Package 'survregVB'

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Title Variational Bayesian Analysis of Survival Data

Version 0.0.2

Description Implements Bayesian inference in accelerated failure time (AFT) models for right-censored survival times assuming a log-logistic distribution. Details of the variational Bayes algorithms, with and without shared frailty, are described in Xian et al. (2024) <doi:10.1007/s11222-023-10365-6> and Xian et al. (2024) <doi:10.48550/arXiv.2408.00177>, respectively.

URL https://github.com/chengqianxian/survregVB

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`alpha_star` *Calculates parameter $\alpha\hat{}*$ of $q\hat{} * (b)$ to optimize the evidence based lower bound (ELBO) in* `survregVB.fit` *and* `survregVB.frailty.fit`.

Description

Calculates parameter α^* of $q^*(b)$ to optimize the evidence based lower bound (ELBO) in `survregVB.fit` and `survregVB.frailty.fit`.

Usage

```
alpha_star(alpha_0, delta)
```

Arguments

`alpha_0`	The shape hyperparameter α_0 of the prior distribution of the scale parameter, b.
`delta`	A binary vector indicating right censoring.

Value

Parameter α^* of $q^*(b)$.

See Also

`survregVB.fit`

`survregVB.frailty.fit`

dnase *Subset of* rhDNase *from the* survival *package*

Description

The dnase dataset is a subset of the rhDNase dataset from the survival package. It is included in this package under the LGPL (≥ 2) license.

Usage

```
dnase
```

Format

A data frame with 767 observations on the following variables:

trt treatment arm: 0=placebo, 1= rhDNase

fev forced expriatory volume at enrollment, a measure of lung capacity

infect an infection that required the use of intravenous antibiotics

time difference between the date of entry into the study and the date of last follow-up capped at 169 days

Source

survival package. https://cran.r-project.org/package=survival

elbo *Calculates the variational Bayes convergence criteria, evidence lower bound (ELBO), optimized in* survregVB.fit.

Description

Calculates the variational Bayes convergence criteria, evidence lower bound (ELBO), optimized in survregVB.fit.

Usage

```
elbo(
  y,
  X,
  delta,
  alpha_0,
  omega_0,
  mu_0,
  v_0,
```

```
  alpha,
  omega,
  mu,
  Sigma,
  expectation_b
)
```

Arguments

y	A vector of observed log-transformed survival times.
X	A design matrix including covariates with first column of ones to represent the intercept.
delta	A binary vector indicating right censoring.
alpha_0	The shape hyperparameter α_0 of the prior distribution of the scale parameter, b.
omega_0	The shape hyperparameter ω_0 of the prior distribution of the scale parameter, b.
mu_0	Hyperparameter μ_0, a vector of means, of the prior distribution of the vector of coefficients, β.
v_0	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
alpha	The shape parameter α^* of $q^*(b)$.
omega	The scale parameter ω^* of $q^*(b)$.
mu	Parameter μ^* of $q^*(\beta)$, a vector of means.
Sigma	Parameter Σ^* of $q^*(\beta)$, a covariance matrix.
expectation_b	The expected value of b.

See Also

survregVB.fit

---

elbo_cluster *Calculates the variational Bayes convergence criteria, evidence lower bound (ELBO), optimized in* survregVB.frailty.fit.

Description

Calculates the variational Bayes convergence criteria, evidence lower bound (ELBO), optimized in survregVB.frailty.fit.

Usage

```
elbo_cluster(
  y,
  X,
  delta,
  alpha_0,
  omega_0,
  mu_0,
  v_0,
  lambda_0,
  eta_0,
  alpha,
  omega,
  mu,
  Sigma,
  tau,
  sigma,
  lambda,
  eta,
  expectation_b,
  cluster
)
```

