Package ‘qcc’

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Description


Details

See vignette and documentation accompanying the package.

Author(s)

Luca Scrucca
boiler

References

See Also
qcc, mqcc, cusum, ewma, oc.curves, process.capability, pareto.chart, cause.and.effect.

boiler

*Boiler temperature data*

Description
Temperature readings from the eight configured burners on a boiler.

Usage
data(boiler)

Format
A data frame with 25 observations on the following 8 variables:

- t1 temperature reading 1
- t2 temperature reading 2
- t3 temperature reading 3
- t4 temperature reading 4
- t5 temperature reading 5
- t6 temperature reading 6
- t7 temperature reading 7
- t8 temperature reading 8

References

Examples
data(boiler)
summary(boiler)
boxplot(boiler)
cause.and.effect  Cause and effect diagram

Description

Draw a basic cause and effect diagram.

Usage

cause.and.effect(cause, effect, title = "Cause-and-Effect diagram",
            cex = c(1, 0.9, 1), font = c(1, 3, 2))

Arguments

cause

a list of causes and branches providing descriptive labels (see the example below).

effect

a string label or the effect.

title

a string specifying the main title to appear on the plot.

cex

a vector of values for the graphical character expansion. The values refer, in order, to branches, causes and effect.

font

a vector of values for the font to use. The values refer, in order, to branches, causes and effect.

Author(s)

Luca Scrucca

References


Examples

cause.and.effect(cause=list(Measurements=c("Micrometers", "Microscopes", "Inspectors"),
                                    Materials=c("Alloys", "Lubricants", "Suppliers"),
                                    Personnel=c("Shifts", "Supervisors", "Training", "Operators"),
                                    Environment=c("Condensation", "Moisture"),
                                    Methods=c("Brake", "Engager", "Angle"),
                                    Machines=c("Speed", "Lathes", "Bits", "Sockets")),
            effect="Surface Flaws")
Description

Number of nonconformities observed in 26 successive samples of 100 printed circuit boards. Sample 6 and 20 are outside the control limits. Sample 6 was examined by a new inspector and he did not recognize several type of nonconformities that could have been present. Furthermore, the unusually large number of nonconformities in sample 20 resulted from a temperature control problem in the wave soldering machine, which was subsequently repaired. The last 20 samples are further samples collected on inspection units (each formed by 100 boards).

Usage

data(circuit)

Format

A data frame with 46 observations on the following 3 variables.

x  number of defectives in 100 printed circuit boards (inspection unit)
size  sample size
trial  trial sample indicator (TRUE/FALSE)

References


Examples

data(circuit)
attach(circuit)
summary(circuit)
boxplot(x ~ trial)
plot(x, type="b")
detach(circuit)
### Cusum chart

**Description**

Create an object of class 'cusum.qcc' to compute a Cusum chart for statistical quality control.

**Usage**

```r
cusum(data, sizes, center, std.dev, head.start = 0, 
      decision.interval = 5, se.shift = 1, data.name, labels, 
      newdata, newsizes, newlabels, plot = TRUE, ...)
```

```r
## S3 method for class 'cusum.qcc'
print(x, ...)
```

```r
## S3 method for class 'cusum.qcc'
summary(object, digits = getOption("digits"), ...)
```

```r
## S3 method for class 'cusum.qcc'
plot(x, add.stats = TRUE, chart.all = TRUE, 
     label.bounds = c("LDB", "UDB"), title, xlab, ylab, ylim, 
     axes.las = 0, digits = getOption("digits"), 
     restore.par = TRUE, ...)
```

**Arguments**

- **data**: a data frame, a matrix or a vector containing observed data for the variable to chart. Each row of a data frame or a matrix, and each value of a vector, refers to a sample or "rationale group".

- **sizes**: a value or a vector of values specifying the sample sizes associated with each group. If not provided the sample sizes are obtained counting the non-NA elements of each row of a data frame or a matrix; sample sizes are set all equal to one if data is a vector.

- **center**: a value specifying the center of group statistics or the "target" value of the process.

- **std.dev**: a value or an available method specifying the within-group standard deviation(s) of the process. Several methods are available for estimating the standard deviation. See `sd.xbar` and `sd.xbar.one` for, respectively, the grouped data case and the individual observations case.

- **head.start**: The initializing value for the above-target and below-target cumulative sums, measured in standard errors of the summary statistics. Use zero for the traditional Cusum chart, or a positive value less than the `decision.interval` for a Fast Initial Response.
decision.interval
A numeric value specifying the number of standard errors of the summary statistics at which the cumulative sum is out of control.

se.shift
The amount of shift to detect in the process, measured in standard errors of the summary statistics.

data.name
a string specifying the name of the variable which appears on the plots. If not provided is taken from the object given as data.

labels
a character vector of labels for each group.

newdata
a data frame, matrix or vector, as for the data argument, providing further data to plot but not included in the computations.

newsizes
a vector as for the sizes argument providing further data sizes to plot but not included in the computations.

newlabels
a character vector of labels for each new group defined in the argument newdata.

plot
logical. If TRUE a Cusum chart is plotted.

add.stats
a logical value indicating whether statistics and other information should be printed at the bottom of the chart.

chart.all
a logical value indicating whether both statistics for data and for newdata (if given) should be plotted.

label.bounds
a character vector specifying the labels for the the decision interval boundaries.

title
a string giving the label for the main title.

xlab
a string giving the label for the x-axis.

ylab
a string giving the label for the y-axis.

ylim
a numeric vector specifying the limits for the y-axis.

axes.las
numeric in \{0,1,2,3\} specifying the style of axis labels. See help(par).

digits
the number of significant digits to use.

restore.par
a logical value indicating whether the previous par settings must be restored. If you need to add points, lines, etc. to a control chart set this to FALSE.

object
an object of class 'cusum.qcc'.

x
an object of class 'cusum.qcc'.

... additional arguments to be passed to the generic function.

Details
Cusum charts display how the group summary statistics deviate above or below the process center or target value, relative to the standard errors of the summary statistics. Useful to detect small and permanent variation on the mean of the process.

Value
Returns an object of class 'cusum.qcc'.

Author(s)
Luca Scrucca
References


See Also

qcc, ewma

Examples

```r
##
## Grouped-data
##
data(pistonrings)
attach(pistonrings)
diameter <- qcc.groups(diameter, sample)

q <- cusum(diameter[1:25,], decision.interval = 4, se.shift = 1)
summary(q)

q <- cusum(diameter[1:25,], newdata=diameter[26:40,])
summary(q)
plot(q, chart.all=FALSE)

detach(pistonrings)
```

---

**dyedcloth**

_Dyed cloth data_

Description

In a textile finishing plant, dyed cloth is inspected for the occurrence of defects per 50 square meters. The data on ten rolls of cloth are presented.

Usage

data(dyedcloth)
**Format**

A data frame with 10 observations on the following 2 variables.

- **x**: number of nonconformities per 50 square meters (inspection units)
- **size**: number of inspection units in roll (variable sample size)

**References**


**Examples**

```r
data(dyedcloth)
attach(dyedcloth)
summary(dyedcloth)
plot(x/size, type="b")
detach(dyedcloth)
```

---

**ellipseChart**

*Multivariate Quality Control Charts*

**Description**

Plot an ellipse chart for a bivariate quality control data.

