# Package: fcmfd (via r-universe)

May 23, 2026

**Type** Package

**Title** Fuzzy C-Means for Fuzzy Data

**Version** 0.1.1

**Description** Implements a fuzzy clustering approach for ordinal Likert-type data using triangular fuzzy numbers (TFNs). The package extends the classical fuzzy C-means algorithm to better handle uncertainty in ordinal scales and includes automatic selection of the number of clusters using the Xie-Beni validity index. References: Coppi, R., D'Urso, P., and Giordani, P. (2012), ``Fuzzy and possibilistic clustering for fuzzy data", <doi:10.1016/j.csda.2010.09.013>. Xie, X. L. and Beni, G. (1991), ``A validity measure for fuzzy clustering", <doi:10.1109/34.85677>.

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**Encoding** UTF-8

**LazyData** true

**Depends** R (>= 3.5)

**Imports** stats, graphics

**Suggests** knitr, rmarkdown, testthat (>= 3.0.0)

**VignetteBuilder** knitr

**Config/testthat/edition** 3

**RoxygenNote** 7.3.3

**NeedsCompilation** no

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

**Date/Publication** 2026-05-23 11:50:39 UTC

**RemoteUrl** https://github.com/cran/fcmfd

**RemoteRef** HEAD

**RemoteSha** 62465c786f01f5d2abbe2e46416f303c8b49e73f

# Contents



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`cluster_assignment` *Hard Cluster Assignment*

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## Description

Assigns each observation to the cluster with the highest membership value.

## Usage

```
cluster_assignment(object)
```

## Arguments

| | |
|---|---|
| `object` | An object of class "fcmTFN". |

## Value

A factor indicating cluster labels.

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`fcmTFN` *Fuzzy C-Means Clustering for Triangular Fuzzy Numbers*

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## Description

Performs fuzzy clustering on ordinal Likert-type data represented as triangular fuzzy numbers (TFNs).

## Usage

```
fcmTFN(
  data,
  type = "symmetric",
  option = "B",
  dictionary = NULL,
  k_values = 2:6,
  m = 2,
  epsilon = 1e-06,
  max_iter = 1000,
  verbose = TRUE
)
```

## Arguments

| | |
|---|---|
| data | A data.frame or matrix containing ordinal Likert-type responses. Rows represent observations (respondents) and columns represent variables (items or dimensions). All values must be integers within the range defined by the selected scale option. |
| type | A character string specifying the type of fuzzy dictionary to use. Must be one of "symmetric" for predefined symmetric triangular fuzzy numbers, or "asymmetric" for a user-defined custom dictionary. Defaults to "symmetric". |
| option | A character string indicating the Likert scale option. Must be one of "A" (5-point scale, 1–5), "B" (7-point scale, 1–7), "C" (10-point scale, 1–10), or "D" (11-point scale, 0–10). Defaults to "B". |
| dictionary | An optional numeric matrix with 3 columns (l, c, r) representing the lower bound, modal value, and upper bound of each triangular fuzzy number. Required when type = "asymmetric"; ignored when type = "symmetric". Defaults to NULL. |
| k_values | A numeric vector specifying the candidate numbers of clusters to evaluate. The algorithm runs independently for each value of k. Defaults to 2:6. |
| m | Fuzzifier parameter (m > 1) specifying the fuzzifier parameter, which controls the degree of membership overlap between clusters. Higher values produce softer partitions. Defaults to 2. |
| epsilon | A positive numeric value specifying the convergence tolerance. The algorithm stops when the change in the objective function between iterations falls below this threshold. Defaults to 1e-06. |
| max_iter | A positive integer specifying the maximum number of iterations allowed per run. If convergence is not reached within this limit, a warning is issued. Defaults to 1000. |
| verbose | A logical value. If TRUE, progress messages are printed to the console during execution, including iteration count and convergence status for each value of k. Defaults to TRUE. |

## Details

The function automatically determines the optimal number of clusters based on the Xie-Beni validity index.

## Value

An object of class ‘"fcmTFN"‘ and ‘"fcm"‘.

## References

Coppi, R., D'Urso, P., & Giordani, P. (2012). Fuzzy and possibilistic clustering for fuzzy data. <doi:10.1016/j.csda.2010.09.013>

Xie, X. L., & Beni, G. (1991). A validity measure for fuzzy clustering. <doi:10.1109/34.85677>

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# membership *Extract Membership Matrix*

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## Description

Returns the fuzzy membership matrix obtained from the Fuzzy C-Means clustering process.

## Usage

```
membership(object)
```

## Arguments

| | |
|---|---|
| object | An object of class "fcmTFN". |

## Value

A matrix where rows represent observations and columns represent clusters.

