Package 'classInt'

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Title Choose Univariate Class Intervals

Depends R (>= 2.2)

Imports grDevices, stats, graphics, e1071, class, KernSmooth

Suggests spData (>= 0.2.6.2), units

NeedsCompilation yes

Description Selected commonly used methods for choosing univariate class intervals for mapping or other graphics purposes.

License GPL (>= 2)

URL https://github.com/r-spatial/classInt/

BugReports https://github.com/r-spatial/classInt/issues/

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R topics documented:

`classIntervals` *Choose univariate class intervals*

Description

The function provides a uniform interface to finding class intervals for continuous numerical variables, for example for choosing colours or symbols for plotting. Class intervals are non-overlapping, and the classes are left-closed — see `findInterval`. Argument values to the style chosen are passed through the dot arguments. `classIntervals2shingle` converts a `classIntervals` object into a shingle. Labels generated in methods are like those found in `cut` unless cutlabels=FALSE.

Usage

```
classIntervals(var, n, style = "quantile", rtimes = 3, ...,
 intervalClosure = c("left", "right"), dataPrecision = NULL,
 warnSmallN = TRUE, warnLargeN = TRUE, largeN = 3000L, samp_prop = 0.1,
 gr = c("[", "]"))
## S3 method for class 'classIntervals'
plot(x, pal, ...)
## S3 method for class 'classIntervals'
print(x, digits = getOption("digits"), ...,
 under="under", over="over", between="-", cutlabels=TRUE, unique=FALSE)
nPartitions(x)
classIntervals2shingle(x)
```

Arguments

`var`	a continuous numerical variable
`n`	number of classes required, if missing, `nclass.Sturges` is used; see also the "dpih" style for automatic choice of the number of classes
`style`	chosen style: one of "fixed", "sd", "equal", "pretty", "quantile", "kmeans", "hclust", "bclust", "fisher", "jenks" or "dpih"
`rtimes`	number of replications of var to catenate and jitter; may be used with styles "kmeans" or "bclust" in case they have difficulties reaching a classification
`intervalClosure`	default “left”, allows specification of whether partition intervals are closed on the left or the right (added by Richard Dunlap). Note that the sense of interval closure is hard-coded as “right”-closed when`style="jenks"` (see Details below).
`dataPrecision`	default NULL, permits rounding of the interval endpoints (added by Richard Dunlap)
`warnSmallN`	default TRUE, if FALSE, quietens warning for n >= nobs
`warnLargeN`	default TRUE, if FALSE large data handling not used

largeN	default 3000L, the QGIS sampling threshold; over 3000, the observations presented to "fisher" and "jenks" are either a samp_prop= sample or a sample of 3000, whichever is larger
samp_prop	default 0.1, QGIS 10% sampling proportion
gr	default c("[","]"), if the **units** package is available, units::units_options("group") may be used directly to give the enclosing bracket style
...	arguments to be passed to the functions called in each style
x	"classIntervals" object for printing, conversion to shingle, or plotting
under	character string value for "under" in printed table labels if cutlabels=FALSE
over	character string value for "over" in printed table labels if cutlabels=FALSE
between	character string value for "between" in printed table labels if cutlabels=FALSE
digits	minimal number of significant digits in printed table labels
cutlabels	default TRUE, use cut-style labels in printed table labels
unique	default FALSE; if TRUE, collapse labels of single-value classes
pal	a character vector of at least two colour names for colour coding the class intervals in an ECDF plot; colorRampPalette is used internally to create the correct number of colours

Details

The "fixed" style permits a "classIntervals" object to be specified with given breaks, set in the fixedBreaks argument; the length of fixedBreaks should be n+1; this style can be used to insert rounded break values.

The "sd" style chooses breaks based on pretty of the centred and scaled variables, and may have a number of classes different from n; the returned par= includes the centre and scale values.

The "equal" style divides the range of the variable into n parts.

The "pretty" style chooses a number of breaks not necessarily equal to n using pretty, but likely to be legible; arguments to pretty may be passed through ....

The "quantile" style provides quantile breaks; arguments to quantile may be passed through ....