**Usage**

```r
ellipseChart(object, chart.all = TRUE, show.id = FALSE, ngrid = 50,
             confidence.level, correct.multiple = TRUE,
             title, xlim, ylim, xlab, ylab,
             restore.par = TRUE, ...)
```

**Arguments**

- **object**: an object of class 'mqcc'.
- **chart.all**: a logical value indicating whether both statistics for data and for newdata (if given) should be plotted.
- **show.id**: a logical value indicating whether to plot point labels (TRUE) or symbols (FALSE) for group means.
- **ngrid**: a value for the size of the grid over which the ellipse is evaluated.
- **confidence.level**: a numeric value between 0 and 1 specifying the confidence level of the computed probability limits.
- **correct.multiple**: a logical value indicating whether to correct or not for multiple comparisons.
title   a string giving the label for the main title.
xlim    a numeric vector specifying the limits for the x-axis.
ylim    a numeric vector specifying the limits for the y-axis.
xlab    a string giving the label for the x-axis.
ylab    a string giving the label for the y-axis.
restore.par    a logical value indicating whether the previous par settings must be restored. If you need to add points, lines, etc. to a control chart set this to FALSE.
...    additional arguments to be passed to the generic points function.

Author(s)
Luca Scrucca

References

See Also
mqcc, stats.T2, stats.T2.single

Examples
# See examples in help(mqcc)

ewma(data, sizes, center, std.dev, lambda = 0.2, nsigmas = 3,
data.name, labels, newdata, newsizes, newlabels,
plot = TRUE, ...)

## S3 method for class 'ewma.qcc'
print(x, ...)

Description
Create an object of class 'ewma.qcc' to compute and draw an Exponential Weighted Moving Average (EWMA) chart for statistical quality control.

Usage
ewma(data, sizes, center, std.dev, lambda = 0.2, nsigmas = 3,
data.name, labels, newdata, newsizes, newlabels,
plot = TRUE, ...)

## S3 method for class 'ewma.qcc'
print(x, ...)
## S3 method for class 'ewma.qcc'

summary(object, digits = getOption("digits"), ...)

## S3 method for class 'ewma.qcc'

plot(x, add.stats = TRUE, chart.all = TRUE,
     label.limits = c("LCL", "UCL"), title, xlab, ylab, ylim,
     axes.las = 0, digits = getOption("digits"),
     restore.par = TRUE, ...)

### Arguments

data  a data frame, a matrix or a vector containing observed data for the variable to chart. Each row of a data frame or a matrix, and each value of a vector, refers to a sample or "rationale group".
sizes a value or a vector of values specifying the sample sizes associated with each group. If not provided the sample sizes are obtained counting the non-NA elements of each row of a data frame or a matrix; sample sizes are set all equal to one if data is a vector.
center a value specifying the center of group statistics or target.
std.dev a value or an available method specifying the within-group standard deviation(s) of the process.
Several methods are available for estimating the standard deviation. See sd.xbar and sd.xbar.one for, respectively, the grouped data case and the individual observations case.
lambda the smoothing parameter $0 \leq \lambda \leq 1$
nsigmas a numeric value specifying the number of sigmas to use for computing control limits.
data.name a string specifying the name of the variable which appears on the plots. If not provided is taken from the object given as data.
labels a character vector of labels for each group.
newdata a data frame, matrix or vector, as for the data argument, providing further data to plot but not included in the computations.
newsizes a vector as for the sizes argument providing further data sizes to plot but not included in the computations.
newlabels a character vector of labels for each new group defined in the argument newdata.
plot logical. If TRUE an EWMA chart is plotted.
add.stats a logical value indicating whether statistics and other information should be printed at the bottom of the chart.
chart.all a logical value indicating whether both statistics for data and for newdata (if given) should be plotted.
label.limits a character vector specifying the labels for control limits.
title a string giving the label for the main title.
xlab a string giving the label for the x-axis.
ylab a string giving the label for the y-axis.
ylim a numeric vector specifying the limits for the y-axis.
axes.las numeric in \{0,1,2,3\} specifying the style of axis labels. See help(par).
digits the number of significant digits to use.
restore.par a logical value indicating whether the previous par settings must be restored. If you need to add points, lines, etc. to a control chart set this to FALSE.
object an object of class 'ewma.qcc'.
x an object of class 'ewma.qcc'.
... additional arguments to be passed to the generic function.

Details
EWMA chart smooths a series of data based on a moving average with weights which decay exponentially. Useful to detect small and permanent variation on the mean of the process.

Value
Returns an object of class 'ewma.qcc'.

Author(s)
Luca Scrucca

References

See Also
qcc, ewmaSmooth, cusum

Examples
##
## Grouped-data
##
data(pistonrings)
attach(pistonrings)
diameter <- qcc.groups(diameter, sample)
ewmaSmooth

```r
q <- ewma(diameter[1:25,], lambda=0.2, nsigmas=3)
summary(q)

q <- ewma(diameter[1:25,], lambda=0.2, nsigmas=2.7, newdata=diameter[26:40,], plot = FALSE)
summary(q)
plot(q)
detach(pistonrings)
```

### Individual observations: viscosity data (Montgomery, pag. 242)

```r
x <- c(33.75, 33.05, 34, 33.81, 33.46, 34.02, 33.68, 
33.27, 33.49, 33.20, 33.62, 33.00, 33.54, 33.12, 33.84)
q <- ewma(x, lambda=0.2, nsigmas=2.7)
summary(q)
```

**ewmaSmooth**  

*EWMA smoothing function*

**Description**

Compute Exponential Weighted Moving Average.

**Usage**

`ewmaSmooth(x, y, lambda = 0.2, start, ...)`

**Arguments**

- `x` a vector of x-values.
- `y` a vector of y-values.
- `lambda` the smoothing parameter.
- `start` the starting value.
- `...` additional arguments (currently not used).

**Details**

EWMA function smooths a series of data based on a moving average with weights which decay exponentially.

For each $y_t$ value the smoothed value is computed as

$$z_t = \lambda y_t + (1 - \lambda)z_{t-1}$$

where $0 \leq \lambda \leq 1$ is the parameter which controls the weights applied.
Value

Returns a list with elements:

- `x`: ordered x-values
- `y`: smoothed y-values
- `lambda`: the smoothing parameter
- `start`: the starting value

Author(s)

Luca Scrucca

References


See Also

`qcc`, `cusum`

Examples

```r
x <- 1:50
y <- rnorm(50, sin(x/5), 0.5)
plot(x,y)
lines(ewmaSmooth(x,y,lambda=0.1), col="red")
```

mqcc

*Multivariate Quality Control Charts*

Description

Create an object of class 'mqcc' to perform multivariate statistical quality control.

Usage

```r
mqcc(data, type = c("T2", "T2.single"), center, cov,
     limits = TRUE, pred.limits = FALSE,
     data.name, labels, newdata, newlabels,
     confidence.level = (1 - 0.0027)^p, rules = shewhart.rules,
     plot = TRUE, ...)
```

```
## S3 method for class 'mqcc'
print(x, ...)
```
## S3 method for class 'mqcc'
summary(object, digits = getOption("digits"), ...)

## S3 method for class 'mqcc'
plot(x, add.stats = TRUE, chart.all = TRUE,
    label.limits = c("LCL", "UCL"), label.pred.limits = c("LPL", "UPL"),
    title, xlab, ylab, ylim, axes.las = 0,
    digits = getOption("digits"), restore.par = TRUE, ...)

