Package ‘PH1XBAR’

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Type Package

Title Phase I Shewhart X-Bar Chart

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Description The purpose of 'PH1XBAR' is to build a Phase I Shewhart control chart for the basic Shewhart, the variance components and the ARMA models in R for subgrouped and individual data. More details can be found: Yao and Chakraborti (2020) <doi:10.1002/qre.2793>, Yao and Chakraborti (2021) <doi:10.1080/0898211

License GPL-3

Encoding UTF-8

LazyData true

Depends R (>= 3.5.0)

Imports forecast, mvtnorm, pracma

URL https://github.com/bolus123/PH1XBAR

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`PH1XBAR-package` *PH1XBAR: Phase I Shewhart X-Bar Chart*

Description

The purpose of 'PH1XBAR' is to build a Phase I Shewhart control chart for the basic Shewhart, the variance components and the ARMA models in R for subgrouped and individual data. More details can be found: Yao and Chakraborti (2020) doi: 10.1002/qre.2793, Yao and Chakraborti (2021) doi: 10.1080/08982112.2021.1878220, and Yao et al. (2023) doi: 10.1080/00224065.2022.2139783.

The utility of this package is in building a Shewhart-type control chart based on new methods for subgrouped and individual data. The Phase I chart is based on the multivariate normal/t or ARMA process.

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References

Champ, C.W., and Jones, L.A. (2004) Designing Phase I X-bar charts with small sample sizes. Quality and Reliability Engineering International. 20(5), 497-510

Yao, Y., Hilton, C.W., and Chakraborti, S. (2017) Designing Phase I Shewhart X-bar charts: Extended tables and software. Quality and Reliability Engineering International. 33(8), 2667-2672.

Yao, Y., and Chakraborti, S. (2021). Phase I monitoring of individual normal data: Design and implementation. Quality Engineering, 33(3), 443-456.

Yao, Y., and Chakraborti, S. (2021). Phase I process monitoring: The case of the balanced one-way random effects model. Quality and Reliability Engineering International, 37(3), 1244-1265.

Yao, Y., Chakraborti, S., Yang, X., Parton, J., Lewis Jr, D., and Hudnall, M. (2023). Phase I control chart for individual autocorrelated data: application to prescription opioid monitoring. Journal of Quality Technology, 55(3), 302-317.

See Also

Useful links:

- https://github.com/bolus123/PH1XBAR

Examples

```
#Build a Phase I basic Shewhart control chart
data(grinder_data)
PH1XBAR(grinder_data, nsim=10)

# Build a Phase I individual control chart with an ARMA model
data(preston_data)
PH1ARMA(preston_data, nsim.process=10, nsim.coefs=10)
```

`bore_diameter_data` *Bore diameter in manufacturing automotive driver gears*

Description

A dataset cotaining bore diameter measurements in mm

Usage

```
bore_diameter_data
```

Format

A data frame with 20 rows and 5 variables:

X1 Diameter measurement at Position 1

X2 Diameter measurement at Position 2

X3 Diameter measurement at Position 3

X4 Diameter measurement at Position 4

X5 Diameter measurement at Position 5

References

Wooluru, Yerriswamy, D. R. Swamy, and P. Nagesh. "THE PROCESS CAPABILITY ANALYSIS-A TOOL FOR PROCESS PERFORMANCE MEASURES AND METRICS-A CASE STUDY." International Journal for Quality Research 8.3 (2014).

