Package ‘TriDimRegression’

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**Title**  Bayesian Statistics for 2D/3D Transformations

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**License**  GPL-3

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https://alexander-pastukhov.github.io/tridim-regression/

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**Author**  Alexander (Sasha) Pastukhov [aut, cre] (<https://orcid.org/0000-0002-8738-8591>), Claus-Christian Carbon [aut] (<https://orcid.org/0000-0002-3446-9347>)}
TriDimRegression-package

Maintainer  Alexander (Sasha) Pastukhov <pastukhov.alexander@gmail.com>
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The 'TriDimRegression' package.
Description

Fits 2D and 3D geometric transformations. Provides posterior via Stan. Includes computation of LOO and WAIC information criteria, R-squared.

To fit transformation, call the main function either via a formula that specifies dependent and independent variables with the data table or by supplying two tables one containing all independent variables and one containing all dependent variables.

For the 2D data, you can fit "translation" (2 parameters for translation only), "euclidean" (4 parameters: 2 for translation, 1 for scaling, and 1 for rotation), "affine" (6 parameters: 2 for translation and 4 that jointly describe scaling, rotation and shear), or "projective" (8 parameters: affine plus 2 additional parameters to account for projection). For 3D data, you can fit "translation" (3 for translation only), "euclidean\_x", "euclidean\_y", "euclidean\_z" (5 parameters: 3 for translation scale, 1 for rotation, and 1 for scaling), "affine" (12 parameters: 3 for translation and 9 to account for scaling, rotation, and sheer), and "projective" (15 parameters: affine plus 3 additional parameters to account for projection). For details on transformation matrices and computation of scale and rotation parameters please see vignette("transformation_matrices", package = "TriDimRegression")

Once the data is fitted, you can extract the transformation coefficients via coef function and the matrix itself via transformation\_matrix. Predicted data, either based on the original data or on the new data, can be generated via predict. Bayesian R-squared can be computed with or without adjustment via R2 function. In all three cases, you have choice between summary (mean + specified quantiles) or full posterior samples. loo and waic provide corresponding measures that can be used for comparison via loo::loo\_compare() function.

Author(s)

Maintainer: Alexander (Sasha) Pastukhov <pastukhov.alexander@gmail.com> (ORCID)

Authors:

- Claus-Christian Carbon <ccc@experimental-psychology.com> (ORCID)

References


See Also

fit\_transformation fit\_transformation\_df tridim\_transformation vignette("transformation\_matrices", package = "TriDimRegression") vignette("calibration", package = "TriDimRegression") vignette("comparing\_faces", package = "TriDimRegression")

Examples

# Fitting via formula
euc2 <- fit\_transformation(depV1 + depV2 ~ indepV1 + indepV2, NakayaData, "euclidean")
aff2 <- fit\_transformation(depV1 + depV2 ~ indepV1 + indepV2, NakayaData, "affine")
CarbonExample1Data

Carbon, C. C. (2013), data set #1

Description

Example 1 from the domain of aesthetics to show how the method can be utilized for assessing the similarity of two portrayed persons, actually the Mona Lisa in the world famous Louvre version and the only recently re-discovered Prado version.

Usage

CarbonExample1Data

Format

A data frame with 36 observations on the following 4 variables:

- **depV1, depV2** numeric vectors, dependent variables
- **indepV1, indepV2** numeric vectors, independent variables

Source

doi:10.18637/jss.v052.c01
CarbonExample2Data  

**Description**

Example 2 originates from the area of geography and inspects the accuracy of different maps of the city of Paris which were created over the last 350 years as compared to a recent map.

**Usage**

CarbonExample2Data

**Format**

A data frame with 13 observations on the following 4 variables:

- **depV1, depV2** numeric vectors, dependent variables
- **indepV1, indepV2** numeric vectors, independent variables

**Source**

doi:10.18637/jss.v052.c01

CarbonExample3Data  

**Description**

Example 3 focuses on demonstrating how good a cognitive map recalculated from averaged cognitive distance data fits with a related real map.

