mgcv
tips sheet

What is mgcv ?

mgcv is an R package for fitting generalized additive models (GAMs). That means we can fit models where the predictors are smooth functions of the covariates. Often these smooth functions are splines, but that's not all they can be.

The main functions in mgcv

gam
For fitting GAMs

gamm
For fitting generalized additive mixed models. Can include correlation structures and performance can be better for random effects. You can specify random effects using lme syntax.

bam
For fitting big additive models. Includes some special tricks for fitting to large datasets.

Formula

formula=

We can write a model formula in mgcv just as we can when we use lm or glm, with some additions.

s() is the general setup for a smooth.

te() interaction via tensor product.

t2() interaction via tensor product (via identity penalty matrices).

Distributions

	family=
Binomial	binomial
Normal	gaussian
Gamma	Gamma
Inverse normal	inverse.gaussian
Poisson	poisson
Quasi	quasi
Quasi-binomial	quasibinomial
Quasi-Poisson	quasipoisson
Tweedie	tw/Tweedie
Negative binomial	nb/negbin
Beta	betar
Censored normal	cnorm
Ordered categorical	ocat
Scaled *t*	scat
Zero inflated Poisson	ziP
Zero inflated Poisson location-scale	ziplss
Cox proportional hazards	cox.ph
Generalized extreme value location-scale	gevlss
Normal location-scale model	gaulss
Multivariate normal	mvn
Gamma location-scale	gammals
Gumbel location-scale	gumbls
Multinomial	multinom
Tweedie location-scale	twlss
Sinh-arcsinh location-scale-shape	shash
General family	gfam

Smoothers

Using the bs= argument in s(), te(), etc. Further details can be found in ?smooth.construct.*.smooth.spec

Univariate only smoothers

Cubic regression splines cr

Cubic regression splines with shrinkage cs

B-splines bs

P-splines ps

Special smoothers

Cyclic cubic splines cc

Adaptive smoothers ad

Factor-smooth interactions sz

Random factor-smooth interactions fs

Smoothers in $\geq$ 1 dimension

Thin plate regression splines tp

Thin plate regression splines within shrinkage ts

Duchon splines ds

Random effects re

Markov random fields mrf

Gaussian process smooths gp

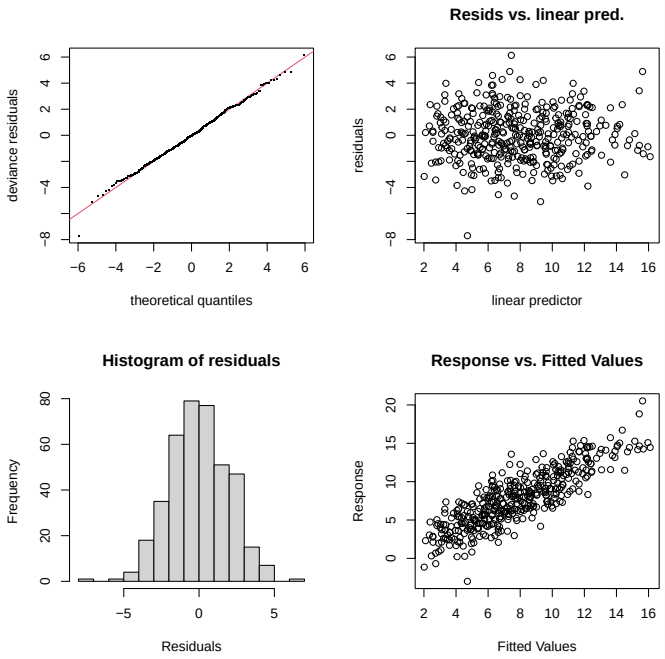
Smoothers in 2 dimensions

Splines on the sphere sos

Soap film smoothing so (sw and sf)

Model checking

gam.check



Top left: Quantile-quantile plot: points should be close to the line, meaning residuals are normally distributed.

Bottom left: Histogram of residuals: again, looking for normal(ish) distribution.

Top right: Residuals vs. linear predictor: looking for no increase or decrease in spread with increasing linear predictor value, otherwise we have heteroskedasticity.

Bottom right: Response vs. linear predictor, expecting tight line relationship indicating good agreement between the predictions and data.

Knots and basis complexity

General strategy: check `k` and double if too small.
When do we know `k` is too small?

Example

```
> gam.check(b)

Method: GCV   Optimizer: magic
Smoothing parameter selection converged
after 12 iterations.
The RMS GCV score gradient at convergence
was 1.739918e-07 .
The Hessian was positive definite.
Model rank =  37 / 37

Basis dimension (k) checking results.
Low p-value (k-index<1) may
indicate that k is too low, especially if
edf is close to k'.

       k' edf k-index p-value
s(x0) 9.0 2.5    1.04    0.85
s(x1) 9.0 2.4    1.03    0.69
s(x2) 9.0 7.7    0.97    0.28
s(x3) 9.0 1.0    1.03    0.68
```

Just as it says, check the `p-value` and `k-index` columns! Double`k` if necessary.

predict

`type=` argument	changes the type of prediction
default	on the link scale
`"response"`	to put on the response scale
`"iterms"`	to give per term predictions
`"lpmatrix"`	for a prediction matrix

Fitting criterion `method=`

`"GCV.Cp"`	Generalized cross validation, default
`"REML"`	REstricted Maximum Likelihood, preferred
`"ML"`	Maximum Likelihood
`"NCV"`	Neighbourhood Cross-Validation

Extras

`gam.mh`	Metropolis-Hastings sampling of the posterior
`concurvity`	Assess concurvity between terms
`gam.vcomp`	Random effects style output
`gamSim`	Simulate GAM-type data
`inSide/in.out`	point-in-polygon test
`jagam`	Generate JAGS/Nimble code
`new.name`	Generate a variable name
`place.knots`	Place knots evenly
`rmvn`	Generate multivariate normal deviates

Extra help

`?gam.models`	Fitting fancy models
`?linear.functionals`	How to use `by=`
`?random.effects`	Random effects syntax
`?mgcv.FAQ`	frequently asked questions
`?mgcv.parallel`	Info on parallelisation
`?missing.data`	What to do about missing data
`?choose.k`	How to select basis size
`?one.se.rule`	Making smoother smooth models

Other packages

`scam`	Shape constrained smoothing
`gratia`	Plotting with `ggplot2`
`mgcViz`	Fancy plotting
`qgam`	Quantile GAMs
`gamm4`	Random effects besed on `lme4`

Useful references

Wood. Generalized Additive Models. An Introduction with R. 2nd ed. CRC Press, 2017

Pedersen, Miller, Simpson and Ross. Hierarchical Generalized Additive Models in Ecology: An Introduction with `mgcv`. PeerJ (2019). https://doi.org/10.7717/peerj.6876