Arguments

y	A vector of observed log-transformed survival times.
X	A design matrix including covariates with first column of ones to represent the intercept.
delta	A binary vector indicating right censoring.
alpha_0	The shape hyperparameter α_0 of the prior distribution of the scale parameter, *b*.
omega_0	The shape hyperparameter ω_0 of the prior distribution of the scale parameter, *b*.
mu_0	Hyperparameter μ_0, a vector of means, of the prior distribution of the vector of coefficients, β.
v_0	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
lambda_0	The shape hyperparameter λ_0 of the prior distribution of the frailty variance, σ_γ^2.
eta_0	The scale hyperparameter η_0 of the prior distribution of the frailty variance, σ_γ^2.
alpha	The shape parameter α^* of $q^*(b)$.
omega	The scale parameter ω^* of $q^*(b)$.
mu	Parameter μ^* of $q^*(\beta)$, a vector of means.
Sigma	Parameter Σ^* of $q^*(\beta)$, a covariance matrix.
tau	Parameter τ^* of $q^*(\gamma_i)$, a vector of means.
sigma	Parameter σ_i^{2*} of $q^*(\gamma_i)$, a vector of variance.
lambda	The shape parameter λ^* of $q^*(\sigma_\gamma^2)$.

eta	The scale parameter η^* of $q^*(\sigma_\gamma^2)$.
expectation_b	The expected value of b.
cluster	A numeric vector indicating the cluster assignment for each observation.

Value

The evidence lower bound (ELBO).

See Also

survregVB.fit

---

eta_star *Calculates parameter $\eta\hat{}*$ of $q\hat{} * (\sigma\hat{}2_\gamma)$ to optimize the evidence based lower bound (ELBO) in* survregVB.frailty.fit.

Description

Calculates parameter η^* of $q^*(\sigma_\gamma^2)$ to optimize the evidence based lower bound (ELBO) in survregVB.frailty.fit.

Usage

```
eta_star(eta_0, tau, sigma)
```

Arguments

eta_0	The scale hyperparameter η_0 of the prior distribution of the frailty variance, σ_γ^2.
tau	Parameter τ^* of $q^*(\gamma_i)$, a vector of means.
sigma	Parameter σ_i^{2*} of $q^*(\gamma_i)$, a vector of variance.

Value

Parameter η^* of $q^*(\sigma_\gamma^2)$.

See Also

survregVB.frailty.fit

lambda_star *Calculates parameter $\lambda\hat{}*$ of $q\hat{} * (\sigma\hat{}2_\gamma)$ to optimize the evidence based lower bound (ELBO) in* `survregVB.frailty.fit`.

Description

Calculates parameter λ^* of $q^*(\sigma^2_\gamma)$ to optimize the evidence based lower bound (ELBO) in `survregVB.frailty.fit`.

Usage

```
lambda_star(lambda_0, K)
```

Arguments

`lambda_0`	The shape hyperparameter λ_0 of the prior distribution of the frailty variance, σ^2_γ.
`K`	The number of clusters.

Value

Parameter λ^* of $q^*(\sigma^2_\gamma)$.

See Also

`survregVB.frailty.fit`

lung_cancer *Subset of GSE102287: African American (AA) Patients*

Description

This dataset is a subset of the GSE102287 dataset that includes only characteristics of patients who are identified as African American (AA).

Usage

```
lung_cancer
```

Format

A data frame with 60 observations on selected patient characteristics:

patient Patient identification number.

age Patient age.

Stage Lung cancer stage (I, II, III).

time Survival time in days.

gender Gender of the patient.

smoking 0 = Never smoked, 1 = Has smoked.

status 0 = Alive, 1 = Death due to lung cancer.

Source

Gene Expression Omnibus (GEO), Accession: GSE102287. https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE102287

References

Mitchell, K. A., Zingone, A., Toulabi, L., Boeckelman, J., & Ryan, B. M. (2017). Comparative Transcriptome Profiling Reveals Coding and Noncoding RNA Differences in NSCLC from African Americans and European Americans. Clinical cancer research: an official journal of the American Association for Cancer Research, 23(23), 7412–7425. doi:10.1158/1078-0432.CCR-17-0527.

`mu_star` *Calculates parameter $\mu\hat{}*$ of $q\hat{}*(\beta)$ to optimize the evidence based lower bound (ELBO) in* `survregVB.fit`.

Description

Calculates parameter μ^* of $q^*(\beta)$ to optimize the evidence based lower bound (ELBO) in `survregVB.fit`.