**Usage**

CarbonExample3Data

**Format**

A data frame with 10 observations on the following 4 variables:

- **depV1, depV2** numeric vectors, dependent variables
- **indepV1, indepV2** numeric vectors, independent variables

**Source**

doi:10.18637/jss.v052.c01
coef.tridim_transformation

Posterior distributions for transformation coefficients in full or summarized form.

Description
Posterior distributions for transformation coefficients in full or summarized form.

Usage
## S3 method for class 'tridim_transformation'
coef(
  object,
  summary = TRUE,
  probs = c(0.055, 0.945),
  convert_euclidean = FALSE,
  ...
)

Arguments
  object          An object of class tridim_transformation.
  summary         Whether summary statistics should be returned instead of raw sample values. Defaults to TRUE
  probs           The percentiles used to compute summary, defaults to 89% credible interval.
  convert_euclidean Whether to convert matrix coefficients to scale(phi) and rotation(theta). Defaults to FALSE.
  ...             Unused

Value
If summary=FALSE, a list with matrix iterationsN x dimensionsN for each variable. If summary=TRUE, a data.frame with columns "dvindex" with mean for each dependent variable plus optional quantiles columns with names "dvindex_quantile".

Examples
euc2 <- fit_transformation(depV1+depV2~indepV1+indepV2,
data = NakayaData,
  transformation = 'euclidean')

# full posterior distribution
transform_posterior <- coef(euc2, summary=FALSE)

# coefficients' summary with 89% CI
EyegazeData

`coef(euc2)`

# scale and rotation coefficients
`coef(euc2, convert_euclidean=TRUE)`

---

**EyegazeData**  
*Eye gaze calibration data*

**Description**  
A dataset containing a monocular eye gaze recording with calibration sequence. Courtesy of Bamberger Baby Institut: BamBI.

**Usage**  
`EyegazeData`

**Format**  
A data frame with 365 rows and 6 variables:
- **time**  sample timestamp, in milliseconds
- **x, y**  recorded gaze, in internal eye tracker units
- **target_x, target_y**  location of the calibration target on the screen, in pixels
- **target**  index of the target within the sequence

**Source**  
https://www.uni-bamberg.de/entwicklungspsychologie/transfer/babyforschung-bambi/.

---

**Face3D_M010**  
*Face landmarks, male, #010*

**Description**  
Face landmarks, male, #010

**Usage**  
`Face3D_M010`

**Format**  
A data frame with 64 landmarks on the following 3 variables:
- **x, y, z**  numeric vectors, coordinates of face landmarks
Source

---

Face3D_M101 | Face landmarks, male, #101

Description
Face landmarks, male, #101

Usage
Face3D_M101

Format
A data frame with 64 landmarks on the following 3 variables:

- x, y, z numeric vectors, coordinates of face landmarks

Source

---

Face3D_M244 | Face landmarks, male, #244

Description
Face landmarks, male, #244

Usage
Face3D_M244

Format
A data frame with 64 landmarks on the following 3 variables:

- x, y, z numeric vectors, coordinates of face landmarks
Source


Face3D_M92

Face landmarks, male, #092

Description

Face landmarks, male, #092

Usage

Face3D_M92

Format

A data frame with 64 landmarks on the following 3 variables:

x, y, z numeric vectors, coordinates of face landmarks

Source


Face3D_W070

Face landmarks, female, #070

Description

Face landmarks, female, #070

Usage

Face3D_W070

Format

A data frame with 64 landmarks on the following 3 variables:

x, y, z numeric vectors, coordinates of face landmarks
### Face3D_W097

**Face landmarks, female, #097**

**Description**

Face landmarks, female, #097
d

**Usage**

Face3D_W097

**Format**

A data frame with 64 landmarks on the following 3 variables:

\[ x, y, z \] numeric vectors, coordinates of face landmarks

**Source**


### Face3D_W182

**Face landmarks, female, #182**

**Description**

Face landmarks, female, #182
d

**Usage**

Face3D_W182

**Format**

A data frame with 64 landmarks on the following 3 variables:

\[ x, y, z \] numeric vectors, coordinates of face landmarks

**Source**

Source

Face3D_W243  
Face landmarks, female, #243

Description
Face landmarks, female, #243

Usage
Face3D_W243

Format
A data frame with 64 landmarks on the following 3 variables:

\[ x, y, z \] numeric vectors, coordinates of face landmarks

Source

fit_transformation  
Fitting Bidimensional or Tridimensional Regression / Geometric Transformation Models via Formula.

