Package 'npANCOVA'

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Title Nonparametric ANCOVA Methods

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Description Nonparametric methods for analysis of covariance (ANCOVA) are distribution-free and provide a flexible statistical framework for situations where the assumptions of parametric ANCOVA are violated or when the response variable is ordinal. This package implements several well-known nonparametric ANCOVA procedures, including Quade, Puri and Sen, McSweeney and Porter, Burnett and Barr, Hettmansperger and McKean, Shirley, and Puri-Sen-Harwell-Serlin. The package provides user-friendly functions to apply these methods in practice.

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URL https://github.com/Mina7Jahangiri7/npANCOVA

BugReports https://github.com/Mina7Jahangiri7/npANCOVA/issues

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Author Mina Jahangiri [aut, cre] (ORCID: <https://orcid.org/0000-0001-9119-7571>), Ali Taghavi Rad [aut] (ORCID: <https://orcid.org/0009-0007-5529-8712>), Keith Goldfeld [aut] (ORCID: <https://orcid.org/0000-0002-0292-8780>), Anoshirvan Kazemnejad [ctb] (ORCID: <https://orcid.org/0000-0002-0143-9635>), Shayan Mostafaei [ctb] (ORCID: <https://orcid.org/0000-0002-1966-1306>)

Maintainer Mina Jahangiri <minajahangiri984@gmail.com>

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Contents

`Burnett_Barr` *Burnett and Barr Method for Nonparametric ANCOVA*

Description

Implements the Burnett and Barr rank-based method for ANCOVA. This method is suitable for models with one response, one covariate, and one grouping variable.

Usage

```
Burnett_Barr(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate + group‘.

Value

A list containing the following components:

regression_equation The summary of the fitted linear model.

anova The ANOVA table from the fitted model.

data The original data frame with added columns for ranks.

References

Burnett TD, Barr DRJE, Measurement P. A nonparametric analogy of analysis of covariance. 1977;37(2):341-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35)
)

# 2. Run the Burnett and Barr method
results <- Burnett_Barr(
  formula = response ~ covariate1 + group,
  data = data
)

# 3. View the results
print(results)
print(results$anova)
```

`Harwell_Serlin` *Harwell and Serlin Method for Nonparametric ANCOVA*

Description

Performs the Harwell and Serlin method using ranked response and covariate variables.

Usage

```
Harwell_Serlin(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate1 + ... + group‘.

Value

A list containing the following components:

regression_equation The summary of the fitted linear model.

anova The ANOVA table from the fitted model.

statistics The Harwell-Serlin test statistic.

df The degrees of freedom for the test.

p_value The p-value of the test.

data The original data frame with added columns for ranks.

References

Harwell MR, Serlin RCJPB. An empirical study of a proposed test of nonparametric analysis of covariance. 1988;104(2):268.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Harwell and Serlin method
results <- Harwell_Serlin(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results$p_value)
print(paste("Statistic:", results$statistics,"df:", results$df, "P-value:", results$p_value))
```

Hettmansperger_McKean *Hettmansperger and McKean Method for ANCOVA*

Description

Applies rank-based residual analysis for ANCOVA. This method involves fitting a model of the response on the covariate, calculating residuals, ranking them, and then performing an ANOVA on the (weighted) ranked residuals.

Usage

```
Hettmansperger_McKean(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate1 + ... + group‘.

Value

A list containing the following components:

regression_equation_covariate The summary of the initial model fitting response on covariates.

regression_equation_residuals The summary of the model fitting weighted ranked residuals on the group.

anova The ANOVA table for the model based on weighted ranked residuals.

group_means A data frame of the mean of weighted ranked residuals for each group.

group_sds A data frame of the standard deviation of weighted ranked residuals for each group.

data The original data frame augmented with residuals, ranked residuals, and weighted ranked residuals.

References

Hettmansperger TP, McKean JWJT. A robust alternative based on ranks to least squares in analyzing linear models. 1977;19(3):275-84.

Hettmansperger TP, McKean JWJJotASA. A geometric interpretation of inferences based on ranks in the linear model. 1983;78(384):885-93.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Hettmansperger and McKean method
results <- Hettmansperger_McKean(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(results$anova)
```

McSweeny_Porter *McSweeny and Porter Method for Nonparametric ANCOVA*

Description

Performs rank-based ANCOVA with and without an interaction term between the covariates and the group.

