

Index

- aggregated data, 103
- AIC
 - criterion, 39
 - two-dimensional tuning, 77
- array
 - algorithm, 68
 - algorithm details, 174–5
 - generalized, 75
 - mortality, 156
 - vectorization, 74
- automatic smoothing, 51
- B-splines
 - construction, 169
 - derivative, 20
 - differences of TPF, 169
 - evenly spaced knots, 9
 - ill-conditioned, 11
 - large basis, 170
 - mixed model, 42
 - polynomial segments, 10
 - proper base, 132
 - reproducibility, 171
 - sparse construction, 171–2
 - tensor product, 67
 - truncated power functions, 169
 - visualization, 9
- baseline estimation, 101
- Bayesian
 - P-splines, 45–50
 - standard errors, 23, 32, 62, 183
- box product, 71
- censoring, individual, 110
- composite link model, 102, 103
- effective dimension, 106
- effective hat matrix, 106
 - penalized, 105
 - penalized likelihood, 106
 - standard error bands, 106
- computational details, 171
- concave and convex, 149
- constraint
 - concave and convex, 149
 - derivative, 148
 - monotonicity, 149
 - shape, 146
- cross validation, 37
 - fast, 171
 - leave-one-out (LOOCV), 37, 125
 - penalty order, 39
- data augmentation, 35, 85
- data sets
 - air quality, 7
 - biscuit NIR, 115
 - chromosome G519, 146
 - coal mining disasters, 28
 - diffractionmetry, 102
 - Dutch boys, 56, 88, 92, 101, 146
 - ECG, 139
 - environmental complaints, 111
 - ethanol, 61, 72
 - Greece deaths, 53, 140, 141
 - hepatitis B, 149
 - HIV, 110
 - IBM hard drives, 64
 - kyphosis, 32, 40
 - lead in children's blood, 103, 106
 - LIDAR, 96

- motorcycle, 8, 85
- Old Faithful, 40, 48, 76, 178
- phoneme, 120
- polio, 66
- RDW red blood cell, 108
- suicide, 41
- variable star, 133
- wind direction, 137
- wood surface, 54
- density estimation, 40
 - boundary, 41
 - conservation of moments, 31
- derivative, 20, 148
- deviance
 - AIC, 38
 - mixed model, 179
 - penalized, 28, 61, 105
 - Poisson, 28
- digit preference, 50, 51
- effective dimension, 21–3
 - additive model, 62
 - composite link model, 106
 - GLM, 39
 - mixed model, 180–1
 - PS-ANOVA, 82
 - signal regression, 125
 - VCM, 66
- equivalent kernels, 26–8, 133, 143
- expectile smoothing, 92
- expectile-expectile plot, 93
- extrapolation, 18–19, *See also* interpolation
 - cosine, 133
 - double penalty, 141
 - harmonic, 133
 - mortality, 158
 - multidimensional, 73–4
- Frobenius norm, 70, 90
- GAMLSS, 97–101
- generalized additive model, 60–3
 - normal equations, 60
 - penalized, 61
- generalized linear additive smooth structures
 - GLASS, 83
- generalized linear model, 28–33
 - components, 28
 - penalized iterative solution, 30
 - signal regression, 120–2
 - two-dimensional smoothing, 75
- GLAM, 175
- gridded data, 70
 - artificial, 172
 - large datasets, 172
- hat matrix, 21–3
 - composite link model, 106
 - expectiles, 92
 - GLM, 32
 - mixed model, 181
 - signal regression, 125
- hazard, 158
- HFS algorithm, 43–5
 - PS-ANOVA, 82
- image regression. *See* signal regression
- impulse response, 28, 133
- INLA, 47–9
- interpolation, 18–19, *See also* extrapolation
 - multidimensional, 73–4
- Kronecker product, 68–74
 - array, 175
- L-curve. *See also* V-curve, 54
- LASSO
 - fused, 143
- least squares, 7–11
 - penalized, 14–18
- LPS (Laplacian P-splines), 47
- memory issues, 174
 - large grids, 74
 - tensor products, 68
- mixed model, 43, 176–81
 - effective dimension, 177
 - fitting, 177
 - Harville, 181
 - Henderson equations, 176
- monotonicity, 149
- mortality, 158
- multidimensional surfaces. *See* smoothing
- multivariate calibration, *See* signal regression
- negative binomial models, 111
- P-splines
 - advantages, 163
 - Bayesian, 45–50
 - computational details, 163
 - construction, 163

- P-splines (Cont.)
 consumer score card, 163, 164
 core idea, 1
 foundation, 6–25
 guidelines, 159
 myths, 160
 nested, 82
 polynomial limit, 24
 proper meaning, 5
 summary, 161
 website, 184
 penalized least squares, 15, 177
 penalized normal equations, 16
 penalty
 L_1 , 85
 adaptive, 152
 anisotropic, 76
 asymmetric, 150
 circular, 137
 concave and convex, 149
 data augmentation, 35
 difference, 14–15, 60
 difference matrix, 15
 double, 141
 harmonic, 49–50, 132–9, 158
 isotropic, 76
 monotonicity, 149
 O’Sullivan, 2
 order, 15
 ridge, 54, 61
 signal separation, 139
 tuning parameter, 15, 37
 two-dimensional, 71
 Poisson
 grouped counts, 104
 polynomial regression, 6–8
 limiting, 18
 PS-ANOVA, 79–82
 quantile sheet, 88
 quantile smoothing, 85–8
 roughness measure. *See* penalty
 shape constraints, 146
 signal regression
 effective dimension, 125
 GLM, 120
 hat matrix, 125
 logit, 120
 multidimensional, 122–6
 objective function, 116
 penalization, 120
 signal separation, 139
 singular value decomposition, 176
 smoothers
 binning, 167
 kernel, 164
 local regression, 164
 regression splines, 165
 smoothing splines, 165
 truncated power functions, 167
 smoothing
 scale and shape, 84
 adaptive, 152
 Box-Cox, 101
 circular, 137
 expectiles, 92
 GAMLSS, 84, 98
 harmonic, 49–50, 132–9
 median, 85
 piecewise constant, 146
 quantile, 87
 two-dimensional GLM, 74
 two-dimensional tuning, 77
 sparse data, 74
 spectra. *See* signal regression
 standard error bands
 Bayesian, 62, 183
 composite link model, 106
 GAM, 66
 GLM, 32
 multidimensional, 82
 P-splines, 23
 signal regression, 117, 120, 126
 standard error surfaces. *See* standard error bands
 structure additive model
 penalized, 65
 structured additive regression
 STAR, 83
 survival, 158
 tensor product, B-splines, 69–71
 Transformation
 independent variable, 56
 truncated power functions, 166–7
 tuning
 AIC, 39
 Bayesian, 46

- cross-validation, 37
- Harville, 43
- mixed model, 43
- two-dimensional penalty, 71–2
- two-dimensional smoothing
 - generalized linear model, 75–6
- two-dimensional surfaces.
 - See* smoothing
- V-curve, *See also* L-curve, 54
- varying coefficient model, 63–7
 - generalized, 66
 - penalized, 64
- Whittaker smoothing, 26
 - application, 139, 146
- Worm plot, 101