Package ‘HistogramTools’

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Title Utility Functions for R Histograms
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Maintainer Murray Stokely <murray@stokely.org>
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Suggests RUnit, emdist, gdata
Enhances RProtoBuf
Description Provides a number of utility functions useful for manipulating large histograms. This includes methods to trim, subset, merge buckets, merge histograms, convert to CDF, and calculate information loss due to binning. It also provides a protocol buffer representations of the default R histogram class to allow histograms over large data sets to be computed and manipulated in a MapReduce environment.
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Author Murray Stokely [aut, cre],
       Tim Hesterberg [ctb]
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R topics documented:

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### Description

This package provides a number of utility functions for manipulating R’s native histogram objects. The functions are focused on operations that are particularly useful when dealing with large numbers of histograms with identical buckets, such as those produced from distributed MapReduce computations. This package also provides a ‘HistogramTools.HistogramState’ protocol buffer representation of the default R histogram class to allow histograms to be very concisely serialized and shared with other systems.

### Details

See `library(help=HistogramTools)` for version number, dates, dependencies, and a complete list of functions.

Index (possibly out of date):

- `AddHistograms` Aggregate histogram objects that have identical breaks.
- `MergeHistograms` Merge adjacent buckets of a histogram.
- `ApproxQuantile` Approximate the quantiles of the underlying distribution.
- `ApproxMean` Approximate the mean of the underlying distribution.
- `Count` Count of all samples in a histogram.
- `HistToEcdf` Approximate the ECDF of the underlying distribution.
- `SubsetHistogram` Subset a histogram by removing some of the buckets.
- `TrimHistogram` Remove empty buckets from the tails of a histogram.
- `ScaleHistogram` Scale histogram bucket counts by a numeric value.
- `PreBinnedHistogram` Generate a histogram from pre-binned data.
- `AshFromHist` Compute Average Shifted Histogram from a histogram.
- `KSDCC` Compute maximal KS-statistic of CDFs constructed from histogram.
EMDCC Compute maximal Earth Mover's Distance of CDFs constructed from histogram.
PlotKSDCC Plot the KSDCC metric and a CDF from the histogram.
PlotEMDCC Plot the EMDCC metric and a CDF from the histogram.
PlotLog2ByteEcdf Plot the CDF from a histogram with log2 scaled byte boundaries.
PlotLogTimeDurationEcdf Plot the CDF from a histogram with log scaled time duration boundaries.
PlotRelativeFrequency Plot a relative frequency histogram.
ReadHistogramsFromDtraceOutputFile Read a list of Histograms from the output of the DTrace tool.
minkowski.dist Compute the Minkowski difference between two histograms.
intersect.dist Compute the histogram intersection distance between two histograms.
kl.divergence Compute the Kullback-Leibler divergence between two histograms.
jeffrey.divergence Compute the Jeffrey divergence between two histograms.

Author(s)
Murray Stokely <mstokely@google.com>

See Also
hist

Examples
if(require(RProtoBuf)) {
  library(HistogramTools)
  tmp.hist <- hist(c(1,2,4,43,20,33,1,1,3), plot=FALSE)
  # The default R serialization takes a fair number of bytes
  length(serialize(tmp.hist, NULL))

  # Convert to a protocol buffer representation.
  hist.msg <- as.Message(tmp.hist)

  # Which has an ASCII representation like this:
  cat(as.character(hist.msg))

  # Or can be serialized and shared with other tools much more
  # succinctly than R's built-in serialization format.
  length(hist.msg$serialize(NULL))

  # And since this isn't even compressed, we can reduce it further
  # with in-memory compression:
  length(memCompress(hist.msg$serialize(NULL)))

  # If we read in the raw.bytes from another tool
  raw.bytes <- hist.msg$serialize(NULL)

  # We can parse the raw bytes as a protocol buffer
  new.hist.proto <- P("HistogramTools.HistogramState")$read(raw.bytes)

  new.hist.proto

  # Then convert back to a native R histogram.
  new.hist <- as.histogram(new.hist.proto)
AddHistograms

 aggregate histograms that have identical breaks.

Description

Aggregate histogram objects that have identical breaks.

