

Package ‘qicharts2’

October 28, 2020

Title Quality Improvement Charts

Version 0.7.1

Date 2020-10-28

Description Functions for making run charts, Shewhart control charts and Pareto charts for continuous quality improvement. Included control charts are: I, MR, Xbar, S, T, C, U, U', P, P', and G charts. Non-random variation in the form of minor to moderate persistent shifts in data over time is identified by the Anhoej rules for unusually long runs and unusually few crossing [Anhoej, Olesen (2014) <doi:10.1371/journal.pone.0113825>]. Non-random variation in the form of larger, possibly transient, shifts is identified by Shewhart's 3-sigma rule [Mohammed, Worthington, Woodall (2008) <doi:10.1136/qshc.2004.012047>].

Depends R (>= 3.0.0)

Imports ggplot2 (>= 2.2.0), scales, stats

Suggests dplyr (>= 0.7.0), knitr, rmarkdown, testthat, tidyr

License GPL-3

Encoding UTF-8

LazyData true

RoxygenNote 7.1.1

VignetteBuilder knitr

URL <https://github.com/anhoej/qicharts2>

NeedsCompilation no

Author Jacob Anhoej [aut, cre]

Maintainer Jacob Anhoej <jacob@anhoej.net>

Repository CRAN

Date/Publication 2020-10-28 15:00:02 UTC

R topics documented:

bchart	2
cabg	3
cdi	4
gtt	4
hospital_infections	5
nhs_accidents	6
paretochart	6
qic	7
qicharts2	11
summary.qic	11
Index	13

bchart	<i>Bernoulli CUSUM chart for binary data (EXPERIMENTAL)</i>
--------	---

Description

The Bernoulli CUSUM chart is useful for monitoring rare events data, e.g. surgical site infections and other types of complications. Based on Neuburger et al. (2017) <https://dx.doi.org/10.1136/bmjqs-2016-005526>.

Usage

```
bchart(
  x,
  target,
  or = 2,
  limit = 3.5,
  title = "",
  ylab = "CUSUM",
  xlab = "Case #"
)
```

Arguments

x	Logical, vector of successes and failures.
target	Baseline risk (0-1) or number (>1) of last observation to end baseline period.
or	Positive odds ratio of minimal detectable change relative to baseline risk.
limit	Control limit.
title	Chart title.
ylab	Y axis label.
xlab	X axis label.

Details

Note that the diagnostic properties of the Bernoulli CUSUM chart is highly dependent on the choice of parameters, target, or and limit, and that these parameters should be decided by people with a solid understanding of the process at hand. The default parameters, or = 2 and limit = 3.5, should, however, work for most processes where the baseline (target) level is about 1 halving of the event rate relative to the target.

Value

An object of class `ggplot`.

Examples

```
# Generate 1000 random successes and failures with success rate = 0.02
set.seed(1)
y <- rbinom(1000, 1, 0.02)

# Plot bchart assuming success rate = 0.01, OR = 2, control limits = +/- 3.5.
bchart(y, target = 0.01)

# Plot bchart of CABG mortality using the first 200 surgeries to estimate target.
bchart(cabg$death, target = 200)

# Plot bchart of CABG readmissions setting the control limits = +/-5.
bchart(cabg$readmission, target = 200, limit = 5)
```

cabg

Coronary artery bypass graft operations

Description

A dataset with data on individual coronary artery bypass graft operations.

Usage

```
cabg
```

Format

A data frame with 2205 rows and 6 variables:

- data Date of operation.
- age Patient age in years.
- gender Patient gender.
- los Length of stay in days.
- death TRUE if patient died within 30 days after surgery.
- readmission TRUE if patient were readmitted for any reason within 30 days after surgery.

Source

Omitted for privacy concerns.

cdi	<i>Clostridium difficile infections</i>
-----	---

Description

A dataset with data on hospital acquired Clostridium difficile infections (CDI) before and after an intervention to reduce the risk of CDI.

Usage

cdi

Format

A data frame with 36 rows and 5 variables:

- month Month of observation.
- n Number of hospital acquired CDI.
- days Number of risk days. A risk day is a patient day without CDI.
- period Factor indicating the period 'pre' or 'post' intervention.
- notes Annotations.

Source

<https://www.esundhed.dk/Emner/Patienter-og-sygehuse/HAIBA/> (Amager Hvidovre Hospital).

gtt	<i>Patient harm indentified using the Global Trigger Tool</i>
-----	---

Description

A dataset with data on adverse events during hospitalisation found by the Global Trigger Tool.

Usage

gtt

Format

A data frame with 340 rows and 11 variables:

- admission_id Admission ID.
- admission_dte Date of admission.
- discharge_dte Date of discharge.
- month Month of discharge.
- days Duration of hospital stay in days.
- harms Number of adverse events.
- E-I Type of adverse event by severity category. E-F: Temporary harm; G-H: Permanent harm; I: Fatal harm.

