# Package ‘ivaBSS’

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**Description** Independent vector analysis (IVA) is a blind source separation (BSS) model where several datasets are jointly unmixed. This package provides several methods for the unmixing together with some performance measures. For details, see Anderson et al. (2011) <doi:10.1109/TSP.2011.2181836> and Lee et al. (2007) <doi:10.1016/j.sigpro.2007.01.010>.

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`ivaBSS-package` *Tools for Independent Vector Analysis*

---

## Description

Independent vector analysis (IVA) is a blind source separation (BSS) model where several datasets are jointly unmixed. This package provides several methods for the unmixing together with some performance measures. For details, see Anderson et al. (2011) <doi:10.1109/TSP.2011.2181836> and Lee et al. (2007) <doi:10.1016/j.sigpro.2007.01.010>.

## Details

The package contains tools for independent vector analysis. The main functions to perform IVA are `"IVANewton"` and `"fastIVA"`. `"NewtonIVA"` performs Newton update based IVA and `"fastIVA"` performs fixed-point iteration based IVA. Both of the algorithms have multiple options for source density models.

## Author(s)

Authors: Mika Sipilä, Klaus Nordhausen, Sara Taskinen

Maintainer: Mika Sipilä

## References

*Anderson, M., Adalı, T., & Li, X.-L. (2011). Joint blind source separation with multivariate Gaussian model: Algorithms and performance analysis. IEEE Transactions on Signal Processing, 60, 1672–1683. <doi:10.1109/TSP.2011.2181836>*

*Anderson, M. (2013). Independent vector analysis: Theory, algorithms, and applications. PhD dissertation, University of Maryland, Baltimore County.*

`avg_ISI` *Average Intersymbol Inference*

## Description

Calculates the average intersymbol inference for two sets of matrices.

## Usage

```
avg_ISI(W, A)
```

## Arguments

| | |
|---|---|
| `W` | Array of unmixing matrices with dimension `[P, P, D]`. |
| `A` | Array of true mixing matrices with dimension `[P, P, D]`. |

## Details

The function returns the average intersymbol inference for the set of estimated unmixing matrices and the set of true mixing matrices. The average ISI gets the value between 0 and 1, where 0 is the optimal result. The average ISI is calculated as the mean ISI over each dataset separately. The average ISI does not take the permutation of the estimated sources into account.

## Value

Numeric value between 0 and 1, where 0 is the optimal result indicating that the sources are separated perfectly in each dataset.

## Author(s)

Mika Sipilä

## References

*Anderson, M. (2013). Independent vector analysis: Theory, algorithms, and applications. PhD dissertation, University of Maryland, Baltimore County.*

## See Also

`joint_ISI`, `jbss_achieved`

### Examples

```
# Mixing matrices and unmixing matrices generated
# from standard normal distribution
P <- 4; D <- 4;
W <- array(rnorm(P * P * D), c(P, P, D))
A <- array(rnorm(P * P * D), c(P, P, D))

avg_ISI(W, A)

if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")
  avg_ISI(coef(res_G), A)
}
```

---

## coef.iva — *Coefficient of the Object of Class iva*

---

### Description

coef method for class "iva".

### Usage

```
## S3 method for class 'iva'
coef(object, which.dataset = NA, ...)
```

### Arguments

| | |
|---|---|
| object | an object of class "iva", usually the result of a call to NewtonIVA or fastIVA. |

`which.dataset` positive integer. Provides the index in case the unmixing matrix only for a specific data set is desired. Default is to return all unmixing matrices.

`...` further arguments are not used.

## Details

Returns the unmixing matrices for all datasets or only for the requested dataset.

## Value

Unmixing matrix or all unmixing matrices of the object of class `"iva"`. If a single unmixing matrix is requested, it is an array with dimension `[P, P]` and if all unmixing matrices are requested, it is an array with dimension `[P, P, D]`.

