Package 'EATME'

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Type Package

Title Exponentially Weighted Moving Average with Adjustments to
Measurement Error

Version 0.1.0

Description The univariate statistical quality control tool aims to address measurement error effects when constructing exponentially weighted moving average p control charts. The method primarily focuses on binary random variables, but it can be applied to any continuous random variables by using sign statistic to transform them to discrete ones. With the correction of measurement error effects, we can obtain the corrected control limits of exponentially weighted moving average p control chart and reasonably adjusted exponentially weighted moving average p control charts. The methods in this package can be found in some relevant references, such as Chen and Yang (2022) <arXiv: 2203.03384>; Yang et al. (2011) <doi:10.1016/j.eswa.2010.11.044>; Yang and

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Encoding UTF-8

Imports qcr, stats, graphics

RoxygenNote 7.1.2

Suggests knitr, rmarkdown

NeedsCompilation no

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cont_to_disc_M   *Convert data to M statistic*

Description

Convert continuous random variables in in-control process into discrete random variables with M statistic, where M statistic is the total number of samples satisfying $X_{ij} > \mu$ at time i, where X_{ij} is the observation for the ith sampling period and the jth sample in the in-control data, n is the number of the sample size and m is the number of the sampling periods. μ is the population mean of continuous in-control data. If μ is unknown, it can be estimated by $\hat{\mu} = \bar{\bar{x}} = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} X_{ij}}{n \times m}$.

Usage

```
cont_to_disc_M(ICdata, OCdata, mu.p = mean(ICdata))
```

Arguments

ICdata	The in-control data.
OCdata	The out-of-control data.
mu.p	Mean of the random variable in the in-control data.

Value

M0	The M statistic for in-control data.
M1	The M statistic for out-of-control data.
p0	The process proportion for in-control data.
p1	The process proportion for out-of-control data.
n	The number of the sample size.

References

Yang, S. F., Lin, J. S., & Cheng, S. W. (2011). A new nonparametric EWMA sign control chart. *Expert Systems with Applications*, *38(5)*, 6239-6243.

Yang, S. F. & Arnold, B. C. (2014). A simple approach for monitoring business service time variation.*The Scientific World Journal*, *2014*:16.

Yang, S. F. (2016). An improved distribution-free EWMA mean chart. *Communications in Statistics-Simulation and Computation*, *45(4)*, 1410-1427.

Examples

```
IC = matrix(rnorm(100,0,1),ncol = 10,byrow = TRUE)
OC = matrix(rnorm(100,2,1),ncol = 10,byrow = TRUE)
cont_to_disc_M(IC,OC)
```

---

cont_to_disc_V	*Convert data to V statistic*

Description

Convert continuous random variables in in-control process to discrete data with V statistic, where V statistic is the total number of sample satisfying $Y_{ij} = \frac{(X_{i2j} - X_{i(2j-1)})^2}{2} > \sigma^2$ at time i, where X_{ij} is the observation for the ith sampling period and the jth sample in the in-control data, n is the number of the sample size and m is the number of the sampling periods. σ^2 is population variance of continuous in-control data. If σ^2 is unknown, it can be estimated by $\hat{\sigma}^2 = \frac{\sum_{i=1}^{m} S_i^2}{m}$ and $S_i^2 = \frac{\sum_{j=1}^{n}(X_{ij} - \overline{X}_i)^2}{n-1}$.

Usage

```
cont_to_disc_V(ICdata, OCdata, var.p = NULL)
```

Arguments

ICdata	The in-control data.
OCdata	The out-of-control data.
var.p	Variance of the random variables in the in-control data.

Value

V0	The V statistic for in-control data.
V1	The V statistic for out-of-control data.
p0	The process proportion for in-control data.
p1	The process proportion for out-of-control data.
n	The number of the sample size.

References

Yang, S. F. & Arnold, B. C. (2014). A simple approach for monitoring business service time variation.*The Scientific World Journal*, *2014*:16.

