Package 'ImpAdaptType2Censor'

August 7, 2026

Type Package

Title Data Generation and Statistical Inference for Improved Adaptive Type-II Progressive Censoring Schemes

Version 0.1.0

Description

Comprehensive computational routines for random data generation, Maximum Likelihood Estimation (MLE), Maximum Product of Spacings Estimation (MPSE), and MCMC Bayesian estimation under the Improved Adaptive Type-II Progressive Censoring Scheme (IAT-II PCS). Users can supply custom probability density functions (PDF), cumulative distribution functions (CDF), survival functions, parameter ranges, and progressive censoring plans for any continuous univariate lifetime distribution, or rely on built-in parametric models (e.g., Generalized Exponential). Point estimation methods include MLE via optimization algorithms (Broyden-Fletcher-Goldfarb-Shanno (BFGS), Newton-Raphson (NR), Nelder-Mead (NM), Conjugate Gradients (CG), L-BFGS-B, Simulated Annealing (SANN), and Berndt-Hall-Hall-Hausman (BHHH)) and MPSE. Bayesian inference utilizes Metropolis-Hastings within Gibbs sampling under Squared Error Loss (SEL) and LINEX Loss (LL) functions to compute point estimates and Highest Posterior Density (HPD) credible intervals. Asymptotic confidence intervals for parameters, reliability, and hazard rate functions are constructed using asymptotic normality and delta method. Methods are based on Dev and Chacko (2026, Journal of the Iranian Statistical Society, 25, 1-29), Yan, Zhang, and Dong (2021, Journal of Computational and Applied Mathematics, 381, 113022, <doi:10.1016/j.cam.2020.113022>), Ng, Kundu, and Chan (2004, Naval Research Logistics, 51, 1145-1168, <doi:10.1002/nav.20045>), Cheng and Amin (1983, Journal of the Royal Statistical Society Series B, 45, 394-403, <doi:10.1111/j.2517-6161.1983.tb01268.x>), Kundu and Gupta (1999, Australian & New Zealand Journal of Statistics, 41, 173-188, <doi:10.1111/1467-842X.00072>), and Berndt, Hall, Hall, and Hausman (1974, Annals of Economic and Social Measurement, 3, 653-665).

License GPL (>= 3)

Encoding UTF-8

RoxygenNote 7.3.3

Depends R (>= 4.0.0)

Imports stats, graphics, grDevices

Suggests testthat (>= 3.0.0)

NeedsCompilation no

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Repository CRAN

Date/Publication 2026-08-07 15:30:02 UTC

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`bayes_impadapt2_censor` *Bayesian MCMC Estimation under Improved Adaptive Type-II Progressive Censoring Scheme*

Description

Performs MCMC Bayesian estimation for Improved Adaptive Type-II Progressive Censored (IAT-II PCS) data using Metropolis-Hastings within Gibbs sampling under Squared Error Loss (SEL) and LINEX Loss (LL) functions.

Usage

```
bayes_impadapt2_censor(
  data,
  n = NULL,
  m = NULL,
  T1 = NULL,
  T2 = NULL,
  R = NULL,
  pdf = NULL,
  cdf = NULL,
  start = NULL,
  prior_mean = NULL,
  prior_sd = NULL,
  loss = c("squared", "linex"),
```

```
  c_linex = 1,
  n_iter = 5000,
  burn_in = 1000,
  thin = 1,
  conf_level = 0.95,
  eval_time = NULL,
  seed = NULL,
  proposal_sd = NULL
)
```