The "kmeans" style uses kmeans to generate the breaks; it may be anchored using set.seed; the pars attribute returns the kmeans object generated; if kmeans fails, a jittered input vector containing rtimes replications of var is tried — with few unique values in var, this can prove necessary; arguments to kmeans may be passed through ....

The "hclust" style uses hclust to generate the breaks using hierarchical clustering; the pars attribute returns the hclust object generated, and can be used to find other breaks using getHclustClassIntervals; arguments to hclust may be passed through ....

The "bclust" style uses bclust to generate the breaks using bagged clustering; it may be anchored using set.seed; the pars attribute returns the bclust object generated, and can be used to find other breaks using getBclustClassIntervals; if bclust fails, a jittered input vector containing rtimes replications of var is tried — with few unique values in var, this can prove necessary; arguments to bclust may be passed through ....

The "fisher" style uses the algorithm proposed by W. D. Fisher (1958) and discussed by Slocum et al. (2005) as the Fisher-Jenks algorithm; added here thanks to Hisaji Ono. This style will subsample

by default for more than 3000 observations. This style should always be preferred to "jenks" as it uses the original Fortran code and runs nested for-loops much faster.

The "jenks" style has been ported from Jenks' code, and has been checked for consistency with ArcView, ArcGIS, and MapInfo (with some remaining differences); added here thanks to Hisaji Ono (originally reported as Basic, now seen as Fortran (as described in a talk last seen at http://www.irlogi.ie/wp-content/uploads/2016/11/NUIM_ChoroHarmful.pdf, slides 26-27)). Note that the sense of interval closure is reversed from the other styles, and in this implementation has to be right-closed - use cutlabels=TRUE in `findColours` on the object returned to show the closure clearly, and use `findCols` to extract the classes for each value. This style will subsample by default for more than 3000 observations.

The "dpih" style uses the `dpih()` function from **KernSmooth** (Wand, 1995) implementing direct plug-in methodology to select the bin width of a histogram.

Value

an object of class "classIntervals":

`var`	the input variable
`brks`	a vector of breaks

and attributes:

`style`	the style used
`parameters`	parameter values used in finding breaks
`nobs`	number of different finite values in the input variable
`call`	this function's call
`intervalClosure`	string, whether closure is "left" or "right"
`dataPrecision`	the data precision used for printing interval values in the legend returned by `findColours`, and in the `print` method for classIntervals objects. If intervalClosure is "left", the value returned is `ceiling` of the data value multiplied by 10 to the dataPrecision power, divided by 10 to the dataPrecision power.

Note

From version 0.1-11, the default representation has been changed to use `cutlabels=TRUE`, and representation within intervals has been corrected, thanks to Richard Dunlap. From version 0.1-15, the print method drops the calculation of the possible number of combinations of observations into classes, which generated warnings for n > 170.

Author(s)

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References

Armstrong, M. P., Xiao, N., Bennett, D. A., 2003. "Using genetic algorithms to create multicriteria class intervals for choropleth maps". Annals, Association of American Geographers, 93 (3), 595–623;

Jenks, G. F., Caspall, F. C., 1971. "Error on choroplethic maps: definition, measurement, reduction". Annals, Association of American Geographers, 61 (2), 217–244;

Dent, B. D., 1999, Cartography: thematic map design. McGraw-Hill, Boston, 417 pp.;

Slocum TA, McMaster RB, Kessler FC, Howard HH 2005 Thematic Cartography and Geographic Visualization, Prentice Hall, Upper Saddle River NJ.;

Fisher, W. D. 1958 "On grouping for maximum homogeneity", Journal of the American Statistical Association, 53, pp. 789–798 (http://lib.stat.cmu.edu/cmlib/src/cluster/fish.f)

Wand, M. P. 1995. Data-based choice of histogram binwidth. The American Statistician, 51, 59-64.

