

Package ‘spINAR’

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Type Package

Title (Semi)Parametric Estimation and Bootstrapping of INAR Models

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Description Semiparametric and parametric estimation of INAR models including a finite sample refinement (Faymonville et al. (2022) <[doi:10.1007/s10260-022-00655-0](https://doi.org/10.1007/s10260-022-00655-0)>) for the semiparametric setting introduced in Drost et al. (2009) <[doi:10.1111/j.1467-9868.2008.00687.x](https://doi.org/10.1111/j.1467-9868.2008.00687.x)>, different procedures to bootstrap INAR data (Jentsch, C. and Weiß, C.H. (2017) <[doi:10.3150/18-BEJ1057](https://doi.org/10.3150/18-BEJ1057)>) and flexible simulation of INAR data.

License GPL (>= 3)

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Depends R (>= 3.6.0)

Imports checkmate (>= 1.8.5), progress, stats

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URL <https://github.com/MFaymon/spINAR>

BugReports <https://github.com/MFaymon/spINAR/issues>

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spINAR-package	<i>(Semi)parametric estimation and bootstrapping of INAR models</i>
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Description

Semiparametric and parametric estimation of INAR models including a finite sample refinement for the semiparametric setting, different procedures to bootstrap INAR data and flexible simulation of INAR data.

Semiparametric INAR Model

The package provides a flexible simulation of INAR data by inserting a user-defined pmf argument in the `spinar_sim` function. Using `spinar_est`, it allows for semiparametric estimation of the INAR model along Drost et al. (2009) and additionally, it includes a small sample refinement `spinar_penal` (Faymonville et al., 2022) together with a validation of the upcoming penalization parameters (`spinar_penal_val`). Furthermore, it contains a semiparametric INAR bootstrap procedure implemented in `spinar_boot` (Jentsch and Weiß, 2017).

Parametric INAR Model

In addition to the semiparametric model, the package also allows for parametric simulation (`spinar_sim`), parametric estimation (`spinar_est_param`) and parametric bootstrapping (`spinar_boot`) of INAR data.

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References

Faymonville, M., Jentsch, C., Weiß, C.H. and Aleksandrov, B. (2022). "Semiparametric Estimation of INAR Models using Roughness Penalization". Statistical Methods & Applications. doi:10.1007/s10260022006550.

Jentsch, C. and Weiß, C. H. (2017), "Bootstrapping INAR Models". Bernoulli 25(3), pp. 2359–2408. doi:10.3150/18BEJ1057.

Drost, F., Van den Akker, R. and Werker, B. (2009), "Efficient estimation of auto-regression parameters and innovation distributions for semiparametric integer-valued AR(p) models". Journal of the Royal Statistical Society. Series B 71(2), pp. 467–485. doi:10.1111/j.14679868.2008.00687.x.

See Also

Useful links:

- <https://github.com/MFaymon/spINAR>
- Report bugs at <https://github.com/MFaymon/spINAR/issues>

spinar_boot

(Semi)parametric INAR bootstrap procedure

Description

INAR bootstrap procedures for the semiparametric and the parametric INAR setting, where the latter allows for moment- and maximum likelihood-based estimation and Poisson, geometrically and negative binomially distributed innovations.

Usage

```
spinar_boot(
  x,
  p,
  B,
  setting,
  type = "mom",
  distr = "poi",
  M = 100,
  level = 0.05,
  progress = TRUE
)
```

Arguments

x	[integer] vector with integer observations.
p	[integer(1)] order of the INAR model, where $p \in \{1, 2\}$.

B	[integer(1)] number of bootstrap repetitions.
setting	[string(1)] estimation setting $\in \{"sp", "p"\}$, where "sp" defines a semiparametric setting and "p" a parametric setting.
type	[string(1)] type of estimation $\in \{"mom", "ml"\}$, where "mom" (default) performs moment-based estimation and "ml" maximum likelihood-based estimation.
distr	[string(1)] parametric family of innovation distribution $\in \{"poi", "geo", "nb"\}$, where "poi" (default) denotes $Poi(\lambda)$, "geo" $Geo(\text{prob})$ and "nb" $NB(r, \text{prob})$ distributions.
M	[integer(1)] upper limit for the innovations.
level	[numeric(1)] level for the bootstrap confidence intervals (percentile interval and Hall's percentile interval (bootstrap-t-interval without studentization)).
progress	[logical(1)] Should a nice progress bar be shown? Turning it off, could lead to significantly faster calculation. Default is TRUE.

Value

[named list] with entries

`x_star` [matrix] of bootstrap observations with `length(x)` rows and B columns.

`parameters_star` [matrix] of bootstrap estimated parameters with B rows. If `setting = "sp"`, each row contains the estimated coefficients $\alpha_1, \dots, \alpha_p$ and the estimated entries of the pmf $\text{pmf}_0, \text{pmf}_1, \dots$ where pmf_i represents the probability of an innovation being equal to i . If `setting = "p"`, each row contains the estimated coefficients $\alpha_1, \dots, \alpha_p$ and the estimated parameter(s) of the innovation distribution.

