Package ‘gastempt’

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Type Package
Title Analyzing Gastric Emptying from MRI or Scintigraphy
Description Fits gastric emptying time series from MRI or scintigraphic measurements using nonlinear mixed-model population fits with ‘nlme’ and Bayesian methods with Stan; computes derived parameters such as t50 and AUC.
License GPL (>= 3)
LazyData TRUE
NeedsCompilation yes
URL http://github.com/dmenne/gastempt
BugReports http://github.com/dmenne/gastempt/issues
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**coef.nlme_gastempt**

Extract coefficients from `nlme_gastempt` result

**Description**

Extract coefficients from `nlme_gastempt` result

**Usage**

```r
## S3 method for class 'nlme_gastempt'
coef(object, ...)
```

**Arguments**

- `object` Result of a call to `nlme_gastempt`
- `...` other arguments

**Value**

A data frame with coefficients. See `nlme_gastempt` for an example.
coef.stan_gastempt

Extract coefficients from stan_gastempt result

Description
Extract coefficients from stan_gastempt result

Usage

```r
## S3 method for class 'stan_gastempt'
coef(object, ...)
```

Arguments

- `object`: Result of a call to `stan_gastempt`
- `...`: other arguments

Value

A data frame with coefficients. See `nlme_gastempt` for an example.

gastemptfunc

Functions for gastric emptying analysis

Description

The linexp and the power exponential (powexp) functions can be used to fit gastric emptying curves.

Usage

```r
linexp(t, v0 = 1, tempt = NULL, kappa = NULL, pars = NULL)
linexp_slope(t, v0 = 1, tempt = NULL, kappa = NULL, pars = NULL)
linexp_auc(v0 = 1, tempt = NULL, kappa = NULL, pars = NULL)
powexp(t, v0 = 1, tempt = NULL, beta = NULL, pars = NULL)
powexp_slope(t, v0 = 1, tempt = NULL, beta = NULL, pars = NULL)
linexp_log(t, v0 = 1, logtempt = NULL, logkappa = NULL, pars = NULL)
powexp_log(t, v0 = 1, logtempt = NULL, logbeta = NULL, pars = NULL)
```
Arguments

- t  
  Time after meal or start of scan, in minutes; can be a vector.
- v0  
  Initial volume at t=0.
- tempt  
  Emptying time constant in minutes (scalar).
- kappa  
  Overshoot term for linexp function (scalar).
- pars  
  Default NULL. If not NULL, the other parameters with exception of t are not used and are retrieved as named parameters from the numeric vector pars instead.
- beta  
  Power term for power exponential function (scalar).
- logtempt  
  Logarithm of emptying time constant in minutes (scalar).
- logkappa  
  Logarithm of overshoot term for linexp function (scalar).
- logbeta  
  Logarithm of power term for power exponential function (scalar).

Details

The linexp function can have an initial overshoot to model secretion.

\[
vol(t) = v0 \times \left(1 + \frac{kappa \times t}{tempt}\right) \times \exp(-t / tempt)
\]

The powexp function introduced by Elashof et al. is monotonously decreasing but has more freedom to model details in the function tail.

\[
vol(t) = v0 \times \exp\left(-\frac{t}{tempt}\right)^\beta
\]

The _slope functions return the first derivatives of linexp and powexp. Use the _log functions to enforce positive parameters tempt and beta. Rarely required for gastric emptying curves.

Value

Vector of length(t) for computed volume.

Examples

```r
t = seq(0,100, by=5)
kappa = 1.3
tempt = 60
v0 = 400
beta = 3
pars = c(v0 = v0, tempt = tempt, kappa = kappa)
par(mfrow=c(1,3))
plot(t, linexp(t, v0, tempt, kappa), type = "l", ylab = "volume", main = "linexp\nkappa = 1.3 and 1.0")
lines(t, linexp(t, v0, tempt, 1), type = "l", col = "green")
# This should give the same plot as above
plot(t, linexp(t, pars = pars), type = "l", ylab = "volume", main = "linexp\nkappa = 1.3 and 1.0\nwith vectored parameters")
lines(t, linexp(t, v0, tempt, 1), type = "l", col = "green")
plot(t, powexp(t, v0, tempt, beta), type = "l", ylab = "volume", main = "powexp\nbeta = 2 and 1")
lines(t, powexp(t, v0, tempt, 1), type = "l", col = "green")
```
Description

Compute coefficients v0, tempt and kappa of a mixed model fit to a linexp function with one grouping variable.