## Author(s)

Mika Sipilä

## See Also

`NewtonIVA`, `fastIVA`

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")


  # All D unmixing matrices
  coef(res_G)

  # The unmixing matrix for the second dataset
```

```
  coef(res_G, 2)
}
```

components.iva *Components of the Object of Class iva*

## Description

Returns the estimated source components of object of class "iva".

## Usage

```
components.iva(object, which.dataset = NA, ...)
```

## Arguments

| | |
|---|---|
| object | an object of class "iva", usually the result of a call to NewtonIVA or fastIVA. |
| which.dataset | positive integer. Provides the index in case the unmixing matrix only for a specific data set is desired. Default is to return all unmixing matrices. |
| ... | further arguments are not used. |

## Details

Returns the estimated source components for all datasets or only for the requested dataset.

## Value

Estimated source components for requested dataset or for all datasets of the object of class "iva". If a single dataset is requested, it is an array with dimension [P, N] and if all datasets are requested, it is an array with dimension [P, N, D].

## Author(s)

Mika Sipilä

## See Also

NewtonIVA, fastIVA

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
```

```
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")


  # Source estimates for all D datasets
  components.iva(res_G)

  # Source estimates for the second dataset
  components.iva(res_G, 2)
}
```

---

`fastIVA` *Fast Fixed-point IVA Algorithm*

---

## Description

The algorithm estimates the sources from multiple dependent datasets jointly using their observed mixtures. The estimation is done by maximizing the independence between the sources, when the estimated unmixing matrices are restricted to be orthogonal. The options for different source densities are provided.

## Usage

```
fastIVA(X, source_density="laplace_diag", student_df=1,
max_iter = 1024, eps = 1e-6, W_init = NA, verbose = FALSE)
```

## Arguments

| | |
|---|---|
| `X` | numeric data array containing the observed mixtures with dimension `[P, N, D]`, where `P` is the dimension of the observed dataset, `N` is the number of the observations and `D` is the number of the datasets. The number of datasets `D` should be at least 2. Missing values are not allowed. |
| `source_density` | string to determine which source density model should be used. The options are `"laplace_diag"`, `"student"` or `"entropic"`. For more information see the details section. |

| | |
|---|---|
| student_df | integer. The degree of freedom for multivariate Student's distribution. Used only if source_denisty = "student". |
| max_iter | positive integer, used to define the maximum number of iterations for algorithm to run. If max_iter is reached, the unmixing matrices of the last iteration are used. |
| eps | convergence tolerance, when the convergence measure is smaller than eps, the algorithm stops. |
| W_init | numeric array of dimension [P, P, D] containing initial unmixing matrices. If not set, initialized with identity matrices. |
| verbose | logical. If TRUE the convergence measure is printed during the learning process. |

## Details

The algorithm uses fixed-point iteration to estimate to estimate the multivariate source signals from their observed mixtures. The elements of the source signals, or the datasets, should be dependent of each other to achieve the estimates where the sources are aligned in same order for each dataset. If the datasets are not dependent, the sources can still be separated but not necessarily aligned. This algorithm restricts the estimates unmixing matrices to be orthogonal. For more of the fast fixed-point IVA algorithm, see Lee, I. et al (2007).

The source density model should be selected to match the density of the true source signals. When source_density = "laplace_diag", the multivariate Laplace source density model with diagonal covariance structure is used. When source_density = "entropic", the approximated entropy based source density model is used. For more about multivariate Laplace and entropic source density models, see Lee, I. et al (2007). When source_density = "student" the multivariate Student's source density model is used, for more see Liang, Y. et al (2013).

The algorithm assumes that observed signals are multivariate, i.e. the number of datasets D >= 2. The estimated signals are zero mean and scaled to unit variance.

