

# Package ‘spnn’

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**Type** Package

**Title** Scale Invariant Probabilistic Neural Networks

**Version** 1.2.1

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## Description

Scale invariant version of the original PNN proposed by Specht (1990) <doi:10.1016/0893-6080(90)90049-q> with the added functionality of allowing for smoothing along multiple dimensions while accounting for covariances within the data set. It is written in the R statistical programming language. Given a data set with categorical variables, we use this algorithm to estimate the probabilities of a new observation vector belonging to a specific category. This type of neural network provides the benefits of fast training time relative to backpropagation and statistical generalization with only a small set of known observations.

**License** GPL (>= 2)

**Imports** MASS (>= 3.1-20), Rcpp (>= 1.0.0)

**LinkingTo** Rcpp, RcppArmadillo

**RoxygenNote** 6.1.1

**NeedsCompilation** yes

**Repository** CRAN

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## Description

Scale invariant version of the original PNN proposed by Specht (1990) <doi:10.1016/0893-6080(90)90049-q> with the added functionality of allowing for smoothing along multiple dimensions while accounting for covariances within the data set. It is written in the R statistical programming language. Given a data set with categorical variables, we use this algorithm to estimate the probabilities of a new observation vector belonging to a specific category. This type of neural network provides the benefits of fast training time relative to backpropagation and statistical generalization with only a small set of known observations.

## Details

The package exports 4 main functions:

- [spnn.learn](#) Create or update a Scale Invariant Probabilistic Neural Network.
- [spnn.predict](#) Estimates the category probabilities of new observations using a fitted SPNN.
- [cspnn.learn](#) Create or update a Condensed Scale Invariant Probabilistic Neural Network.
- [cspnn.predict](#) Estimates the category probabilities of new observations using a fitted CSPNN.

## Author(s)

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## References

- [1] Specht, Donald F. "Probabilistic neural networks." Neural networks 3.1 (1990): 109-118.
- [2] Specht, Donald F. "Enhancements to probabilistic neural networks." Neural Networks, 1992.IJCNN., International Joint Conference on. Vol. 1. IEEE, 1992.
- [3] Ebrahimi, Romin "Scale Invariant Probabilistic Neural Networks." The University of Texas, 2018 <https://repositories.lib.utexas.edu/handle/2152/65166>

## See Also

[spnn.learn](#), [spnn.predict](#), [cspnn.learn](#), [cspnn.predict](#)

## Examples

```
library(spnn)
library(datasets)

data(iris)

# shuffle the iris data set
indexRandom <- sample(1:nrow(iris), size = nrow(iris), replace = FALSE)
```

```

# use 100 observations for training set
trainData <- iris[indexRandom[1:100],]

# use remaining observations for testing
testData <- iris[indexRandom[101:length(indexRandom)],]

# fit spnn
spnn <- spnn.learn(set = trainData, category.column = 5)

# estimate probabilities
predictions <- spnn.predict(nn = spnn, newData = testData[,1:4])

# reference matrix must be supplied
# this is not the optimal reference matrix
# this matrix is provided as a simple example
xr <- matrix(c(c(5.00, 3.41, 1.44, 0.24),
               c(5.88, 2.75, 4.23, 1.30),
               c(6.61, 2.97, 5.59, 2.01)),
             nrow = length(unique(trainData$Species)),
             ncol = ncol(trainData) - 1,
             byrow = TRUE)

# fit cspnn
cspnn <- cspnn.learn(set = trainData, xr = xr, category.column = 5)

# estimate probabilities
predictions <- cspnn.predict(nn = cspnn, newData = testData[,1:4])

```

---

cspnn.learn

*cspnn.learn*


---

## Description

Create or update a Condensed Scale Invariant Probabilistic Neural Network.

## Usage

```
cspnn.learn(set, nn, xr, sigma, category.column = 1)
```

## Arguments

|     |                                                                                                                                                                                                                                              |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| set | data.frame or matrix representing the training set. The first column (default category.column = 1) is used to define the category or class of each observation.                                                                              |
| nn  | (optional) A Condensed Scale Invariant Probabilistic Neural Network object. If provided, the training data set input is concatenated to the current training data set of the neural network. If not provided, a new CSPNN object is created. |

|                              |                                                                                                                                                                                                           |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>xr</code>              | The m by n reference matrix containing optimal parameters for probability estimation. Where m is the number of unique categories and n is the number of input factors used. This matrix must be provided. |
| <code>sigma</code>           | An n by n square matrix of smoothing parameters where n is the number of input factors. Defaults to using the covariance matrix of the training data set excluding the category.column.                   |
| <code>category.column</code> | The column number of category data. Default is 1.                                                                                                                                                         |

### Details

The function `cspnn.learn` creates a new Condensed Scale Invariant Probabilistic Neural Network with a given training data set or updates the training data of an existing CSPNN. It sets the parameters: `model`, `set`, `xr`, `category.column`, `categories`, `sigma`, `sigmaInverse`, `k`, and `n` for the CSPNN.

