Package ‘diptest’

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Title Hartigan's Dip Test Statistic for Unimodality - Corrected
Description Compute Hartigan's dip test statistic for unimodality / multimodality and provide a test with simulation based p-values, where the original public code has been corrected.
Imports graphics, stats
BuildResaveData no

BugReports https://github.com/mmaechler/diptest/issues
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dip  

Compute Hartigans' Dip Test Statistic for Unimodality

Description

Computes Hartigans' dip test statistic for testing unimodality, and additionally the modal interval.

Usage

dip(x, full.result = FALSE, min.is.0 = FALSE, debug = FALSE)

Arguments

x  numeric; the data.
full.result  logical or string; dip(., full.result=TRUE) returns the full result list; if “all” it additionally uses the mn and mj components to compute the initial GCM and LCM, see below.
min.is.0  logical indicating if the minimal value of the dip statistic \( D_n \) can be zero or not. Arguably should be set to TRUE for internal consistency reasons, but is false by default both for continuity and backwards compatibility reasons, see the examples below.
debug  logical; if true, some tracing information is printed (from the C routine).

Value

depending on full.result either a number, the dip statistic, or an object of class "dip" which is a list with components

x  the sorted unname(.)d data.
n  length(x).
dip  the dip statistic
lo.hi  indices into x for lower and higher end of modal interval
xl, xu  lower and upper end of modal interval
gcm, lcm  (last used) indices for greatest convex minorant and the least concave majorant.
mn, mj  index vectors of length n for the GC minorant and the LC majorant respectively.

For “full” results of class "dip", there are print and plot methods, the latter with its own manual page.
Note

For $n \leq 3$ where $n \leftarrow \text{length}(x)$, the dip statistic $D_n$ is always the same minimum value, $1/(2n)$, i.e., there's no possible dip test. Note that up to May 2011, from Hartigan’s original Fortran code, $D_n$ was set to zero, when all $x$ values were identical. However, this entailed discontinuous behavior, where for arbitrarily close data $\bar{x}$, $D_n(\bar{x}) = \frac{1}{2n}$.

Yong Lu <lyongu+@cs.cmu.edu> found in Oct 2003 that the code was not giving symmetric results for mirrored data (and was giving results of almost 1, and then found the reason, a misplaced ‘”’ in the original Fortran code. This bug has been corrected for diptest version 0.25-0 (Feb 13, 2004).

Nick Cox (Durham Univ.) said (on March 20, 2008 on the Stata-list):
As it comes from a bimodal husband-wife collaboration, the name perhaps should be “Hartigan-Hartigan dip test”, but that does not seem to have caught on. Some of my less statistical colleagues would sniff out the hegemony of patriarchy there, although which Hartigan is being overlooked is not clear.

Martin Maechler, as a Swiss, and politician, would say:
Let’s find a compromise, and call it “Hartigans’ dip test”, so we only have to adapt orthography (:-).

Author(s)

Martin Maechler <maechler@stat.math.ethz.ch>, 1994, based on S (S-PLUS) and C code donated from Dario Ringach <dario@wotan.cns.nyu.edu> who had applied f2c on the original Fortran code available from Statlib.

In Aug.1993, recreated and improved Hartigans’ “P-value” table, which later became qDiptab.

References

Corresponding (buggy!) Fortran code of ‘AS 217’ available from Statlib, http://lib.stat.cmu.edu/apstat/217


See Also
dip.test to compute the dip and perform the unimodality test, based on P-values, interpolated from qDiptab; isoreg for isotonic regression.