Source

Omitted for privacy concerns.

References

<http://www.ihl.org/resources/Pages/Tools/IHIGlobalTriggerToolforMeasuringAEs.aspx>

hospital_infections *Hospital acquired infections*

Description

A dataset containing the number of hospital acquired bacteremia, Clostridium difficile infections, and urinary tract infections in six hospitals in the Capital Region of Denmark 2015-2016.

Usage

```
hospital_infections
```

Format

A data frame with 432 rows and 5 variables:

- hospital Abbreviated hospital name.
- infection Type of infection. BAC: Bacteremia, CDI: Clostridium difficile infection. UTI: Urinary tract infection.
- month First day of month.
- n Number of cases.
- days Number of risk days. A risk day is a patient day without infection.

Source

<https://www.esundhed.dk/Emner/Patienter-og-sygehuse/HAIBA/> (Capital Region of Denmark).

nhs_accidents

NHS accidents

Description

The number of attendances to major accident and emergency hospital departments in the NHS that were seen within 4 hours of arrival over twenty weeks.

Usage

nhs_accidents

Format

A data frame with 20 rows and 3 variables:

- i Week number.
- r Attendances seen within 4 hours.
- n Total number of attendances.

Source

Mohammed MA, et al. Quality and Safety in Health Care 2013;22:362–368. <https://doi.org/10.1136/bmjqs-2012-001373>.

paretochart*Paretochart*

Description

Creates a pareto chart from a categorical variable

Usage

```
paretochart(  
  x,  
  title = "",  
  subtitle = NULL,  
  caption = NULL,  
  ylab = NULL,  
  xlab = NULL,  
  x.angle = NULL,  
  useNA = FALSE,  
  print.data = FALSE  
)
```

Arguments

x	Categorical variable to plot.
title	Chart title.
subtitle	Chart subtitle.
caption	Chart caption.
ylab	Y axis label.
xlab	X axis label.
x.angle	Number indicating the angle of x axis labels.
useNA	If TRUE, NA values will be included in the analysis.
print.data	If TRUE, prints data frame with results.

Value

An object of class ggplot.

Examples

```
# Generate categorical vector
x <- rep(LETTERS[1:9], c(256, 128, 64, 32, 16, 8, 4, 2, 1))

# Make paretochart
paretochart(x)

# Save paretochart object to variable
p <- paretochart(x)

# Print data frame
p$data
```

qic

Statistical process control charts.

Description

The `qic()` function creates run charts and Shewhart control charts for process control and improvement. Included control charts are: I, MR, Xbar, S, T, C, U, U', P, P', and G charts.

Usage

```
qic(
  x,
  y = NULL,
  n = NULL,
  data = NULL,
```

```

facets = NULL,
notes = NULL,
chart = c("run", "i", "mr", "xbar", "s", "t", "p", "pp", "c", "u", "up", "g"),
agg.fun = c("mean", "median", "sum", "sd"),
method = c("anhoej", "bestbox", "cutbox"),
multiply = 1,
freeze = NULL,
part = NULL,
exclude = NULL,
target = NA * 1,
cl = NA * 1,
nrow = NULL,
ncol = NULL,
scales = "fixed",
title = "",
ylab = "Value",
xlab = "Subgroup",
subtitle = NULL,
caption = NULL,
part.labels = NULL,
show.labels = is.null(facets),
decimals = 1,
point.size = 1,
x.period = NULL,
x.format = NULL,
x.angle = NULL,
x.pad = 1,
y.expand = NULL,
y.neg = TRUE,
y.percent = FALSE,
show.grid = FALSE,
flip = FALSE,
strip.horizontal = FALSE,
print.summary = FALSE
)

```

Arguments

x	Vector of subgroup values to plot along the x axis.
y	Vector of measures or counts to plot on the y axis (numerator).
n	Vector of subgroup sizes (denominator).
data	Data frame containing variables used in the plot.
facets	One or two sided formula with factors used for facetting plots.
notes	Character vector of notes to be added to individual data points.
chart	Character value indicating the chart type. Possible values are: 'run' (default), 'i', 'mr', 'xbar', 't', 's', 'c', 'u', 'up', 'p', 'pp', and 'g'.