`bs_ci_percentile` [named matrix] with the lower and upper bounds of the bootstrap percentile confidence intervals for each parameter in `parameters_star`.

`bs_ci_hall` [named matrix] with the lower and upper bounds of Hall's bootstrap percentile confidence intervals for each parameter in `parameters_star`.

Examples

```
# generate data
dat1 <- spinar_sim(n = 200, p = 1, alpha = 0.5,
  pmf = c(0.3, 0.3, 0.2, 0.1, 0.1))
dat2 <- spinar_sim(n = 200, p = 2, alpha = c(0.2, 0.3),
  pmf = dgeom(0:60, 0.5))

# semiparametric INAR(1) bootstrap
spinar_boot(x = dat1, p = 1, B = 50, setting = "sp")
```

```
# parametric Geo-INAR(2) bootstrap using moment-based estimation
spinar_boot(x = dat2, p = 2, B = 50, setting = "p", type = "mom", distr = "geo")
```

spinar_est

Semiparametric estimation of INAR models

Description

Semiparametric estimation of the autoregressive parameters and the innovation distribution of INAR(p) models, $p \in \{1, 2\}$. The estimation is conducted by maximizing the conditional likelihood of the model.

Usage

```
spinar_est(x, p)
```

Arguments

<code>x</code>	[integer] vector with integer observations.
<code>p</code>	[integer(1)] order of the INAR model, where $p \in \{1, 2\}$.

Value

Vector containing the estimated coefficients $\alpha_1, \dots, \alpha_p$ and the estimated entries of the pmf $\text{pmf}_0, \text{pmf}_1, \dots$ where pmf_i represents the probability of an innovation being equal to i .

Examples

```
# generate data
dat1 <- spinar_sim(n = 200, p = 1, alpha = 0.5,
  pmf = c(0.3, 0.3, 0.2, 0.1, 0.1))
dat2 <- spinar_sim(n = 200, p = 2, alpha = c(0.2, 0.3),
  pmf = c(0.25, 0.2, 0.15, 0.1, 0.1, 0.1, 0.1))

# semiparametric estimation of INAR(1) model
spinar_est(x = dat1, p = 1)
# semiparametric estimation of INAR(2) model
spinar_est(x = dat2, p = 2)
```

spinar_est_param	<i>Parametric estimation of INAR models</i>
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Description

Parametric estimation of the autoregressive parameters and the innovation distribution of INAR(p) models, $p \in \{1, 2\}$, with Poisson, geometrically or negative binomially distributed innovations. The estimation can either be moment- or maximum likelihood-based.

Usage

```
spinar_est_param(x, p, type, distr)
```

Arguments

<code>x</code>	[integer] vector with integer observations.
<code>p</code>	[integer(1)] order of the INAR model, where $p \in \{1, 2\}$.
<code>type</code>	[string(1)] type of estimation $\in \{"mom", "ml"\}$, where "mom" performs moment-based estimation and "ml" maximum likelihood-based estimation.
<code>distr</code>	[string(1)] parametric family of innovation distribution $\in \{'poi', 'geo', 'nb'\}$, where "poi" denotes $Poi(\lambda)$, "geo" $Geo(\text{prob})$ and "nb" $NB(r, \text{prob})$ distributions.

Value

Named vector containing the estimated coefficients $\alpha_1, \dots, \alpha_p$ and the estimated parameter(s) of the innovation distribution.

Examples

```
# generate data
# Poi-INAR(1) data
dat1 <- spinar_sim(n = 200, p = 1, alpha = 0.5, pmf = dpois(0:20, 1))
# Geo-INAR(2) data
dat2 <- spinar_sim(n = 200, p = 2, alpha = c(0.2, 0.3),
                  pmf = dgeom(0:60, 0.5))
# NB-INAR(1) data
dat3 <- spinar_sim(n = 200, p = 1, alpha = 0.5, pmf = dnbinom(0:40, 2, 2/3))

# moment-based parametric estimation of Poi-INAR(1) model
spinar_est_param(x = dat1, p = 1, type = "mom", distr = "poi")
# moment-based parametric estimation of Geo-INAR(2) model
spinar_est_param(x = dat2, p = 2, type = "mom", distr = "geo")
```

```
# maximum likelihood-based parametric estimation of NB-INAR(1) model
spinar_est_param(x = dat3, p = 1, type = "ml", distr = "nb")
```

spinar_penal

Penalized semiparametric estimation of INAR models

Description

Semiparametric penalized estimation of the autoregressive parameters and the innovation distribution of INAR(p) models, $p \in \{1, 2\}$. The estimation is conducted by maximizing the penalized conditional likelihood of the model. If both penalization parameters are set to zero, the function coincides to the `spinar_est` function of this package.