See Also

findColours, findCols, pretty, quantile, kmeans, hclust, bclust, findInterval, colorRamp, nclass, shingle

Examples

```
if (!require("spData", quietly=TRUE)) {
  message("spData package needed for examples")
  run <- FALSE
} else {
  run <- TRUE
}
if (run) {
data(jenks71, package="spData")
pal1 <- c("wheat1", "red3")
opar <- par(mfrow=c(2,3))
plot(classIntervals(jenks71$jenks71, n=5, style="fixed",
 fixedBreaks=c(15.57, 25, 50, 75, 100, 155.30)), pal=pal1, main="Fixed")
plot(classIntervals(jenks71$jenks71, n=5, style="sd"), pal=pal1, main="Pretty standard deviations")
plot(classIntervals(jenks71$jenks71, n=5, style="equal"), pal=pal1, main="Equal intervals")
plot(classIntervals(jenks71$jenks71, n=5, style="quantile"), pal=pal1, main="Quantile")
set.seed(1)
plot(classIntervals(jenks71$jenks71, n=5, style="kmeans"), pal=pal1, main="K-means")
plot(classIntervals(jenks71$jenks71, n=5, style="hclust", method="complete"),
 pal=pal1, main="Complete cluster")
}
if (run) {
plot(classIntervals(jenks71$jenks71, n=5, style="hclust", method="single"),
 pal=pal1, main="Single cluster")
set.seed(1)
plot(classIntervals(jenks71$jenks71, n=5, style="bclust", verbose=FALSE),
 pal=pal1, main="Bagged cluster")
plot(classIntervals(jenks71$jenks71, n=5, style="fisher"), pal=pal1,
 main="Fisher's method")
plot(classIntervals(jenks71$jenks71, n=5, style="jenks"), pal=pal1,
```

```
 main="Jenks' method")
par(opar)
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="fixed",
 fixedBreaks=c(15.57, 25, 50, 75, 100, 155.30)))
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="sd"))
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="equal"))
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="quantile"))
}
if (run) {
set.seed(1)
print(classIntervals(jenks71$jenks71, n=5, style="kmeans"))
}
if (run) {
set.seed(1)
print(classIntervals(jenks71$jenks71, n=5, style="kmeans", intervalClosure="right"))
}
if (run) {
set.seed(1)
print(classIntervals(jenks71$jenks71, n=5, style="kmeans", dataPrecision=0))
}
if (run) {
set.seed(1)
print(classIntervals(jenks71$jenks71, n=5, style="kmeans"), cutlabels=FALSE)
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="hclust", method="complete"))
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="hclust", method="single"))
}
if (run) {
set.seed(1)
print(classIntervals(jenks71$jenks71, n=5, style="bclust", verbose=FALSE))
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="bclust",
 hclust.method="complete", verbose=FALSE))
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="fisher"))
}
if (run) {
print(classIntervals(jenks71$jenks71, n=5, style="jenks"))
}
if (run) {
```

```
print(classIntervals(jenks71$jenks71, style="dpih"))
}
if (run) {
print(classIntervals(jenks71$jenks71, style="dpih", range.x=c(0, 160)))
}
x <- c(0, 0, 0, 1, 2, 50)
print(classIntervals(x, n=3, style="fisher"))
print(classIntervals(x, n=3, style="jenks"))

# Argument 'unique' will collapse the label of classes containing a
# single value. This is particularly useful for 'censored' variables
# that contain for example many zeros.

data_censored<-c(rep(0,10), rnorm(100, mean=20,sd=1),rep(26,10))
plot(density(data_censored))
cl2 <- classIntervals(data_censored, n=5, style="jenks", dataPrecision=2)
print(cl2, unique=FALSE)
print(cl2, unique=TRUE)

## Not run:
set.seed(1)
n <- 1e+05
x <- runif(n)
classIntervals(x, n=5, style="sd")
classIntervals(x, n=5, style="pretty")
classIntervals(x, n=5, style="equal")
classIntervals(x, n=5, style="quantile")
# the class intervals found vary a little because of sampling
classIntervals(x, n=5, style="kmeans")
classIntervals(x, n=5, style="fisher")
classIntervals(x, n=5, style="fisher")
classIntervals(x, n=5, style="fisher")

## End(Not run)
have_units <- FALSE
if (require(units, quietly=TRUE)) have_units <- TRUE
if (have_units) {
set.seed(1)
x_units <- set_units(sample(seq(1, 100, 0.25), 100), km/h)
classIntervals(x_units, n=5, style="sd")
}
if (have_units) {
classIntervals(x_units, n=5, style="pretty")
}
if (have_units) {
classIntervals(x_units, n=5, style="equal")
}
if (have_units) {
classIntervals(x_units, n=5, style="quantile")
}
if (have_units) {
classIntervals(x_units, n=5, style="kmeans")
}
```

```
if (have_units) {
classIntervals(x_units, n=5, style="fisher")
}
st <- Sys.time()
x_POSIXt <- sample(st+((0:500)*3600), 100)
fx <- st+((0:5)*3600)*100
classIntervals(x_POSIXt, style="fixed", fixedBreaks=fx)
classIntervals(x_POSIXt, n=5, style="sd")
classIntervals(x_POSIXt, n=5, style="pretty")
classIntervals(x_POSIXt, n=5, style="equal")
classIntervals(x_POSIXt, n=5, style="quantile")
classIntervals(x_POSIXt, n=5, style="kmeans")
classIntervals(x_POSIXt, n=5, style="fisher")
```

