103
 - normal neighborhood, 102
 - normal space, 47, 99
 - normalized essential manifold, 15
 - normed vector space, 190
- notation
 - Ω , 194
 - O, 194
 - o, 194

- oblique manifold, 12, 29
- Olsen formula, 131
- one-form field, 108
- one-to-one correspondence, 193
- open set, 191
- operator, 190
 - bilinear, 190
 - bilinear positive-definite, 190
 - bilinear symmetric, 190
 - eigenvalue, 191
 - eigenvector, 191
 - invertible, 191
 - singular, 191
- order of convergence, 68
- orthogonal complement, 191
- orthogonal group, 27
- orthogonal projection, 191
- orthonormal, 6
- orthonormal basis, 190

- paracompact, 21, 52
- parallel translation, 104
- parallel vector field, 104
- parameterization, 20
- partition of unity, 20
- pencil, 7
- polar decomposition, 58
- polarization identity, 106
- positive-definite, 113
- preimage, 193
- Procrustes problem, 12
- product manifold, 23
- product topology, 192
- projection
 - canonical, 28
 - natural, 28
 - of function, 29
- pseudo-inverse, 131, 186, 191
- pullback, 55, 140

- qf, 58
- QR decomposition, 58
 - thin, 196
- quotient, 28
- quotient manifold, 28, 83
 - Riemannian, 49, 83
- quotient topology, 193

- range, 191, 193
- rank, 24, 26
- Rayleigh quotient, 8
 - generalized, 7, 84
- Rayleigh quotient iteration, 130
- real projective space, 30
- regular value, 25
- residual, 180
- restriction, 6, 26
- retraction, 76
 - second-order, 107
- Riemannian connection, 112
- Riemannian distance, 46
- Riemannian Hessian, 105
- Riemannian manifold, 45
- Riemannian metric, 45
 - horizontally invariant, 100
- Riemannian quotient manifold, 49
- Riemannian submersion, 49
- Riemannian trust region, 141
- Ritz value, 129
- Ritz vector, 129
- root, 91
- RTR, 141

- saddle point, 66
- saddle-point problem, 130, 133
- search direction, 54
- second covariant derivative, 109
- second-countable, 20, 192
- sequence
 - convergent, 63
- similarity transformation, 6
- singular values, 11
- skew-symmetric, 42
- skew-symmetric part, 81
- smooth, 19, 24, 197
- span, 6, 31
- spectrum, 6
- sphere, 27
- stable point, 67
- star-shaped neighborhood, 102
- stationary point, 54
- step size, 54
- Stiefel manifold
 - noncompact, 23
 - orthogonal, 26, 80
- structure space, 29, 42
- subimmersion, 52
- submanifold, 25
 - embedded, 25, 47
 - open, 21
 - regular, 25, 52
 - Riemannian, 47
- submersion, 24, 38
 - canonical, 24
 - Riemannian, 49, 100

- subspace
 - linear, 6
 - topological, 193
- subspace topology, 193
- surjection, 193
- symmetric operator, 191
- symmetric part, 81

- T_1 , 192
- T_2 , 192
- tangent bundle, 36
- tangent map, 38
- tangent space, 34
 - as vector space, 34
- tangent vector, 34
 - coordinates, 35
 - realization, 34
 - to a curve, 33
- Taylor expansion, 198
- tCG, 143
- thin SVD, 104
- topological space, 192
- topology, 191
 - basis, 192
 - finer, 192
 - Hausdorff, 192
 - of a manifold, 21
 - product, 192
 - quotient, 193
 - subspace, 193
 - vector space, 193
- total space, 28
- trace, 7, 189
- transpose, 189
- truncated CG, 143
- trust-region subproblem, 140

- unstable, 67

- vector field, 36
 - coordinate, 37
 - on a curve, 102
- vector space, 189
 - normed, 190
- vector transport, 169
 - associated retraction, 170
- velocity, 101
- vertical space, 43

- Whitney sum, 169

- zero of a function, 91