Arguments

data	Numeric vector of observed failure times, or an object of class "impadapt2_sample".
n	Integer, total number of units placed on test. Required if data is a numeric vector.
m	Integer, pre-fixed target number of failures. Required if data is a numeric vector.
T1	Numeric, first threshold time point T1. Required if data is a numeric vector.
T2	Numeric or NULL, second threshold time point T2 (T2 > T1). Required if data is a numeric vector.
R	Numeric vector of length m, pre-fixed progressive censoring scheme. Required if data is a numeric vector.
pdf	Function (optional), user-supplied probability density function pdf(x, par).
cdf	Function (optional), user-supplied cumulative distribution function cdf(x, par).
start	Numeric vector of initial parameter values.
prior_mean	Optional numeric vector of prior means for parameters.
prior_sd	Optional numeric vector of prior standard deviations for parameters.
loss	Character vector specifying loss function(s) to compute: "squared" (Squared Error Loss) and/or "linex" (LINEX Loss).
c_linex	Numeric, shape parameter c for LINEX loss function (default 1.0).
n_iter	Integer, total number of MCMC iterations (default 5000).
burn_in	Integer, number of initial burn-in iterations to discard (default 1000).
thin	Integer, thinning interval (default 1).
conf_level	Numeric, credible level for HPD intervals (default 0.95).
eval_time	Optional numeric, time point t > 0 for calculating reliability S(t) and hazard rate h(t).
seed	Optional integer, seed for random number generation.
proposal_sd	Optional numeric vector of proposal standard deviations for Metropolis-Hastings steps.

Value

An object of class "impadapt2_bayes" containing:

bayes_sel	Bayes point estimates under Squared Error Loss.

bayes_linex	Bayes point estimates under LINEX Loss.
post_sd	Posterior standard deviations of parameters.
hpd_interval	Matrix of Highest Posterior Density (HPD) credible intervals for parameters.
chain	Matrix of retained MCMC posterior samples.
rel_est	Bayes estimates, SD, and HPD interval for Reliability S(t) if eval_time is provided.
haz_est	Bayes estimates, SD, and HPD interval for Hazard rate h(t) if eval_time is provided.
acceptance_rate	Acceptance rate of the Metropolis-Hastings MCMC sampler.
case	Realized censoring scenario ("Case I", "Case II", or "Case III").

References

Dev, S. S., & Chacko, M. (2026). Statistical inference for generalized exponential distribution under improved adaptive Type-II progressive censoring. *Journal of the Iranian Statistical Society*, 25(2), 1-29. DOI: 10.22034/jirss.2026.2077492.1165.

Examples

```
set.seed(123)
ge_cdf <- function(x, par) (1 - exp(-par[2] * x))^par[1]
ge_pdf <- function(x, par) par[1] * par[2] * exp(-par[2] * x) * (1 - exp(-par[2] * x))^(par[1] - 1)
ge_qdf <- function(p, par) - (1 / par[2]) * log(1 - p^(1 / par[1]))

samp <- r_impadapt2_censor(
  n = 20, m = 10, T1 = 0.8, T2 = 2.0,
  R = c(rep(1, 10)),
  pdf = ge_pdf, cdf = ge_cdf, qdf = ge_qdf,
  par = c(1.5, 0.8)
)

fit_bayes <- bayes_impadapt2_censor(
  data = samp, pdf = ge_pdf, cdf = ge_cdf,
  start = c(1.2, 0.7), n_iter = 1000, burn_in = 200, eval_time = 0.5
)
summary(fit_bayes)
```

---

mle_impadapt2_censor *Maximum Likelihood Estimation under Improved Adaptive Type-II Progressive Censoring Scheme*

Description

Fits a probability distribution to Improved Adaptive Type-II Progressive Censored (IAT-II PCS) data using Maximum Likelihood Estimation (MLE).

Usage

```
mle_impadapt2_censor(
  data,
  n = NULL,
  m = NULL,
  T1 = NULL,
  T2 = NULL,
  R = NULL,
  pdf = NULL,
  cdf = NULL,
  start = NULL,
  lower = NULL,
  upper = NULL,
  method = "BFGS",
  conf_level = 0.95,
  eval_time = NULL,
  ...
)
```

