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 et al. (2016) <doi:10.1080/03610918.2013.763980> and Yang and Arnold (2016) <doi:10.1080/00949655.2015.1125901>.

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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 $i^{th}$ sampling period and the $j^{th}$ sample in the in-control data, $n$ is the number of the sample size and $m$ is the number of the sampling periods. $\mu$ is the population mean of continuous in-control data. If $\mu$ is unknown, it can be estimated by $\hat{\mu} = \bar{x} = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} X_{ij}}{n \times m}$.

**Usage**

```r
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**


**Examples**

```r
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 \( Y_{ij} = \frac{(X_{ij} - X_{(j-1)})^2}{\sigma^2} > 1 \) at time \( i \), where \( X_{ij} \) is the observation for the \( i^{th} \) sampling period and the \( j^{th} \) sample in the in-control data, \( n \) is the number of the sample size and \( m \) is the number of the sampling periods. \( \sigma^2 \) is population variance of continuous in-control data. If \( \sigma^2 \) 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**

```r
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**

- \( V_0 \)  
The V statistic for in-control data.
- \( V_1 \)  
The V statistic for out-of-control data.
- \( p_0 \)  
The process proportion for in-control data.
- \( p_1 \)  
The process proportion for out-of-control data.
- \( n \)  
The number of the sample size.

**References**


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


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)
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 prespecified 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.
EWMA_p_chart_two

References

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
<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICdata</td>
<td>The in-control data for attributes.</td>
</tr>
<tr>
<td>OCdata</td>
<td>The out-of-control data for attributes.</td>
</tr>
<tr>
<td>lambda</td>
<td>An EWMA smooth constant, which is a scalar in [0,1].</td>
</tr>
<tr>
<td>n</td>
<td>A sample size in the data.</td>
</tr>
<tr>
<td>pi1</td>
<td>The proportion that the observed defectives are the same as unobserved ones.</td>
</tr>
<tr>
<td>pi2</td>
<td>The proportion that the observed non-defectives are the same as unobserved ones.</td>
</tr>
<tr>
<td>ARL0</td>
<td>A prespecified average run length (ARL) of a control chart in the in-control process.</td>
</tr>
</tbody>
</table>
The number of simulation times for the Monte Carlo method
\( M \)

The tolerant for the absolute difference between an iterated ARL value and pre-specified ARL0.
\( \text{error} \)

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


Examples

```r
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)
```

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 \( \pi_1 \) and \( \pi_2 \) are given by 1, then the corresponding control limit is free of measurement error.

Usage

```r
EWMA_p_one_LCL(
  p,
  lambda,
  n,
  \pi_1 = 1,
  \pi_2 = \pi_1,
  \text{ARL}_0 = 200,
  M = 500,
  \text{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 difference between an iterated ARL value 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


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 p11 and p12 are given by 1, then the corresponding control limit is free of measurement error.
Usage

```r
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 iterated ARL value 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


Examples

```r
EWMA_p_one_UCL(0.2, 0.05, 5, 1, 1)
```
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 \( p_{i1} \) and \( p_{i2} \) are given by 1, then the corresponding control limit is free of measurement error.

Usage

\[
\text{EWMA}_p\_\text{two}(p, \lambda, n, p_{i1} = 1, p_{i2} = p_{i1}, ARL_0 = 200, M = 500, \text{error} = 10)
\]

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.
- \( p_{i1} \): The proportion that the observed defectives are the same as unobserved ones.
- \( p_{i2} \): The proportion that the observed non-defectives are the same as unobserved ones.
- \( ARL_0 \): 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.
- \( \text{error} \): The tolerant for the absolute different between an itevated ARL value and pre-specified ARL0.

Value

- \( L_1 \): The coefficient of the upper control limit.
- \( L_2 \): The coefficient of the lower control limit.
- \( \hat{ARL}_0 \): The estimated in-control average run length based on given \( L_1 \) and \( L_2 \).
- \( \hat{MRL}_0 \): The estimated in-control median of run length based on given \( L_1 \) and \( L_2 \).
- \( \hat{SDRL}_0 \): The estimated in-control standard deviation of run length based on given \( L_1 \) and \( L_2 \).
- \( \text{UCL} \): The limiting value of the upper control limit with \( L_1 \).
- \( \text{LCL} \): The limiting value of the lower control limit with \( L_2 \).

References

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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