Usage

```
mu_star(y, X, delta, mu_0, v_0, alpha, omega, mu, Sigma, expectation_b)
```

Arguments

`y`	A vector of observed log-transformed survival times.
`X`	A design matrix including covariates with first column of ones to represent the intercept.
`delta`	A binary vector indicating right censoring.
`mu_0`	Hyperparameter μ_0, a vector of means, of the prior distribution of the vector of coefficients, β.
`v_0`	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
`alpha`	The shape parameter α^* of $q^*(b)$.
`omega`	The scale parameter ω^* of $q^*(b)$.
`mu`	Parameter μ^* of $q^*(\beta)$, a vector of means.
`Sigma`	Parameter Σ^* of $q^*(\beta)$, a covariance matrix.
`expectation_b`	The expected value of b.

Value

Parameter μ^* of $q^*(\beta)$.

See Also

`survregVB.fit`

`mu_star_cluster` *Calculates parameter $\mu\hat{}*$ of $q\hat{} * (\beta)$ to optimize the evidence based lower bound (ELBO) in* `survregVB.frailty.fit`.

Description

Calculates parameter μ^* of $q^*(\beta)$ to optimize the evidence based lower bound (ELBO) in `survregVB.frailty.fit`.

Usage

```
mu_star_cluster(
  y,
  X,
  delta,
  mu_0,
  v_0,
  alpha,
  omega,
  mu,
  Sigma,
  tau,
  expectation_b,
  cluster
)
```

Arguments

`y`	A vector of observed log-transformed survival times.
`X`	A design matrix including covariates with first column of ones to represent the intercept.
`delta`	A binary vector indicating right censoring.
`mu_0`	Hyperparameter μ_0, a vector of means, of the prior distribution of the vector of coefficients, β.
`v_0`	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
`alpha`	The shape parameter α^* of $q^*(b)$.
`omega`	The scale parameter ω^* of $q^*(b)$.
`mu`	Parameter μ^* of $q^*(\beta)$, a vector of means.
`Sigma`	Parameter Σ^* of $q^*(\beta)$, a covariance matrix.
`tau`	Parameter τ^* of $q^*(\gamma_i)$, a vector of means.
`expectation_b`	The expected value of *b*.
`cluster`	A numeric vector indicating the cluster assignment for each observation.

Value

Parameter μ^* of $q^*(\beta)$

See Also

survregVB.frailty.fit

---

omega_star — *Calculates parameter $\omega\hat{}*$ of $q\hat{} * (b)$ to optimize the evidence based lower bound (ELBO) in* survregVB.fit.

Description

Calculates parameter ω^* of $q^*(b)$ to optimize the evidence based lower bound (ELBO) in survregVB.fit.

Usage

```
omega_star(y, X, delta, omega_0, mu, expectation_b)
```

Arguments

y	A vector of observed log-transformed survival times.
X	A design matrix including covariates with first column of ones to represent the intercept.
delta	A binary vector indicating right censoring.
omega_0	The shape hyperparameter ω_0 of the prior distribution of the scale parameter, b.
mu	Parameter μ^* of $q^*(\beta)$, a vector of means.
expectation_b	The expected value of b.

Value

Parameter ω^* of $q^*(b)$.

See Also

survregVB.fit

omega_star_cluster *Calculates parameter $\omega\hat{}*$ of $q\hat{} * (b)$ to optimize the evidence based lower bound (ELBO) in* survregVB.frailty.fit.

Description

Calculates parameter ω^* of $q^*(b)$ to optimize the evidence based lower bound (ELBO) in survregVB.frailty.fit.

Usage

```
omega_star_cluster(y, X, delta, omega_0, mu, tau, expectation_b, cluster)
```

Arguments

y	A vector of observed log-transformed survival times.
X	A design matrix including covariates with first column of ones to represent the intercept.
delta	A binary vector indicating right censoring.
omega_0	The shape hyperparameter ω_0 of the prior distribution of the scale parameter, b.
mu	Parameter μ^* of $q^*(\beta)$, a vector of means.
tau	Parameter τ^* of $q^*(\gamma_i)$, a vector of means.
expectation_b	The expected value of b.
cluster	A numeric vector indicating the cluster assignment for each observation.

Value

Parameter ω^* of $q^*(b)$.

See Also

survregVB.frailty.fit

sigma_squared_star *Calculates parameter $\sigma\hat{}2*_i$ of $q\hat{} * (\gamma_i)$ for $i = 1, ..., K$ clusters to optimize the evidence based lower bound (ELBO) in* survregVB.frailty.fit.