Arguments

`data`	Numeric vector of observed failure times, or an object of class `"impadapt2_sample"`.
`n`	Integer, total number of units placed on test. Required if data is a numeric vector.
`m`	Integer, pre-fixed target number of failures. Required if data is a numeric vector.
`T1`	Numeric, first threshold time point T1. Required if data is a numeric vector.
`T2`	Numeric or NULL, second threshold time point T2 (T2 > T1). Required if data is a numeric vector.
`R`	Numeric vector of length m, pre-fixed progressive censoring scheme. Required if data is a numeric vector.
`pdf`	Function (optional), user-supplied probability density function pdf(x, par).
`cdf`	Function (optional), user-supplied cumulative distribution function cdf(x, par).
`start`	Numeric vector of initial parameter guesses.
`lower`	Optional numeric vector of lower parameter bounds.
`upper`	Optional numeric vector of upper parameter bounds.
`method`	Character string specifying optimization method: `"BFGS"`, `"NR"`, `"Nelder-Mead"`, `"CG"`, `"L-BFGS-B"`, `"SANN"`, or `"BHHH"`. Default is `"BFGS"`.
`conf_level`	Numeric, confidence level for asymptotic confidence intervals (default 0.95).
`eval_time`	Optional numeric, time point t > 0 for calculating reliability S(t) and hazard rate h(t).
`...`	Further arguments passed to optimization routines.

Value

An object of class "impadapt2_mle" containing:

par	MLE parameter estimates.
std_er	Standard errors of parameter estimates.
vcov	Variance-covariance matrix.
loglik	Log-likelihood value at MLE.
aic	Akaike Information Criterion (AIC).
bic	Bayesian Information Criterion (BIC).
confint	Matrix of asymptotic confidence intervals for parameters.
rel_est	Point estimate, SE, and ACI of Reliability function S(t) if eval_time is provided.
haz_est	Point estimate, SE, and ACI of Hazard rate function h(t) if eval_time is provided.
case	Realized censoring scenario ("Case I", "Case II", or "Case III").
method	Optimization routine used.
convergence	Convergence code (0 = successful convergence).

References

Dev, S. S., & Chacko, M. (2026). Statistical inference for generalized exponential distribution under improved adaptive Type-II progressive censoring. *Journal of the Iranian Statistical Society*, 25(2), 1-29. DOI: 10.22034/jirss.2026.2077492.1165.

Berndt, E. R., Hall, B. H., Hall, R. E., & Hausman, J. A. (1974). Estimation and inference in nonlinear structural models. *Annals of Economic and Social Measurement*, 3(4), 653-665.

Examples

```
set.seed(123)
ge_cdf <- function(x, par) (1 - exp(-par[2] * x))^par[1]
ge_pdf <- function(x, par) par[1] * par[2] * exp(-par[2] * x) * (1 - exp(-par[2] * x))^(par[1] - 1)
ge_qdf <- function(p, par) - (1 / par[2]) * log(1 - p^(1 / par[1]))

samp <- r_impadapt2_censor(
  n = 25, m = 12, T1 = 0.8, T2 = 2.0,
  R = c(rep(1, 11), 2),
  pdf = ge_pdf, cdf = ge_cdf, qdf = ge_qdf,
  par = c(1.5, 0.8)
)

fit <- mle_impadapt2_censor(
  data = samp, pdf = ge_pdf, cdf = ge_cdf,
  start = c(1.0, 1.0), eval_time = 0.5
)
summary(fit)
```

`mpse_impadapt2_censor` *Maximum Product of Spacings Estimation under Improved Adaptive Type-II Progressive Censoring Scheme*

Description

Fits a probability distribution to Improved Adaptive Type-II Progressive Censored (IAT-II PCS) data using Maximum Product of Spacings Estimation (MPSE).

Usage

```
mpse_impadapt2_censor(
  data,
  n = NULL,
  m = NULL,
  T1 = NULL,
  T2 = NULL,
  R = NULL,
  cdf = NULL,
  pdf = NULL,
  start = NULL,
  lower = NULL,
  upper = NULL,
  method = "BFGS",
  conf_level = 0.95,
  eval_time = NULL,
  ...
)
```