### Arguments

data
For subgrouped data, a list with a data frame or a matrix for each variable to
monitor. Each row of the data frame or matrix refers to a sample or "rationale"
group. For individual observations, where each sample has a single observation,
users can provide a list with a data frame or a matrix having a single column,
or a data frame or a matrix where each rows refer to samples and columns to
variables. See examples.

type
a character string specifying the type of chart:

<table>
<thead>
<tr>
<th>Chart description</th>
<th>Hotelling $T^2$ chart for subgrouped data</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;T2&quot;</td>
<td>&quot;T2.single&quot; Hotelling $T^2$ chart for individual observations</td>
</tr>
</tbody>
</table>

center
a vector of values to use for center of input variables.
cov
a matrix of values to use for the covariance matrix of input variables.
limits
a logical indicating if control limits (Phase I) must be computed (by default
using limits.T2 or limits.T2.single) and plotted, or a two-values vector
specifying control limits.
pred.limits
a logical indicating if prediction limits (Phase II) must be computed (by default
using limits.T2 or limits.T2.single) and plotted, or a two-values vector
specifying prediction limits.
data.name
a string specifying the name of the variable which appears on the plots. If not
provided is taken from the object given as data.
labels
a character vector of labels for each group.
newdata
a data frame, matrix or vector, as for the data argument, providing further data
to plot but not included in the computations.
newlabels
a character vector of labels for each new group defined in the argument newdata.
confidence.level
a numeric value between 0 and 1 specifying the confidence level of the computed
probability limits. By default is set at $(1 - 0.0027)^p$ where $p$ is the number of
variables, and 0.0027 is the probability of Type I error for a single Shewhart
chart at the usual 3-sigma control level.
rules
a function of rules to apply to the chart. By default, the shewhart.rules func-
tion is used.
plot
logical. If TRUE a quality chart is plotted.
add.stats  a logical value indicating whether statistics and other information should be printed at the bottom of the chart.

chart.all  a logical value indicating whether both statistics for data and for newdata (if given) should be plotted.

label.limits  a character vector specifying the labels for control limits (Phase I).

label.pred.limits  a character vector specifying the labels for prediction control limits (Phase II).

title  a string giving the label for the main title.

xlab  a string giving the label for the x-axis.

ylab  a string giving the label for the y-axis.

ylim  a numeric vector specifying the limits for the y-axis.

axes.las  numeric in \{0,1,2,3\} specifying the style of axis labels. See help(par).

digits  the number of significant digits to use when add.stats = TRUE.

restore.par  a logical value indicating whether the previous par settings must be restored. If you need to add points, lines, etc. to a control chart set this to FALSE.

object  an object of class 'mqcc'.

x  an object of class 'mqcc'.

...  additional arguments to be passed to the generic function.

Value

Returns an object of class 'mqcc'.

Author(s)

Luca Scrucca

References


See Also

stats.T2, stats.T2.single, limits.T2, limits.T2.single, ellipseChart, qcc
Examples

## Subgrouped data

# Ryan (2000, Table 9.2) data with p = 2 variables, m = 20 samples, n = 4 sample size:

```r
X1 <- matrix(c(72, 56, 55, 44, 97, 83, 47, 88, 57, 26, 46,
               49, 71, 71, 67, 55, 49, 72, 61, 35, 84, 87, 73, 80, 26, 89, 66,
               50, 47, 39, 27, 62, 63, 58, 69, 63, 51, 80, 74, 38, 79, 33, 22,
               54, 48, 91, 53, 84, 41, 52, 63, 78, 82, 69, 70, 72, 55, 61, 62,
               41, 49, 42, 60, 74, 58, 62, 58, 69, 46, 48, 34, 87, 55, 70, 94,
               49, 76, 59, 57, 46), ncol = 4)
X2 <- matrix(c(23, 14, 13, 9, 36, 30, 12, 31, 14, 7, 10,
               11, 22, 21, 18, 15, 13, 22, 19, 10, 30, 31, 22, 28, 10, 35, 18,
               11, 10, 11, 8, 20, 16, 19, 19, 16, 28, 20, 11, 28, 8, 6,
               15, 14, 36, 14, 30, 8, 35, 19, 27, 31, 17, 18, 20, 16, 18, 16,
               13, 10, 9, 16, 25, 15, 18, 16, 19, 10, 30, 9, 31, 15, 20, 35,
               12, 26, 17, 14, 16), ncol = 4)
X <- list(X1 = X1, X2 = X2)
```

```r
q <- mqcc(X, type = "T2")
summary(q)
ellipseChart(q)
ellipseChart(q, show.id = TRUE)
```

```r
q <- mqcc(X, type = "T2", pred.limits = TRUE)
```

# Ryan (2000) discussed Xbar-charts for single variables computed adjusting the
# confidence level of the T^2 chart:

```r
q1 <- qcc(X1, type = "xbar", confidence.level = q$confidence.level^(1/2))
summary(q1)
q2 <- qcc(X2, type = "xbar", confidence.level = q$confidence.level^(1/2))
summary(q2)
```

```r
require(MASS)
```

# generate new "in control" data

```r
Xnew <- list(X1 = matrix(NA, 10, 4), X2 = matrix(NA, 10, 4))
for(i in 1:4)
{
  x <- mvrnorm(10, mu = q$center, Sigma = q$cov)
  Xnew$X1[,i] <- x[,1]
  Xnew$X2[,i] <- x[,2]
}
qq <- mqcc(X, type = "T2", newdata = Xnew, pred.limits = TRUE)
summary(qq)
```

# generate new "out of control" data

```r
Xnew <- list(X1 = matrix(NA, 10, 4), X2 = matrix(NA, 10, 4))
for(i in 1:4)
{
  x <- mvrnorm(10, mu = 1.2*q$center, Sigma = q$cov)
  Xnew$X1[,i] <- x[,1]
  Xnew$X2[,i] <- x[,2]
}
library(qcc)

# Individual observations data

##

## Individual observations data


qq <- mqcc(X, type = "T2", newdata = Xnew, pred.limits = TRUE)
summary(qq)

##

## Individual observations data


data(boiler)

data(boiler)

q <- mqcc(boiler, type = "T2.single", confidence.level = 0.999)
summary(q)

# generate new "in control" data

boilerNew <- mvrnorm(10, mu = q$center, Sigma = q$cov)

qq <- mqcc(boiler, type = "T2.single", confidence.level = 0.999, 
newdata = boilerNew, pred.limits = TRUE)
summary(qq)

# generate new "out of control" data

boilerNew = mvrnorm(10, mu = 1.01*q$center, Sigma = q$cov)

qq <- mqcc(boiler, type = "T2.single", confidence.level = 0.999, 
newdata = boilerNew, pred.limits = TRUE)
summary(qq)

# provides "robust" estimates of means and covariance matrix

library(MASS)

rob <- cov.rob(boiler)

qrob <- mqcc(boiler, type = "T2.single", center = rob$center, cov = rob$cov)

summary(qrob)

---

### oc.curves

**Operating Characteristic Function**

**Description**

Draws the operating characteristic curves for a `qcc` object.

**Usage**

```r
oc.curves(object, ...)