## Value

An object of class "iva".

| | |
|---|---|
| S | The estimated source signals with dimension [P, N, D]. The estimated source signals are zero mean with unit variance. |
| W | The estimated unmixing matrices with dimension [P, P, D]. |
| W_whitened | The estimated unmixing matrices with dimension [P, P, D] for whitened data. |
| V | The whitening matrices with dimension [P, P, D]. |
| X_means | The means for each observed mixture with dimension [P, D]. |
| niter | The number of iterations that the algorithm did run. |
| converged | Logical value which tells if the algorithm converged. |
| source_density | The source density model used. |
| N | The number of observations. |
| D | The number of datasets. |
| P | The number of sources. |

| | |
|---|---|
| student_df | The degree of freedom for Student's source density model. |
| call | The function call. |
| DNAME | The name of the variable containing the observed mixtures. |

## Author(s)

Mika Sipilä

## References

*Lee, I., Kim, T., & Lee, T.-W. (2007). Fast fixed-point independent vector analysis algorithms for convolutive blind source separation. Signal Processing, 87, 1859–1871. <doi:10.1016/j.sigpro.2007.01.010>*

*Liang, Y., Chen, G., Naqvi, S., & Chambers, J. A. (2013). Independent vector analysis with multivariate Student's t-distribution source prior for speech separation. Electronics Letters, 49, 1035–1036. <doi:10.1049/el.2013.1999>*

## See Also

NewtonIVA

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 2; N <- 1000; D <- 5;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    S[i, , ] <- rmvl(N, rep(0, D), diag(D))
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res <- fastIVA(X)
}
```

## jbss_achieved *JBSS Achieved*

### Description

The function calculates if the joint blind source separation (JBSS) is achieved.

### Usage

```
jbss_achieved(W, A)
```

### Arguments

| | |
|---|---|
| W | Array of unmixing matrices with dimension [P, P, D]. |
| A | Array of true mixing matrices with dimension [P, P, D]. |

### Details

The function calculates if the joint blind source separation is achieved. JBSS is considered achieved when the the location of maximum absolute values of each row of gain matrix G[,,d] = W[,,d] %*% A[,,d] is unique within the dataset, but shared between the datasets 1, ...,D. The first indicates that the sources are separated within dataset and the second indicates that the estimated sources are aligned in same order for each dataset.

### Value

Logical. If TRUE the JBSS is considered achieved.

### Author(s)

Mika Sipilä

### References

*Anderson, M. (2013). Independent vector analysis: Theory, algorithms, and applications. PhD dissertation, University of Maryland, Baltimore County.*

### See Also

joint_ISI, avg_ISI

## Examples

```
# Mixing matrices and unmixing matrices generated
# from standard normal distribution
P <- 4; D <- 4;
W <- array(rnorm(P * P * D), c(P, P, D))
A <- array(rnorm(P * P * D), c(P, P, D))

jbss_achieved(W, A)

if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")
  jbss_achieved(coef(res_G), A)
}
```

---

`joint_ISI` *Joint Intersymbol Inference*

---

## Description

Calculates the joint intersymbol inference for two sets of matrices.

## Usage

```
joint_ISI(W, A)
```

## Arguments

| | |
|---|---|
| `W` | Array of unmixing matrices with dimension `[P, P, D]`. |
| `A` | Array of true mixing matrices with dimension `[P, P, D]`. |

### Details

The function returns the joint intersymbol inference for the set of estimated unmixing matrices and the set of true mixing matrices. The joint ISI gets the value between 0 and 1, where 0 is the optimal result. The joint ISI calculates the average intersymbol inference over each dataset as well as penalizes if the sources are not aligned in same order for each dataset.

### Value

Numeric value between 0 and 1, where 0 is the optimal result indicating that the sources are separated perfectly and aligned in same order in each dataset.

### Author(s)

Mika Sipilä

### References

*Anderson, M. (2013). Independent vector analysis: Theory, algorithms, and applications. PhD dissertation, University of Maryland, Baltimore County.*

### See Also

avg_ISI, jbss_achieved

### Examples

```
# Mixing matrices and unmixing matrices generated
# from standard normal distribution
P <- 4; D <- 4;
W <- array(rnorm(P * P * D), c(P, P, D))
A <- array(rnorm(P * P * D), c(P, P, D))

joint_ISI(W, A)

if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
```

```
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")
  joint_ISI(coef(res_G), A)
}
```

---

NewtonIVA *Newton Update Based IVA Algorithm*

---

## Description

The algorithm estimates the sources from multiple dependent datasets jointly using their observed mixtures. The estimation is done by maximizing the independence between the sources. The options for different source densities are provided.

## Usage

