

# Package ‘tramnet’

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**Title** Penalized Transformation Models

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**Description** Partially penalized versions of specific transformation models implemented in package 'mlt'. Available models include a fully parametric version of the Cox model, other parametric survival models (Weibull, etc.), models for binary and ordered categorical variables, normal and transformed-normal (Box-Cox type) linear models, and continuous outcome logistic regression. Hyperparameter tuning is facilitated through model-based optimization functionalities from package 'mlrMBO'. The accompanying vignette describes the methodology used in 'tramnet' in detail. Transformation models and model-based optimization are described in Hothorn et al. (2019) <[doi:10.1111/sjos.12291](https://doi.org/10.1111/sjos.12291)> and Bischl et al. (2016) <[doi:10.48550/arXiv.1703.03373](https://doi.org/10.48550/arXiv.1703.03373)>, respectively.

**Depends** R (>= 3.5.0), tram (>= 1.4), CVXR (>= 1.8), mlrMBO (>= 1.1-2)

**Imports** mlt, basefun, sandwich, ParamHelpers, lhs, mlr, smooof, stats

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coef.tramnet	<i>coef method for class "tramnet"</i>
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---

### Description

coef method for class "tramnet"

### Usage

```
## S3 method for class 'tramnet'
coef(object, with_baseline = FALSE, tol = 1e-06, ...)
```

### Arguments

object	object of class "tramnet"
with_baseline	If TRUE, also prints coefficients for the baseline transformation
tol	tolerance when an estimate should be considered 0 and not returned (default: 1e-6)
...	Additional arguments to coef

**Value**

Numeric vector containing the model shift parameter estimates

**Author(s)**

Torsten Hothorn, Lucas Kook

---

coef.tramnet_Lm	<i>coef method for class "tramnet_Lm"</i>
-----------------	---

---

**Description**

coef method for class "tramnet\_Lm"

**Usage**

```
## S3 method for class 'tramnet_Lm'
coef(object, with_baseline = FALSE, tol = 1e-06,
      as.lm = FALSE, ...)
```

**Arguments**

object	object of class "tramnet_Lm"
with_baseline	If TRUE, also prints coefficients for the baseline transformation
tol	tolerance when an estimate should be considered 0 and not returned (default: 1e-6)
as.lm	If TRUE parameters are rescaled to the usual parametrization of lm
...	Additional arguments to coef

**Value**

Numeric vector containing the linear model shift parameter estimates

**Author(s)**

Torsten Hothorn, Lucas Kook

**Examples**

```
data(cars)
m0 <- Lm(dist ~ 1, data = cars)
x <- as.matrix(cars[, "speed", drop = FALSE])
mt <- tramnet(m0, x = x, alpha = 0, lambda = 0)
coef(mt)
coef(mt, with_baseline = TRUE)
coef(mt, as.lm = TRUE)
coef(lm(dist ~ speed, data = cars))
```

---

 cvl\_tramnet

*Cross validation for "tramnet" models*


---

### Description

k-fold cross validation for "tramnet" objects over a grid of the tuning parameters based on out-of-sample log-likelihood.

### Usage

```
cvl_tramnet(object, fold = 2, lambda = 0, alpha = 0, folds = NULL,
            fit_opt = FALSE)
```

### Arguments

object	object of class "tramnet"
fold	number of folds for cross validation
lambda	values for lambda to iterate over
alpha	values for alpha to iterate over
folds	manually specify folds for comparison with other methods
fit_opt	If TRUE, returns the full model evaluated at optimal hyper parameters

### Value

Returns out-of-sample logLik and coefficient estimates for corresponding folds and values of the hyperparameters as an object of class "cvl\_tramnet"

### Author(s)

Lucas Kook

### Examples

```
set.seed(241068)
if (require("survival") & require("TH.data")) {
  data("GBSG2", package = "TH.data")
  X <- 1 * matrix(GBSG2$horTh == "yes", ncol = 1)
  colnames(X) <- "horThyes"
  GBSG2$urv <- with(GBSG2, Surv(time, cens))
  m <- Coxph(surv ~ 1, data = GBSG2, log_first = TRUE)
  mt <- tramnet(model = m, x = X, lambda = 0, alpha = 0)
  mc <- Coxph(surv ~ horTh, data = GBSG2)
  cvl_tramnet(mt, fold = 2, lambda = c(0, 1), alpha = c(0, 1))
}
```

---

elnet_obj	<i>Elastic net objective function for model based optimization</i>
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---

**Description**

This function generates an objective function for model-based optimization based on the cross-validated log-likelihood of a tramnet model with an elastic net penalty. It is not intended to be called by the user directly, instead it will be given as an argument to [mbo\\_tramnet](#).