### Value

A trained Condensed Scale Invariant Probabilistic Neural Network (CSPNN)

### See Also

[spnn-package](#), [cspnn.predict](#), [iris](#)

### Examples

```
library(spnn)
library(datasets)

data(iris)

# shuffle the iris data set
indexRandom <- sample(1:nrow(iris), size = nrow(iris), replace = FALSE)

# use 100 observations for training set
trainData <- iris[indexRandom[1:100],]

# use remaining observations for testing
testData <- iris[indexRandom[101:length(indexRandom)],]

# reference matrix must be supplied
# this is not the optimal reference matrix
# this matrix is provided as a simple example
xr <- matrix(c(c(5.00, 3.41, 1.44, 0.24),
               c(5.88, 2.75, 4.23, 1.30),
               c(6.61, 2.97, 5.59, 2.01)),
             nrow = length(unique(trainData$Species)),
             ncol = ncol(trainData) - 1,
             byrow = TRUE)

# fit cspnn
cspnn <- cspnn.learn(set = trainData, xr = xr, category.column = 5)
```

```
# estimate probabilities
predictions <- cspnn.predict(nn = cspnn, newData = testData[,1:4])
```

---

|               |                      |
|---------------|----------------------|
| cspnn.predict | <i>cspnn.predict</i> |
|---------------|----------------------|

---

## Description

Estimates the category probabilities of new observations using a fitted CSPNN.

## Usage

```
cspnn.predict(nn, newData)
```

## Arguments

|         |                                                                                     |
|---------|-------------------------------------------------------------------------------------|
| nn      | A trained Condensed Scaled Invariant Probabilistic Neural Network.                  |
| newData | A matrix of new observations where each row represents a single observation vector. |

## Details

Given a trained Condensed Scale Invariant Probabilistic Neural Network and new data, the function `cspnn.predict` returns the category with the highest probability and the probability estimates for each category.

## Value

A list of the guessed categories and the probability estimates of each category.

## See Also

[spnn-package](#), [cspnn.learn](#), [iris](#)

## Examples

```
library(spnn)
library(datasets)

data(iris)

# shuffle the iris data set
indexRandom <- sample(1:nrow(iris), size = nrow(iris), replace = FALSE)

# use 100 observations for training set
trainData <- iris[indexRandom[1:100],]
```

```

# use remaining observations for testing
testData <- iris[indexRandom[101:length(indexRandom)],]

# reference matrix must be supplied
# this is not the optimal reference matrix
# this matrix is provided as a simple example
xr <- matrix(c(c(5.00, 3.41, 1.44, 0.24),
               c(5.88, 2.75, 4.23, 1.30),
               c(6.61, 2.97, 5.59, 2.01)),
             nrow = length(unique(trainData$Species)),
             ncol = ncol(trainData) - 1,
             byrow = TRUE)

# fit cspnn
cspnn <- cspnn.learn(set = trainData, xr = xr, category.column = 5)

# estimate probabilities
predictions <- cspnn.predict(nn = cspnn, newData = testData[,1:4])

```

---

spnn.learn

*spnn.learn*


---

## Description

Create or update a Scale Invariant Probabilistic Neural Network.

## Usage

```
spnn.learn(set, nn, sigma, category.column = 1)
```

## Arguments

|                 |                                                                                                                                                                                                                                   |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| set             | data.frame or matrix representing the training set. The first column (default category.column = 1) is used to define the category or class of each observation.                                                                   |
| nn              | (optional) A Scale Invariant Probabilistic Neural Network object. If provided, the training data set input is concatenated to the current training data set of the neural network. If not provided, a new SPNN object is created. |
| sigma           | An n by n square matrix of smoothing parameters where n is the number of input factors. Defaults to using the covariance matrix of the training data set excluding the category.column.                                           |
| category.column | The column number of category data. Default is 1.                                                                                                                                                                                 |

## Details

The function `spnn.learn` creates a new Scale Invariant Probabilistic Neural Network with a given training data set or updates the training data of an existing SPNN. It sets the parameters: model, set, category.column, categories, sigma, sigmaInverse, k, and n for the SPNN.

**Value**

A trained Scale Invariant Probabilistic Neural Network (SPNN)

**See Also**

[spnn-package](#), [spnn.predict](#), [iris](#)

**Examples**

```
library(spnn)
library(datasets)

data(iris)

# shuffle the iris data set
indexRandom <- sample(1:nrow(iris), size = nrow(iris), replace = FALSE)

# use 100 observations for training set
trainData <- iris[indexRandom[1:100],]

# use remaining observations for testing
testData <- iris[indexRandom[101:length(indexRandom)],]

# fit spnn
spnn <- spnn.learn(set = trainData, category.column = 5)

# estimate probabilities
predictions <- spnn.predict(nn = spnn, newData = testData[,1:4])
```

---

spnn.predict

*spnn.predict*

---

**Description**

Estimates the category probabilities of new observations using a fitted SPNN.

**Usage**

```
spnn.predict(nn, newData)
```

**Arguments**

|         |                                                                                     |
|---------|-------------------------------------------------------------------------------------|
| nn      | A trained Scaled Invariant Probabilistic Neural Network.                            |
| newData | A matrix of new observations where each row represents a single observation vector. |

**Details**

Given a trained Scale Invariant Probabilistic Neural Network and new data, the function `spnn.predict` returns the category with the highest probability and the probability estimates for each category.

**Value**

A list of the guessed categories and the probability estimates of each category.

**See Also**

[spnn-package](#), [spnn.learn](#), [iris](#)

**Examples**

```
library(spnn)
library(datasets)

data(iris)

# shuffle the iris data set
indexRandom <- sample(1:nrow(iris), size = nrow(iris), replace = FALSE)

# use 100 observations for training set
trainData <- iris[indexRandom[1:100],]

# use remaining observations for testing
testData <- iris[indexRandom[101:length(indexRandom)],]

# fit spnn
spnn <- spnn.learn(set = trainData, category.column = 5)

# estimate probabilities
predictions <- spnn.predict(nn = spnn, newData = testData[,1:4])
```

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