```
NewtonIVA(X, source_density="laplace", student_df=1,
init = "default", max_iter = 1024, eps = 1e-6, W_init = NA,
step_size=1, step_size_min = 0.1, alpha = 0.9, verbose = FALSE)
```

## Arguments

| | |
|---|---|
| X | numeric data array containing the observed mixtures with dimension [P, N, D], where P is the dimension of the observed dataset, N is the number of the observations and D is the number of the datasets. The number of datasets D should be at least 2. Missing values are not allowed. |
| source_density | string to determine which source density model should be used. The options are "laplace", "laplace_diag", "gaussian" or "student". For more information see the details section. |
| student_df | integer. The degree of freedom for multivariate Student's distribution. Used only if source_denisty = "student". |
| init | string, to determine how to initialize the algorithm. The options are "default", "IVA-G+fastIVA", "IVA-G", "fastIVA" or "none". For more information see the details section. |
| max_iter | positive integer, used to define the maximum number of iterations for algorithm to run. If max_iter is reached, the unmixing matrices of the last iteration are used. |
| eps | convergence tolerance, when the convergence measure is smaller than eps, the algorithm stops. |
| W_init | numeric array of dimension [P, P, D] containing initial unmixing matrices. If not set, initialized with identity matrices. |
| step_size | initial step size for Newton step, should be between 0 and 1, default is 1. |

| | |
|---|---|
| step_size_min | the minimum step size. |
| alpha | multiplier for how much to decrease step size when convergence is not getting smaller. |
| verbose | logical. If TRUE the convergence measure is printed during the learning process. |

### Details

The algorithm uses Newton update together with decoupling trick to estimate the multivariate source signals from their observed mixtures. The elements of the source signals, or the datasets, should be dependent of each other to achieve the estimates where the sources are aligned in same order for each dataset. If the datasets are not dependent, the sources can still be separated but not necessarily aligned. The algorithm does not assume the unmixing matrices to be orthogonal. For more of the nonorthogonal Newton update based IVA algorithm, see Anderson, M. et al (2011) and Anderson, M. (2013).

The source density model should be selected to match the density of the true source signals. When `source_density = "laplace"`, the multivariate Laplace source density model is used. This is the most flexible choice as it takes both second-order and higher-order dependence into account.

When `source_density = "laplace_diag"`, the multivariate Laplace source density model with diagonal covariance structure is used. Multivariate diagonal Laplace source density model should be considered only when the sources are mainly higher-order dependent. It works best when the number of sources is significantly less than the number of datasets.

When `source_density = "gaussian"` the multivariate Gaussian source density model is used. This is the superior choice in terms of computation power and should be used when the sources are mostly second-order dependent.

When `source_density = "student"` the multivariate Student's source density model is used. Multivariate Student's source density model should be considered only when the sources are mainly higher-order dependent. It works best when the number of sources is significantly less than the number of datasets.

The `init` parameter defines how the algorithm is initialized. When `init = "default"`, the default initialization is used. As default the algorithm is initialized using `init = "IVA-G+fastIVA"` when `source_density` is `"laplace"`, `"laplace_diag"` or `"student"`, and using `init = "none"` when `source_density = "gaussian"`.

When `init = "IVA-G+fastIVA"`, the algorithm is initialized using first the estimated unmixing matrices of IVA-G, which is `NewtonIVA` with `source_density = "gaussian"`, to initialize `fastIVA` algorithm. Then the estimated unmixing matrices `W` of `fastIVA` are used as initial unmixing matrices for `NewtonIVA`. IVA-G is used to solve the permutation problem of aligning the source estimates when ever the true sources are second-order dependent. If the true sources are not second-order dependent, `fastIVA` is used as backup as it solves the permutation problem more regularly than `NewtonIVA` when the sources are purely higher-order dependent. When the sources possess any second-order dependence, IVA-G also speeds the computation time up a lot. This option should be used whenever there is no prior information about the sources and `source_density` is either `"laplace"`, `"laplace_diag"` or `"student"`.

When `init = "IVA-G"`, the estimated unmixing matrices of IVA-G are used to initialize this algorithm. This option should be used if the true sources are expected to possess any second-order dependence and `source_density` is not `"gaussian"`.

When init = "fastIVA", the estimated unmixing matrices of fastIVA algorithm is used to initialize this algorithm. This option should be used if the true sources are expected to possess only higher-order dependence. For more details, see fastIVA.

When init = "none", the unmixing matrices are initialized randomly from standard normal distribution.

The algorithm assumes that observed signals are multivariate, i.e. the number of datasets D >= 2. The estimated signals are zero mean and scaled to unit variance.

## Value

An object of class "iva".

| | |
|---|---|
| S | The estimated source signals with dimension [P, N, D]. The estimated source signals are zero mean with unit variance. |
| W | The estimated unmixing matrices with dimension [P, P, D]. |
| W_whitened | The estimated unmixing matrices with dimension [P, P, D] for whitened data. |
| V | The whitening matrices with dimension [P, P, D]. |
| X_means | The means for each observed mixture with dimension [P, D]. |
| niter | The number of iterations that the algorithm did run. |
| converged | Logical value which tells if the algorithm converged. |
| source_density | The source density model used. |
| N | The number of observations. |
| D | The number of datasets. |
| P | The number of sources. |
| student_df | The degree of freedom for Student's source density model. |
| call | The function call. |
| DNAME | The name of the variable containing the observed mixtures. |

## Author(s)

Mika Sipilä

## References

*Anderson, M., Adalı, T., & Li, X.-L. (2011). Joint blind source separation with multivariate Gaussian model: Algorithms and performance analysis. IEEE Transactions on Signal Processing, 60, 1672–1683. <doi:10.1109/TSP.2011.2181836>*

*Anderson, M. (2013). Independent vector analysis: Theory, algorithms, and applications. PhD dissertation, University of Maryland, Baltimore County.*

*Liang, Y., Chen, G., Naqvi, S., & Chambers, J. A. (2013). Independent vector analysis with multivariate Student's t-distribution source prior for speech separation. Electronics Letters, 49, 1035–1036. <doi:10.1049/el.2013.1999>*

## See Also

fastIVA

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")
}
```

