

Package ‘mrfse’

July 23, 2025

Title Markov Random Field Structure Estimator

Version 0.4.2

Date 2024-10-21

Description Three algorithms for estimating a Markov random field structure. Two of them are an exact version and a simulated annealing version of a penalized maximum conditional likelihood method similar to the Bayesian Information Criterion. These algorithms are described in Frondana (2016) <[doi:10.11606/T.45.2018.tde-02022018-151123](https://doi.org/10.11606/T.45.2018.tde-02022018-151123)>. The third one is a greedy algorithm, described in Bresler (2015) <[doi:10.1145/2746539.2746631](https://doi.org/10.1145/2746539.2746631)>.

License GPL (>= 3)

Maintainer Rodrigo Carvalho <rodrigorsdc@gmail.com>

LinkingTo Rcpp

Imports Rcpp

Depends gtools, Rfast

NeedsCompilation yes

Author Rodrigo Carvalho [aut, cre],
Florença Leonardi [rev, ths]

Repository CRAN

Date/Publication 2024-10-21 17:40:01 UTC

Contents

mrfse.ci	2
mrfse.ci.con	3
mrfse.ci.ncon	4
mrfse.create.sampler	5
mrfse.exact	6
mrfse.exact.con	7
mrfse.exact.ncon	8
mrfse.sa	9
mrfse.sa.con	10
mrfse.sa.ncon	11
mrfse.sample	12

Index**13**

mrfse.ci

*Bresler's non-binary Markov random field structure estimator***Description**

A greedy algorithm to estimate Markovian neighborhoods.

Usage

```
mrfse.ci(a_size, sample, tau, max_degree=ncol(sample)-1)
```

Arguments

a_size	Size of the alphabet.
sample	A integer-valued matrix. Each value must belong range 0 and a_size - 1. Matrix has dimension n x V, where n is number of samples and V is number of nodes.
tau	A hyperparameter. See references.
max_degree	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than ncol(sample).

Value

A list filled with estimated Markov neighborhood for each graph vertex

Author(s)

Rodrigo Carvalho

References

Guy Bresler. 2015. Efficiently Learning Ising Models on Arbitrary Graphs. In Proceedings of the forty-seventh annual ACM symposium on Theory of Computing (STOC '15). Association for Computing Machinery, New York, NY, USA, 771–782. DOI:<https://doi.org/10.1145/2746539.2746631>

Examples

```
library(mrfse)
a_size = c(0, 1)
s = matrix(sample(a_size, size=1000, replace=TRUE), ncol=5)
mrfse.ci(length(a_size), s, 0.2)
```

Description

A greedy algorithm to estimate Markovian neighborhoods.

Usage

```
mrfse.ci.con(a_size, sample, tau, max_degree=ncol(sample)-1)
```

Arguments

<code>a_size</code>	Size of the alphabet.
<code>sample</code>	A integer-valued matrix. Each value must belong range 0 and <code>a_size - 1</code> . Matrix has dimension $n \times V$, where n is number of samples and V is number of nodes.
<code>tau</code>	A hyperparameter. See references.
<code>max_degree</code>	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than <code>ncol(sample)</code> .

Value

A adjacency matrix of the estimated Markov random field graph.

Author(s)

Rodrigo Carvalho

References

Guy Bresler. 2015. Efficiently Learning Ising Models on Arbitrary Graphs. In Proceedings of the forty-seventh annual ACM symposium on Theory of Computing (STOC '15). Association for Computing Machinery, New York, NY, USA, 771–782. DOI:<https://doi.org/10.1145/2746539.2746631>

Examples

```
library(mrfse)
a_size = c(0, 1)
s = matrix(sample(a_size, size=1000, replace=TRUE), ncol=5)
mrfse.ci.con(length(a_size), s, 0.2)
```

`mrfse.ci.ncon`*Non-conservative approach for Bresler's non-binary estimator*

Description

A greedy algorithm to estimate Markovian neighborhoods.