Usage

AddHistograms(..., x=list(...), main=.NewHistogramName(x))

Arguments

... Histogram objects (created by hist).

x A list of histogram objects. If x is supplied then the ... are ignored.

main A title to add to the aggregated/merged histogram. By default, if two histograms are provided a title will be created that includes the names of the original histograms. If more histograms are provided the title will simply include the number of aggregated histograms.

Details

This function adds the buckets of the provided histograms to return a single aggregated histogram. .NewHistogramName is a utility that takes the list of histogram objects to be aggregated and returns a name for the new merged histogram. It is normally hidden, but can be viewed using HistogramTools:::.NewHistogramName.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

histogramtools-package and hist.

Examples

hist.1 <- hist(c(1,2,3,4), plot=FALSE)
hist.2 <- hist(c(1,2,2,4), plot=FALSE)
hist.sum <- AddHistograms(hist.1, hist.2)
hist.3 <- hist(c(1,2,2,4), plot=FALSE)
hist.sum <- AddHistograms(hist.1, hist.2, hist.3)
as.histogram

Convert histogram protocol buffers to histogram objects

Description

This package provides a number of utility functions useful for manipulating large histograms. It provides a 'HistogramTools.HistogramState' protocol buffer representation of the default R histogram class to allow histograms to be very concisely serialized and shared with other systems in a distributed MapReduce environment. It also includes a number of utility functions for manipulating large histograms.

Usage

## S3 method for class 'Message'
as.histogram(x, ...)

Arguments

- `x` An RProtoBuf Message of type "HistogramTools.HistogramState" to convert to a histogram object.
- `...` Not used.

Details

as.histogram reads the provided Protocol Buffer message and extracts the buckets and counts to populate into the standard R histogram class which can be plotted.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

histogramtools-package, as.Message, and RProtoBuf.

Examples

```r
if(require(RProtoBuf)) {
  library(HistogramTools)
  tmp.hist <- hist(c(1,2,4,43,20,33,1,1,3), plot=FALSE)
  # The default R serialization takes a fair number of bytes
  length(serialize(tmp.hist, NULL))

  # Convert to a protocol buffer representation.
  hist.msg <- as.Message(tmp.hist)

  # Which has an ASCII representation like this:
```
as.Message

Convert R histograms to Protocol Buffer representation

Description

This package provides a number of utility functions useful for manipulating large histograms. It provides a 'HistogramTools.HistogramState' protocol buffer representation of the default R histogram class to allow histograms to be very concisely serialized and shared with other systems in a distributed MapReduce environment. It also includes a number of utility functions for manipulating large histograms.

Usage

## S3 method for class 'histogram'
as.Message(x)

Arguments

x                      A histogram object (created by hist).

Details

as.Message converts the provided histogram object into a protocol buffer representation that can be compactly serialized and shared with tools written in other languages.
ASH

Author(s)
Murray Stokely <mstokely@google.com>

See Also

histogramtools-package, as.histogram, and RProtoBuf.

Examples

```r
if (require(RProtoBuf)) {
  library(HistogramTools)

  tmp.hist <- hist(c(1,2,4,43,20,33,1,1,3), plot=FALSE)
  # The default R serialization takes a fair number of bytes
  length(serialize(tmp.hist, NULL))

  # Convert to a protocol buffer representation.
  hist.msg <- as.Message(tmp.hist)

  # Which has an ASCII representation like this:
  cat(as.character(hist.msg))

  # Or can be serialized and shared with other tools much more
  # succinctly than R's built-in serialization format.
  length(hist.msg$serialize(NULL))

  # And since this isn't even compressed, we can reduce it further
  # with in-memory compression:
  length(memCompress(hist.msg$serialize(NULL)))

  # If we read in the raw.bytes from another tool
  raw.bytes <- hist.msg$serialize(NULL)

  # We can parse the raw bytes as a protocol buffer
  new.hist.proto <- P("HistogramTools.HistogramState")$read(raw.bytes)
  new.hist.proto

  # Then convert back to a native R histogram.
  new.hist <- as.histogram(new.hist.proto)

  # The new histogram and the old are identical except for xname
}
```

ASH

Average Shifted Histograms From a Histogram.