Description
Fits Bidimensional or Tridimensional regression / geometric transformation models using Stan engine. The formula described dependent and independent numeric variables in the data. See also `fit_transformation_df`.

For the 2D data, you can fit "translation" (2 parameters for translation only), "euclidean" (4 parameters: 2 for translation, 1 for scaling, and 1 for rotation), "affine" (6 parameters: 2 for translation and 4 that jointly describe scaling, rotation and sheer), or "projective" (8 parameters: affine plus 2 additional parameters to account for projection).

For 3D data, you can fit "translation" (3 for translation only), "euclidean_x", "euclidean_y", "euclidean_z" (5 parameters: 3 for translation scale, 1 for rotation, and 1 for scaling), "affine" (12 parameters: 3 for translation and 9 to account for scaling, rotation, and sheer), and "projective" (15 parameters: affine plus 3 additional parameters to account for projection). transformations.

For details on transformation matrices and computation of scale and rotation parameters please see vignette("transformation_matrices", package = "TriDimRegression")
Usage

```r
## S3 method for class 'formula'
fit_transformation(
  formula, 
  data, 
  transformation, 
  priors = NULL, 
  chains = 1, 
  cores = NULL, 
  ... 
)
```

Arguments

- `formula` a symbolic description of the model to be fitted in the format `Xdep + Ydep ~ Xind + Yind`, where `Xdep` and `Ydep` are dependent and `Xind` and `Yind` are independent variables.
- `data` a data frame containing variables for the model.
- `transformation` the transformation to be used: "translation" (both 2D and 3D), "euclidean" (2D), "euclidean_x", "euclidean_y", "euclidean_z" (3D, rotation about, respectively, x, y, and z axis), "affine" (2D and 3D), or "projective" (2D and 3D).
- `priors` named list of parameters for prior distributions of parameters `a` (translation, normal distribution), `b` (all other parameters, normal distribution), and `sigma` (residual variance, exponential). E.g., `list("a" = c(0, 10), "b" = c(0, 1), "sigma" = 1)`. Default priors are "a" = `c(0, max_absolute_difference_in_means(d, iv)) / 2)" and "sigma" = `1 * sd(dv)".
- `chains` Number of chains for sampling.
- `cores` Number of CPU cores to use for sampling. If omitted, all available cores are used.
- `...` Additional arguments passed to `sampling` function.

Value

A `tridim_transformation` object

See Also

- `fit_transformation_df`

Examples

```r
# Geometric transformations of 2D data
euc2 <- fit_transformation(depV1 + depV2 ~ indepV1 + indepV2, 
  NakayaData, 'euclidean')
aff2 <- fit_transformation(depV1 + depV2 ~ indepV1 + indepV2, 
```
prj2 <- fit_transformation(depV1 + depV2 ~ indepV1 + indepV2, NakayaData, 'projective')

# summary of transformation coefficients
coef(euc2)

# statistical comparison via WAIC criterion
loo::loo_compare(waic(euc2), waic(aff2), waic(prj2))

fit_transformation_df

Fitting Bidimensional or Tridimensional Regression / Geometric Transformation Models via Two Tables.

Description

Fits Bidimensional or Tridimensional regression / geometric transformation models using Stan engine. Two sets of coordinates are supplied via iv (for an independent variable) and dv (for the dependent one). The two tables must have the same dimensions (both N×2 or N×3).

For the 2D data, you can fit "translation" (2 for translation only), "euclidean" (4 parameters: 2 for translation, 1 for scaling, and 1 for rotation), "affine" (6 parameters: 2 for translation and 4 that jointly describe scaling, rotation and shear), or "projective" (8 parameters: affine plus 2 additional parameters to account for projection).