Usage

```
mrfse.ci.ncon(a_size, sample, tau, max_degree=ncol(sample)-1)
```

Arguments

<code>a_size</code>	Size of the alphabet.
<code>sample</code>	A integer-valued matrix. Each value must belong range 0 and <code>a_size - 1</code> . Matrix has dimension $n \times V$, where n is number of samples and V is number of nodes.
<code>tau</code>	A hyperparameter. See references.
<code>max_degree</code>	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than <code>ncol(sample)</code> .

Value

A adjacency matrix of the estimated Markov random field graph.

Author(s)

Rodrigo Carvalho

References

Guy Bresler. 2015. Efficiently Learning Ising Models on Arbitrary Graphs. In Proceedings of the forty-seventh annual ACM symposium on Theory of Computing (STOC '15). Association for Computing Machinery, New York, NY, USA, 771–782. DOI:<https://doi.org/10.1145/2746539.2746631>

Examples

```
library(mrfse)
a_size = c(0, 1)
s = matrix(sample(a_size, size=1000, replace=TRUE), ncol=5)
mrfse.ci.ncon(length(a_size), s, 0.2)
```

`mrfse.create.sampler` *Create a sampler for Markov random field.*

Description

Create a sampler for Markov random field from a DAG

Usage

```
mrfse.create.sampler(dag_adj, A)
```

Arguments

<code>dag_adj</code>	An direct acyclic graph adjacency matrix
<code>A</code>	Size of alphabet

Value

A list filled with the following components:

`neigh`: A list of neighborhood. For each `i`, `neigh[[i]]` is a markovian neighborhood of vertex `i`

`probs`: A list of probabilities. For each `i`, `probs[[i]]` is matrix of probabilities of vertex `i` given your markovian neighborhood. Those probabilities will be used to generate a sample.

`moral_adj`: moral graph of `adj_dag`

`topol_sort`: topological sort of `adj_dag`

`num_nodes`: number of nodes de `adj_dag`

`A`: alphabet size

Author(s)

Rodrigo Carvalho

Examples

```
library(mrfse)
adj = matrix(c(0, 1, 0, 0, 0, 0, 0, 1, 0), byrow=TRUE, ncol=3)
mrfse.create.sampler(adj, 3)
```

mrfse.exact

A Markov random field structure estimator

Description

A penalized likelihood BIC-based to estimate Markovian neighborhoods.

Usage

```
mrfse.exact(a_size, sample, c, max_neigh= ncol(sample) - 1)
```

Arguments

a_size	Size of the alphabet.
sample	A integer-valued matrix. Each value must belong range 0 and a_size - 1. Matrix has dimension n x V, where n is number of samples and V is number of nodes.
c	The penalization constant. Must be positive.
max_neigh	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than ncol(sample).

Value

A list filled with estimated Markov neighborhood for each graph vertex

Author(s)

Rodrigo Carvalho

References

FRONDANA, Iara Moreira. *Model selection for discrete Markov random fields on graphs*. São Paulo : Instituto de Matemática e Estatística, University of São Paulo, 2016. Doctoral Thesis in Estatística. <doi:10.11606/T.45.2018.tde-02022018-151123> http://www.teses.usp.br/teses/disponiveis/45/45133/tde-02022018-151123/publico/tese_Iara_Frondana.pdf

Examples

```
library(mrfse)
a_size = c(0, 1)
s = matrix(sample(a_size, size=1000, replace=TRUE), ncol=5)
mrfse.exact(length(a_size), s, 1.0)
```

mrfse.exact.con*Conservative approach for Frondana's mrfse*

Description

Conservative construction of the estimated Markov random field graph.

Usage

```
mrfse.exact.con(a_size, sample, c, max_neigh = ncol(sample) - 1)
```

Arguments

a_size	Size of the alphabet.
sample	A integer-valued matrix. Each value must belong range 0 and a_size - 1. Matrix has dimension n x V, where n is number of samples and V is number of nodes.
c	The penalization constant. Must be positive.
max_neigh	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than ncol(sample).