oc.curves.xbar(object, n, c = seq(0, 5, length=101),
nsigmas = object$nsigmas, identify=FALSE, restore.par=TRUE)

oc.curves.R(object, n, c = seq(1, 6, length=101),
nsigmas = object$nsigmas, identify = FALSE, restore.par=TRUE)
```
oc.curves.S(object, n, c = seq(1, 6, length=101),
        nsigmas = object$nsigmas, identify = FALSE, restore.par=TRUE)

oc.curves.p(object, nsigmas = object$nsigmas, identify = FALSE, restore.par=TRUE)
oc.curves.c(object, nsigmas = object$nsigmas, identify = FALSE, restore.par=TRUE)

Arguments

object an object of class 'qcc'.
identify logical specifying whether to interactively identify points on the plot (see help for identify).
n a vector of values specifying the sample sizes for which to draw the OC curves.
c a vector of values specifying the multipliers for sigma in case of continuous variable.
nsigmas a numeric value specifying the number of sigmas to use for computing control limits; if nsigmas is NULL, object$conf is used to set up probability limits; nsigmas is ignored for types "p" and "c".
restore.par a logical value indicating whether the previous par settings must be restored. If you need to add points, lines, etc. to a chart set this to FALSE.
... additional arguments to be passed to the generic function.

Details

An operating characteristic curve graphically provides information about the probability of not detecting a shift in the process. oc.curves is a generic function which calls the proper function depending on the type of 'qcc' object. Further arguments provided through ... are passed to the specific function depending on the type of chart.

The probabilities are based on the conventional assumptions about process distributions: the normal distribution for "xbar", "R", and "S", the binomial distribution for "p" and "np", and the Poisson distribution for "c" and "u". They are all sensitive to departures from those assumptions, but to varying degrees. The performance of the "S" chart, and especially the "R" chart, are likely to be seriously affected by longer tails.

Value

The function invisibly returns a matrix or a vector of beta values, the probability of type II error.

Author(s)

Luca Scrucca

References


See Also

qcc

Examples

data(pistonrings)
attach(pistonrings)
diameter <- qcc.groups(diameter, sample)
beta <- oc.curves.xbar(qcc(diameter, type="xbar", nsigmas=3, plot=FALSE))
print(round(beta, digits=4))
# or to identify points on the plot use
## Not run: oc.curves.xbar(qcc(diameter, type="xbar", nsigmas=3, plot=FALSE), identify=TRUE)
detach(pistonrings)

data(orangejuice)
attach(orangejuice)
beta <- oc.curves(qcc(D[[trial]], sizes=size[[trial]], type="p", plot=FALSE))
print(round(beta, digits=4))
# or to identify points on the plot use
## Not run: oc.curves(qcc(D[[trial]], sizes=size[[trial]], type="p", plot=FALSE), identify=TRUE)
detach(orangejuice)

data(circuit)
attach(circuit)
q <- qcc(x[[trial]], sizes=size[[trial]], type="c", plot=FALSE)
beta <- oc.curves(q)
print(round(beta, digits=4))
# or to identify points on the plot use
## Not run: oc.curves(qcc(x[[trial]], sizes=size[[trial]], type="c", plot=FALSE), identify=TRUE)
detach(circuit)

orangejuice

*Orange juice data*

Description

Frozen orange juice concentrate is packed in 6-oz cardboard cans. These cans are formed on a machine by spinning them from cardboard stock and attaching a metal bottom panel. A can is then inspected to determine whether, when filled, the liquid could possible leak either on the side seam or around the bottom joint. If this occurs, a can is considered nonconforming. The data were collected as 30 samples of 50 cans each at half-hour intervals over a three-shift period in which the machine was in continuous operation. From sample 15 used a new batch of cardboard stock was pun into
production. Sample 23 was obtained when an inexperienced operator was temporarily assigned to the machine. After the first 30 samples, a machine adjustment was made. Then further 24 samples were taken from the process.

Usage
data(orangejuice)

Format
A data frame with 54 observations on the following 4 variables:

- **sample**: sample id
- **D**: number of defectives
- **size**: sample sizes
- **trial**: trial samples (TRUE/FALSE)

References

Examples
data(orangejuice)
orangejuice$d <- orangejuice$D/orangejuice$size
attach(orangejuice)
summary(orangejuice)
boxplot(d ~ trial)
mark <- ifelse(trial, 1, 2)
plot(sample, d, type="b", col=mark, pch=mark)
detach(orangejuice)

Orange juice data – Part 2

Description
A full description of the problem is given in *orangejuice*.

This dataset contains samples taken after the machine adjustment was made.

Usage
data(orangejuice)
Format

A data frame with 64 observations on the following 4 variables:

- **sample**  sample id
- **D**  number of defectives
- **size**  sample sizes
- **trial**  trial samples (TRUE/FALSE)

References


Examples

```r
data(orangejuice2)
orangejuice2$d <- orangejuice2$D/orangejuice2$size
attach(orangejuice2)
summary(orangejuice2)
boxplot(d ~ trial)
mark <- ifelse(trial, 1, 2)
plot(sample, d, type="b", col=mark, pch=mark)
detach(orangejuice2)
```

---

**Description**

Computes a table of statistics and plot a Pareto chart.

**Usage**

```r
pareto.chart(data, plot = TRUE, ...)
```

```r
# S3 method for class 'pareto.chart'
plot(x, xlab = NULL, ylab = "Frequency",
ylab2 = "Cumulative Percentage",
cumperc = seq(0, 100, by = 25),
ylab2 = "Cumulative Percentage",
cumperc = seq(0, 100, by = 25),
ylim = NULL, main = NULL,
col = blues.colors(nlevels),
...)```
Arguments

data a vector of values. names(data) are used for labelling the bars.
plot a logical specifying if the chart should be provided (TRUE, default).
x the object of class 'pareto.chart' returned by a call to pareto.chart function.
xlab a string specifying the label for the x-axis.
ylab a string specifying the label for the y-axis.
ylab2 a string specifying the label for the second y-axis on the right side.
cumperc a vector of percentage values to be used as tickmarks for the second y-axis on the right side.
ylim a numeric vector specifying the limits for the y-axis.
main a string specifying the main title to appear on the plot.
col a value for the color, a vector of colors, or a palette for the bars. See the help for colors and palette.
... other graphical arguments to be passed to the corresponding plot method, and eventually to the barplot function.

Details

A Pareto chart is a barplot where the categories are ordered in non increasing order, and a line is also added to show the cumulative sum.

Value

Returns an object of class 'pareto.chart' containing the descriptive statistics used to draw the Pareto chart. This object has associated a print and plot method.

Author(s)

Luca Scrucca

References


See Also

barplot
Examples

defect <- c(80, 27, 66, 94, 33)
names(defect) <- c("price code", "schedule date", "supplier code", "contact num.", "part num.")
pareto.chart(defect, ylab = "Error frequency")
pareto.chart(defect, ylab = "Error frequency", xlab = "Error causes", las=1)
pareto.chart(defect, ylab = "Error frequency", col=rainbow(length(defect)))
pareto.chart(defect, cumperc = seq(0, 100, by = 5), ylab2 = "A finer tickmarks grid")

pcmanufact  Personal computer manufacturer data

Description

A personal computer manufacturer counts the number of nonconformities per unit on the final assembly line. He collects data on 20 samples of 5 computers each.

Usage

data(pcmanufact)

Format

A data frame with 10 observations on the following 2 variables.

x  number of nonconformities (inspection units)
size  number of computers inspected

References


Examples

data(pcmanufact)
attach(pcmanufact)
summary(pcmanufact)
plot(x/size, type="b")
detach(pcmanufact)
pistonrings

Piston rings data

Description

Piston rings for an automotive engine are produced by a forging process. The inside diameter of the rings manufactured by the process is measured on 25 samples, each of size 5, for the control phase I, when preliminary samples from a process being considered 'in control' are used to construct control charts. Then, further 15 samples, again each of size 5, are obtained for phase II.

Usage

data(pistonrings)

Format

A data frame with 200 observations on the following 3 variables.