For 3D data, you can fit "translation" (3 for translation only), "euclidean_x", "euclidean_y", "euclidean_z" (5 parameters: 3 for translation scale, 1 for rotation, and 1 for scaling), "affine" (12 parameters: 3 for translation and 9 to account for scaling, rotation, and shear), and "projective" (15 parameters: affine plus 3 additional parameters to account for projection), transformations.

For details on transformation matrices and computation of scale and rotation parameters please see vignette("transformation_matrices", package = "TriDimRegression")

Usage

fit_transformation_df(iv, dv, transformation, priors = NULL, chains = 1, cores = NULL, ...)

Arguments

iv a data frame containing independent variable, must by numeric only, N×2 or N×3.
dv a data frame containing dependent variable, must by numeric only, N×2 or N×3.
transformation the transformation to be used: "translation" (both 2D and 3D), "euclidean" (2D), "euclidean_x", "euclidean_y", "euclidean_z" (3D, rotation about, respectively, x, y, and z axis), "affine" (2D and 3D), or "projective" (2D and 3D).

priors named list of parameters for prior distributions of parameters a (translation, normal distribution), b (all other parameters, normal distribution), and sigma (residual variance, exponential). E.g. list("a" = c(0, 10), "b" = c(0, 1), "sigma" = 1). Default priors are "a" = c(0, max_absolute_difference_in_means(d, iv)) / 2), "b" = c(0, max_absolute_difference_in_means(d, iv)) / 2), "sigma" = 1 * sd(dv).

chains Number of chains for sampling.

cores Number of CPU cores to use for sampling. If omitted, all available cores are used.

... Additional arguments passed to sampling function.

Value
A tridim_transformation object

See Also
fit_transformation

Examples

# Geometric transformations of 2D data
euc2 <- fit_transformation_df(NakayaData[, 1:2], NakayaData[, 3:4], 'euclidean')
tr3 <- fit_transformation_df(Face3D_W070, Face3D_W097, transformation = 'translation')
Source

Friedman & Kohler (2003), data set #2

Description

Data from Friedman, A., & Kohler, B. (2003). Bidimensional regression: Assessing the configu-
ral similarity and accuracy of cognitive maps and other two-dimensional data sets. Psychological
Methods, 8(4), 468-491. DOI: 10.1037/1082-989X.8.4.468

Usage

FriedmanKohlerData2

Format

A data frame with 4 observations on the following 4 variables:

- **depV1, depV2** numeric vectors, dependent variables
- **indepV1, indepV2** numeric vectors, independent variables

Source

FriedmanKohlerData2

doi:10.1037/1082989X.8.4.468

is.tridim_transformation

Checks if argument is a tridim_transformation object

Description

Checks if argument is a tridim_transformation object

Usage

is.tridim_transformation(x)

Arguments

- x An R object

Value

Logical
### `loo.tridim_transformation`

*Computes an efficient approximate leave-one-out cross-validation via loo library. It can be used for a model comparison via `loo::loo_compare()` function.*

---

**Description**

Computes an efficient approximate leave-one-out cross-validation via loo library. It can be used for a model comparison via `loo::loo_compare()` function.

**Usage**

```r
## S3 method for class 'tridim_transformation'
loo(x, ...)
```

**Arguments**

- `x`: A `tridim_transformation` object
- `...`: unused

**Value**

A named list, see `loo::loo()` for details.

**Examples**

```r
euc2 <- fit_transformation(depV1+depV2~indepV1+indepV2, NakayaData, transformation = 'euclidean')
aff2 <- fit_transformation(depV1+depV2~indepV1+indepV2, NakayaData, transformation = 'affine')
loo::loo_compare(loo(euc2), loo(aff2))
```

---

**NakayaData**

*Nakaya (1997)*

**Description**


**Usage**

NakayaData
Format
A data frame with 19 observations on the following 4 variables:

- **depV1**, **depV2** numeric vectors, dependent variables
- **indepV1**, **indepV2** numeric vectors, independent variables