Description

Computes a univariate average shifted histogram (polynomial kernel) given a single input histogram.
Usage

HistToASH(h, m=5, kopt=c(2,2))

Arguments

h           A histogram object (created by hist) representing a pre-binned dataset.
m           optional integer smoothing parameter, passed to ash1().
kopt        vector of length 2 specifying the kernel, passed to ash1().

Details

This function takes a histogram and uses the counts as the input to the ash1() function in the ash package to compute the average shifted histogram.

Author(s)

Murray Stokely <mstokely@google.com>

References


See Also

histogramtools-package, ash1, and hist.

Examples

x <- runif(1000, min=0, max=100)
h <- hist(x, breaks=0:100, plot=FALSE)
plot(h, freq=FALSE)

# Superimpose the Average Shifted Histogram on top of the original.
lines(HistToASH(h), col="red")

dtracehistograms

Read Histograms from text DTrace output file.

Description

Parses the text output of the DTrace command to convert the ASCII representation of aggregate distributions into R histogram objects.

Usage

ReadHistogramsFromDtraceOutputFile(filename)
Arguments

filename A character vector naming a file that is the output of dtrace with aggregate distribution statistics in it.

Details

The DTrace dynamic tracing framework allows users to trace applications and computer operating systems. One of its common outputs is aggregates of a distribution (for example, read request sizes) that are output as a histogram. This function takes the text output from a dtrace command and looks for text distribution representations that can be parsed into R histogram objects.

Value

A list of histogram objects representing the histograms present in the Dtrace output file.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

histogramtools-package, hist.

Examples

```r
## Not run:
system("dtrace -n 'syscall::read:return { @[execname] = quantize(arg0);}> /tmp/dtraceoutput", intern=TRUE)
system.readsize.hists <- ReadHistogramsFromDtraceOutputFile("/tmp/dtraceoutput")
plot(system.readsize.hists[[1]])
## End(Not run)
```

## HistogramDistance

### Histogram Distance Measures

**Description**

The pairs of bins in two histograms with the same bucket boundaries are compared to compute dissimilarity measures.

**Usage**

```r
minkowski.dist(h1, h2, p)
intersect.dist(h1, h2)
kl.divergence(h1, h2)
jeffrey.divergence(h1, h2)
```
HistogramDistance

Arguments

- **h1, h2**: "histogram" objects (created by `hist`) representing a binned dataset.
- **p**: Order of the Minkowski distance between two histograms to compute.

Details

The `minkowski.dist` function computes the Minkowski distance of order `p` between two histograms. `p=1` is the Manhattan distance and `p=2` is the Euclidean distance.

The `intersect.dist` function computes the intersection distance of two histograms, as defined in Swain and Ballard 1991, p15. If histograms `h1` and `h2` do not contain the same total of counts, then this metric will not be symmetric.

The `kl.divergence` function computes the Kullback-Leibler divergence between two histograms.

The `jeffrey.divergence` function computes the Jeffrey divergence between two histograms.

Author(s)

Murray Stokely <mstokely@google.com>

References


See Also

`histogramtools-package`, `ecdf`, and `hist`.

Examples

```r
h1 <- hist(runif(100), plot=FALSE)
h2 <- hist(runif(100), plot=FALSE)

minkowski.dist(h1, h2, 1)
minkowski.dist(h1, h2, 2)
minkowski.dist(h1, h2, 3)
intersect.dist(h1, h2)
kl.divergence(h1, h2)
jeffrey.divergence(h1, h2)
```
HistToEcdf

Empirical Cumulative Distribution Function From a Histogram.

Description

Computes an approximate empirical cumulative distribution function of a data set given a binned histogram representation of that dataset.

Usage

HistToEcdf(h, method="constant", f=0, inverse=FALSE)

Arguments

h
A histogram object (created by hist) representing a pre-binned dataset on which we’d like to calculate an ECDF.

method
specifies the interpolation method to be used in call to approxfun(). Choices are "linear" or "constant".

f
if method="constant" a number between 0 and 1 inclusive, indicating a compromise between left- and right-continuous step functions. See ?approxfun

inverse
if TRUE return the inverse Ecdf.

Details

This function approximates the e.c.d.f. (empirical cumulative distribution function) of a data set given a binned histogram representation of that data set.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

histogramtools-package, ecdf, approxfun, and hist.