Usage

```
spinar_penal(x, p, penal1 = 0, penal2 = 0)
```

Arguments

<code>x</code>	[integer] vector with integer observations.
<code>p</code>	[integer(1)] order of the INAR model, where $p \in \{1, 2\}$.
<code>penal1</code>	L_1 penalization parameter (default value zero results in no L_1 penalization)
<code>penal2</code>	L_2 penalization parameter (default value zero results in no L_2 penalization)

Value

Vector containing the penalized estimated coefficients $\alpha_1, \dots, \alpha_p$ and the penalized estimated entries of the pmf $\text{pmf}_0, \text{pmf}_1, \dots$ where pmf_i represents the probability of an innovation being equal to i .

Examples

```
# generate data
dat1 <- spinar_sim(n = 50, p = 1, alpha = 0.5,
  pmf = c(0.3, 0.25, 0.2, 0.15, 0.1))

# penalized semiparametric estimation
spinar_penal(x = dat1, p = 1, penal1 = 0, penal2 = 0.1)
```

spinar_penal_val

Validated penalized semiparametric estimation of INAR models

Description

Semiparametric penalized estimation of the autoregressive parameters and the innovation distribution of INAR(p) models, $p \in \{1, 2\}$. The estimation is conducted by maximizing the penalized conditional likelihood of the model. Included is a possible validation of one or both penalization parameters. If no validation is wanted, the function coincides to the spinar_penal function of this package.

Usage

```
spinar_penal_val(
  x,
  p,
  validation,
  penal1 = NA,
  penal2 = NA,
  over = NA,
  folds = 10,
  init1 = 1,
  init2 = 1,
  progress = TRUE
)
```

Arguments

x	[integer] vector with integer observations.
p	[integer(1)] order of the INAR model, where $p \in \{1, 2\}$.
validation	[logical(1)] indicates whether validation is wanted.
penal1	[numeric(1)] L_1 penalization parameter. It will be ignored if validation = TRUE and over $\in \{\text{"both"}, \text{"L}_1\}$. It is mandatory if validation = FALSE.
penal2	[numeric(1)] L_2 penalization parameter. It will be ignored if validation = TRUE and over $\in \{\text{"both"}, \text{"L}_2\}$. It is mandatory if validation = FALSE.
over	[string(1)] validation over "both" penalization parameters or only over "L_1" or "L_2". It is mandatory if validation = TRUE, otherwise it will be ignored.
folds	[integer(1)] number of folds for (cross) validation.

init1	[numeric(1)] initial value for penal1 in validation. Default value is init1 = 1.
init2	[numeric(1)] initial value for penal2 in validation. Default value is init2 = 1
progress	[logical(1)] Should a nice progress bar be shown? Turning it off, could lead to significantly faster calculation. Default is TRUE.

Value

If validation = FALSE, the function returns a vector containing the penalized estimated coefficients $\alpha_1, \dots, \alpha_p$ and the penalized estimated entries of the pmf $\text{pmf}_0, \text{pmf}_1, \dots$ where pmf_i represents the probability of an innovation being equal to i .

If validation = TRUE, the function returns a named list, where the first entry contains the penalized estimated coefficients $\alpha_1, \dots, \alpha_p$ and the penalized estimated entries of the pmf $\text{pmf}_0, \text{pmf}_1, \dots$ where pmf_i represents the probability of an innovation being equal to i . The second (and if over = both also the third entry) contain(s) the validated penalization parameter(s).

Examples

```
# generate data
dat1 <- spinar_sim(n = 50, p = 1, alpha = 0.5,
                  pmf = c(0.3, 0.3, 0.2, 0.1, 0.1))

# penalized semiparametric estimation with validation over L1
spinar_penal_val(x = dat1, p = 1, validation = TRUE, penal2 = 0.1,
                 over = "L1")

# penalized semiparametric estimation with validation over both L1 and L2
spinar_penal_val(x = dat1, p = 1, validation = TRUE, over = "both")
```

spinar_sim	<i>Simulation of (semi)parametric integer autoregressive (INAR) models</i>
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Description

Generating INAR(p) observations, where $p \in \{1, 2\}$. It allows for general pmfs which can be generated parametrically or "manually" (semiparametrically).

Usage

```
spinar_sim(n, p, alpha, pmf, prerun = 500)
```

Arguments

n	[integer(1)] number of observations.
p	[integer(1)] lag of the INAR(p) model, where $p \in \{1, 2\}$.
alpha	[integer(p)] vector of INAR coefficients $\alpha_1, \dots, \alpha_p$.
pmf	[numeric] vector of probability mass function $\text{pmf}_0, \dots, \text{pmf}_k$ where pmf_i represents the probability of an innovation being equal to i .
prerun	[integer(1)] number of observations which are generated additionally and then omitted (to ensure stationarity).

Value

Vector with n INAR(p) observations.

Examples

```
# generate (semiparametrically) 100 INAR(1) observations with
# alpha_1 = 0.5 and a manually set pmf
spinar_sim(n = 100, p = 1, alpha = 0.5, pmf = c(0.3, 0.3, 0.2, 0.1, 0.1))

# generate 100 observations of an INAR(2) model with
# alpha_1 = 0.2, alpha_2 = 0.3 and Poi(1)-innovations
spinar_sim(n = 100, p = 2, alpha = c(0.2, 0.3), pmf = dpois(0:20, 1))
```

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