Usage

```r
nlme_gastempt(d, pnlstol = 0.001, model = linexp, variant = 1)
```

Arguments

- `d` A data frame with columns
  - `record` Record descriptor as grouping variable, e.g. patient ID
  - `minute` Time after meal or start of recording.
  - `vol` Volume of meal or stomach
- `pnlstol` The value of pnlsTol at the initial iteration. See `nlmeControl` When the model does not converge, pnlsTol is multiplied by 5 and the iteration repeated until convergence or pnlsTol >= 0.5. The effective value of pnlsTol is returned in a separate list item. When it is known that a data set converges badly, it is recommended to set the initial pnlsTol to a higher value, but below 0.5, for faster convergence.
- `model` `linexp` (default) or `powexp`
- `variant` For both models, there are 3 variants
  - `variant = 1` The most generic version with independent estimates of all three parameters per record (`random = v0 + tempt + kappa ~ 1 | record`). The most likely to fail for degenerate cases. If this variant converges, use it.
  - `variant = 2` Diagonal random effects (`random = pdDiag(v0 + tempt + kappa) ~ 1; groups = record`). Better convergence in critical cases. Note: I never found out why I have to use the `groups` parameter instead of the `|`; see also p. 380 of Pinheiro/Bates.
  - `variant = 3` Since parameters kappa and beta respectively are the most difficult to estimate, these are fixed in this variant (`random = v0 + tempt ~ 1`). This variant converges in all reasonable cases, but the estimates of kappa and beta cannot be use for secondary between-group analysis. If you are only interested in t50, you can use this safe version.

Value

A list of class `nlme_gastempt` with elements `coef`, `summary`, `plot`, `pnlstol`, `message`

- `coef` is a data frame with columns:
  - `record` Record descriptor, e.g. patient ID
### Description

Plot data points and fit curve of an nlme_gastempt fit

### Usage

```r
## S3 method for class 'nlme_gastempt'
plot(x, ...)
```

### Arguments

- `x` Result of a call to nlme_gastempt
- `...` other arguments
plot.stan_gastempt

Value

a ggplot object. Use print() if used non-interactively to show the curve

plot.stan_gastempt

Plot data points and fit curve of an stan_gastempt fit

Description

Plot data points and fit curve of an stan_gastempt fit

Usage

## S3 method for class 'stan_gastempt'
plot(x, ...)

Arguments

x Result of a call to stan_gastempt
...
other arguments

Value

a ggplot object. Use print() if used non-interactively to show the curve

run_shiny

Run shiny app demonstrating fit strategies with simulated data

Description

Run shiny app demonstrating fit strategies with simulated data

Usage

run_shiny()

Value

Not used, starts shiny app
**simulate_gastempt**  
*Simulate gastric emptying data following a linexp or powexp function*

**Description**
Simulate gastric emptying data following a linexp or powexp function.

**Usage**
```r
simulate_gastempt(n_records = 10L, v0_mean = 400L, v0_std = 50L,  
tempt_mean = ifelse(identical(model, linexp), 60L, 120L),  
tempt_std = tempt_mean/3, kappa_mean = 0.7L,  
kappa_std = kappa_mean/3, beta_mean = 0.7L, beta_std = beta_mean/3,  
noise = 20, student_t_df = NULL, missing = 0, model = linexp,  
seed = NULL, max_minute = NULL)
```

**Arguments**
- **n_records**: Number of records
- **v0_mean, v0_std**: Mean and between-record standard deviation of initial volume, typically in ml.
- **tempt_mean, tempt_std**: Mean and between-record standard deviation of parameter $t_{empt}$, typically in minutes.
- **kappa_mean, kappa_std**: For linexp only: Mean and between-record standard deviation of overshoot parameter $\kappa$. For values of $\kappa$ above 1, curve has an overshoot that can be used to follow volume time series with secretion.
- **beta_mean, beta_std**: For powexp only: Mean and between-record standard deviation of the so called lag parameter.
- **noise**: Standard deviation of normal noise when student_t_df = NULL; scaling of noise when student_t_df >= 2.
- **student_t_df**: When NULL (default), Gaussian noise is added; when >= 2, Student_t distributed noise is added, which generates more realistic outliers. Values from 2 to 5 are useful, when higher values are used the result comes close to that of Gaussian noise. Values below 2 are rounded to 2.
- **missing**: When 0 (default), all curves have the same number of data points. When > 0, this is the fraction of points that were removed randomly to simulate missing points. Maximum value is 0.5.
- **model**: linexp(default) or powexp
- **seed**: optional seed; not set if seed = NULL (default)
- **max_minute**: Maximal time in minutes; if NULL, a sensible default rounded to hours is used
**Value**

A list with 3 elements:

- **record** Data frame with columns `record(chr)`, `v0`, `tempt`, `kappa/beta` giving the effective `linexp` or `powexp` parameters for the individual record. `v0` is rounded to nearest integer.