**Usage**

```
elnet_obj(object, minlambda = 0, maxlambda = 16, minalpha = 0,
          maxalpha = 1, folds, noisy = FALSE, fold)
```

**Arguments**

object	object of class tramnet
minlambda	minimum value for lambda (default: 0)
maxlambda	maximum value for lambda (default: 16)
minalpha	minimum value for alpha (default: 0)
maxalpha	maximum value for alpha (default: 1)
folds	self specified folds for cross validation (mainly for reproducibility and comparability purposes)
noisy	indicates whether folds for k-fold cross-validation should be random for each iteration, leading to a noisy objective function (default: FALSE)
fold	fold for cross validation

**Value**

Single objective function for model based optimization.

---

estfun.tramnet	<i>estfun method for class "tramnet"</i>
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---

**Description**

estfun method for class "tramnet" which computes the score contributions w.r.t. each model parameter.

**Usage**

```
## S3 method for class 'tramnet'
estfun(x, parm = coef(x, with_baseline =
  TRUE, tol = 0), w = NULL, newdata, ...)
```

**Arguments**

x	object of class "tramnet"
parm	parameters for evaluating the score
w	weights
newdata	data on which to compute the score contributions
...	additional arguments to estfun

**Value**

Matrix of score contributions w.r.t. model parameters evaluated at parm

**Author(s)**

Lucas Kook

---

lasso_obj	<i>Lasso objective function for model based optimization</i>
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---

**Description**

This function generates an objective function for model-based optimization based on the cross-validated log-likelihood of a tramnet model with a lasso penalty only. It is not intended to be called by the user directly, instead it will be given as an argument to [mbo\\_tramnet](#).

**Usage**

```
lasso_obj(object, minlambda = 0, maxlambda = 16, folds,
          noisy = FALSE, fold)
```

**Arguments**

object	object of class tramnet
minlambda	minimum value for lambda (default: 0)
maxlambda	maximum value for lambda (default: 16)
folds	self specified folds for cross validation (mainly for reproducibility and comparability purposes)
noisy	indicates whether folds for k-fold cross-validation should be random for each iteration, leading to a noisy objective function (default: FALSE)
fold	fold for cross validation

**Value**

Single objective function for model based optimization.

---

logLik.tramnet	<i>logLik method for class "tramnet"</i>
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**Description**

logLik method for class "tramnet"

**Usage**

```
## S3 method for class 'tramnet'
logLik(object, parm = coef(object, tol = 0,
  with_baseline = TRUE), w = NULL, newdata, ...)
```

**Arguments**

object	object of class "tramnet"
parm	parameters to evaluate the log likelihood at
w	weights
newdata	data to evaluate the log likelihood at
...	Additional arguments to logLik

**Value**

returns potentially weighted (w) log-likelihood based on object evaluated at parameters parm and data newdata

**Author(s)**

Lucas Kook, Torsten Hothorn

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mbo_recommended	<i>Fit recommended regularized tram based on model based optimization output</i>
-----------------	--

---

**Description**

Extracts the "optimal" tuning parameters from an object of class "MBOsingleObjResult" and fits the corresponding tramnet model

**Usage**

```
mbo_recommended(mbo_obj, m0, x, ...)
```

**Arguments**

mbo_obj	object return by mbo_tramnet
m0	null model of class "tram"
x	matrix of covariables
...	additional arguments to tramnet()

**Value**

Object of class "tramnet"

---

mbo_tramnet	<i>Model based optimization for regularized transformation models</i>
-------------	---

---

**Description**

Uses model based optimization to find the optimal tuning parameter(s) in a regularized transformation model based on cross-validated log-likelihoods. Here the tramnet package makes use of the mlrMBO interface for Bayesian Optimization in machine learning problems to maximize the cv-logLik as a black-box function of the tuning parameters alpha and lambda.

