Package: pfclust (via r-universe)

May 25, 2026

Type Package

Title Power Fuzzy Clustering and Cluster-Wise Regression

Version 0.1.0

Description Implementations of Power Fuzzy Clustering (PFC) and Power Fuzzy Cluster-wise Regression (PFCR) for multivariate data. The package supports Minkowski distances, with the L1 case solved via iteratively re-weighted least squares and the case p > 1 solved via coordinate-wise root finding, as well as an adaptive, regularised Mahalanobis distance with per-cluster covariance matrices. Both plain fuzzy clustering and cluster-wise linear regression are provided. The corresponding paper can be found at Nguyen P.T., Tortora C., and Punzo A. (2026) <doi:10.1109/TFUZZ.2026.3683998>.

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Encoding UTF-8

Depends R (>= 3.5.0)

Imports stats

Suggests flexCWM

RoxygenNote 7.3.3

NeedsCompilation no

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Repository https://cran.r-universe.dev

Date/Publication 2026-04-28 20:46:09 UTC

RemoteUrl https://github.com/cran/pfclust

RemoteRef HEAD

RemoteSha 9261df9ff8022e6f470c39f9ce2348b130480282

Contents

PFC *Power Fuzzy Clustering*

Description

Clusters the rows of `Y` into `K` groups using Minkowski or adaptive regularised Mahalanobis distance.

Usage

```
PFC(
  Y,
  K,
  m = 2,
  q = 2,
  distance = "Minkowski",
  p = 2,
  alpha = 0.5,
  beta = 10^15,
  threshold = 0.01,
  max.iter = 100
)
```

Arguments

`Y`	An `n x dy` data frame or matrix of observations.
`K`	Number of clusters (positive integer).
`m`	Fuzzifier, must be strictly greater than 1. Default `2`.
`q`	Distance exponent, must be strictly greater than 0. Default `2`.
`distance`	Either `"Minkowski"` or `"Mahalanobis"`.
`p`	Minkowski exponent (`>= 1`). Ignored when `distance = "Mahalanobis"`. Default `2`.
`alpha`	Regularisation weight for the Mahalanobis covariance. Default `0.5`.
`beta`	Eigenvalue ratio bound for the Mahalanobis covariance. Default `1e15`.
`threshold`	Convergence tolerance. Default `0.01`.
`max.iter`	Maximum number of iterations. Default `100`.

Value

A list with elements `B` (or `C`) for cluster centres, `d` (distances), `p` (memberships), `JDF` (objective history), and `l` (hard labels). For Mahalanobis, also `rho` and `cov`.

References

P.T. Nguyen, C. Tortora, and A. Punzo. (2026) "Power fuzzy clustering: flexible distance metrics and inclusion of covariates". IEEE Transactions on Fuzzy Systems 10.1109/TFUZZ.2026.3683998

D. E. Gustafson and W. C. Kessel, "Fuzzy clustering with a fuzzy covariance matrix," in 1978 IEEE conference on decision and control including the 17th symposium on adaptive processes. IEEE, 1979, pp. 761–766.

Examples

```
Y <- iris[, 1:4]
l <- iris[, 5]

# --- 2a. Mahalanobis distance ---
resMahC <- PFC(Y, K = 3, distance = "Mahalanobis")
table(resMahC$l, l)
pairs(Y, col = resMahC$l)

# --- 2b. Minkowski distance (default p=2) ---
resMinC <- PFC(Y, K = 3)
table(resMinC$l, l)
pairs(Y, col = resMinC$l)

# --- 2c. Minkowski distance (p=1, Manhattan) ---
resMin1C <- PFC(Y, K = 3, p = 1)
table(resMin1C$l, l)
pairs(Y, col = resMin1C$l)
```

PFCR *Power Fuzzy Cluster-wise Regression*

Description

Fits K cluster-specific linear models $Y = XB_k + \varepsilon$, selecting an internal solver based on the chosen distance and exponent.

Usage

```
PFCR(
  X,
  Y,
  K,
  m = 2,
  q = 2,
  distance = "Minkowski",
  p = 2,
  alpha = 0.5,
  beta = 10^15,
```

```
  threshold = 0.01,
  max.iter = 100
)
```

Arguments

X	An n x dx data frame or matrix of covariates.
Y	An n x dy data frame or matrix of dependent variables.
K	Number of clusters (positive integer).
m	Fuzzifier, must be strictly greater than 1. Default 2.
q	Distance exponent, must be strictly greater than 0. Default 2.
distance	Either "Minkowski" or "Mahalanobis".
p	Minkowski exponent (>= 1). Ignored when distance = "Mahalanobis". Default 2.
alpha	Regularisation weight for the Mahalanobis covariance. Default 0.5.
beta	Eigenvalue ratio bound for the Mahalanobis covariance. Default 1e15.
threshold	Convergence tolerance on successive coefficient updates. Default 0.01.
max.iter	Maximum number of iterations. Default 100.

Value

A list with elements:

B Array of regression coefficients.

d Data frame of distances (n x K).

p Data frame of membership degrees (n x K).

JDF Vector of objective-function values per iteration.

l Hard cluster labels (length n).

rho, cov (Mahalanobis only) cluster proportions and covariance matrices.

References

P.T. Nguyen, C. Tortora, and A. Punzo. (2026) "Power fuzzy clustering: flexible distance metrics and inclusion of covariates". IEEE Transactions on Fuzzy Systems 10.1109/TFUZZ.2026.3683998

Examples

```
library(flexCWM)
data("students")
Y <- students[, 2:3]
X <- students[, 4]
l <- students[, 1]


# --- 1a. Mahalanobis distance (default m=2, q=2) ---
resMah <- PFCR(X, Y, K = 2, distance = "Mahalanobis")
```

```
table(resMah$l, l)

# --- 1b. Minkowski distance (default m=2, q=2, p=2) ---
resMin <- PFCR(X, Y, K = 2)
table(resMin$l, l)

# --- 1c. Mahalanobis with m=3, q=3 ---
resMah33 <- PFCR(X, Y, K = 2, m = 3, q = 3, distance = "Mahalanobis")
table(resMah33$l, l)

# --- Plots for the (m=3, q=3) Mahalanobis result ---
pp    <- apply(resMah33$p, 1, max)
color <- ifelse(resMah33$l == unique(resMah33$l)[1], "blue", "red")

plot(Y, col = color, pch = 16, cex = pp,
     main = "PFCR Mahalanobis (3,3)")

plot(X, Y[, 1], ylab = "HEIGHT", xlab = "HEIGHT.F",
     pch = 16, cex = pp, col = color,
     main = "PFCR Mahalanobis (3,3)")
abline(resMah33$B[1, 1, 1], resMah33$B[2, 1, 1], col = "blue", lwd = 2)
abline(resMah33$B[1, 1, 2], resMah33$B[2, 1, 2], col = "red",  lwd = 2)

plot(X, Y[, 2], ylab = "WEIGHT", xlab = "HEIGHT.F",
     pch = 16, cex = pp, col = color,
     main = "PFCR Mahalanobis (3,3)")
abline(resMah33$B[1, 2, 1], resMah33$B[2, 2, 1], col = "blue", lwd = 2)
abline(resMah33$B[1, 2, 2], resMah33$B[2, 2, 2], col = "red",  lwd = 2)
```

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