- **data** Data frame with columns `record(chr)`, `minute(dbl)`, `vol(dbl)` giving the time series and grouping parameters. `vol` is rounded to nearest integer.

- **stan_data** A list for use as data in Stan-based fits with elements `prior_v0`, `n`, `n_record`, `record`, `minute`, `volume`.

A comment is attached to the return value that can be used as a title.

**Examples**

```r
suppressWarnings(RNGversion("3.5.0"))
set.seed(4711)
library(ggplot2)

vol_linexp = simulate_gastempt(n_records = 4, noise = 0)
ggplot(vol_linexp$data, aes(x = minute, y = vol)) + geom_point() +
  facet_wrap(~record) + ggtitle("linexp, noise = 0, no missing")

vol_powexp = simulate_gastempt(n_records = 4, missing = 0.2, student_t_df = 2)
ggplot(vol_powexp$data, aes(x = minute, y = vol)) + geom_point() +
  facet_wrap(~record) + ggtitle("powexp, noise = 10 (default), 20% missing, 
  Student-t (df = 2) noise")
```

**Description**

Fit gastric emptying curves with Stan

**Usage**

```r
stan_gastempt(d, model_name = "linexp_gastro_2b", lkj = 2,
  student_df = 5L, init_r = 0.2, chains = 4, ...)
```

**Arguments**

- **d** A data frame with columns
  - `rec` Record descriptor as grouping variable, e.g. patient ID
  - `minute` Time after meal or start of recording.
  - `vol` Volume of meal or stomach

- **model_name** Name of predefined model in gastempt/exec. Use `stan_model_names()` to get a list of available models.
stan_model_names

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>lkj</td>
<td>LKJ prior for kappa/temp correlation, only required for model linexp_gastro_2b. Values from 1.5 (strong correlation) to 50 (almost independent) are useful. See <a href="http://www.psychstatistics.com/2014/12/27/d-lkj-priors/">http://www.psychstatistics.com/2014/12/27/d-lkj-priors/</a> for examples.</td>
</tr>
<tr>
<td>student_df</td>
<td>Student-t degrees of freedom for residual error; default 5. Use 3 for strong outliers; values above 10 are close to gaussian residual distribution.</td>
</tr>
<tr>
<td>init_r</td>
<td>For stan, default = 0.2; Stan's own default is 2, which often results in stuck chains.</td>
</tr>
<tr>
<td>chains</td>
<td>For stan; default = 4. For debugging, use 1.</td>
</tr>
<tr>
<td>...</td>
<td>Additional parameter passed to sampling</td>
</tr>
</tbody>
</table>

Value

A list of class stan_gastempt with elements coef, fit, plot

- coef is a data frame with columns:
  - rec Record descriptor, e.g. patient ID
  - v0 Initial volume at t=0
  - tempt Emptying time constant
  - kappa Parameter kappa for model = linexp
  - beta Parameter beta for model = powexp
  - t50 Half-time of emptying
  - slope_t50 Slope in t50; typically in units of ml/minute On error, coef is NULL
- fit Result of class 'stanfit'
- plot A ggplot graph of data and prediction. Plot of raw data is returned even when convergence was not achieved.

Examples

```r
## Not run:
 dd = simulate_gastempt(n_records = 6, seed = 471)
 d = dd$data
 ret = stan_gastempt(d)
 print(ret$coef)

## End(Not run)
```

---

**Description**

By default, line 2 and 3 of comments starting with # or // in Stan file are returned.
Usage

stan_model_names(n_lines = 2, skip = 1, sep = "\n")

Arguments

n_lines Number of comment lines to retrieve
skip Number of lines to skip from beginning of Stan Model file
sep separator for multiline strings

Value

A data frame with model_name and the first n_lines comment lines in model as description

---

t50

Compute half-emptying time from nlme parameters

Description

No closed solution known for linexp, we use a Newton approximation.

Usage

t50(x)

Arguments

x Result of a nlme fit, with named components ‘tempt, beta, logbeta, kappa, logkappa’ depending on model. Function used ‘logbeta’ when it is present, in ‘x’, otherwise beta, and similar for logkappa/kappa.

Value

Half-emptying time. Name of evaluated function is returned as attribute fun. Negative of slope is returned as attribute slope.
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