**Usage**

```
mbo_tramnet(object, fold = 2, n_design = 5, n_iter = 5,
  minlambda = 0, maxlambda = 16, minalpha = 0, maxalpha = 1,
  folds = NULL, learner = "regr.km", pred.type = "se",
  opt_crit = makeMBOInfillCritEI(), noisy = FALSE,
  obj_type = c("lasso", "ridge", "elnet"), verbose = TRUE, ...)
```

**Arguments**

object	object of class tramnet
fold	fold for cross validation
n_design	results in n_design times the number of tuning parameters rows for the initial design matrix based on a random latin hypercube design
n_iter	number of iterations in the model based optimization procedure
minlambda	minimum value for lambda (default: 0)
maxlambda	maximum value for lambda (default: 16)
minalpha	minimum value for alpha (default: 0)
maxalpha	maximum value for alpha (default: 1)
folds	self specified folds for cross validation (mainly for reproducibility and comparability purposes)
learner	type of learner used for the optimization (default: "regr.km")
pred.type	prediction type of the learner (default: "se")

opt_crit	optimization criterion, default: expected improvement
noisy	indicates whether folds for k-fold cross-validation should be random for each iteration, leading to a noisy objective function (default: FALSE)
obj_type	objective type, one of "lasso", "ridge" or "elnet"
verbose	toggle for a verbose output (default: TRUE)
...	additional arguments are ignored

**Value**

returns an object of class "MBOSingleObjResult" which is documented in [mbo](#)

---

plot.tramnet	<i>plot method for class "tramnet"</i>
--------------	--

---

**Description**

plot method for class "tramnet"

**Usage**

```
## S3 method for class 'tramnet'
plot(x, newdata, type = c("distribution", "survivor",
  "density", "logdensity", "hazard", "loghazard", "cumhazard", "quantile",
  "trafo"), q = NULL, prob = 1:(K - 1)/K, K = 50, col = rgb(0.1,
  0.1, 0.1), lty = 1, add = FALSE, ...)
```

**Arguments**

x	object of class "tramnet"
newdata	data used to predict and plot
type	type of plot produced
q	vector of quantiles
prob	vector of probabilities
K	number of data points to plot
col	see <a href="#">plot</a>
lty	see <a href="#">plot</a>
add	see <a href="#">plot</a>
...	additional options to plot

**Value**

None

**Author(s)**

Lucas Kook

---

plot_path	<i>Plot regularization paths for "prof_*" classes</i>
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---

### Description

Plot regularization paths and optionally log-likelihood trajectories of objects of class "prof\_alpha" and "prof\_lambda". Coefficient names are automatically added to the plot.

### Usage

```
plot_path(object, plot_logLik = FALSE, ...)
```

### Arguments

object	object of class "prof_alpha" or "prof_lambda"
plot_logLik	Whether logLik trajectory should be plotted (default: FALSE)
...	additional arguments to <code>plot</code>

### Value

None

### Author(s)

Lucas Kook

### Examples

```
library("tramnet")
if (require("survival") & require("penalized")) {
  data("nki70", package = "penalized")
  nki70$resp <- with(nki70, Surv(time, event))
  x <- scale(model.matrix(~ 0 + DIAPH3 + NUSAP1 + TSPYL5 + C20orf46, data = nki70))
  y <- Coxph(resp ~ 1, data = nki70, order = 10, log_first = TRUE)
  fit1 <- tramnet(y, x, lambda = 0, alpha = 1)
  pfl <- prof_lambda(fit1)
  plot_path(pfl)
  fit2 <- tramnet(y, x, lambda = 1, alpha = 1)
  pfa <- prof_alpha(fit2)
  plot_path(pfa)
}
```

---

predict.tramnet      *predict method for class "tramnet"*

---

**Description**

predict method for class "tramnet"