`getCC.ARMA` *get Phase I corrected charting constant with an ARMA model*

Description

get Phase I corrected charting constant with an ARMA model

Usage

```
getCC.ARMA(
  fap0 = 0.05,
  interval = c(1, 4),
  n = 50,
  order = c(1, 0, 0),
  phi.vec = 0.5,
  theta.vec = NULL,
  case = "U",
  method = "MLE+MOM",
  nsim.coefs = 100,
  nsim.process = 1000,
  burn.in = 50,
  sim.type = "Matrix",
  verbose = FALSE
)
```

Arguments

`fap0`	nominal false Alarm Probabilty in Phase 1
`interval`	searching range of charting constants for the exact method
`n`	number of observations
`order`	order for ARMA model
`phi.vec`	given vectors of autoregressive parameters for ARMA models
`theta.vec`	given vectors of moving-average parameters for ARMA models
`case`	known or unknown case. When case = 'U', the parameters are unknown and the charting constant is calculated based on a bootstrapping method. When case = 'K', the parameters are known and the charting constant is found using the quantile function of multivariate normal distribution
`method`	estimation method for the control chart. When method = 'Method 3' is maximum likehood estimations plus method of moments. Other options are 'Method 1' which is pure MLE and 'Method 2' which is pure CSS.
`nsim.coefs`	number of simulation for coeficients. It is functional when double.sim = TRUE.
`nsim.process`	number of simulation for ARMA processes
`burn.in`	number of burn-ins. When burn.in = 0, the ECM gets involved. When burn.in is large enough, the ACM gets involved.

sim.type	type of simulation. When sim.type = 'Matrix', the simulation is generated using matrix computation. When sim.type = 'Recursive', the simulation is based on a recursion.
verbose	print diagnostic information about fap0 and the charting constant during the simulations for the exact method
phi	vector of autoregressive coefficient(s). When case = 'K', it must be provided. The length must be the same as the first value in the order. It needs to be NULL if no autoregressor presents
theta	vector of moving-average coefficient(s). When case = 'K', it must be provided. The length must be the same as the third value in the order. It needs to be NULL if no moving average presents

Value

Object type double. The corrected charting constant.

Examples

```
# load the data in the package as an example
set.seed(12345)

# Calculate the charting constant using fap0 of 0.05, and 50 observations
getCC.ARMA(fap0=0.05, n=50, nsim.coefs=10, nsim.process=10)
```

---

getCC.XBAR *Random Flexible Level Shift Model*

Description

get Phase I corrected charting constant

Usage

```
getCC.XBAR(
  m,
  fap0 = 0.05,
  var.est = c("S", "MR"),
  ub.cons = 1,
  method = c("exact", "BA"),
  interval = c(1, 5),
  nsim = 10000,
  nu = m - 1,
  lambda = 1,
  verbose = FALSE
)
```

Arguments

`m`	nominal false Alarm Probabilty in Phase 1
`fap0`	number of subgroups
`var.est`	'S' - use mean-square-based estimator, 'MR' - use moving-range-based estimator
`ub.cons`	unbiasing constant
`method`	'exact' - calculate results using the exact method, 'BA' - calculate results using the Bonfferoni approximation
`interval`	searching range of charting constants for the exact method
`nsim`	number of simulation for the exact method
`nu`	degrees of freedom for the Bonfferoni approximation
`lambda`	constant for the Bonfferoni approximation
`verbose`	print diagnostic information about fap0 and the charting constant during the simulations for the exact method

Value

Object type double. The corrected charting constant.

Examples

```
set.seed(12345)

# Calculate the charting constant using 10 simulations and mean-square-based estimator
getCC.XBAR(fap0=0.05, m=20, nsim=10, var.est='S', verbose = TRUE)

# Calculate the charting constant using 10 simulations and moving-range-based estimator
getCC.XBAR(fap0=0.05, m=20, nsim=10, var.est='MR', verbose = TRUE)
```

---

grinder_data   *Thickness measurement of silicon wafer*

Description

A dataset containing the thickness measurements in nm at different positions on the silicon wafer

Usage

```
grinder_data
```

Format

A data frame with 30 rows and 5 variables:

pos1 Thickness measurement at Position 1 (outer circle)

pos2 Thickness measurement at Position 2 (outer circle)

pos3 Thickness measurement at Position 3 (middle circle)

pos4 Thickness measurement at Position 4 (middle circle)

pos5 Thickness measurement at Position 5 (inner circle)

References

Roes, Kit CB, and Ronald JMM Does. "Shewhart-type charts in nonstandard situations." Technometrics 37.1 (1995): 15-24

PH1ARMA *Phase I individual control chart with an ARMA model*

Description

Build a Phase I individual control chart for the ARMA models. The charting constant is corrected by this approach.