Usage

```
McSweeny_Porter(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate1 + ... + group‘.

Value

A list containing the following components:

regression_equation_covariate Summary of the model with only covariates.

regression_equation_covariate_group Summary of the model with covariates and group main effects.

group_effect The result of an ANOVA test for group effect.

interaction_effect The result of an ANOVA test for interaction effect between group and covariate variables.

regression_equation_interaction Summary of the model including the interaction term.

data The original data frame with added columns for ranks.

References

McSweeney M, Porter AJOp. Small sample properties of nonparametric index of response and rank analysis of covariance. 1971;16.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the McSweeny and Porter method
results <- McSweeny_Porter(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(results$group_effect)
```

```
print(results$interaction_effect)
```

`Puri_Sen_MB` *Puri and Sen Method with Biased Variance-Covariance Matrix for Nonparametric ANCOVA: Multiple Covariates*

Description

Performs the Puri and Sen method for multiple covariates using a biased variance-covariance matrix.

Usage

```
Puri_Sen_MB(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate1 + ... + group‘.

Value

A list containing the following components:

residuals A vector of residuals for each group.

V The biased variance-covariance matrix.

inverse_V The inverse of the variance-covariance matrix.

L_statistic The Puri and Sen L-statistic.

df The degrees of freedom for the test.

p_value The corresponding p-value of the L-statistic.

data The original data frame with added columns for ranks.

References

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Puri and Sen (MB) method
results <- Puri_Sen_MB(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic,"df:", results$df, "P-value:", results$p_value))
```

`Puri_Sen_MU` *Puri and Sen Method with Unbiased Variance-Covariance Matrix for Nonparametric ANCOVA: Multiple Covariates*

Description

Performs the Puri and Sen method for multiple covariates using an unbiased variance-covariance matrix.

Usage

```
Puri_Sen_MU(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate1 + ... + group‘.

Value

A list containing the following components:

residuals A vector of residuals for each group.

V The unbiased variance-covariance matrix.

inverse_V The inverse of the variance-covariance matrix.

L_statistic The Puri and Sen L-statistic.

df The degrees of freedom for the test.

p_value The corresponding p-value of the L-statistic.

data The original data frame with added columns for ranks.

References

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Puri and Sen (MU) method
results <- Puri_Sen_MU(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic,"df:", results$df, "P-value:", results$p_value))
```

`Puri_Sen_OB` *Puri and Sen Method with Biased Variance-Covariance Matrix for Nonparametric ANCOVA: One Covariate*

Description

Performs the Puri and Sen method for a single covariate using a biased variance-covariance matrix.

Usage

```
Puri_Sen_OB(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate + group‘.

Value

A list containing the following components:

residuals A vector of residuals for each group.

V The biased variance-covariance matrix.

inverse_V The inverse of the variance-covariance matrix.

L_statistic The Puri and Sen L-statistic.

df The degrees of freedom for the test.

p_value The corresponding p-value of the L-statistic.

data The original data frame with added columns for ranks.

References

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35)
)

# 2. Run the Puri and Sen (OB) method
results <- Puri_Sen_OB(
  formula = response ~ covariate1 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic,"df:", results$df, "P-value:", results$p_value))
```

Puri_Sen_OU *Puri and Sen Method with Unbiased Variance-Covariance Matrix for Nonparametric ANCOVA: One Covariate*

Description

Performs the Puri and Sen method for a single covariate using an unbiased variance-covariance matrix.