- **diameter** a numeric vector
- **sample** sample ID
- **trial** preliminary sample indicator (TRUE/FALSE)

References


Examples

data(pistonrings)
attach(pistonrings)
summary(pistonrings)
boxplot(diameter ~ sample)
plot(sample, diameter, cex=0.7)
lines(tapply(diameter,sample,mean))
detach(pistonrings)

---

process.capability

Process capability analysis

Description

Computes process capability indices for a 'qcc' object of type "xbar" and plot the histogram.
process.capability

Usage

process.capability(object, spec.limits, target, std.dev, nsigmas, confidence.level = 0.95, breaks = "scott", add.stats = TRUE, print = TRUE, digits = getOption("digits"), restore.par = TRUE)

Arguments

object a 'qcc' object of type "xbar"

spec.limits a two-values vector specifying the lower and upper specification limits. For one-sided specification limits, the value of the missing limit must be set to NA.

target a value specifying the target of the process. If missing the value from the 'qcc' object is used if not NULL, otherwise the target is set at the middle value between specification limits.

std.dev a value specifying the within-group standard deviation. If not provided is taken from the 'qcc' object.

nsigmas a numeric value specifying the number of sigmas to use. If not provided is taken from the 'qcc' object.

certainty.level a numeric value between 0 and 1 specifying the level to use for computing confidence intervals.

breaks a value or string used to draw the histogram. See the help for hist for more details.

add.stats a logical value indicating whether statistics and capability indices should be added at the bottom of the chart.

print a logical value indicating whether statistics and capability indices should be printed.

digits the number of significant digits to use.

restore.par a logical value indicating whether the previous par settings must be restored. If you need to add points, lines, etc. to a chart set this to FALSE.

Details

This function calculates confidence limits for $C_p$ using the method described by Chou et al. (1990). Approximate confidence limits for $C_{pl}$, $C_{pu}$ and $C_{pk}$ are computed using the method in Bissell (1990). Confidence limits for $C_{pms}$ are based on the method of Boyles (1991); this method is approximate and it assumes that the target is midway between the specification limits.

Value

Invisibly returns a list with components:

nobs number of observations
center center
std.dev standard deviation
Description

Create an object of class 'qcc' to perform statistical quality control. This object may then be used to plot Shewhart charts, drawing OC curves, computes capability indices, and more.
Usage

qcc(data, type, sizes, center, std.dev, limits,
data.name, labels, newdata, newsizes, newdata.name,
newlabels, nsigmas = 3, confidence.level,
rules = shewhart.rules, plot = TRUE, ...)

## S3 method for class 'qcc'
print(x, ...)  

## S3 method for class 'qcc'
summary(object, digits = getOption("digits"), ...)

## S3 method for class 'qcc'
plot(x, add.stats = TRUE, chart.all = TRUE,
    label.limits = c("LCL ", "UCL"), title, xlab, ylab, ylim,
    axes.las = 0, digits = getOption("digits"),
    restore.par = TRUE, ...)

Arguments

data a data frame, a matrix or a vector containing observed data for the variable to chart. Each row of a data frame or a matrix, and each value of a vector, refers to a sample or "rationale group".

type a character string specifying the group statistics to compute. Available methods are:

<table>
<thead>
<tr>
<th>Statistic charted</th>
<th>Chart description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;xbar&quot;</td>
<td>mean</td>
</tr>
<tr>
<td>&quot;R&quot;</td>
<td>range</td>
</tr>
<tr>
<td>&quot;S&quot;</td>
<td>standard deviation</td>
</tr>
<tr>
<td>&quot;xbar.one&quot;</td>
<td>one-at-time data of a continuous process variable</td>
</tr>
<tr>
<td>&quot;p&quot;</td>
<td>proportion</td>
</tr>
<tr>
<td>&quot;np&quot;</td>
<td>count</td>
</tr>
<tr>
<td>&quot;c&quot;</td>
<td>count</td>
</tr>
<tr>
<td>&quot;u&quot;</td>
<td>count</td>
</tr>
<tr>
<td>&quot;g&quot;</td>
<td>count</td>
</tr>
</tbody>
</table>

Furthermore, a user specified type of chart, say "newchart", can be provided. This requires the definition of "stats.newchart", "sd.newchart", and "limits.newchart". As an example, see stats.xbar.

sizes a value or a vector of values specifying the sample sizes associated with each group. For continuous data provided as data frame or matrix the sample sizes are obtained counting the non-NA elements of each row. For "p", "np" and "u" charts the argument sizes is required.

center a value specifying the center of group statistics or the "target" value of the process.

std.dev a value or an available method specifying the within-group standard deviation(s)
Several methods are available for estimating the standard deviation in case of a continuous process variable; see `sd.xbar`, `sd.xbar.one`, `sd.R`, `sd.S`.

- **limits**: a two-values vector specifying control limits.
- **data.name**: a string specifying the name of the variable which appears on the plots. If not provided is taken from the object given as data.
- **labels**: a character vector of labels for each group.
- **newdata**: a data frame, matrix or vector, as for the `data` argument, providing further data to plot but not included in the computations.
- **newsizes**: a vector as for the `sizes` argument providing further data sizes to plot but not included in the computations.
- **newdata.name**: a string specifying the name of the variable which appears on the plots. If not provided is taken from the object given as newdata.
- **newlabels**: a character vector of labels for each new group defined in the argument `newdata`.
- **nsigmas**: a numeric value specifying the number of sigmas to use for computing control limits. It is ignored when the `confidence.level` argument is provided.
- **confidence.level**: a numeric value between 0 and 1 specifying the confidence level of the computed probability limits.
- **rules**: a function of rules to apply to the chart. By default, the `shewhart.rules` function is used.
- **plot**: logical. If TRUE a Shewhart chart is plotted.
- **add.stats**: a logical value indicating whether statistics and other information should be printed at the bottom of the chart.
- **chart.all**: a logical value indicating whether both statistics for `data` and for `newdata` (if given) should be plotted.
- **label.limits**: a character vector specifying the labels for control limits.
- **title**: a string giving the label for the main title.
- **xlab**: a string giving the label for the x-axis.
- **ylab**: a string giving the label for the y-axis.
- **ylim**: a numeric vector specifying the limits for the y-axis.
- **axes.las**: numeric in \{0,1,2,3\} specifying the style of axis labels. See `help(par)`.
- **digits**: the number of significant digits to use.
- **restore.par**: a logical value indicating whether the previous `par` settings must be restored. If you need to add points, lines, etc. to a control chart set this to FALSE.
- **object**: an object of class `qcc`.
- **x**: an object of class `qcc`.
- **...**: additional arguments to be passed to the generic function.

**Value**

Returns an object of class `qcc`.
Note

For a nice blog post discussing the qcc package, in particular how to implement the Western Eletric Rules (WER), see http://blog.yhathq.com/posts/quality-control-in-r.html.