Yang, S. F., & Arnold, B. C. (2016). A new approach for monitoring process variance. *Journal of Statistical Computation and Simulation*, *86(14)*, 2749-2765.

Examples

```
IC = matrix(rnorm(100,0,1),ncol = 10,byrow = TRUE)
OC = matrix(rnorm(100,0,2),ncol = 10,byrow = TRUE)
cont_to_disc_V(IC,OC)
```

---

ewma   *EWMA chart statistics of the data*

Description

A conventional exponential weighted moving average (EWMA) charting statistic evaluated by the data.

Usage

```
ewma(data, lambda, EWMA0)
```

Arguments

data	An one-dimensional random variable.
lambda	An EWMA smooth constant, which is a scalar in [0,1].
EWMA0	A starting point of EWMA charting statistic.

Value

A vector of EWMA charting statistics of data at different t times.

Examples

```
x = rnorm(20,0,1)
ewma(x,0.05,0)
```

EWMA_p_chart_one_LCL   *A one-sided lower EWMA-p control chart*

Description

This function displays one-sided lower EWMA-p chart control charts based on in-control and out-of-control data that are number of defectives. In the presence of measurement error, this function is able to provide suitable charts with corrections of measurement error effects.

Usage

```
EWMA_p_chart_one_LCL(
  ICdata,
  OCdata,
  lambda,
  n,
  pi1 = 1,
  pi2 = pi1,
  ARL0 = 200,
  M = 500,
  error = 10
)
```

Arguments

ICdata	The in-control data for attributes.
OCdata	The out-of-control data for attributes.
lambda	An EWMA smooth constant, which is a scalar in [0,1].
n	A sample size in the data.
pi1	The proportion that the observed defectives are the same as unobserved ones.
pi2	The proportion that the observed non-defectives are the same as unobserved ones.
ARL0	A prespecified average run length (ARL) of a control chart in the in-control process.
M	The number of simulation times for the Monte Carlo method
error	The tolerant for the absolute difference between an iterated ARL value and pre-specified ARL0.

Value

The first chart is an EWMA-p chart obtained by the in-control data, and the second chart is an EWMA-p chart based in the out-of-control data. In two figures, horizontal solid line represents lower control limit (LCL), black solid dots are detections of in-control data, and red solid dots are detections of out-of-control data.

References

Chen, L.-P. & Yang, S.-F. (2022). A new p-chart with measurement error correction. arXiv: 2203.03384.

Examples

```
library(qcr)
data = orangejuice
IC = data[1:30,1]
OC = data[31:54,1]
EWMA_p_chart_one_LCL(IC,OC,0.05,50,1,1)
```

EWMA_p_chart_one_UCL   *A one-sided upper EWMA-p control chart*

Description

This function displays one-sided upper EWMA-p chart control charts based on in-control and out-of-control data that are number of defectives. In the presence of measurement error, this function is able to provide suitable charts with corrections of measurement error effects.

Usage

```
EWMA_p_chart_one_UCL(
  ICdata,
  OCdata,
  lambda,
  n,
  pi1 = 1,
  pi2 = pi1,
  ARL0 = 200,
  M = 500,
  error = 10
)
```

Arguments

ICdata	The in-control data for attributes.
OCdata	The out-of-control data for attributes.
lambda	An EWMA smooth constant, which is a scalar in [0,1].
n	A sample size in the data.
pi1	The proportion that the observed defectives are the same as unobserved ones.
pi2	The proportion that the observed non-defectives are the same as unobserved ones.
ARL0	A prespecified average run length (ARL) of a control chart in the in-control process.
M	The number of simulation times for the Monte Carlo method
error	The tolerant for the absolute difference between an iterated ARL value and pre-specified ARL0.

