Package 'greta.gp'

November 13, 2024

Type Package

Title Gaussian Process Modelling in 'greta'

Version 0.2.2

Description Provides a syntax to create and combine Gaussian process kernels
in 'greta'. You can then them to define either full rank or sparse Gaussian
processes. This is an extension to the 'greta' software, Golding (2019)
<doi:10.21105/joss.01601>.

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URL https://github.com/greta-dev/greta.gp,
https://greta-dev.github.io/greta.gp/

BugReports https://github.com/greta-dev/greta.gp/issues

Depends greta (>= 0.5.0), R (>= 4.1.0)

Imports cli, glue, rlang (>= 1.1.4), tensorflow (>= 2.7.0)

Suggests covr, knitr, rmarkdown, spelling, testthat (>= 3.1.0)

VignetteBuilder knitr

Config/testthat/edition 3

Encoding UTF-8

Language en-GB

RoxygenNote 7.3.2

SystemRequirements Python (>= 3.7.0) with header files and shared
library; TensorFlow (>= v2.0.0; https://www.tensorflow.org/);
TensorFlow Probability (v0.8.0;
https://www.tensorflow.org/probability/)

NeedsCompilation no

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Repository CRAN

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gp   *Define a Gaussian process*

Description

Define Gaussian processes, and project them to new coordinates.

Usage

```
gp(x, kernel, inducing = NULL, n = 1, tol = 1e-04)

project(f, x_new, kernel = NULL)
```

Arguments

x, x_new	greta array giving the coordinates at which to evaluate the Gaussian process
kernel	a kernel function created using one of the [kernel()](#) methods
inducing	an optional greta array giving the coordinates of inducing points in a sparse (reduced rank) Gaussian process model
n	the number of independent Gaussian processes to define with the same kernel
tol	a numerical tolerance parameter, added to the diagonal of the self-covariance matrix when computing the cholesky decomposition. If the sampler is hitting a lot of numerical errors, increasing this parameter could help
f	a greta array created with gp$gp representing the values of one or more Gaussian processes

Details

gp() returns a greta array representing the values of the Gaussian process(es) evaluated at x. This Gaussian process can be made sparse (via a reduced-rank representation of the covariance) by providing an additional set of inducing point coordinates inducing. project() evaluates the values of an existing Gaussian process (created with gp()) to new data.

Value

A greta array

Examples

```
## Not run:
# build a kernel function on two dimensions
k1 <- rbf(lengthscales = c(0.1, 0.2), variance = 0.6)
k2 <- bias(variance = lognormal(0, 1))
K <- k1 + k2

# use this kernel in a full-rank Gaussian process
f <- gp(1:10, K)

# or in sparse Gaussian process
f_sparse <- gp(1:10, K, inducing = c(2, 5, 8))

# project the values of the GP to new coordinates
f_new <- project(f, 11:15)

# or project with a different kernel (e.g. a sub-kernel)
f_new_bias <- project(f, 11:15, k2)

## End(Not run)
```

| greta.gp | *Gaussian process modelling in greta* |

Description

A greta module to create and combine covariance functions and use them to build Gaussian process models in greta. See kernels() and gp()

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See Also

Useful links:

- https://github.com/greta-dev/greta.gp
- https://greta-dev.github.io/greta.gp/
- Report bugs at https://github.com/greta-dev/greta.gp/issues

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kernels	*Gaussian process kernels*

Description

Create and combine Gaussian process kernels (covariance functions) for use in Gaussian process models.

Usage

```
bias(variance)

constant(variance)

white(variance)

iid(variance, columns = 1)

rbf(lengthscales, variance, columns = seq_along(lengthscales))

rational_quadratic(
  lengthscales,
  variance,
  alpha,
  columns = seq_along(lengthscales)
)

linear(variances, columns = seq_along(variances))

polynomial(variances, offset, degree, columns = seq_along(variances))

expo(lengthscales, variance, columns = seq_along(lengthscales))

mat12(lengthscales, variance, columns = seq_along(lengthscales))

mat32(lengthscales, variance, columns = seq_along(lengthscales))

mat52(lengthscales, variance, columns = seq_along(lengthscales))

cosine(lengthscales, variance, columns = seq_along(lengthscales))

periodic(period, lengthscale, variance)
```

Arguments

`variance, variances`

(scalar/vector) the variance of a Gaussian process prior in all dimensions (`variance`) or in each dimension (`variances`)

columns	(scalar/vector integer, not a greta array) the columns of the data matrix on which this kernel acts. Must have the same dimensions as lengthscale parameters.
alpha	(scalar) additional parameter in rational quadratic kernel
offset	(scalar) offset in polynomial kernel
degree	(scalar) degree of polynomial kernel
period	(scalar) the period of the Gaussian process
lengthscale, lengthscales	
	(scalar/vector) the correlation decay distance along all dimensions (`lengthscale`) or each dimension ((`lengthscales`)) of the Gaussian process

Details

The kernel constructor functions each return a *function* (of class `greta_kernel`) which can be executed on greta arrays to compute the covariance matrix between points in the space of the Gaussian process. The + and * operators can be used to combine kernel functions to create new kernel functions.

Note that `bias` and `constant` are identical names for the same underlying kernel.

`iid` is equivalent to `bias` where all entries in `columns` match (where the absolute euclidean distance is less than 1e-12), and `white` where they don't; i.e. an independent Gaussian random effect.

Value

greta kernel with class "greta_kernel"

Examples

```
## Not run:
# create a radial basis function kernel on two dimensions
k1 <- rbf(lengthscales = c(0.1, 0.2), variance = 0.6)

# evaluate it on a greta array to get the variance-covariance matrix
x <- greta_array(rnorm(8), dim = c(4, 2))
k1(x)

# non-symmetric covariance between two sets of points
x2 <- greta_array(rnorm(10), dim = c(5, 2))
k1(x, x2)

# create a bias kernel, with the variance as a variable
k2 <- bias(variance = lognormal(0, 1))

# combine two kernels and evaluate
K <- k1 + k2
K(x, x2)

# other kernels
constant(variance = lognormal(0, 1))
white(variance = lognormal(0, 1))
iid(variance = lognormal(0, 1))
```

```
rational_quadratic(lengthscales = c(0.1, 0.2), alpha = 0.5, variance = 0.6)
linear(variances = 0.1)
polynomial(variances = 0.6, offset = 0.8, degree = 2)
expo(lengthscales = 0.6, variance = 0.9)
mat12(lengthscales = 0.5, variance = 0.7)
mat32(lengthscales = 0.4, variance = 0.8)
mat52(lengthscales = 0.3, variance = 0.9)
cosine(lengthscales = 0.68, variance = 0.8)
periodic(period = 0.71, lengthscale = 0.59, variance = 0.2)

## End(Not run)
```

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