Examples

h <- hist(runif(100), plot=FALSE)
plot(HistToEcdf(h))
Description

Computes a metric between 0 and 1 of the amount of information lost about the underlying distribution of data for a given histogram.

Usage

KSDCC(h)
EMDCC(h)

PlotKSDCC(h, arrow.size.scale=1, main=paste("KSDCC =", KSDCC(h)), ...)
PlotEMDCC(h, main=paste("EMDCC =", EMDCC(h)), ...)

Arguments

h  A "histogram" object (created by \texttt{hist}) representing a pre-binned dataset on which we’d like to calculate the information loss due to binning.

arrow.size.scale  specifies a size scaling factor for the arrow illustrating the point of Kolmogorov-Smirnov distance between the two e.c.d.fs

main  if 'method="constant"' a number between 0 and 1 inclusive, indicating a compromise between left- and right-continuous step functions. See \texttt{approxfun}

...  Any other arguments to pass to \texttt{plot}

Details

The KSDCC (Kolmogorov-Smirnov Distance of the Cumulative Curves) function provides the Kolmogorov-Smirnov distance between the empirical distribution functions of the smallest and largest datasets that could be represented by the binned data in the provided histogram. This quantity is also called the Maximum Displacement of the Cumulative Curves (MDCC) in the computer science performance evaluation community (see references).

The EMDCC (Earth Mover’s Distance of the Cumulative Curves) function is like the Kolmogorov-Smirnov statistic, but uses an integral to capture the difference across all points of the curve rather than just the maximum difference. This is also known as Mallows distance, or Wasserstein distance with $p=1$.

The \texttt{PlotKSDCC} and \texttt{PlotEMDCC} functions take a histogram and generate a plot showing a geometric representation of the information loss metrics for the provided histogram.

Author(s)

Murray Stokely <mstokely@google.com>
Intersect Histograms

Description

Takes two histograms with identical bucket boundaries and returns a histogram of the intersection of the two. Each bucket of the returned histogram contains the minimum of the equivalent buckets in the two provided histograms.

Usage

IntersectHistograms(h1, h2)
MergeBuckets

Arguments

h1,h2 "histogram" objects (created by `hist`) representing a dataset summarized by binning.

Author(s)

Murray Stokely <mstokely@google.com>

References


See Also

`histogramtools-package`, `hist`.

Examples

```r
h1 <- hist(runif(100), plot=FALSE)
h2 <- hist(runif(100), plot=FALSE)
plot(IntersectHistograms(h1, h2))
```

MergeBuckets

Merge adjacent buckets in a histogram to create a new histogram.

Description

Merge adjacent buckets in a histogram and return a new histogram.

Usage

```r
MergeBuckets(x, adj.buckets=NULL, breaks=NULL, FUN=sum)
```

Arguments

x A histogram object (created by `hist`).
adj.buckets The number of adjacent buckets to merge together.
breaks If `adj.buckets` is equal to `NULL`, then this argument either specifies a vector giving the breakpoints between cells, or a single number giving the total number of cells in the new histogram. The vector of new buckets must have the same range as the original break list. If a single number is provided it must be less than `length(x$breaks)`.
FUN The user defined function that should be run to merge the counts of adjacent buckets in the histogram.
Details

Many data analysis pipelines write out histogram protocol buffers with thousands of buckets so as to be applicable in a wide range of contexts. This function provides a way to transform the histogram into one with fewer buckets.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

`histogramtools-package` and `hist`.

Examples

```r
hist.1 <- hist(c(1,2,3), breaks=c(0,1,2,3,4,5,6,7,8,9), plot=FALSE)
hist.2 <- MergeBuckets(hist.1, adj.buckets=2)

hist.1
hist.2
```

---

**PlotLog2ByteEcdf**

*Plot Binned Histogram and ECDF Data.*

**Description**

Produces aesthetically pleasing ECDF plots for two common classes of non-equiwidth histograms. Specifically, (1) histograms with power of two bucket boundaries commonly used in computer science for measuring resource usage, and (2) histograms with log-scaled time duration buckets with a range from 1 second to 10 years.