Value

The first chart is an EWMA-p chart obtained by the in-control data, and the second chart is an EWMA-p chart based in the out-of-control data. In two figures, horizontal solid line represents upper control limit (UCL), black solid dots are detections of in-control data, and red solid dots are detections of out-of-control data.

References

Chen, L.-P. & Yang, S.-F. (2022). A new p-chart with measurement error correction. arXiv: 2203.03384.

Examples

```
library(qcr)
data = orangejuice
IC = data[31:54,1]
OC = data[1:30,1]
EWMA_p_chart_one_UCL(IC,OC,0.05,50,1,1)
```

EWMA_p_chart_two   *A two-sided EWMA-p control chart*

Description

This function displays two-sided EWMA-p chart control charts based on in-control and out-of-control data that are number of defectives. In the presence of measurement error, this function is able to provide suitable charts with corrections of measurement error effects.

Usage

```
EWMA_p_chart_two(
  ICdata,
  OCdata,
  lambda,
  n,
  pi1 = 1,
  pi2 = pi1,
  ARL0 = 200,
  M = 500,
  error = 10
)
```

Arguments

ICdata	The in-control data for attributes.
OCdata	The out-of-control data for attributes.
lambda	An EWMA smooth constant, which is a scalar in [0,1].
n	A sample size in the data.
pi1	The proportion that the observed defectives are the same as unobserved ones.
pi2	The proportion that the observed non-defectives are the same as unobserved ones.
ARL0	A prespecified average run length (ARL) of a control chart in the in-control process.

M	The number of simulation times for the Monte Carlo method
error	The tolerant for the absolute difference between an iterated ARL value and pre-specified ARL0.

Value

The first chart is an EWMA-p chart obtained by the in-control data, and the second chart is an EWMA-p chart based in the out-of-control data. In two figures, horizontal solid lines represents upper control limit (UCL) and lower control limit (LCL), black solid dots are detections of in-control data, and red solid dots are detections of out-of-control data.

References

Chen, L.-P. & Yang, S.-F. (2022). A new p-chart with measurement error correction. arXiv: 2203.03384.

Examples

```
library(qcr)
data = orangejuice
IC = data[31:54,1]
OC = data[1:30,1]
set.seed(2)
EWMA_p_chart_two(IC,OC,0.05,50,1,1,200,100,20)
```

EWMA_p_one_LCL   *The one-sided lower control limit of an EWMA-p chart*

Description

This function is used to calculate the one-sided lower control limit for EWMA-p charts with the correction of measurement error effects. If two truly classified probabilities pi1 and pi2 are given by 1, then the corresponding control limit is free of measurement error.

Usage

```
EWMA_p_one_LCL(
  p,
  lambda,
  n,
  pi1 = 1,
  pi2 = pi1,
  ARL0 = 200,
  M = 500,
  error = 10
)
```

Arguments

p	The proportion of defectives in the in-control process.
lambda	An EWMA smooth constant, which is a scalar in [0,1].
n	A sample size in the data.
pi1	The proportion that the observed defectives are the same as unobserved ones.
pi2	The proportion that the observed non-defectives are the same as unobserved ones.
ARL0	A prespecified average run length (ARL) of a control chart in the in-control process.
M	The number of simulation times for the Monte Carlo method
error	The tolerant for the absolute different between an itevated ARL calue and pre-specified ARL0.

Value

L2	The coefficient of the lower control limit.
hat_ARL0	The estimated in-control average run length based on given L2.
hat_MRL0	The estimated in-control median of run length based on given L2.
hat_SDRL0	The estimated in-control standard deviation of run length based on given L2.
LCL	The limiting value of the lower control limit with L2.

References

Chen, L. P., & Yang, S. F. (2022). A New *p*-Control Chart with Measurement Error Correction. *arXiv preprint* arXiv:2203.03384.