**Usage**

```
## S3 method for class 'tramnet'
predict(object, newdata = .get_tramnet_data(object),
  ...)
```

**Arguments**

object	object of class "tramnet"
newdata	data used for prediction
...	Additional arguments to predict.ctm

**Value**

Vector of predictions based on object evaluated at each row of newdata

**Author(s)**

Lucas Kook

---

print.summary.tramnet    *print summary method for class "tramnet"*

---

**Description**

print summary method for class "tramnet"

**Usage**

```
## S3 method for class 'summary.tramnet'
print(x, digits = max(3L, getOption("digits")) -
  3L), ...)
```

**Arguments**

x	object of class "tramnet"
digits	number of digits to print
...	additional arguments

**Value**

prints textual summary in the console and returns an invisible copy of the "tramnet" object

**Author(s)**

Lucas Kook

---

print.tramnet	<i>print method for class "tramnet"</i>
---------------	---

---

**Description**

print method for class "tramnet"

**Usage**

```
## S3 method for class 'tramnet'
print(x, ...)
```

**Arguments**

x	object of class "tramnet"
...	additional arguments to <a href="#">summary</a>

**Value**

prints textual summary in the console and returns an invisible copy of the "tramnet" object

**Author(s)**

Lucas Kook

---

prof_alpha	<i>Profiling tuning parameters</i>
------------	------------------------------------

---

**Description**

Computes the regularization path of all coefficients for a single tuning, alpha, parameter over a sequence of values.

**Usage**

```
prof_alpha(model, min_alpha = 0, max_alpha = 1, nprof = 5,
  as.lm = FALSE)
```

**Arguments**

model	model of class tramnet
min_alpha	minimal value of alpha (default = 0)
max_alpha	maximal value of alpha (default = 15)
nprof	number of profiling steps (default = 5)
as.lm	return scaled coefficients for class "tramnet_Lm"

**Value**

Object of class "prof\_alpha" which contains the regularization path of all coefficients and the log-likelihood over the mixing parameter alpha

**Author(s)**

Lucas Kook

**Examples**

```
library("tramnet")

if (require("survival") & require("penalized")) {
  data("nki70", package = "penalized")
  nki70$resp <- with(nki70, Surv(time, event))
  x <- scale(model.matrix(~ 0 + DIAPH3 + NUSAP1 + TSPYL5 + C20orf46, data = nki70))
  y <- Coxph(resp ~ 1, data = nki70, order = 10, log_first = TRUE)
  fit <- tramnet(y, x, lambda = 1, alpha = 1)
  pfa <- prof_alpha(fit)
  plot_path(pfa)
}
```

---

prof\_lambda

*Profiling tuning parameters*

---

**Description**

Computes the regularization path of all coefficients for a single tuning parameter, lambda, over a sequence of values.

**Usage**

```
prof_lambda(model, min_lambda = 0, max_lambda = 15, nprof = 5,
  as.lm = FALSE)
```

**Arguments**

model	model of class "tramnet"
min_lambda	minimal value of lambda (default = 0)
max_lambda	maximal value of lambda (default = 15)
nprof	number of profiling steps (default = 5)
as.lm	return scaled coefficients for class "tramnet_Lm"

**Value**

Object of class "prof\_lambda" which contains the regularization path of all coefficients and the log-likelihood over the penalty parameter lambda

**Author(s)**

Lucas Kook

**Examples**

```
library("tramnet")
if (require("survival") & require("penalized")) {
  data("nki70", package = "penalized")
  nki70$resp <- with(nki70, Surv(time, event))
  x <- scale(model.matrix(~ 0 + DIAPH3 + NUSAP1 + TSPYL5 + C20orf46, data = nki70))
  y <- Coxph(resp ~ 1, data = nki70, order = 10, log_first = TRUE)
  fit <- tramnet(y, x, lambda = 0, alpha = 1)
  pfl <- prof_lambda(fit)
  plot_path(pfl)
}
```

---

residuals.tramnet      *residuals method for class "tramnet"*

---

**Description**

residuals method for class "tramnet"