Source

---

**Description**
Posterior interval plots for key parameters. Uses bayesplot::mcmc_intervals.

**Usage**
```r
## S3 method for class 'tridim_transformation'
plot(x, convert_euclidean = FALSE, ...)
```

**Arguments**
- `x` A tridim_transformation object
- `convert_euclidean` Whether to convert matrix coefficients to scale(\(\phi\)) and rotation(\(\theta\)). Defaults to FALSE.
- `...` Extra parameters to be passed to bayesplot::mcmc_intervals()

**Value**
A ggplot object produced by bayesplot::mcmc_intervals()

**Examples**
euc2 <- fit_transformation(depV1+depV2~indepV1+indepV2,
data = NakayaData,
transformation = 'euclidean')

plot(euc2)

# same but for converted coefficients
plot(euc2, convert_euclidean=TRUE)
predict.tridim_transformation

Computes posterior samples for the posterior predictive distribution.

Description

Predicted values based on the bi/tridimensional regression model object.

Usage

## S3 method for class 'tridim_transformation'
predict(object, newdata = NULL, summary = TRUE, probs = NULL, ...)

Arguments

- **object**: An object of class `tridim_transformation`
- **newdata**: An optional two column data frame with independent variables. If omitted, the fitted values are used.
- **summary**: Whether summary statistics should be returned instead of raw sample values. Defaults to `TRUE`.
- **probs**: The percentiles used to compute summary, defaults to NULL (no CI).
- **...**: Unused

Value

If summary=FALSE, a numeric matrix iterationsN x observationsN x variablesN. If summary=TRUE, a data.frame with columns "dvindex" with mean for each dependent variable plus optional quantiles columns with names "dvindex_quantile".

See Also

`fit_transformation`

Examples

euc2 <- fit_transformation(depV1+depV2~indepV1+indepV2, NakayaData, transformation = 'euclidean')

# prediction summary
predictions <- predict(euc2)

# full posterior prediction samples
predictions <- predict(euc2, summary=FALSE)
print.tridim_transformation

Prints out tridim_transformation object

Description

Prints out tridim_transformation object

Usage

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

Arguments

x
A tridim_transformation object

... Unused

Value

Nothing, console output only.

Examples

euc2 <- fit_transformation(depV1+depV2~indepV1+indepV2,
                           data = NakayaData,
                           transformation = 'euclidean')
euc2

R2


Description


Usage

## S3 method for class 'tridim_transformation'
R2(object, summary = TRUE, probs = c(0.055, 0.945), ...)

R2
Arguments

object An object of class `tridim_transformation`
summary Whether summary statistics should be returned instead of raw sample values. Defaults to TRUE
probs The percentiles used to compute summary, defaults to 89% credible interval.

Value

vector of values or a data.frame with summary

Examples

euc2 <- fit_transformation(depV1+depV2~indepV1+indepV2, NakayaData, transformation = 'euclidean')
R2(euc2)

summary(euc2)
tridim_transformation-class

Class tridim_transformation.

Description

Geometric transformations fitted with the `fit_transformation` function represented as a `tridim_transformation` object with information about transformation, data dimension, call formula, and fitted `stanfit` object.

Details

See methods(class = "tridim_transformation") for an overview of available methods.

Slots

- `transformation` A string with the transformation name.
- `formula` A `formula` object.
- `Ndim` An integer with data dimension, either 2 or 3.
- `data` A list containing variables used for the sampling.
- `stanmodel` A `stanmodel` used for sampling.
- `stanfit` a `stanfit` object.

See Also

- `fit_transformation`

waic.tridim_transformation

Computes widely applicable information criterion (WAIC).

Description

Computes widely applicable information criterion via loo library. It can be used for a model comparison via `loo::loo_compare()` function.

Usage

```r
## S3 method for class 'tridim_transformation'
waic(x, ...)
```

Arguments

- `x` A `tridim_transformation` object
- `...` unused
Value

A named list, see `loo::waic()` for details.

Examples

euc2 <- fit_transformation(depV1+depV2~indepV1+indepV2,
NakayaData, transformation = 'euclidean')
aff2 <- fit_transformation(depV1+depV2~indepV1+indepV2,
NakayaData, transformation = 'affine')
loo::loo_compare(waic(euc2), waic(aff2))
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