Description

Calculates parameter σ_i^{2*} of $q^*(\gamma_i)$ for $i = 1, ..., K$ clusters to optimize the evidence based lower bound (ELBO) in survregVB.frailty.fit.

Usage

```
sigma_squared_star(
  y,
  X,
  delta,
  alpha,
  omega,
  mu,
  tau,
  lambda,
  eta,
  expectation_b,
  cluster
)
```

Arguments

y	A vector of observed log-transformed survival times.
X	A design matrix including covariates with first column of ones to represent the intercept.
delta	A binary vector indicating right censoring.
alpha	The shape parameter α^* of $q^*(b)$.
omega	The scale parameter ω^* of $q^*(b)$.
mu	Parameter μ^* of $q^*(\beta)$, a vector of means.
tau	Parameter τ^* of $q^*(\gamma_i)$, a vector of means.
lambda	The shape parameter λ^* of $q^*(\sigma_\gamma^2)$.
eta	The scale parameter η^* of $q^*(\sigma_\gamma^2)$.
expectation_b	The expected value of b.
cluster	A numeric vector indicating the cluster assignment for each observation.

Value

Parameter vector σ_i^{2*} of $q^*(\gamma_i)$ for all clusters.

See Also

survregVB.frailty.fit

`Sigma_star` *Calculates parameter $\Sigma\hat{}*$ of $q\hat{} * (\beta)$ to optimize the evidence based lower bound (ELBO) in* `survregVB.fit`.

Description

Calculates parameter Σ^* of $q^*(\beta)$ to optimize the evidence based lower bound (ELBO) in `survregVB.fit`.

Usage

```
Sigma_star(y, X, delta, v_0, alpha, omega, mu, expectation_b)
```

Arguments

`y`	A vector of observed log-transformed survival times.
`X`	A design matrix including covariates with first column of ones to represent the intercept.
`delta`	A binary vector indicating right censoring.
`v_0`	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
`alpha`	The shape parameter α^* of $q^*(b)$.
`omega`	The scale parameter ω^* of $q^*(b)$.
`mu`	Parameter μ^* of $q^*(\beta)$, a vector of means.
`expectation_b`	The expected value of b.

Value

Parameter Σ^* of $q^*(\beta)$.

See Also

`survregVB.fit`

`Sigma_star_cluster` *Calculates parameter $\Sigma\hat{}*$ of $q\hat{} * (\beta)$ to optimize the evidence based lower bound (ELBO) in* `survregVB.frailty.fit`.

Description

Calculates parameter Σ^* of $q^*(\beta)$ to optimize the evidence based lower bound (ELBO) in `survregVB.frailty.fit`.

Usage

```
Sigma_star_cluster(
  y,
  X,
  delta,
  v_0,
  alpha,
  omega,
  mu,
  tau,
  expectation_b,
  cluster
)
```

Arguments

y	A vector of observed log-transformed survival times.
X	A design matrix including covariates with first column of ones to represent the intercept.
delta	A binary vector indicating right censoring.
v_0	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
alpha	The shape parameter α^* of $q^*(b)$.
omega	The scale parameter ω^* of $q^*(b)$.
mu	Parameter μ^* of $q^*(\beta)$, a vector of means.
tau	Parameter τ^* of $q^*(\gamma_i)$, a vector of means.
expectation_b	The expected value of b.
cluster	A numeric vector indicating the cluster assignment for each observation.

Value

Parameter Σ^* of $q^*(\beta)$.

See Also

survregVB.frailty.fit

`simulation_frailty` *Simulated data incorporating shared frailty effects to model clustered time-to-event data.*

Description

Simulated data incorporating shared frailty effects to model clustered time-to-event data.

Usage

```
simulation_frailty
```

Format

A dataframe with 75 observations grouped into 15 clusters, each with 5 individuals.

x1 Continuous covariate from `N(1, 0.2^2)`

x2 Binary covariate from `Bernoulli(0.5)`

Time True survival time

Time.15 Observed survival time accounting for uniformly distributed right censoring time from `uniform(0,u)`

delta Event indicator for uncensored data (always 1 in this simulation.)

delta.15 Event indicator after censoring (1 = event, 0 = censored).

cluster Cluster ID (1–15), indicating group-level frailty .