Author(s)

Luca Scrucca

References


See Also

shewhart.rules, cusum, ewma, oc.curves, process.capability, qcc.groups

Examples

## Continuous data
##
data(pistonrings)
attach(pistonrings)
diameter <- qcc.groups(diameter, sample)

qcc(diameter[1:25,], type="xbar")
qcc(diameter[1:25,], type="xbar", newdata=diameter[26:40,])
q <- qcc(diameter[1:25,], type="xbar", newdata=diameter[26:40,], plot=FALSE)
plot(q, chart.all=FALSE)
qcc(diameter[1:25,], type="xbar", newdata=diameter[26:40,], nsigmas=2)
qcc(diameter[1:25,], type="xbar", newdata=diameter[26:40,], confidence.level=0.99)

qcc(diameter[1:25,], type="R")
qcc(diameter[1:25,], type="R", newdata=diameter[26:40,])

qcc(diameter[1:25,], type="S")
qcc(diameter[1:25,], type="S", newdata=diameter[26:40,])

# add warning limits at 2 std. deviations
q <- qcc(diameter[1:25,], type="xbar", newdata=diameter[26:40,], plot=FALSE)
(warn.limits <- limits.xbar(q$center, q$std.dev, q$sizes, 2))
plot(q, restore.par = FALSE)
abline(h = warn.limits, lty = 3, col = "chocolate")
# variable control limits
out <- c(9, 10, 30, 35, 45, 64, 65, 74, 75, 85, 99, 100)
diameter <- qcc.groups(pistonrings$diameter[-out], sample[-out])
qcc(diameter[1:25,], type="xbar")
qcc(diameter[1:25,], type="R")
qcc(diameter[1:25,], type="S")
qcc(diameter[1:25,], type="xbar", newdata=diameter[26:40,])
qcc(diameter[1:25,], type="R", newdata=diameter[26:40,])
qcc(diameter[1:25,], type="S", newdata=diameter[26:40,])
detach(pistonrings)

##
## Attribute data
##

data(orangejuice)
attach(orangejuice)
qcc(D[trial], sizes=size[trial], type="p")

# remove out-of-control points (see help(orangejuice) for the reasons)
inc <- setdiff(which(trial), c(15,23))
q1 <- qcc(D[inc], sizes=size[inc], type="p")
qcc(D[inc], sizes=size[inc], type="p", newdata=D[!trial], newsizes=size[!trial])
detach(orangejuice)

data(orangejuice2)
attach(orangejuice2)
names(D) <- sample
qcc(D[trial], sizes=size[trial], type="p")
q2 <- qcc(D[trial], sizes=size[trial], type="p", newdata=D[!trial], newsizes=size[!trial])
detach(orangejuice2)

# put on the same graph the two orange juice samples
oldpar <- par(no.readonly = TRUE)
par(mfrow=c(1,2), mar=c(5,5,3,0))
plot(q1, title="First samples", ylim=c(0,0.5), add.stats=FALSE, restore.par=FALSE)
par("mar"=c(5,0,3,3), yaxt="n")
plot(q2, title="Second samples", add.stats=FALSE, ylim=c(0,0.5))
par(oldpar)

data(circuit)
attach(circuit)
qcc(x[trial], sizes=size[trial], type="c")
# remove out-of-control points (see help(circuit) for the reasons)
inc <- setdiff(which(trial), c(6,20))
qcc(x[inc], sizes=size[inc], type="c", labels=inc)
qcc(x[inc], sizes=size[inc], type="c", labels=inc,
newdata=x[!trial], newsizes=size[!trial], newlabels=which(!trial))
qcc(x[inc], sizes=size[inc], type="u", labels=inc,
newdata=x[!trial], newsizes=size[!trial], newlabels=which(!trial))
detach(circuit)
data(pcmanufact)  
attach(pcmanufact)  
qcc(x, sizes=size, type="u")  
detach(pcmanufact)  

data(dyedcloth)  
attach(dyedcloth)  
qcc(x, sizes=size, type="u")  
# standardized control chart  
q <- qcc(x, sizes=size, type="u", plot=FALSE)  
z <- (q$statistics - q$center)/sqrt(q$center/q$size)  
plot(z, type="o", ylim=range(z,3,-3), pch=16)  
abline(h=0, lty=2)  
abline(h=c(-3,3), lty=2)  
detach(dyedcloth)  

##  
## Continuous one-at-time data  
##  
# viscosity data (Montgomery, pag. 242)  
x <- c(33.75, 33.05, 34, 33.81, 33.46, 34.02, 33.68, 33.27, 33.49, 33.20, 33.62, 33.00, 33.54, 33.12, 33.84)  
qcc(x, type="xbar.one")  
qcc(x, type="xbar.one", std.dev = "SD")

---

**qcc.groups**  
*Grouping data based on a sample indicator*

**Description**

This function allows to easily group data to use as input to the 'qcc' function.

**Usage**

qcc.groups(data, sample)

**Arguments**

- **data**: the observed data values
- **sample**: the sample indicators for the data values

**Value**

The function returns a matrix of suitable dimensions. If one or more group have few observations than others, NA values are appended.
qcc.options

Author(s)

Luca Scrucca

See Also

qcc

Examples

data(pistonrings)
attach(pistonrings)
# 40 sample of 5 obs each
qcc.groups(diameter, sample)
# some obs are removed, the result is still a 40x5 matrix but with NAs added
qcc.groups(diameter[-c(1, 2, 50, 52, 199)], sample[-c(1, 2, 50, 52, 199)])

qcc.options

Set or return options for the 'qcc' package.

Description

This function can be used to control the behavior of the 'qcc' library such as the background color, out-of-control points appearance, and many others.

Usage

qcc.options(...)

Arguments

... the option to be set or retrieved. See details.

Details

The available options are:

exp.R.unscaled a vector specifying, for each sample size, the expected value of the relative range (i.e. $R/\sigma$) for a normal distribution. This appears as $d_2$ on most tables containing factors for the construction of control charts.

se.R.unscaled a vector specifying, for each sample size, the standard error of the relative range (i.e. $R/\sigma$) for a normal distribution. This appears as $d_3$ on most tables containing factors for the construction of control charts.

beyond.limits$pch plotting character used to highlight points beyond control limits.

beyond.limits$col color used to highlight points beyond control limits.

violating.runs$pch plotting character used to highlight points violating runs.

violating.runs$col color used to highlight points violating runs.
run.length  the maximum value of a run before to signal a point as out of control.
b.g.margin background color used to draw the margin of the charts.
b.g.figure  background color used to draw the figure of the charts.
cex character expansion used to draw plot annotations (labels, title, tickmarks, etc.).
font.stats  font used to draw text at the bottom of control charts.
cex.stats  character expansion used to draw text at the bottom of control charts.

Value
If the functions is called with no argument return a list of available options.
If an option argument is provided the corresponding value is returned.
If a value is associated with an option argument, such option is set and the list of updated option values is invisibly returned. In this case the list .qcc.options is modified and any modification will remain in effect for the rest of the session.

Author(s)
Luca Scrucca

See Also
qcc

Examples
old <- qcc.options() # save defaults
qcc.options("cex.stats") # get a single parameter
qcc.options("cex.stats"=1.2) # change parameters
qcc.options(bg.margin="azure2")
qcc.options("violating.runs" = list(pch = 15, col = "purple"))
qcc.options("beyond.limits" = list(pch = 15, col = "orangered"))
qcc(rnorm(100), type = "xbar.one", std.dev = 0.7) # see the results
qcc.options(old) # restore old defaults

qcc.overdispersion.test

Overdispersion test for binomial and poisson data

Description
This function allows to test for overdispersed data in the binomial and poisson case.

Usage
qcc.overdispersion.test(x, size, type=ifelse(missing(size), "poisson", "binomial"))
Arguments

x a vector of observed data values
size for binomial data, a vector of sample sizes
type a character string specifying the distribution for testing, either "poisson" or "binomial". By default, if size is provided a binomial distributed is assumed, otherwise a poisson distribution.

Details

This very simple test amounts to compute the statistic

\[ D = \frac{\text{Observed variance}}{\text{Theoretical variance}} \times (\text{no. observations} - 1) \]

and refer this to a Chi-square distribution with (no. observations - 1) degrees of freedom.