Usage

```
PH1ARMA(
  X,
  cc = NULL,
  fap0 = 0.05,
  order = c(1, 0, 0),
  plot.option = TRUE,
  interval = c(1, 4),
  case = "U",
  phi.vec = NULL,
  theta.vec = NULL,
  mu0 = NULL,
  sigma0 = NULL,
  method = "MLE+MOM",
  nsim.coefs = 100,
  nsim.process = 1000,
  burn.in = 50,
  sim.type = "Matrix",
  standardize = TRUE,
  verbose = FALSE
)
```

Arguments

`X`	input and it must be a vector
`cc`	nominal Phase I charting constant. If this is given, the function will not re-compute the charting constant.
`fap0`	nominal false Alarm Probabilty in Phase I
`order`	order for ARMA model
`plot.option`	- draw a plot for the process; FALSE - Not draw a plot for the process
`interval`	searching range of charting constants for the exact method
`case`	known or unknown case. When case = 'U', the parameters are estimated
`phi.vec`	vector of autoregressive coefficient(s). When case = 'K', the vector needs to be provided with the length same as the first value in the order. If autoregressive coefficents does not present, phi needs to be NULL
`theta.vec`	vector of moving-average coefficient(s). When case = 'K', the vector needs to be provided with the length same as the third value in the order. If moving-average coefficents does not present, theta needs to be NULL
`mu0`	value of the IC process mean. When case = 'K', the value needs to be provided.
`sigma0`	value of the IC process standard deviation. When case = 'K', the value needs to be provided.
`method`	estimation method for the control chart. When method = 'MLE+MOM' is maximum likehood estimations plus method of moments. Other options are 'MLE' which is pure MLE and 'CSS' which is pure CSS.
`nsim.coefs`	number of simulation for coeficients.
`nsim.process`	number of simulation for ARMA processes
`burn.in`	number of burn-ins. When burn.in = 0, the simulated process is assumed to be in the initial stage. When burn.in is large enough, the simulated process is assumed to be in the stable stage.
`sim.type`	type of simulation. When sim.type = 'Matrix', the simulation is generated using matrix computation. When sim.type = 'Recursive', the simulation is based on a recursion.
`standardize`	Output standardized data instead of raw data
`verbose`	print diagnostic information about fap0 and the charting constant during the simulations for the exact method

Value

CL Object type double - central line

gamma Object type double - process variance estimate

cc Object type double - charting constant

order Object type integer - order for ARMA model

phi.vec Object type integer - values of autoregressors

theta.vec Object type integer - values of moving averages

LCL Object type double - lower charting limit

UCL Object type double - upper charting limit

CS Object type double - charting statistic

References

Yao, Y., Chakraborti, S., Yang, X., Parton, J., Lewis Jr, D., and Hudnall, M. (2023). Phase I control chart for individual autocorrelated data: application to prescription opioid monitoring. Journal of Quality Technology, 55(3), 302-317.

Examples

```
# load the data in the package as an example
data(preston_data)

# set number of simulations
nsim.process <- 10
nsim.coefs <- 10

# An example using the default setting whose fap0 = 0.1
PH1ARMA(preston_data, nsim.process = nsim.process, nsim.coefs = nsim.coefs)

# When users get an error message about the size of matrix,
# the function needs to use the alternative simulation type as follows
PH1ARMA(preston_data, fap0 = 0.05,
nsim.process = nsim.process, nsim.coefs = nsim.coefs, sim.type = 'Recursive')
```

PH1XBAR *Phase I X-bar control chart with a corrected charting constant*

Description

Build a Phase I Shewhart control chart for the variance components model if the data are subgrouped or for the basic Shewhart model if the data are individual. The charting constant is correted by this approach.