@references Xian, C., Souza, C. P. E. de, He, W., Rodrigues, F. F., & Tian, R. (2024). Fast variational bayesian inference for correlated survival data: An application to invasive mechanical ventilation duration analysis. https://doi.org/10.48550/ARXIV.2408.00177

`simulation_nofrailty` *Simulated data without shared frailty effects to model unclustered time-to-event data.*

Description

Simulated data without shared frailty effects to model unclustered time-to-event data.

Usage

```
simulation_nofrailty
```

Format

A dataframe with 300 observations.

x1 Continuous covariate from `N(1, 0.2^2)`

x2 Binary covariate from `Bernoulli(0.5)`

Time True survival time

Time.10 Observed survival time accounting for uniformly distributed right censoring time from `uniform(0,48)`

Time.30 Observed survival time accounting for uniformly distributed right censoring time from `uniform(0,17)`

delta Event indicator for uncensored data (always 1 in this simulation.)

delta.10 Event indicator for T.10 (1 = event, 0 = censored).

delta.30 Event indicator for T.30 (1 = event, 0 = censored).

@references Xian, C., Souza, C. P. E. de, He, W., Rodrigues, F. F., & Tian, R. (2024). Variational Bayesian analysis of survival data using a log-logistic accelerated failure time model. Statistics and Computing, 34(2). https://doi.org/10.1007/s11222-023-10365-6

`summary.survregVB` *Summary for Variational Bayes log-logistic AFT models.*

Description

Produces a summary of a fitted Variational Bayes Parametric Survival Regression Model for a Log-Logistic AFT Model

Usage

```
## S3 method for class 'survregVB'
summary(object, ci = 0.95, ...)
```

Arguments

`object`	The result of a `survregVB` fit.
`ci`	The significance level for the credible intervals. (Default:0.95).
`...`	For future arguments.

Value

An object of class `summary.survregVB` with components:

- `ELBO`: The final value of the Evidence Lower Bound (ELBO) at the last iteration.
- `alpha`: The shape parameter α^* of $q^*(b)$.
- `omega`: The scale parameter ω^* of $q^*(b)$.

- mu: Parameter μ^* of $q^*(\beta)$, a vector of means.
- Sigma: Parameter Σ^* of $q^*(\beta)$, a covariance matrix.
- na.action: A missing-data filter function, applied to the model.frame, after any subset argument has been used.
- iterations: The number of iterations performed by the VB algorithm: before converging or reaching max_iteration.
- n: The number of observations.
- call: The function call used to invoke the survregVB method.
- not_converged: A boolean indicating if the algorithm converged.
  - TRUE: If the algorithm did not converge prior to achieving max_iteration.
  - NULL: If the algorithm converged successfully.
- estimates: A matrix with one row for each regression coefficient, and one row for the scale parameter. The columns contain:
  - Value: The estimated value based on the posterior distribution mean.
  - Lower CI: The lower bound of the credible interval.
  - Upper CI: The upper bound of the credible interval.

If called with shared frailty, the object also contains components:

- lambda: The shape parameter λ^* of $q^*(\sigma_\gamma^2)$.
- eta: The scale parameter η^* of $q^*(\sigma_\gamma^2)$.
- tau: Parameter τ_i^* of $q^*(\gamma_i)$, a vector of means.
- sigma: Parameter σ_i^{2*} of $q^*(\gamma_i)$, a vector of variance.

The estimates component will contain an additional row for the frailty, the estimated variance based on the posterior mean for the random intercepts.

See Also

survregVB

---

survregVB *Variational Bayesian Analysis of Survival Data Using a Log-Logistic Accelerated Failure Time Model*

Description

Applies a mean-field Variational Bayes (VB) algorithm to infer the parameters of an accelerated failure time (AFT) survival model with right-censored survival times following a log-logistic distribution.