`findColours` *assign colours to classes from classInterval object*

Description

This helper function is a wrapper for `findCols` to extract classes from a "classInterval" object and assign colours from a palette created by `colorRampPalette` from the two or more colours given in the `pal` argument. It also returns two attributes for use in constructing a legend.

Usage

```
findColours(clI, pal, under="under", over="over", between="-",
 digits = getOption("digits"), cutlabels=TRUE)
```

Arguments

`clI`	a "classIntervals" object
`pal`	a character vector of at least two colour names; `colorRampPalette` is used internally to create the required number of colours
`under`	character string value for "under" in legend if cutlabels=FALSE
`over`	character string value for "over" in legend if cutlabels=FALSE
`between`	character string value for "between" in legend if cutlabels=FALSE
`digits`	minimal number of significant digits in legend
`cutlabels`	use cut-style labels in legend

Value

a character vector of colours with attributes: "table", a named frequency table; "palette", a character vector of colours corresponding to the specified breaks.

Author(s)

Roger Bivand <Roger.Bivand@nhh.no

See Also

classIntervals, findInterval, findCols, colorRamp

Examples

```
if (!require("spData", quietly=TRUE)) {
  message("spData package needed for examples")
  run <- FALSE
} else {
  run <- TRUE
}
if (run) {
data(jenks71, package="spData")
mypal <- c("wheat1", "red3")
h5 <- classIntervals(jenks71$jenks71, n=5, style="hclust", method="complete")
print(findColours(h5, mypal))
}
if (run) {
print(findColours(getHclustClassIntervals(h5, k=7), mypal))
}
if (run) {
h5Colours <- findColours(h5, mypal)
plot(h5, mypal, main="Complete hierarchical clustering")
legend(c(95, 155), c(0.12, 0.4), fill=attr(h5Colours, "palette"),
 legend=names(attr(h5Colours, "table")), bg="white")
}
if (run) {
h5tab <- attr(h5Colours, "table")
legtext <- paste(names(h5tab), " (", h5tab, ")", sep="")
plot(h5, mypal, main="Complete hierarchical clustering (with counts)")
legend(c(95, 165), c(0.12, 0.4), fill=attr(h5Colours, "palette"),
 legend=legtext, bg="white")
}
```

---

findCols *extract classes from classInterval object*

Description

This helper function is a wrapper for findInterval to extract classes from a "classInterval" object

Usage

```
findCols(clI)
```

Arguments

clI	a "classIntervals" object

Value

an integer vector of class indices

Author(s)

Roger Bivand <Roger.Bivand@nhh.no>

See Also

classIntervals, findInterval

Examples

```
if (!require("spData", quietly=TRUE)) {
  message("spData package needed for examples")
  run <- FALSE
} else {
  run <- TRUE
}
if (run) {
data(jenks71, package="spData")
fix5 <- classIntervals(jenks71$jenks71, n=5, style="fixed",
 fixedBreaks=c(15.57, 25, 50, 75, 100, 155.30))
print(fix5)
}
if (run) {
print(findCols(fix5))
}
```

---

getBclustClassIntervals

Change breaks in a "classIntervals" object

Description

Because "classIntervals" objects of style "hclust" or "bclust" contain hierarchical classification trees in their "par" attribute, different numbers of classes can be chosen without repeating the initial classification. This function accesses the "par" attribute and modifies the "brks" member of the returned "classIntervals" object.