Arguments

`data`	Numeric vector of observed failure times, or an object of class `"impadapt2_sample"`.
`n`	Integer, total number of units placed on test. Required if data is a numeric vector.
`m`	Integer, pre-fixed target number of failures. Required if data is a numeric vector.
`T1`	Numeric, first threshold time point T1. Required if data is a numeric vector.
`T2`	Numeric or NULL, second threshold time point T2 (T2 > T1). Required if data is a numeric vector.
`R`	Numeric vector of length m, pre-fixed progressive censoring scheme. Required if data is a numeric vector.
`cdf`	Function (optional), user-supplied cumulative distribution function cdf(x, par).
`pdf`	Function (optional), user-supplied probability density function pdf(x, par) for hazard rate evaluation.
`start`	Numeric vector of initial parameter guesses.
`lower`	Optional numeric vector of lower parameter bounds.

upper	Optional numeric vector of upper parameter bounds.
method	Character string specifying optimization method: "BFGS", "NR", "Nelder-Mead", "CG", "L-BFGS-B", or "SANN". Default is "BFGS".
conf_level	Numeric, confidence level for asymptotic confidence intervals (default 0.95).
eval_time	Optional numeric, time point t > 0 for calculating reliability S(t) and hazard rate h(t).
...	Further arguments passed to optimization routines.

Value

An object of class "impadapt2_mpse" containing:

par	MPSE parameter estimates.
std_er	Standard errors of parameter estimates.
vcov	Variance-covariance matrix.
log_ps	Log product-of-spacings value at MPSE.
confint	Matrix of asymptotic confidence intervals for parameters.
rel_est	Point estimate, SE, and ACI of Reliability function S(t) if eval_time is provided.
haz_est	Point estimate, SE, and ACI of Hazard rate function h(t) if eval_time is provided.
case	Realized censoring scenario ("Case I", "Case II", or "Case III").
method	Optimization routine used.
convergence	Convergence code (0 = successful convergence).

References

Dev, S. S., & Chacko, M. (2026). Statistical inference for generalized exponential distribution under improved adaptive Type-II progressive censoring. *Journal of the Iranian Statistical Society*, 25(2), 1-29. DOI: 10.22034/jirss.2026.2077492.1165.

Cheng, R. C. H., & Amin, N. A. K. (1983). Estimating parameters in continuous univariate distributions with a shifted origin. *Journal of the Royal Statistical Society: Series B (Methodological)*, 45(3), 394-403.

Examples

```
set.seed(123)
ge_cdf <- function(x, par) (1 - exp(-par[2] * x))^par[1]
ge_pdf <- function(x, par) par[1] * par[2] * exp(-par[2] * x) * (1 - exp(-par[2] * x))^(par[1] - 1)
ge_qdf <- function(p, par) - (1 / par[2]) * log(1 - p^(1 / par[1]))

samp <- r_impadapt2_censor(
  n = 25, m = 12, T1 = 0.8, T2 = 2.0,
  R = c(rep(1, 11), 2),
  pdf = ge_pdf, cdf = ge_cdf, qdf = ge_qdf,
  par = c(1.5, 0.8)
)
```

```
fit <- mpse_impadapt2_censor(
  data = samp, cdf = ge_cdf, pdf = ge_pdf,
  start = c(1.0, 1.0), eval_time = 0.5
)
summary(fit)
```

`plot_impadapt2_sample` *Diagnostic Visualizations for Improved Adaptive Type-II Progressive Censoring*

Description

Generates diagnostic graphics (histogram, dot plot, empirical vs fitted survival curves, MCMC trace and autocorrelation plots).

Usage

```
plot_impadapt2_sample(x, ...)
```

Arguments

`x`	An object of class `"impadapt2_sample"`, `"impadapt2_mle"`, `"impadapt2_mpse"`, or `"impadapt2_bayes"`.
`...`	Additional graphical arguments.

Value

No return value, called for side effects (plotting).