Value

The function returns a matrix of results.

Author(s)

Luca Scrucca

References


Examples

# data from Wetherill and Brown (1991) pp. 212--213, 216--218:
x <- c(12,11,18,11,10,16,9,11,14,15,11,9,10,13,12,
      8,12,13,10,12,13,16,12,18,16,10,16,10,12,14)
size <- rep(50, length(x))
qcc.overdispersion.test(x,size)

x <- c(11,8,13,11,13,17,25,23,11,16,9,15,10,16,12,
      8,9,15,4,12,12,15,17,14,17,12,12,7,16)
qcc.overdispersion.test(x)

shewhart.rules

Functions specifying rules for Shewhart charts

Description

These functions are used to signal out of control points in Shewhart charts.
Usage

shewhart.rules(object, limits = object$limits, run.length = qcc.options("run.length"))
beyond.limits(object, limits = object$limits)
violating.runs(object, run.length = qcc.options("run.length"))

Arguments

object an object of class 'qcc'.
limits control limits
run.length the maximum value of a run before to signal a point as out of control.

Details

The function shewhart.rules simply calls the beyond.limits and violating.runs functions which actually do the real calculations.

Value

The shewhart.rules function returns a list with components:

- beyond.limits the indices of points beyond control limits.
- violating.runs the indices of points violating runs.

Author(s)

Luca Scrucca

Description

Statistics used in computing and drawing a Shewhart c chart.

Usage

stats.c(data, sizes)
sd.c(data, sizes, ...)
limits.c(center, std.dev, sizes, conf)
**stats.g**

**Arguments**
- **data** the observed data values
- **center** sample/group center statistic.
- **sizes** samples sizes.
- **std.dev** within group standard deviation.
- **conf** a numeric value used to compute control limits, specifying the number of standard deviations (if \( conf > 1 \)) or the confidence level (if \( 0 < conf < 1 \)).
- ... further arguments are ignored.

**Value**

The function `stats.c` returns a list with components `statistics` and `center`.

The function `sd.c` returns `std.dev` the standard deviation of the statistic charted.

The function `limits.c` returns a matrix with lower and upper control limits.

**Author(s)**

Luca Scrucca

**References**


**See Also**

`qcc`

---

**stats.g**  
*Statistics used in computing and drawing a Shewhart g chart*

**Description**

These functions are used to compute statistics required by the g chart (geometric distribution) for use with the qcc package.

**Usage**

```r
stats.g(data, sizes)
sd.g(data, sizes, ...)
limits.g(center, std.dev, sizes, conf)
```
Arguments

- **data**: the observed data values
- **center**: sample center statistic
- **sizes**: sample sizes (not used)
- **std.dev**: standard deviation of geometric distribution
- **conf**: a numeric value used to compute control limits, specifying the number of standard deviations (if `conf > 1`) or the confidence level (if `0 < conf < 1`).
- **...**: further arguments are ignored.

Details

The `g` chart plots the number of non-events between events. **np charts do not work well when the probability of an event is rare** (see example below). Instead of plotting the number of events, the `g` chart plots the number of non-events between events.

Value

- The function `stats.g()` returns a list with components `statistics` and `center`.
- The function `sd.g()` returns `std.dev` the standard deviation `sqrt(1 - p)/p`.
- The function `limits.g()` returns a matrix with lower and upper control limits.

Note

The geometric distribution is quite skewed so it is best to set `conf` at the required confidence interval `(0 < conf < 1)` rather than as a multiplier of sigma.

Author(s)

Greg Snow <greg.snow@ihc.com>

References


See Also

- qcc

Examples

```r
success <- rbinom(1000, 1, 0.01)
num.noevent <- diff(which(c(1,success)==1))-1
qcc(success, type = "np", sizes = 1)
qcc(num.noevent, type = "g")
```
Description

These functions are used to compute statistics required by the np chart.

Usage

stats.np(data, sizes)
sd.np(data, sizes, ...)
limits.np(center, std.dev, sizes, conf)

Arguments

data the observed data values
center sample/group center statistic.
sizes samples sizes.
std.dev within group standard deviation.
conf a numeric value used to compute control limits, specifying the number of standard deviations (if conf > 1) or the confidence level (if 0 < conf < 1).
... further arguments are ignored.

Value

The function stats.np returns a list with components statistics and center.
The function sd.np returns std.dev the standard deviation of the statistic charted.
The function limits.np returns a matrix with lower and upper control limits.

Author(s)

Luca Scrucca

References


See Also

qcc
stats.p  Statistics used in computing and drawing a Shewhart p chart

Description

These functions are used to compute statistics required by the p chart.

Usage

stats.p(data, sizes)
sd.p(data, sizes, ...)
limits.p(center, std.dev, sizes, conf)

Arguments

data   the observed data values
center  sample/group center statistic.
sizes   samples sizes.
std.dev within group standard deviation.
conf    a numeric value used to compute control limits, specifying the number of standard deviations (if conf > 1) or the confidence level (if 0 < conf < 1).
...     further arguments are ignored.

Value

The function stats.p returns a list with components statistics and center.
The function sd.p returns std.dev the standard deviation of the statistic charted.
The function limits.p returns a matrix with lower and upper control limits.

Author(s)

Luca Scrucca

References


See Also

qcc
stats.R

Statistics used in computing and drawing a Shewhart R chart

Description

These functions are used to compute statistics required by the R chart.

Usage

stats.R(data, sizes)
sd.R(data, sizes, std.dev = c("UWAVE-R", "MVLUE-R"))
limits.R(center, std.dev, sizes, conf)

Arguments

data the observed data values
center sample/group center statistic.
sizes samples sizes. Optional
std.dev within group standard deviation. Optional for sd.R function, required for limits.R. See sd.xbar.
conf a numeric value used to compute control limits, specifying the number of standard deviations (if conf > 1) or the confidence level (if 0 < conf < 1).

Value

The function stats.R returns a list with components statistics and center.
The function sd.R returns std.dev the standard deviation of the statistic charted.
The function limits.R returns a matrix with lower and upper control limits.

Author(s)

Luca Scrucca

References


See Also

qcc
Functions to plot Shewhart S chart

Description

These functions are used to compute statistics required by the S chart.

Usage

```
stats.S(data, sizes)
sd.S(data, sizes, std.dev = c("UWAVE-SD", "MVLUE-SD", "RMSDF"))
limits.S(center, std.dev, sizes, conf)
```

Arguments

- `data` : the observed data values
- `center` : sample/group center statistic.
- `sizes` : samples sizes. Optional
- `conf` : a numeric value used to compute control limits, specifying the number of standard deviations (if `conf > 1`) or the confidence level (if `0 < conf < 1`).

Value

The function `stats.S` returns a list with components `statistics` and `center`.

The function `sd.S` returns `std.dev` the standard deviation of the statistic charted.

The function `limits.S` returns a matrix with lower and upper control limits.

Author(s)

Luca Scrucca

References


See Also

$qcc$
Description

These functions are used to compute statistics required by the $T^2$ chart.

Usage

stats.T2(data, center = NULL, cov = NULL)

limits.T2(ngroups, size, nvars, conf)

Arguments

data the observed data values
center a vector of values to use for center of input variables.
cov a matrix of values to use for the covariance matrix of input variables.
ngroups number of groups
size sample size
nvars number of variables
conf confidence level (0 < conf < 1)

Value

The function stats.T2 returns a list with components:

statistics a vector of values for the $T^2$ statistic
means a matrix of within group means for each variable
center sample/group center statistic
S covariance matrix

The function limits.T2 returns a list with components:

control control limits
prediction pred.limits

Author(s)

Luca Scrucca
References


See Also

mqcc, stats.T2.single

stats.T2.single  Statistics used in computing and drawing the Hotelling T^2 chart for individual observations data

Description

These functions are used to compute statistics required by the \( T^2 \) chart for individual observations.