agg.fun	Aggregate function for summarising the y variable if there are more than one observation per subgroup. Only relevant for run charts and I charts. Possible values are: 'mean' (default), 'median', 'sum', and 'sd'.
method	Character indicating the method used for runs analysis. One of 'anhoej' (default), 'bestbox', and 'cutbox'. EXPERIMENTAL!
multiply	Number indicating a number to multiply y axis by, e.g. 100 for percents rather than proportions. See also y.percent argument.
freeze	Integer indicating the last data point to include in calculation of baseline parameters for centre and control lines. Ignored if part argument is given.
part	Either integer vector indicating data points before recalculation of centre and control lines or character vector indicating chart parts.
exclude	Integer vector indicating data points to exclude from calculations of centre and control lines.
target	Numeric, either a single value indicating a target value to be plotted as a horizontal line or a vector for variable target line.
cl	Numeric, either a single value indicating the centre line if known in advance or a vector for variable centre line.
nrow, ncol	Number indicating the preferred number of rows and columns in facets.
scales	Character string, one of 'fixed' (default), 'free_y', 'free_x', or 'free' indicating whether y and x axis scales should be the same for all panels or free.
title	Character string specifying the title of the plot.
ylab	Character string specifying the y axis label.
xlab	Character string specifying the x axis label.
subtitle	Character string specifying the subtitle.
caption	Character string specifying the caption.
part.labels	Character vector specifying labels for chart parts created with the freeze or part argument.
show.labels	Logical indicating whether to show labels for centre and control lines on chart. Defaults to TRUE when facets argument is NULL.
decimals	Integer indicating the preferred number of decimals in centre and control line labels.
point.size	Number specifying the size of data points.
x.period	Character string specifying the interval cut points of datetime x values used for aggregating y values by week, month, etc. See the breaks argument of ?cut.POSIXt() for possible values.
x.format	Date format of x axis labels. See ?strftime() for possible date formats.
x.angle	Number indicating the angle of x axis labels.
x.pad	Number indicating expansion of x axis to make room for axis labels.
y.expand	Numeric value to include in y axis. Useful e.g. for starting the y axis at zero.
y.neg	If TRUE (default), the y axis is allowed to be negative (only relevant for I and Xbar charts).

y.percent	If TRUE, formats y axis labels as percentages.
show.grid	If TRUE, shows grid.
flip	If TRUE, rotates the plot 90 degrees.
strip.horizontal	If TRUE, makes y strip horizontal.
print.summary	If TRUE, prints summary.

Details

Non-random variation in the form of minor to moderate persistent shifts in data over time is (by default) identified by the Anhoej rules for unusually long runs and unusually few crossing. Use the EXPERIMENTAL method argument to apply the bestbox or cutbox methods as described in Anhøj & Wentzel-Larsen (2020) <https://doi.org/10.1371/journal.pone.0233920>.

Special cause variation in the form of larger, possibly transient, shifts in data is identified by Shewhart's 3-sigma rule.

Value

A qic object. Inherits from 'ggplot'.

See Also

vignette('qic').

Examples

```
# Lock random number generator to make reproducible results.
set.seed(2)

# Generate vector of 24 random normal numbers
y <- rnorm(24)

# Run chart
qic(y)

# I control chart
qic(y, chart = 'i')

# U control chart from build-in data set of hospital infection rates faceted
# by hospital and type of infection.
qic(month, n,
     n      = days,
     data   = hospital_infections,
     facets = infection ~ hospital,
     chart  = 'u',
     multiply = 10000,
     title  = 'Hospital infection rates',
     ylab   = 'Number of infections per 10.000 risk days',
     xlab   = 'Month')
```

qicharts2	qicharts2 <i>package</i>
-----------	--------------------------

Description

Statistical Process Control chart for R

Details

#' See the README on <https://github.com/anhoej/qicharts2/>

summary.qic	<i>Prints summary of a qic object</i>
-------------	---------------------------------------

Description

Prints summary of a qic object

Usage

```
## S3 method for class 'qic'
summary(object, ...)
```

Arguments

object	A qic object.
...	For compatibility with generic summary function.

Value

A data frame of summary values of each facet and part of a qic plot.

- facet1 Vertical facets.
- facet2 Horizontal facets
- part Number of chart part when argument break.points is given.
- aLCL Average of lower control limit.
- CL Centre line.
- aUCL Average of upper control limit.
- longest.run Length of the longest run of data points on the same side of the centre line.
- longest.run.max Upper limit of expected length of longest run.
- n.crossings Number of times the data line crosses the centre line.
- n.crossings.min Lower limit of expected number of crossings.
- runs.signal 1 if either longest run or number of crossings are outside expected limits.
- sigma.signal Number of data points outside control limits.

Examples

```
p <- qic(rnorm(24), chart = 'i')
p
summary(p)
```

Index

* datasets

cabg, [3](#)

cdi, [4](#)

gtt, [4](#)

hospital_infections, [5](#)

nhs_accidents, [6](#)

bchart, [2](#)

cabg, [3](#)

cdi, [4](#)

gtt, [4](#)

hospital_infections, [5](#)

nhs_accidents, [6](#)

paretochart, [6](#)

qic, [7](#)

qicharts2, [11](#)

summary.qic, [11](#)