Usage

```
getBclustClassIntervals(clI, k)
getHclustClassIntervals(clI, k)
```

Arguments

clI	a "classIntervals" object
k	number of classes required

Value

a "classIntervals" object with a "modified" attribute set

Author(s)

Roger Bivand <Roger.Bivand@nhh.no>

See Also

classIntervals

Examples

```
if (!require("spData", quietly=TRUE)) {
  message("spData package needed for examples")
  run <- FALSE
} else {
  run <- TRUE
}
if (run) {
data(jenks71, package="spData")
pal1 <- c("wheat1", "red3")
opar <- par(mfrow=c(2,2))
hCI5 <- classIntervals(jenks71$jenks71, n=5, style="hclust", method="complete")
plot(attr(hCI5, "par"))
plot(hCI5, pal=pal1, main="hclust k=5")
plot(getHclustClassIntervals(hCI5, k=7), pal=pal1, main="hclust k=7")
plot(getHclustClassIntervals(hCI5, k=9), pal=pal1, main="hclust k=9")
par(opar)
}
if (run) {
set.seed(1)
bCI5 <- classIntervals(jenks71$jenks71, n=5, style="bclust")
plot(attr(bCI5, "par"))
}
if (run) {
opar <- par(mfrow=c(2,2))
plot(getBclustClassIntervals(bCI5, k=3), pal=pal1, main="bclust k=3")
plot(bCI5, pal=pal1, main="bclust k=5")
plot(getBclustClassIntervals(bCI5, k=7), pal=pal1, main="bclust k=7")
plot(getBclustClassIntervals(bCI5, k=9), pal=pal1, main="bclust k=9")
par(opar)
}
```

---

jenks.tests *Indices for assessing class intervals*

Description

The function returns values of two indices for assessing class intervals: the goodness of variance fit measure, and the tabular accuracy index; optionally the overview accuracy index is also returned if the `area` argument is not missing.

Usage

```
jenks.tests(clI, area)
```

Arguments

`clI`	a "classIntervals" object
`area`	an optional vector of object areas if the overview accuracy index is also required

Details

The goodness of variance fit measure is given by Armstrong et al. (2003, p. 600) as:

$$GVF = 1 - \frac{\sum_{j=1}^{k}\sum_{i=1}^{N_j}\left(z_{ij} - \bar{z}_j\right)^2}{\sum_{i=1}^{N}\left(z_i - \bar{z}\right)^2}$$

where the $z_i, i = 1, \ldots, N$ are the observed values, k is the number of classes, $\bar{z}_j$ the class mean for class j, and N_j the number of counties in class j.

The tabular accuracy index is given by Armstrong et al. (2003, p. 600) as:

$$TAI = 1 - \frac{\sum_{j=1}^{k}\sum_{i=1}^{N_j}\left|z_{ij} - \bar{z}_j\right|}{\sum_{i=1}^{N}\left|z_i - \bar{z}\right|}$$

The overview accuracy index for polygon observations with known areas is given by Armstrong et al. (2003, p. 600) as:

$$OAI = 1 - \frac{\sum_{j=1}^{k}\sum_{i=1}^{N_j}\left|z_{ij} - \bar{z}_j\right|a_{ij}}{\sum_{i=1}^{N}\left|z_i - \bar{z}\right|a_i}$$

where $a_i, i = 1, \ldots, N$ are the polygon areas, and as above the a_{ij} term is indexed over $j = 1, \ldots, k$ classes, and $i = 1, \ldots, N_j$ polygons in class j.