Usage

```
survregVB(
  formula,
  data,
  alpha_0,
  omega_0,
  mu_0,
  v_0,
  lambda_0,
  eta_0,
  na.action,
  cluster,
  max_iteration = 100,
  threshold = 1e-04
)
```

Arguments

formula	A formula object, with the response on the left of a ~ operator, and the covariates on the right. The response must be a survival object of type right, as returned by the Surv function.
data	A data.frame in which to interpret the variables named in the formula and cluster arguments.
alpha_0	The shape hyperparameter α_0 of the prior distribution of the scale parameter, b.
omega_0	The shape hyperparameter ω_0 of the prior distribution of the scale parameter, b.
mu_0	Hyperparameter μ_0, a vector of means, of the prior distribution of the vector of coefficients, β.
v_0	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
lambda_0	The shape hyperparameter λ_0 of the prior distribution of the frailty variance, σ_γ^2.
eta_0	The scale hyperparameter η_0 of the prior distribution of the frailty variance, σ_γ^2.
na.action	A missing-data filter function, applied to the model.frame, after any subset argument has been used. (Default:options()$na.action).
cluster	An optional variable which clusters the observations to introduce shared frailty for correlated survival data.
max_iteration	The maximum number of iterations for the variational inference optimization. If reached, iteration stops. (Default:100)
threshold	The convergence threshold for the evidence based lower bound (ELBO) optimization. If the difference between the current and previous ELBO's is smaller than this threshold, iteration stops. (Default:0.0001)

Details

The goal of survregVB is to maximize the evidence lower bound (ELBO) to approximate posterior distributions of the AFT model parameters using the VB algorithms with and without shared frailty proposed in Xian et al. (2024) doi:10.1007/s11222-023-10365-6 and doi:10.48550/ARXIV.2408.00177 respectively.

Value

An object of class survregVB.

References

Xian, C., Souza, C. P. E. de, He, W., Rodrigues, F. F., & Tian, R. (2024). "Variational Bayesian analysis of survival data using a log-logistic accelerated failure time model." Statistics and Computing, 34(2). https://doi.org/10.1007/s11222-023-10365-6

Xian, C., Souza, C. P. E. de, He, W., Rodrigues, F. F., & Tian, R. (2024). "Fast variational bayesian inference for correlated survival data: An application to invasive mechanical ventilation duration analysis." https://doi.org/10.48550/ARXIV.2408.00177

See Also

survregVB.object

Examples

```
# Data frame containing survival data
fit <- survregVB(
  formula = survival::Surv(time, infect) ~ trt + fev,
  data = dnase,
  alpha_0 = 501,
  omega_0 = 500,
  mu_0 = c(4.4, 0.25, 0.04),
  v_0 = 1,
  max_iteration = 100,
  threshold = 0.0005
)
summary(fit)

# Call the survregVB function with shared frailty
fit2 <- survregVB(
  formula = survival::Surv(Time.15, delta.15) ~ x1 + x2,
  data = simulation_frailty,
  alpha_0 = 3,
  omega_0 = 2,
  mu_0 = c(0, 0, 0),
  v_0 = 0.1,
  lambda_0 = 3,
  eta_0 = 2,
  cluster = cluster,
  max_iteration = 100,
  threshold = 0.01
)
summary(fit2)
```

`survregVB.fit` *Variational Bayesian Analysis of Survival Data Using a Log-Logistic Accelerated Failure Time Model*

Description

Called by `survregVB` to do the actual parameter and ELBO computations. This routine does no checking that the arguments are the proper length or type.

Usage

```
survregVB.fit(
  Y,
  X,
  alpha_0,
  omega_0,
  mu_0,
  v_0,
  max_iteration = 100,
  threshold = 1e-04
)
```

Arguments

`Y`	A `Surv` object containing 2 columns: time and event.
`X`	A design matrix including covariates with first column of ones to represent the intercept.
`alpha_0`	The shape hyperparameter α_0 of the prior distribution of the scale parameter, b.
`omega_0`	The shape hyperparameter ω_0 of the prior distribution of the scale parameter, b.
`mu_0`	Hyperparameter μ_0, a vector of means, of the prior distribution of the vector of coefficients, β.
`v_0`	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
`max_iteration`	The maximum number of iterations for the variational inference optimization. If reached, iteration stops. (Default:100)
`threshold`	The convergence threshold for the evidence based lower bound (ELBO) optimization. If the difference between the current and previous ELBO's is smaller than this threshold, iteration stops. (Default:0.0001)

Details

Implements the Variational Bayes algorithm proposed in the paper "Variational Bayesian analysis of survival data using a log-logistic accelerated failure time model."