Examples

```
set.seed(123)
ge_cdf <- function(x, par) (1 - exp(-par[2] * x))^par[1]
ge_pdf <- function(x, par) par[1] * par[2] * exp(-par[2] * x) * (1 - exp(-par[2] * x))^(par[1] - 1)
ge_qdf <- function(p, par) - (1 / par[2]) * log(1 - p^(1 / par[1]))

samp <- r_impadapt2_censor(
  n = 20, m = 10, T1 = 0.8, T2 = 2.0,
  R = c(rep(1, 10)),
  pdf = ge_pdf, cdf = ge_cdf, qdf = ge_qdf,
  par = c(1.5, 0.8)
)
plot(samp)
```

`r_impadapt2_censor` *Data Generation under Improved Adaptive Type-II Progressive Censoring Scheme*

Description

Generates random censored lifetime data under the Improved Adaptive Type-II Progressive Censoring Scheme (IAT-II PCS) as described by Dev and Chacko (2026) and Yan et al. (2021).

Usage

```
r_impadapt2_censor(
  n,
  m,
  T1,
  T2 = NULL,
  R,
  pdf = NULL,
  cdf = NULL,
  qdf = NULL,
  par = NULL,
  seed = NULL,
  lower = 1e-07,
  upper = 100000
)
```

Arguments

`n`	Integer, total number of units placed on test (n >= 1).
`m`	Integer, pre-fixed target number of failures (1 <= m <= n).
`T1`	Numeric, first pre-fixed threshold time point (T1 > 0).
`T2`	Numeric or NULL, second pre-fixed threshold time point (T2 > T1). If NULL, defaults to Inf.
`R`	Numeric vector of length m, pre-fixed progressive censoring scheme satisfying sum(R) + m = n.
`pdf`	Function (optional), user-supplied probability density function pdf(x, par).
`cdf`	Function (optional), user-supplied cumulative distribution function cdf(x, par).
`qdf`	Function (optional), user-supplied quantile function qdf(p, par).
`par`	Numeric vector, true parameter values for the specified distribution.
`seed`	Optional integer, seed for random number generation.
`lower`	Numeric, lower bound for numerical quantile root finding (default 1e-7).
`upper`	Numeric, upper bound for numerical quantile root finding (default 1e5).

Value

An object of class "impadapt2_sample" containing:

data	Numeric vector of observed failure times up to test termination.
case	Character string indicating the realized censoring case ("Case I", "Case II", or "Case III").
d1	Number of failures observed at or before threshold time T1.
d2	Number of failures observed at or before threshold time T2.
D1	Value of D1 parameter for likelihood construction.
D2	Value of D2 parameter (total observed failures) for likelihood construction.
R_effective	Numeric vector of effective progressive censoring plan applied.
R_star	Number of remaining live units removed at experiment termination time T_star.
T_star	Terminal time of the experiment (X_m for Cases I and II; T2 for Case III).
T1	Threshold time T1.
T2	Threshold time T2.
n	Total sample size.
m	Target failure count.
R_initial	Initial pre-fixed progressive censoring plan.
par	True parameter values.

References

Dev, S. S., & Chacko, M. (2026). Statistical inference for generalized exponential distribution under improved adaptive Type-II progressive censoring. *Journal of the Iranian Statistical Society*, 25(2), 1-29. DOI: 10.22034/jirss.2026.2077492.1165.

Yan, L., Zhang, Q., & Dong, A. (2021). Inference for the Burr XII distribution based on improved adaptive progressive Type-II censoring. *Journal of Computational and Applied Mathematics*, 381, 113022. DOI: 10.1016/j.cam.2020.113022.

Balakrishnan, N., & Sandhu, R. (1995). A simple simulational algorithm for generating progressively Type-II censored samples. *The American Statistician*, 49(2), 229-230.

Examples

```
set.seed(123)
ge_cdf <- function(x, par) (1 - exp(-par[2] * x))^par[1]
ge_pdf <- function(x, par) par[1] * par[2] * exp(-par[2] * x) * (1 - exp(-par[2] * x))^(par[1] - 1)
ge_qdf <- function(p, par) - (1 / par[2]) * log(1 - p^(1 / par[1]))

res <- r_impadapt2_censor(
  n = 20, m = 10, T1 = 0.8, T2 = 2.0,
  R = c(rep(1, 10)),
  pdf = ge_pdf, cdf = ge_cdf, qdf = ge_qdf,
  par = c(1.5, 0.8)
)
print(res)
```

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