Usage

```
Puri_Sen_OU(data, formula)
```

Arguments

data	A data frame containing the variables specified in the formula.
formula	An object of class "formula": a symbolic description of the model to be fitted. The structure should be ‘response ~ covariate + group‘.

Value

A list containing the following components:

residuals A vector of residuals for each group.

V The unbiased variance-covariance matrix.

inverse_V The inverse of the variance-covariance matrix.

L_statistic The Puri and Sen L-statistic.

df The degrees of freedom for the test.

p_value The corresponding p-value of the L-statistic.

data The original data frame with added columns for ranks.

References

Puri ML, Sen PKJAoMS. Analysis of covariance based on general rank scores. 1969;40(2):610-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35)
)

# 2. Run the Puri and Sen (OU) method
results <- Puri_Sen_OU(
  formula = response ~ covariate1 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$L_statistic,"df:", results$df, "P-value:", results$p_value))
```

Quade *Quade Method for Nonparametric ANCOVA*

Description

Performs Quade's ANCOVA using ranked variables and analysis of residuals. The method fits a linear model of the ranked response on the ranked covariates, and then performs an ANOVA on the residuals of that model.

Usage

```
Quade(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'.

Value

A list containing the following components:

regression_equation Summary of the linear model regressing the ranked response on the ranked covariates.

anova_summary The summary of the ANOVA model performed on the residuals.

group_means A data frame of the mean of residuals for each group.

group_sds A data frame of the standard deviation of residuals for each group.

regression_equation_residuals The summary of the model fitting residuals on the group.

data The original data frame augmented with ranked variables and residuals.

References

Quade DJJotASA. Rank analysis of covariance. 1967;62(320):1187-200.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)
```

```
# 2. Run the Quade method
results <- Quade(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(results$anova_summary)
```

`Shirley` *Shirley Method for Nonparametric ANCOVA*

Description

Calculates group and interaction effects based on ranked response and covariate variables using changes in R-squared values between models.

Usage

```
Shirley(data, formula)
```

Arguments

`data`	A data frame containing the variables specified in the formula.
`formula`	An object of class "formula": a symbolic description of the model to be fitted. The structure should be 'response ~ covariate1 + ... + group'.

Value

A list containing components related to the group and interaction effects, including:

statistics_group The test statistic for the main group effect.

p_value_group The p-value for the main group effect.

df_group Degrees of freedom for the group effect.

statistics_interaction The test statistic for the interaction effect.

p_value_interaction The p-value for the interaction effect.

df_interaction Degrees of freedom for the interaction effect.

regression_equation_covariate Summary of the model with only covariates.

regression_equation_covariate_group Summary of the model with covariates and group main effects.

regression_equation_interaction Summary of the model including the interaction term.

data The original data frame with added columns for ranks.

References

Burnett TD, Barr DRJE, Measurement P. A nonparametric analogy of analysis of covariance. 1977;37(2):341-8.

Olejnik SF, Algina JJER. A review of nonparametric alternatives to analysis of covariance. 1985;9(1):51-83.

Examples

```
# 1. Create a sample data frame
data <- data.frame(
  group = c(1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3),
  response = c(16, 60, 82, 126, 137, 44, 67, 87, 100, 142, 17, 28, 105, 149, 160),
  covariate1 = c(26, 10, 42, 49, 55, 21, 28, 5, 12, 58, 1, 19, 41, 48, 35),
  covariate2 = c(12, 21, 24, 29, 34, 17, 2, 40, 38, 36, 8, 1, 9, 28, 16)
)

# 2. Run the Shirley method
results <- Shirley(
  formula = response ~ covariate1 + covariate2 + group,
  data = data
)

# 3. View the results
print(results)
print(paste("Statistic:", results$statistics_group,
  "df_group:", results$df_group,
  "P-value:", results$p_value_group))

print(paste("Statistic:", results$statistics_interaction,
  "df_interaction:", results$df_interaction,
  "P-value:", results$p_value_interaction))
```

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