For right-censored survival time T_i of the i_{th} subject in a sample, $i = 1, ..., n$, the log-logistic AFT model is specified as follows:

$\log(T_i) = X_i^T \beta + bz_i$, where

- X_i is a column vector of length $p, p \geq 2$ containing $p-1$ covariates and a constant one to incorporate the intercept (i.e., $X_i = (1, x_{i1}, ..., x_{i(p-1)})^T$),
- β is the corresponding vector of coefficients for the fixed effects,
- z_i is a random variable following a standard logistic distribution, and
- b is a scale parameter.

Value

A list containing results of the fit.

References

Xian, C., Souza, C. P. E. de, He, W., Rodrigues, F. F., & Tian, R. (2024). "Variational Bayesian analysis of survival data using a log-logistic accelerated failure time model." Statistics and Computing, 34(2). https://doi.org/10.1007/s11222-023-10365-6

See Also

survregVB

Examples

```
fit <- survregVB.fit(
  Y = survival::Surv(simulation_nofrailty$Time, simulation_nofrailty$delta),
 X = matrix(c(rep(1, 300), simulation_nofrailty$x1, simulation_nofrailty$x2), nrow = 300),
  alpha_0 = 11,
  omega_0 = 10,
  mu_0 = c(0, 0, 0),
  v_0 = 1
)
```

---

survregVB.frailty.fit *Variational Bayesian Analysis of Correlated Survival Data Using a Log-Logistic Accelerated Failure Time Model*

Description

Called by survregVB to do the actual parameter and ELBO computations for correlated survival data with shared frailty (a random intercept). This routine does no checking that the arguments are the proper length or type.

Usage

```
survregVB.frailty.fit(
  Y,
  X,
  alpha_0,
  omega_0,
  mu_0,
  v_0,
  lambda_0,
  eta_0,
  cluster,
  max_iteration = 100,
  threshold = 1e-04
)
```

Arguments

Y	A Surv object containing 2 columns: time and event.
X	A design matrix including covariates with first column of ones to represent the intercept.
alpha_0	The shape hyperparameter α_0 of the prior distribution of the scale parameter, b.
omega_0	The shape hyperparameter ω_0 of the prior distribution of the scale parameter, b.
mu_0	Hyperparameter μ_0, a vector of means, of the prior distribution of the vector of coefficients, β.
v_0	The precision (inverse variance) hyperparameter v_0, of the prior distribution of the vector of coefficients, β.
lambda_0	The shape hyperparameter λ_0 of the prior distribution of the frailty variance, σ^2_γ.
eta_0	The scale hyperparameter η_0 of the prior distribution of the frailty variance, σ^2_γ.
cluster	An optional variable which clusters the observations to introduce shared frailty for correlated survival data.
max_iteration	The maximum number of iterations for the variational inference optimization. If reached, iteration stops. (Default:100)
threshold	The convergence threshold for the evidence based lower bound (ELBO) optimization. If the difference between the current and previous ELBO's is smaller than this threshold, iteration stops. (Default:0.0001)

Details

Implements the Variational Bayes algorithm with random intercepts proposed in the paper "Fast variational bayesian inference for correlated survival data: An application to invasive mechanical ventilation duration analysis".

For right-censored survival time T_{ij} of the j_{th} subject from the i_{th} cluster in the sample, in a sample, $i = 1, ..., K$ and $j = 1, ..., n_i$, the shared-frailty log-logistic AFT model is specified as follows:

$\log(T_{ij}) = \gamma_i + X_{ij}^T\beta + b\epsilon_{ij}$, where

- X_{ij} is a column vector of length $p, p \geq 2$ containing $p-1$ covariates and a constant one to incorporate the intercept (i.e., $X_i = (1, x_{ij1}, ..., x_{ij(p-1)})^T$),
- β is the corresponding vector of coefficients for the fixed effects,
- γ_i is a random intercept for the i_{th} cluster,
- ϵ_{ij} is a random variable following a standard logistic distribution, and
- b is a scale parameter.

Value

A list containing results of the fit.