---

plot.iva *Plotting an Object of Class iva*

---

## Description

plot method for the class "iva".

## Usage

```
## S3 method for class 'iva'
plot(x, which.dataset = NA, which.source = NA,
type = "l", xlabs = c(), ylabs = c(), colors = c(),
oma = c(1, 1, 0, 0), mar = c(2, 2, 1, 1), ...)
```

## Arguments

| | |
|---|---|
| x | An object of class "iva", usually the result of a call to NewtonIVA or fastIVA. |
| which.dataset | Positive integer to determine which dataset is returned. If not set, returns all datasets. |

| | |
|---|---|
| which.source | Positive integer to determine which dataset is returned. If not set, returns all datasets. |
| type | 1-character string giving the type of plot desired. For details, see plot. |
| xlabs | Vector containing the labels for x-axis. |
| ylabs | Vector containing the labels for y-axis. |
| colors | Vector containing the colors for each plot. |
| oma | A vector of the form c(bottom, left, top, right) giving the size of the outer margins in lines of text. For more details, see par. |
| mar | A numerical vector of the form *c(bottom, left, top, right)* which gives the number of lines of margin to be specified on the four sides of the plot. For more details, see par. |
| ... | Further arguments passed to plot function. |

## Details

Plots either all estimated sources of the object of class "iva" or the estimates for specific dataset and/or source.

## Value

No return value, called for plotting the estimated sources of the object of class "iva".