Examples

```
EWMA_p_one_LCL(0.2,0.05,5,1,1)
```

EWMA_p_one_UCL	*The one-sided upper control limit of an EWMA-p chart*

Description

This function is used to calculate the one-sided upper control limit for EWMA-p charts with the correction of measurement error effects. If two truly classified probabilities pi1 and pi2 are given by 1, then the corresponding control limit is free of measurement error.

Usage

```
EWMA_p_one_UCL(
  p,
  lambda,
  n,
  pi1 = 1,
  pi2 = pi1,
  ARL0 = 200,
  M = 500,
  error = 10
)
```

Arguments

p	The proportion of defectives in the in-control process.
lambda	An EWMA smooth constant, which is a scalar in [0,1].
n	A sample size in the data.
pi1	The proportion that the observed defectives are the same as unobserved ones.
pi2	The proportion that the observed non-defectives are the same as unobserved ones.
ARL0	A prespecified average run length (ARL) of a control chart in the in-control process.
M	The number of simulation times for the Monte Carlo method
error	The tolerant for the absolute different between an itevated ARL calue and pre-specified ARL0.

Value

L1	The coefficient of the upper control limit.
hat_ARL0	The estimated in-control average run length based on given L1.
hat_MRL0	The estimated in-control median of run length based on given L1.
hat_SDRL0	The estimated in-control standard deviation of run length based on given L1.
UCL	The limiting value of the upper control limit with L1.

References

Chen, L. P., & Yang, S. F. (2022). A New *p*-Control Chart with Measurement Error Correction. *arXiv preprint* arXiv:2203.03384.

Examples

```
EWMA_p_one_UCL(0.2,0.05,5,1,1)
```

| EWMA_p_two | *The two-sided control limits of an EWMA-p chart* |

Description

This function is used to calculate the two-sided control limit for EWMA-p charts with the correction of measurement error effects. If two truly classified probabilities pi1 and pi2 are given by 1, then the corresponding control limit is free of measurement error.

Usage

```
EWMA_p_two(p, lambda, n, pi1 = 1, pi2 = pi1, ARL0 = 200, M = 500, error = 10)
```

Arguments

p	The proportion of defectives in the in-control process.
lambda	An EWMA smooth constant, which is a scalar in [0,1].
n	A sample size in the data.
pi1	The proportion that the observed defectives are the same as unobserved ones.
pi2	The proportion that the observed non-defectives are the same as unobserved ones.
ARL0	A prespecified average run length (ARL) of a control chart in the in-control process.
M	The number of simulation times for the Monte Carlo method
error	The tolerant for the absolute different between an itevated ARL calue and pre-specified ARL0.

Value

L1	The coefficient of the upper control limit.
L2	The coefficient of the lower control limit.
hat_ARL0	The estimated in-control average run length based on given L1 and L2.
hat_MRL0	The estimated in-control median of run length based on given L1 and L2.
hat_SDRL0 L2.	The estimated in-control standard deviation of run length based on given L1 and L2.
UCL	The limiting value of the upper control limit with L1.
LCL	The limiting value of the lower control limit with L2.

References

Chen, L. P., & Yang, S. F. (2022). A New *p*-Control Chart with Measurement Error Correction. *arXiv preprint* arXiv:2203.03384.

Examples

```
set.seed(2)
EWMA_p_two(0.2,0.05,5,1,1,200,100,20)
```

ME_data_generate   *Generate the discrete random variable with measurement error*

Description

Generate the discrete random variable with measurement error.

Usage

```
ME_data_generate(p, n, m, pi1, pi2 = pi1)
```

Arguments

p	A probability of the unobserved defectives.
n	A number of sample size in the data.
m	A number of observation in the data.
pi1	The proportion that the observed defectives are the same as unobserved ones.
pi2	The proportion that the observed non-defectives are the same as unobserved ones.

Value

real_data	The generated data without measurement error.
obs_data	The generated data with measurement error.
n	A sample size in the generated data.

Examples

```
ME_data_generate(0.7,50,50,0.95)
```

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