Value

a named vector of index values

Author(s)

Roger Bivand <Roger.Bivand@nhh.no>

References

Armstrong, M. P., Xiao, N., Bennett, D. A., 2003. "Using genetic algorithms to create multicriteria class intervals for choropleth maps". Annals, Association of American Geographers, 93 (3), 595–623; Jenks, G. F., Caspall, F. C., 1971. "Error on choroplethic maps: definition, measurement, reduction". Annals, Association of American Geographers, 61 (2), 217–244

See Also

classIntervals

Examples

```
if (!require("spData", quietly=TRUE)) {
  message("spData package needed for examples")
  run <- FALSE
} else {
  run <- TRUE
}
if (run) {
data(jenks71, package="spData")
fix5 <- classIntervals(jenks71$jenks71, n=5, style="fixed",
 fixedBreaks=c(15.57, 25, 50, 75, 100, 155.30))
print(jenks.tests(fix5, jenks71$area))
}
if (run) {
q5 <- classIntervals(jenks71$jenks71, n=5, style="quantile")
print(jenks.tests(q5, jenks71$area))
}
if (run) {
set.seed(1)
k5 <- classIntervals(jenks71$jenks71, n=5, style="kmeans")
print(jenks.tests(k5, jenks71$area))
}
if (run) {
h5 <- classIntervals(jenks71$jenks71, n=5, style="hclust", method="complete")
print(jenks.tests(h5, jenks71$area))
}
if (run) {
print(jenks.tests(getHclustClassIntervals(h5, k=7), jenks71$area))
}
if (run) {
print(jenks.tests(getHclustClassIntervals(h5, k=9), jenks71$area))
}
if (run) {
set.seed(1)
b5 <- classIntervals(jenks71$jenks71, n=5, style="bclust")
print(jenks.tests(b5, jenks71$area))
}
if (run) {
print(jenks.tests(getBclustClassIntervals(b5, k=7), jenks71$area))
}
if (run) {
```

```
print(jenks.tests(getBclustClassIntervals(b5, k=9), jenks71$area))
}
```

`logLik.classIntervals` *Log-likelihood for classIntervals objects*

Description

Log-likelihood for classIntervals objects

Usage

```
## S3 method for class 'classIntervals'
logLik(object, ...)
```

Arguments

`object`	A classIntervals object
`...`	Ignored.

Details

Generally, the likelihood is a method for minimizing the standard deviation within an interval, and with the AIC, a per-interval penalty can be used to maximize the information and self-similarity of data in the interval.

Based on Birge 2006 and Davies 2009 (see references), interval binning selections may be compared by likelihood to optimize the number of intervals selected for a set of data. The ‘logLik()‘ function (and associated ‘AIC()‘ function) can be used to optimize binning by maximizing the likelihood across choices of intervals.

As illustrated by the examples below (the AIC comparison does not specifically select 3 intervals when comparing 2, 3, and 4 intervals for data with 3 intervals), while likelihood-based methods can provide evidence toward optimization of binning, they are not infallible for bin selection.

Value

A ‘logLik‘ object (see ‘stats::logLik‘).

References

Lucien Birge, Yves Rozenholc. How many bins should be put in a regular histogram. ESAIM: Probability and Statistics. 31 January 2006. 10:24-45. url: https://www.esaim-ps.org/articles/ps/abs/2006/01/ps0322/ps0322.html doi:10.1051/ps:2006001

Laurie Davies, Ursula Gather, Dan Nordman, Henrike Weinert. A comparison of automatic histogram constructions. ESAIM: Probability and Statistics. 11 June 2009. 13:181-196. url: https://www.esaim-ps.org/articles/ps/abs/2009/01/ps0721/ps0721.html doi:10.1051/ps:2008005

Examples

```
x <- classIntervals(rnorm(100), n=5, style="fisher")
logLik(x)
AIC(x) # By having a logLik method, AIC.default is used.

# When the intervals are made of a limited number of discrete values, the
# logLik is zero by definition (the standard deviation is zero giving a dirac
# function at the discrete value indicating a density of 1 and a log-density
# of zero).
x <- classIntervals(rep(1:2, each=10), n=2, style="jenks")
logLik(x)
x <- classIntervals(rep(1:3, each=10), n=2, style="jenks")
logLik(x)

# With slight jitter but notable categorical intervals (at 1, 2, and 3), the
# AIC will make selection of the optimal intervals easier.
data <- rep(1:3, each=100) + runif(n=300, min=-0.01, max=0.01)
x_2 <- classIntervals(data, n=2, style="jenks")
x_3 <- classIntervals(data, n=3, style="jenks")
x_4 <- classIntervals(data, n=4, style="jenks")
AIC(x_2, x_3, x_4)
```

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