References

Xian, C., Souza, C. P. E. de, He, W., Rodrigues, F. F., & Tian, R. (2024). "Fast variational bayesian inference for correlated survival data: An application to invasive mechanical ventilation duration analysis." https://doi.org/10.48550/ARXIV.2408.00177

See Also

survregVB

Examples

```
fit <- survregVB.frailty.fit(
  X = matrix(c(rep(1, 75), simulation_frailty$x1, simulation_frailty$x2), nrow = 75),
  Y = survival::Surv(simulation_frailty$Time, simulation_frailty$delta),
  alpha_0 = 3,
  omega_0 = 2,
  mu_0 = c(0, 0, 0),
  v_0 = 0.1,
  lambda_0 = 3,
  eta_0 = 2,
  cluster = simulation_frailty$cluster
)
```

---

survregVB.object *Variational Bayes Accelererated Failure Time Survival Model Object*

Description

This class of objects is returned by the survregVB function to represent a fitted parametric log-logistic accelerated failure time (AFT) survival model. Objects of this class have methods for the functions `print` and `summary`.

Details

For approximate posterior distributions:

- $q^*(\beta)$, a $N_p(\mu^*, \Sigma^*)$ density function, and
- $q^*(b)$, an Inverse-Gamma(α^*, ω^*) density function,

the components of this class are:

- `ELBO`: The final value of the Evidence Lower Bound (ELBO) at the last iteration.
- `alpha`: The shape parameter α^* of $q^*(b)$.
- `omega`: The scale parameter ω^* of $q^*(b)$.
- `mu`: Parameter μ^* of $q^*(\beta)$, a vector of means.
- `Sigma`: Parameter Σ^* of $q^*(\beta)$, a covariance matrix.
- `na.action`: A missing-data filter function, applied to the `model.frame`, after any subset argument has been used.
- `iterations`: The number of iterations performed by the VB algorithm: before converging or reaching `max_iteration`.
- `n`: The number of observations.
- `call`: The function call used to invoke the `survregVB` method.
- `not_converged`: A boolean indicating if the algorithm converged.
  - `TRUE`: If the algorithm did not converge prior to achieving `max_iteration`.
  - `NULL`: If the algorithm converged successfully.

If `survregVB` was called with shared frailty (with the `cluster` argument), for approximate posterior distributions:

- $q^*(\sigma_\gamma^2)$, an Inverse-Gamma(λ^*, η^*) density function,
- $q^*(\gamma_i)$, a $N(\tau_i^*, \sigma_i^{2*})$ density function, for $i = 1, ..., K$ clusters, and

the additional components are present:

- `lambda`: The shape parameter λ^* of $q^*(\sigma_\gamma^2)$.
- `eta`: The scale parameter η^* of $q^*(\sigma_\gamma^2)$.
- `tau`: Parameter τ_i^* of $q^*(\gamma_i)$, a vector of means.
- `sigma`: Parameter σ_i^{2*} of $q^*(\gamma_i)$, a vector of variance.

tau_star — *Calculates parameter τ^ * _i of q^ * (γ_i) for $i = 1, ..., K$ clusters to optimize the evidence based lower bound (ELBO) in* `survregVB.frailty.fit`.

Description

Calculates parameter τ_i^* of $q^*(\gamma_i)$ for $i = 1, ..., K$ clusters to optimize the evidence based lower bound (ELBO) in `survregVB.frailty.fit`.

Usage

```
tau_star(y, X, delta, alpha, omega, mu, tau, sigma, expectation_b, cluster)
```

Arguments

`y`	A vector of observed log-transformed survival times.
`X`	A design matrix including covariates with first column of ones to represent the intercept.
`delta`	A binary vector indicating right censoring.
`alpha`	The shape parameter α^* of $q^*(b)$.
`omega`	The scale parameter ω^* of $q^*(b)$.
`mu`	Parameter μ^* of $q^*(\beta)$, a vector of means.
`tau`	Parameter τ^* of $q^*(\gamma_i)$, a vector of means.
`sigma`	Parameter σ_i^{2*} of $q^*(\gamma_i)$, a vector of variance.
`expectation_b`	The expected value of b.
`cluster`	A numeric vector indicating the cluster assignment for each observation.

Value

Parameter vector τ_i^* of $q^*(\gamma_i)$ for $i = 1, ..., K$ clusters.

See Also

`survregVB.frailty.fit`

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