**Usage**

```
## S3 method for class 'tramnet'
residuals(object, parm = coef(object, tol = 0,
  with_baseline = TRUE), w = NULL, newdata, ...)
```

**Arguments**

object	object of class "tramnet"
parm	parameters to evaluate score at
w	weights
newdata	data to evaluate score at
...	additional arguments to residuals

**Value**

Returns a numeric vector of residuals for each row in newdata

**Author(s)**

Lucas Kook

---

ridge_obj	<i>Ridge objective function for model based optimization</i>
-----------	--

---

**Description**

This function generates an objective function for model-based optimization based on the cross-validated log-likelihood of a tramnet model with a ridge penalty only. It is not intended to be called by the user directly, instead it will be given as an argument to [mbo\\_tramnet](#).

**Usage**

```
ridge_obj(object, minlambda = 0, maxlambda = 16, folds,
          noisy = FALSE, fold)
```

**Arguments**

object	object of class tramnet
minlambda	minimum value for lambda (default: 0)
maxlambda	maximum value for lambda (default: 16)
folds	self specified folds for cross validation (mainly for reproducibility and comparability purposes)
noisy	indicates whether folds for k-fold cross-validation should be random for each iteration, leading to a noisy objective function (default: FALSE)
fold	fold for cross validation

**Value**

Single objective function for model based optimization.

---

simulate.tramnet      *simulate method for class "tramnet"*

---

**Description**

simulate method for class "tramnet"

**Usage**

```
## S3 method for class 'tramnet'  
simulate(object, nsim = 1, seed = NULL,  
  newdata = .get_tramnet_data(object), bysim = TRUE, ...)
```

**Arguments**

object	object of class "tramnet"
nsim	number of simulation
seed	random number generator seed
newdata	new data to simulate from
bysim	see <a href="#">simulate.ctm</a>
...	Additional arguments to simulate.ctm

**Value**

returns a list of data.frames containing parametric bootstrap samples based on the data supplied in newdata

**Author(s)**

Lucas Kook

---

summary.tramnet      *summary method for class "tramnet"*

---

**Description**

summary method for class "tramnet"

**Usage**

```
## S3 method for class 'tramnet'  
summary(object, ...)
```

**Arguments**

object            object of class "tramnet"  
 ...                additional arguments

**Value**

Returns an object of class "summary.tramnet" containing information about the model, optimization status, sparsity and tuning parameters

**Author(s)**

Lucas Kook

---

 tramnet

*Regularised Transformation Models*


---

**Description**

Partially penalized and constrained transformation models, including Cox models and continuous outcome logistic regression. The methodology is described in the tramnet vignette accompanying this package.

**Usage**

```
tramnet(model, x, lambda, alpha, constraints = NULL, ...)
```

**Arguments**

model            an object of class "tram" as returned by any of the modelling functions from package tram.  
 x                a numeric matrix, where each row corresponds to the same row in the data argument used to fit model  
 lambda          a positive penalty parameter for the whole penalty function  
 alpha          a mixing parameter (between zero and one) defining the fraction between absolute and quadratic penalty terms  
 constraints    an optional list containing a matrix of linear inequality constraints on the regression coefficients and a vector specifying the rhs of the inequality  
 ...             additional parameters to [psolve](#)

**Value**

An object of class "tramnet" with coef, logLik, summary, simulate, residuals and plot methods

**Author(s)**

Lucas Kook, Balint Tamasi, Sandra Sigfried

**Examples**

```
if (require("penalized") & require("survival")) {  
  ## --- Comparison with penalized  
  data("nki70", package = "penalized")  
  nki70$resp <- with(nki70, Surv(time, event))  
  x <- scale(model.matrix(~ 0 + DIAPH3 + NUSAP1 + TSPYL5 + C20orf46,  
                        data = nki70))  
  fit <- penalized(response = resp, penalized = x, lambda1 = 1, lambda2 = 0,  
                 standardize = FALSE, data = nki70)  
  y <- Coxph(resp ~ 1, data = nki70, order = 10, log_first = TRUE)  
  fit2 <- tramnet(y, x, lambda = 1, alpha = 1) ## L1 only  
  coef(fit)  
  coef(fit2)  
}
```

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