Usage

stats.T2.single(data, center = NULL, cov = NULL)

limits.T2.single(ngroups, size, nvars, conf)

Arguments

data  the observed data values
center  a vector of values to use for center of input variables.
cov  a matrix of values to use for the covariance matrix of input variables.
ngroups  number of groups
size  sample size
nvars  number of variables
conf  confidence level (0 < conf < 1)

Value

The function stats.T2.single returns a list with components:

statistics  a vector of values for the \( T^2 \) statistic
means  a matrix of within group means for each variable (which is equal to data since sample are of sizes one)
center  sample/group center statistic
S  covariance matrix
The function `limits.T2.single` returns a list with components:

- `control`: control limits
- `prediction`: pred.limits

**Author(s)**

Luca Scrucca

**References**


**See Also**

`mqcc`, `stats.T2`

---

**Description**

These functions are used to compute statistics required by the u chart.

**Usage**

```r
stats.u(data, sizes)
sd.u(data, sizes, ...)
limits.u(center, std.dev, sizes, conf)
```

**Arguments**

- `data`: the observed data values
- `center`: sample/group center statistic.
- `sizes`: samples sizes.
- `std.dev`: within group standard deviation.
- `conf`: a numeric value used to compute control limits, specifying the number of standard deviations (if `conf > 1`) or the confidence level (if `0 < conf < 1`).
- `...`: further arguments are ignored.
Value

The function `stats.u` returns a list with components `statistics` and `center`.
The function `sd.u` returns `std.dev` the standard deviation of the statistic charted.
The function `limits.u` returns a matrix with lower and upper control limits.

Author(s)

Luca Scrucca

References


See Also

qcc

---

`stats.xbar`  
*Statistics used in computing and drawing a Shewhart xbar chart*

Description

These functions are used to compute statistics required by the xbar chart.

Usage

```r
stats.xbar(data, sizes)
sd.xbar(data, sizes, std.dev = c("UWAVE-R", "UWAVE-SD", "MVLUE-R", "MVLUE-SD", "RMSDF"))
limits.xbar(center, std.dev, sizes, conf)
```

Arguments

- `data`: the observed data values
- `center`: sample/group center statistic
- `sizes`: samples sizes. Optional
- `std.dev`: within group standard deviation. Optional for `sd.xbar` function, required for `limits.xbar`. See details.
- `conf`: a numeric value used to compute control limits, specifying the number of standard deviations (if `conf` > 1) or the confidence level (if 0 < `conf` < 1).
Details

The following methods are available for estimating the process standard deviation:

"UWAVE-R"  UnWeighted AVERage of subgroup estimates based on subgroup Ranges
"UWAVE-SD"  UnWeighted AVERage of subgroup estimates based on subgroup Standard Deviations
"MVLUE-R"  Minimum Variance Linear Unbiased Estimator computed as a weighted average of
subgroup estimates based on subgroup Ranges
"MVLUE-SD"  Minimum Variance Linear Unbiased Estimator computed as a weighted average of
subgroup estimates based on subgroup Standard Deviations
"RMSDF"    Root-Mean-Square estimator computed as a weighted average of subgroup estimates
based on subgroup Standard Deviations

Depending on the chart, a method may be available or not, or set as the default according to the
following table:

<table>
<thead>
<tr>
<th>Method</th>
<th>&quot;xbar&quot;</th>
<th>&quot;R&quot;</th>
<th>&quot;S&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;UWAVE-R&quot;</td>
<td>default</td>
<td>default</td>
<td>not available</td>
</tr>
<tr>
<td>&quot;UWAVE-SD&quot;</td>
<td>not available</td>
<td>default</td>
<td></td>
</tr>
<tr>
<td>&quot;MVLUE-R&quot;</td>
<td>not available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;MVLUE-SD&quot;</td>
<td>not available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;RMSDF&quot;</td>
<td>not available</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Detailed definitions of formulae implemented are available in the SAS/QC 9.2 User's Guide.

Value

The function `stats.xbar` returns a list with components `statistics` and `center`.

The function `sd.xbar` returns `std.dev` the standard deviation of the statistic charted. This is based
on results from Burr (1969).

The function `limits.xbar` returns a matrix with lower and upper control limits.

Author(s)

Luca Scrucca

References


Wiley & Sons.


See Also

`qcc`
**stats.xbar.one**

Statistics used in computing and drawing a Shewhart xbar chart for one-at-time data

---

**Description**

These functions are used to compute statistics required by the xbar chart for one-at-time data.

**Usage**

```r
codes <- c("MR", "SD")
stats.xbar.one(data, sizes)
sd.xbar.one(data, sizes, std.dev = codes, k=2)
limits.xbar.one(center, std.dev, sizes, conf)
```

**Arguments**

- `data`: the observed data values
- `center`: sample/group center statistic.
- `sizes`: samples sizes. Not needed, size=1 is used.
- `k`: number of successive pairs of observations for computing the standard deviation based on moving ranges of k points.
- `std.dev`: within group standard deviation. Optional for `sd.xbar.one` function, required for `limits.xbar.one`. See details.
- `conf`: a numeric value used to compute control limits, specifying the number of standard deviations (if `conf` > 1) or the confidence level (if 0 < `conf` < 1).

**Details**

Methods available for estimating the process standard deviation:

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;MR&quot;</td>
<td>moving range: this estimate is based on the scaled mean of moving ranges</td>
</tr>
<tr>
<td>&quot;SD&quot;</td>
<td>sample standard deviation: this estimate is defined as ( \frac{\text{as(x)}}{\text{cd(n)}} ), where n = number of observations x.</td>
</tr>
</tbody>
</table>

**Value**

The function `stats.xbar.one` returns a list with components `statistics` and `center`.

The function `sd.xbar.one` returns `std.dev` the standard deviation of the statistic charted.

The function `limits.xbar.one` returns a matrix with lower and upper control limits.

**Author(s)**

Luca Scrucca
References


See Also

qcc

Examples

# Water content of antifreeze data (Wetherill and Brown, 1991, p. 120)
x <- c(2.23, 2.53, 2.62, 2.63, 2.58, 2.44, 2.49, 2.34, 2.95, 2.54, 2.60, 2.45,
      2.17, 2.58, 2.57, 2.44, 2.38, 2.23, 2.23, 2.54, 2.66, 2.84, 2.81, 2.39,
      2.56, 2.70, 3.00, 2.81, 2.77, 2.89, 2.54, 2.98, 2.35, 2.53)

# the Shewhart control chart for one-at-time data
# 1) using MR (default)
qucc(x, type="xbar.one", data.name="Water content (in ppm) of batches of antifreeze")
# 2) using SD
nqucc(x, type="xbar.one", std.dev = "SD", data.name="Water content (in ppm) of batches of antifreeze")

# "as the size increases further, we would expect sigma-hat to settle down
# at a value close to the overall sigma-hat" (Wetherill and Brown, 1991,
# p. 121)
sigma <- NA
k <- 2:24
for (j in k)
    sigma[j] <- sd.xbar.one(x, k=j)
plot(k, sigma[k], type="b")  # plot estimates of sigma for
abline(h=sd(x), col=2, lty=2)  # different values of k
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