Value

A adjacency matrix of the estimated Markov random field graph.

Author(s)

Rodrigo Carvalho

References

FRONDANA, Iara Moreira. *Model selection for discrete Markov random fields on graphs*. São Paulo : Instituto de Matemática e Estatística, University of São Paulo, 2016. Doctoral Thesis in Estatística. <doi:10.11606/T.45.2018.tde-02022018-151123> http://www.teses.usp.br/teses/disponiveis/45/45133/tde-02022018-151123/publico/tese_Iara_Frondana.pdf

Examples

```
library(mrfse)
a = c(0, 1)
s = matrix(sample(a, size=1000, replace=TRUE), ncol=5)
mrfse.exact.con(length(a), s, 1.0)
```

mrfse.exact.ncon

Non-conservative approach for Frondana's mrfse

Description

Conservative construction of the estimated Markov random field graph.

Usage

```
mrfse.exact.ncon(a_size, sample, c, max_neigh = ncol(sample) - 1)
```

Arguments

a_size	Size of the alphabet.
sample	A integer-valued matrix. Each value must belong range 0 and a_size - 1. Matrix has dimension n x V, where n is number of samples and V is number of nodes.
c	The penalization constant. Must be positive.
max_neigh	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than ncol(sample).

Value

A adjacency matrix of the estimated Markov random field graph.

Author(s)

Rodrigo Carvalho

References

FRONDANA, Iara Moreira. *Model selection for discrete Markov random fields on graphs*. São Paulo : Instituto de Matemática e Estatística, University of São Paulo, 2016. Doctoral Thesis in Estatística. <doi:10.11606/T.45.2018.tde-02022018-151123> http://www.teses.usp.br/teses/disponiveis/45/45133/tde-02022018-151123/publico/tese_Iara_Frondana.pdf

Examples

```
library(mrfse)
a = c(0, 1)
s = matrix(sample(a, size=1000, replace=TRUE), ncol=5)
mrfse.exact.ncon(length(a), s, 1.0)
```

mrfse.sa	<i>A Markov random field structure estimator using simulated annealing approach</i>
----------	---

Description

A penalized likelihood BIC-based to estimate Markovian neighborhoods.

Usage

```
mrfse.sa(a_size, sample, c, t0, iterations=1000, max_neigh=ncol(sample)-1)
```

Arguments

a_size	Size of the alphabet.
sample	A integer-valued matrix. Each value must belong range 0 and a_size - 1. Matrix has dimension n x V, where n is number of samples and V is number of nodes.
c	The penalization constant. Must be positive.
t0	Initial temperature
iterations	Number of simulated annealing iterations
max_neigh	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than ncol(sample).

Value

A list filled with estimated Markov neighborhood for each graph vertex

Author(s)

Rodrigo Carvalho

References

FRONDANA, Iara Moreira. *Model selection for discrete Markov random fields on graphs*. São Paulo : Instituto de Matemática e Estatística, University of São Paulo, 2016. Doctoral Thesis in Estatística. <doi:10.11606/T.45.2018.tde-02022018-151123> http://www.teses.usp.br/teses/disponiveis/45/45133/tde-02022018-151123/publico/tese_Iara_Frondana.pdf

Examples

```
library(mrfse)
a_size = c(0, 1)
s = matrix(sample(a_size, size=1000, replace=TRUE), ncol=5)
mrfse.sa(length(a_size), s, 1.0, 500, 1000)
```

mrfse.sa.con

Conservative approach for Frondana's mrfse using simulated annealing

Description

A penalized likelihood BIC-based to estimate Markovian neighborhoods.