Usage

```
PH1XBAR(
  X,
  cc = NULL,
  fap0 = 0.05,
  var.est = c("S", "MR"),
  ub.option = TRUE,
  method = c("exact", "BA"),
  plot.option = TRUE,
  interval = c(1, 5),
```

```
  nsim = 10000,
  verbose = FALSE
)
```

Arguments

X	input and it must be a matrix
cc	nominal Phase I charting constant. If this is given, the function will not recompute the charting constant.
fap0	nominal false Alarm Probabilty in Phase 1
var.est	'S' - use mean-square-based estimator, 'MR' - use moving-range-based estimator
ub.option	TRUE - the standard deviation estimator corrected by a unbiasing constant. For S, it is c4 and for MR, it is d2. FALSE - no unbiasing constant
method	'exact' - calculate results using the exact method, 'BA' - calculate results using the Bonfferoni approximation
plot.option	- draw a plot for the process; FALSE - Not draw a plot for the process
interval	searching range of charting constants for the exact method
nsim	number of simulation for the exact method
verbose	print diagnostic information about fap0 and the charting constant during the simulations for the exact method

Value

CL Object type double - central line

var.est Object type double - variance estimate

ub.cons Object type double - unbiasing constant

cc Object type double - charting constant

m Object type integer - number of observations

nu Object type integer - degrees of freedom

lambda Object type integer - chi-squared unbiasing constant

LCL Object type double - lower charting limit

UCL Object type double - upper charting limit

CS Object type double - charting statistic

References

Champ, C.W., and Jones, L.A. (2004) Designing Phase I X-bar charts with small sample sizes. Quality and Reliability Engineering International. 20(5), 497-510

Yao, Y., Hilton, C.W., and Chakraborti, S. (2017) Designing Phase I Shewhart X-bar charts: Extended tables and software. Quality and Reliability Engineering International. 33(8), 2667-2672.

Yao, Y., and Chakraborti, S. (2021). Phase I monitoring of individual normal data: Design and implementation. Quality Engineering, 33(3), 443-456.

Yao, Y., and Chakraborti, S. (2021). Phase I process monitoring: The case of the balanced one-way random effects model. Quality and Reliability Engineering International, 37(3), 1244-1265.

Examples

```
set.seed(12345)

# load the data in the package as an example
data(grinder_data)

# An example using a false alarm probability of 0.05, and 10 simulations
PH1XBAR(grinder_data, fap0 = 0.05, nsim=10, verbose=TRUE)
```

`preston_data` *Prescription fentanyl consumption in Preston county, WV*

Description

A dataset containing prescription fentanyl consumption in Preston county, WV, measured using MME percapita. This is a subset from Rich et al. <doi: 10.21105/joss.02450>

Usage

```
preston_data
```

Format

A vector with 60 elements

References

Rich, S., Tran, A. B., Williams, A., Holt, J., Sauer, J., & Oshan, T. M. (2020). arcos and arcospy: R and Python packages for accessing the DEA ARCOS database from 2006-2014. Journal of Open Source Software, 5(53), 2450.

`snowfall_data` *Seasonal snowfall in inches in Minneapolis/St. Paul, MN*

Description

A dataset containing snowfalls measured in inches in Minneapolis/St. Paul, MN.

Usage

```
snowfall_data
```

Format

A data frame with 82 rows and 4 variables:

Year year of the snowfalls

jan snowfalls in January

feb snowfalls in February

mar snowfalls in March

References

Mukherjee, P. S. (2016). On phase II monitoring of the probability distributions of univariate continuous processes. Statistical Papers, 57(2), 539-562.

Index