---

# plot_dictionary *Plot Fuzzy Dictionary*

---

## Description

Plots the triangular fuzzy numbers defining the Likert-scale dictionary.

## Usage

```
plot_dictionary(object)
```

### Arguments

| | |
|---|---|
| object | An object of class "fcmTFN". |

### Value

A plot showing triangular membership functions.

---

## plot_prototypes *Plot Cluster Prototypes*

---

### Description

Visualizes cluster prototypes as interval plots using triangular fuzzy numbers (l, c, r).

### Usage

```
plot_prototypes(
  object,
  cluster = 1,
  use_var_names = FALSE,
  var_names = NULL,
  ...
)
```

### Arguments

| | |
|---|---|
| object | An object of class "fcmTFN". |
| cluster | Integer cluster to plot. |
| use_var_names | Logical. |
| var_names | Optional variable names. |
| ... | Additional graphical parameters. |

### Value

Invisibly returns NULL.

## plot_xb *Plot Xie-Beni Index*

### Description

Plots the Xie-Beni validity index across candidate numbers of clusters.

### Usage

```
plot_xb(object, mark_optimal = TRUE, type = "b", ...)
```

### Arguments

| | |
|---|---|
| object | An object of class "fcmTFN". |
| mark_optimal | Logical. Whether to highlight the optimal k. |
| type | Plot type (default = "b"). |
| ... | Additional graphical parameters. |

### Value

Invisibly returns NULL.

## print_fcmTFN *Print Method for fcmTFN Objects*

### Description

Displays a concise summary of a fitted fuzzy C-means model using triangular fuzzy numbers.

### Usage

```
print_fcmTFN(x, ...)
```

### Arguments

| | |
|---|---|
| x | An object of class "fcmTFN". |
| ... | Additional arguments (not used). |

### Value

The input object (invisibly).

## prototype_matrix *Prototype Matrix Extraction*

### Description

Returns cluster prototypes as a readable matrix containing l, c, r values for each variable.

### Usage

```
prototype_matrix(object, use_var_names = FALSE, var_names = NULL)
```

### Arguments

| | |
|---|---|
| object | An object of class "fcmTFN". |
| use_var_names | Logical. |
| var_names | Optional variable names. |

### Value

A data.frame containing prototype values.

## sim_likert_0_10 *Simulated Likert Data (0–10 Scale)*

### Description

A synthetic dataset representing ordinal Likert-type responses measured on a 0–10 scale.

### Usage

```
sim_likert_0_10
```

### Format

A data.frame with 500 observations and 10 variables:

**life_satisfaction** Overall life satisfaction
**happiness** Self-reported happiness
**anxiety** Anxiety level
**depression** Depression level
**health** Self-rated health
**income_satisfaction** Income satisfaction
**job_satisfaction** Job satisfaction
**social_relationships** Social relationships quality
**trust_in_others** Trust in others
**future_expectations** Future expectations

### Details

The dataset is designed with an underlying cluster structure (low, medium, high profiles) to support clustering validation.

The dataset contains three latent groups representing different levels of well-being.

### Source

Simulated data

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`sim_likert7` *Simulated Likert 1–7 Survey Dataset*

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### Description

A simulated Likert-type dataset with three well-separated clusters. Designed for testing fuzzy clustering of ordinal data.

### Usage

```
sim_likert7
```

### Format

A data.frame with 300 rows and 12 variables:

**Q1** Likert response (1–7)

**Q2** Likert response (1–7)

**Q3** Likert response (1–7)

**Q4** Likert response (1–7)

**Q5** Likert response (1–7)

**Q6** Likert response (1–7)

**Q7** Likert response (1–7)

**Q8** Likert response (1–7)

**Q9** Likert response (1–7)

**Q10** Likert response (1–7)

**Q11** Likert response (1–7)

**Q12** Likert response (1–7)

### Details

The dataset contains responses measured on a 1–7 Likert scale across 12 variables.

The dataset was generated using three latent profiles centered approximately at:

• Low agreement ($\approx 2$) • Moderate agreement ($\approx 4$) • High agreement ($\approx 6$)

Each cluster contains 100 observations.

## Source

Simulated data generated for package examples.

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`summary.fcmTFN` *Summary for fcmTFN Objects*

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## Description

Displays a summary of the Fuzzy C-Means clustering results for triangular fuzzy numbers.

## Usage

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

## Arguments

| | |
|---|---|
| `object` | An object of class "fcmTFN". |
| `...` | Additional arguments (not used). |

## Value

Prints a formatted summary of the clustering result.

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