Examples

data(statfaculty)
plot(density(statfaculty))
rug(statfaculty, col="midnight blue"); abline(h=0, col="gray")
dip(statfaculty)
(dS <- dip(statfaculty, full = TRUE, debug = TRUE))
plot(dS)
## even more output -- + plot showing "global" GCM/LCM:
(dS2 <- dip(statfaculty, full = "all", debug = 3))
plot(dS2)

data(faithful)
fE <- faithful$eruptions
density(fE))
rug(fE, col="midnight blue"); abline(h=0, col="gray")
dip(fE, debug = 2) ## showing internal work
(dE <- dip(fE, full = TRUE)) ## note the print method
plot(dE, do.points=FALSE)

data(precip)
density(precip)
rug(precip, col="midnight blue"); abline(h=0, col="gray")
str(dip(precip, full = TRUE, debug = TRUE))

##----------------- The 'min.is.0' option : ---------------------
##
##' dip(.) continuity and 'min.is.0' exploration:

dd <- function(x, debug=FALSE) {
x_ <- x ; x_[1] <- 0.9999999999 * x[1]
rbind(dip(x , debug=debug),
      dip(x_ , debug=debug),
      dip(x , min.is.0=TRUE, debug=debug),
      dip(x_ , min.is.0=TRUE, debug=debug),
      deparse.level=2)
}

dd( rep(1, 8) ) # the 3rd one differs ==> min.is.0=TRUE is *dis*continuous
dd( 1:7 )      # ditto

dd( 1:7, debug=TRUE)
## border-line case ..

dd( 1:2, debug=TRUE)

## Demonstrate that 'min.is.0 = TRUE' does not change the typical result:
B.sim <- 1000 # or larger
D5 <- {set.seed(1); replicate(B.sim, dip(runif(5)))}
D5. <- {set.seed(1); replicate(B.sim, dip(runif(5), min.is.0=TRUE))}
stopifnot(identical(D5, D5.), all.equal(min(D5), 1/(2*5))
hist(D5, 64); rug(D5)

D8 <- {set.seed(7); replicate(B.sim, dip(runif(8)))}
D8. <- {set.seed(7); replicate(B.sim, dip(runif(8), min.is.0=TRUE))}
stopifnot(identical(D8, D8.))

---

dip.test

*Hartigans’ Dip Test for Unimodality*

**Description**

Compute Hartigans’ dip statistic $D_n$, and its p-value for the test for unimodality, by interpolating tabulated quantiles of $\sqrt{n}D_n$. 
For $X_i \sim F, i.i.d.$, the null hypothesis is that $F$ is a unimodal distribution. Consequently, the test alternative is non-unimodal, i.e., at least bimodal. Using the language of medical testing, you would call the test "Test for Multimodality".

Usage

```r
dip.test(x, simulate.p.value = FALSE, B = 2000)
```

Arguments

- `x` numeric vector; sample to be tested for unimodality.
- `simulate.p.value` a logical indicating whether to compute p-values by Monte Carlo simulation.
- `B` an integer specifying the number of replicates used in the Monte Carlo test.

Details

If `simulate.p.value` is FALSE, the p-value is computed via linear interpolation (of $\sqrt{nD_n}$) in the `qDiptab` table. Otherwise the p-value is computed from a Monte Carlo simulation of a uniform distribution (runif(n)) with B replicates.

Value

A list with class "htest" containing the following components:

- `statistic` the dip statistic $D_n$, i.e., dip(x).
- `p.value` the p-value for the test, see details.
- `method` character string describing the test, and whether Monte Carlo simulation was used.
- `data.name` a character string giving the name(s) of the data.

Note

see also the package vignette, which describes the procedure in more details.

Author(s)

Martin Maechler

References

see those in `dip`.

See Also

For goodness-of-fit testing, notably of continuous distributions, `ks.test`.
Examples

```r
## a first non-trivial case
(d.t <- dip.test(c(0,0, 1,1))) # "perfect bi-modal for n=4" --> p-value = 0
stopifnot(d.t$p.value == 0)

data(statfaculty)
plot(density(statfaculty)); rug(statfaculty)
(d.t <- dip.test(statfaculty))

x <- c(rnorm(50), rnorm(50) + 3)
pplot(density(x)); rug(x)
## border-line bi-modal ... BUT (most of the times) not significantly:
dip.test(x)
dip.test(x, simulate=TRUE, B=5000)

## really large n -- get a message
dip.test(runif(4e5))
```

---

**exHartigan**  
Hartigan's Artificial n-modal Example Data Set

**Description**

63 (integer) numbers; unimodal or bimodal, that's the question.