## Author(s)

Mika Sipilä

## See Also

NewtonIVA, fastIVA

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
```

```
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")

  # Plot all estimated sources
  plot(res_G)

  # Plot the source estimates for the first dataset only
  plot(res_G, which.dataset = 1)

  # Plot the source estimates for the second source only
  plot(res_G, which.source = 2)

  # Plot the source estimate of the second dataset and third source
  plot(res_G, which.dataset = 2, which.source = 3, type = "p")

  # Plot all source estimates with custom colors and labels
  plot(res_G, col=c(rep(1, 4), rep(2, 4), rep(3, 4), rep(4, 4)),
      xlabs = c("Subject 1", "Subject 2", "Subject 3", "Subject 4"),
      ylabs = c("Channel 1", "Channel 2", "Channel 3", "Channel 4"))
}
```

---

predict.iva *Predict Method for Object of Class iva*

---

## Description

Predict the new source estimates best on fitted object of "iva" class.

## Usage

```
## S3 method for class 'iva'
predict(object, newdata, which.dataset = NA, ...)
```

## Arguments

| | |
|---|---|
| object | An object of class "iva", usually the result of a call to NewtonIVA or fastIVA. |
| newdata | A numeric data array containing new observed mixtures. Either with dimension [P, N, D] (if which.dataset = NA) or [P, N], where P is the number of sources, N is the number of observations and D is the number of datasets. |
| which.dataset | Positive integer to determine which dataset is returned. If not set, returns all datasets. |
| ... | further arguments are not used. |

## Details

The function calculates the source estimates for new observed mixtures based on the model fitted originally. The estimates are zero mean and scaled to unit variance.

## Value

Numeric array containing the estimated sources with dimension [P, N] if which.dataset is provided and with dimension [P, N, D] if which.dataset is not provided.

## Author(s)

Mika Sipilä

## See Also

NewtonIVA, fastIVA

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))
  sigmas <- list()

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    sigmas[[i]] <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), sigmas[[i]])
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")

  # Generate new observarions
  N_new <- 10
  S_new <- array(NA, c(P, N_new, D))
  for (i in 1:P) {
    S_new[i, , ] <- rmvl(N_new, rep(0, D), sigmas[[i]])
  }
  X_new <- array(NaN, c(P, N_new, D))
  for (d in 1:D) {
    X_new[, , d] <- A[, , d] %*% S_new[, , d]
  }

  # Get source estimates for the new observations
  pred <- predict(res_G, X_new)
```

```
  # Get source estimates for only the second dataset
  pred2 <- predict(res_G, X_new[, , 2], which.dataset = 2)
}
```

---

print.iva *Print an Object of Class iva*

---

## Description

`print` method for the class `"iva"`.

## Usage

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

## Arguments

| | |
|---|---|
| `x` | An object of class `"iva"`, usually the result of a call to `NewtonIVA` or `fastIVA`. |
| `...` | Further arguments are not used. |

## Details

The function prints all information of `"iva"` object, except the estimated source signals.

## Value

No return value, called for printing information of the object of class `"iva"`.

## Author(s)

Mika Sipilä

## See Also

`NewtonIVA`, `fastIVA`

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }
```

```
  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")
  print(res_G)
}
```

---

`summary.iva` *Summarize an Object of Class iva*

---

## Description

`summary` method for the class `"iva"`.

## Usage

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

## Arguments

| | |
|---|---|
| `object` | An object of class `"iva"`, usually the result of a call to `NewtonIVA` or `fastIVA`. |
| `...` | Further arguments are not used. |

## Details

The function print all the information of the `"iva"` object except the estimated sources and the estimated unmixing matrices.

## Value

No return value, called for summarizing the object of class `"iva"`.

## Author(s)

Mika Sipilä

## See Also

`NewtonIVA`, `fastIVA`

## Examples

```
if (require("LaplacesDemon")) {
  # Generate sources from multivariate Laplace distribution
  P <- 4; N <- 1000; D <- 4;
  S <- array(NA, c(P, N, D))

  for (i in 1:P) {
    U <- array(rnorm(D * D), c(D, D))
    Sigma <- crossprod(U)
    S[i, , ] <- rmvl(N, rep(0, D), Sigma)
  }

  # Generate mixing matrices from standard normal distribution
  A <- array(rnorm(P * P * D), c(P, P, D))

  # Generate mixtures
  X <- array(NaN, c(P, N, D))
  for (d in 1:D) {
    X[, , d] <- A[, , d] %*% S[, , d]
  }

  # Estimate sources and unmixing matrices
  res_G <- NewtonIVA(X, source_density = "gaussian")
  summary(res_G)
}
```

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