Usage

```
mrfse.sa.con(a_size, sample, c, t0, iterations=1000, max_neigh=ncol(sample)-1)
```

Arguments

a_size	Size of the alphabet.
sample	A integer-valued matrix. Each value must belong range 0 and a_size - 1. Matrix has dimension n x V, where n is number of samples and V is number of nodes.
c	The penalization constant. Must be positive.
t0	Initial temperature
iterations	Number of simulated annealing iterations
max_neigh	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than ncol(sample).

Value

A adjacency matrix of the estimated Markov random field graph.

Author(s)

Rodrigo Carvalho

References

FRONDANA, Iara Moreira. *Model selection for discrete Markov random fields on graphs*. São Paulo : Instituto de Matemática e Estatística, University of São Paulo, 2016. Doctoral Thesis in Estatística. <doi:10.11606/T.45.2018.tde-02022018-151123> http://www.teses.usp.br/teses/disponiveis/45/45133/tde-02022018-151123/publico/tese_Iara_Frondana.pdf

Examples

```
library(mrfse)
a_size = c(0, 1)
s = matrix(sample(a_size, size=1000, replace=TRUE), ncol=5)
mrfse.sa.con(length(a_size), s, 1.0, 500, 1000)
```

mrfse.sa.ncon	<i>Non-conservative approach for Frondana's mrfse using simulated annealing</i>
---------------	---

Description

A penalized likelihood BIC-based to estimate Markovian neighborhoods.

Usage

```
mrfse.sa.ncon(a_size, sample, c, t0, iterations=1000, max_neigh=ncol(sample)-1)
```

Arguments

a_size	Size of the alphabet.
sample	A integer-valued matrix. Each value must belong range 0 and a_size - 1. Matrix has dimension n x V, where n is number of samples and V is number of nodes.
c	The penalization constant. Must be positive.
t0	Initial temperature
iterations	Number of simulated annealing iterations
max_neigh	The maximum length of a candidate Markovian neighborhood. Must be non-negative and less than ncol(sample).

Value

A adjacency matrix of the estimated Markov random field graph.

Author(s)

Rodrigo Carvalho

References

FRONDANA, Iara Moreira. *Model selection for discrete Markov random fields on graphs*. São Paulo : Instituto de Matemática e Estatística, University of São Paulo, 2016. Doctoral Thesis in Estatística. <doi:10.11606/T.45.2018.tde-02022018-151123> http://www.teses.usp.br/teses/disponiveis/45/45133/tde-02022018-151123/publico/tese_Iara_Frondana.pdf

Examples

```
library(mrfse)
a_size = c(0, 1)
s = matrix(sample(a_size, size=1000, replace=TRUE), ncol=5)
mrfse.sa.ncon(length(a_size), s, 1.0, 500, 1000)
```

mrfse.sample	<i>Generate a independent sample of a Markov random field</i>
--------------	---

Description

Generate a independent sample of a Markov random field according to the probabilities of the sampler.

Usage

```
mrfse.sample(sampler, n)
```

Arguments

sampler	A sampler created by <code>mrfse.create.sampler</code> function
n	Size of sample

Value

A matrix whose number of columns is the number of nodes. Each line is a single independent sample of Markov random field given by the probabilities of sampler.

Author(s)

Rodrigo Carvalho

Examples

```
library(mrfse)
adj = matrix(c(0, 1, 0, 0, 0, 0, 0, 1, 0), byrow=TRUE, ncol=3)
sampler = mrfse.create.sampler(adj, 3)
mrfse.sample(sampler, 3000)
```

Index

`mrfse.ci`, [2](#)
`mrfse.ci.con`, [3](#)
`mrfse.ci.ncon`, [4](#)
`mrfse.create.sampler`, [5](#)
`mrfse.exact`, [6](#)
`mrfse.exact.con`, [7](#)
`mrfse.exact.ncon`, [8](#)
`mrfse.sa`, [9](#)
`mrfse.sa.con`, [10](#)
`mrfse.sa.ncon`, [11](#)
`mrfse.sample`, [12](#)