This is now **deprecated**. Please use **statfaculty** instead!

**Examples**

data(exHartigan)
plot(dH <- density(exHartigan))
rug(exHartigan)# should jitter

---

**plot.dip**  
Plot a dip() Result, i.e., Class "dip" Object

**Description**

Plot method for "dip" objects, i.e., the result of dip(., full.result=TRUE) or similar.

Note: We may decide to enhance the plot in the future, possibly not entirely back-compatibly.

**Usage**

```r
## S3 method for class 'dip'
plot(x, do.points = (n < 20),
     colG = "red3", colL = "blue3", colM = "forest green",
     col.points = par("col"), col.hor = col.points,
     doModal = TRUE, doLegend = TRUE, ...)
```
Arguments

- x: an R object of class "dip", i.e., typically the result of dip(. , full.result=FF) where FF is TRUE or a string such as "all".
- do.points: logical indicating if the ECDF plot should include points; passed to plot.ecdf.
- colG, colL, colM: the colors to be used in the graphics for the Greatest convex minorant, the Least concave majorant, and the Modal interval, respectively.
- col.points, col.hor: the color of points or horizontal lines, respectively, simply passed to plot.ecdf.
- doModal: logical indicating if the modal interval \([x_L, x_U]\) should be shown.
- doLegend: logical indicating if a legend should be shown.
- ... further optional arguments, passed to plot.ecdf.

Author(s)

Martin Maechler

See Also

dip, also for examples; plot.ecdf.

### qDiptab

Table of Quantiles from a Large Simulation for Hartigan's Dip Test

Description

Whereas Hartigan(1985) published a table of empirical percentage points of the dip statistic (see dip) based on \(N=9999\) samples of size \(n\) from \(U[0, 1]\), our table of empirical quantiles is currently based on \(N=1'000'001\) samples for each \(n\).

Format

A numeric matrix where each row corresponds to sample size \(n\), and each column to a probability (percentage) in \([0, 1]\). The dimnames are named \(n\) and \(Pr\) and coercable to these values, see the examples. attr(qDiptab, "N_1") is \(N-1\), such that with k <- as.numeric(dimnames(qDiptab)$Pr) * attr(qDiptab, "N_1"), e.g., qDiptab[n == 15] contains exactly the order statistics \(D_{\lfloor k\rfloor}\) (from the \(N + 1\) simulated values of dip(U), where U <- runif(15).

Note

Taking \(N=1'000'001\) ensures that all the quantile(X, p) used here are exactly order statistics sort(X)[k].

Author(s)

Martin Maechler <maechler@stat.math.ethz.ch>, in its earliest form in August 1994.
See Also
dip, also for the references; dip.test() which performs the hypothesis test, using qDtiptab (and its null hypothesis of a uniform distribution).

Examples

```r
data(qDiptab)
str(qDiptab)
## the sample sizes 'n':
dnqd <- dinames(qDiptab)
(nn <- as.integer(dnqd $n))
## the probabilities:
P.p <- as.numeric(print(dnqd $ Pr))

## This is as "Table 1" in Hartigan & Hartigan (1985) -- but more accurate
ps <- c(1,5,10,50,90,99, 99.5, 99.9)/100
tab1 <- qDiptab[nn <= 200, as.character(ps)]
round(tab1, 4)
```

Description

Faculty quality in statistics departments was assessed as part of a larger study reported by Scully(1982). Accidentally, this is also provided as the exHartigan ("example of Hartigan") data set.

Usage

data(statfaculty)

Format

A numeric vector of 63 (integer) numbers, sorted increasingly, as reported by the reference.

Source


References

Examples

```r
data(statfaculty)
plot(dH <- density(statfaculty))
rug(jitter(statfaculty))

data(exHartigan)
stopifnot(identical(exHartigan, statfaculty))
```
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