**Usage**

```r
PlotLog2ByteEcdf(x, xlab="Bytes (log)",
                 ylab="Cumulative Fraction", with.grid=TRUE, ...)
PlotLogTimeDurationEcdf(x, with.grid=TRUE,
                        xlab="Age (log)",
                        ylab="Cumulative Fraction",
                        cex.lab=1.6,
                        cex.axis=1.6, ...)
```

**Arguments**

- `x` A "histogram" object (created by `hist`) representing a pre-binned dataset or an "ecdf" object (created by `ecdf` or `HistToEcdf`).
- `xlab` x-axis label for the Ecdf plot.
- `ylab` y-axis label for the Ecdf plot.
PlotRelativeFrequency

with.grid Logical. If TRUE, draw faint grid lines on the ECDF plot.
cex.lab Graphical parameters for plot and axes.
cex.axis Graphical parameters for plot and axes.
... Additional parameters are passed to plot().

Details

The PlotLog2ByteEcdf function takes a "histogram" or "ecdf" which has power of 2 bucket boundaries representing bytes and creates an Ecdf plot.

The PlotLogTimeDurationEcdf function takes a "histogram" or "ecdf" with exponential bucket boundaries representing seconds of age or duration and creates an Ecdf plot.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

histogramtools-package, hist, ecdf.

Examples

filename <- system.file("unitTests/data/buildkernel-readsize-dtrace.txt", package="HistogramTools")
dtrace.hists <- ReadHistogramsFromDtraceOutputFile(filename)
x <- SubsetHistogram(dtrace.hists["TOTAL"], minbreak=1)
PlotLog2ByteEcdf(x, cex.lab=1.4)

x <- rexp(100000)
x <- x*(86400*300)/diff(range(x))
n <- as.integer(1+log2(max(x)))
h <- hist(x, breaks=c(0, unique(as.integer(2^seq(from=0, to=n, by=.25)))))
PlotLogTimeDurationEcdf(h)

PlotRelativeFrequency  Plot Relative Frequency Histogram

Description

Produces a relative frequency histogram.

Usage

PlotRelativeFrequency(x, ylab="Relative Frequency", ...)

--
**PreBinnedHistogram**

**Arguments**

- *x* A "histogram" object (created by `hist`) representing a pre-binned dataset.
- *ylab* y-axis label for the plot.
- ... Additional parameters are passed to `plot()`.

**Details**

The default `plot.histogram` function supports Frequency or Density plots, but does not provide a way to produce a relative frequency histogram. This function plots this type of histogram.

**Author(s)**

Murray Stokely <mstokely@google.com>

**See Also**

`histogramtools-package`, `hist`, `plot.histogram`.

**Examples**

```r
x <- runif(100)
h <- hist(x, plot=FALSE)
PlotRelativeFrequency(h)
```

---

**PreBinnedHistogram**

**Description**

Takes a set of already binned data represented by a vector of $n+1$ breaks and a vector of $n$ counts and returns a normal R histogram object.

**Usage**

```r
PreBinnedHistogram(breaks, counts, xname="")
```

**Arguments**

- *breaks* A numeric vector of $n+1$ breakpoints for the histogram.
- *counts* A numeric vector of $n$ counts for each bucket of the histogram.
- *xname* A character string with the name for this histogram.

**Author(s)**

Murray Stokely <mstokely@google.com>

**See Also**

`histogramtools-package`, `hist`.
quantile  

*Histogram Approximate Quantiles.*

**Description**

Approximate the quantiles of the underlying distribution for which only a histogram is available.

**Usage**

ApproxQuantile(x, probs, ...)
ApproxMean(x)
Count(x)

**Arguments**

- **x**: A histogram object (created by `hist`).
- **probs**: Numeric vector of probabilities with values in [0,1].
- **...**: Any other arguments to pass to `wtd.quantile`.

**Details**

Many data analysis pipelines write out histogram protocol buffers with thousands of buckets so as to be applicable in a wide range of contexts. This function provides a way to transform the histogram into approximations of the quantile, median, mean, etc of the underlying distribution. `Count(x)` returns the number of observations in the histogram.

**Author(s)**

Murray Stokely <mstokely@google.com>

**See Also**

`histogramtools-package` and `hist`.

**Examples**

```r
x <- hist(c(1,2,3), breaks=c(0,1,2,3,4,5,6,7,8,9), plot=FALSE)
Count(x)
ApproxMean(x)
ApproxQuantile(x, .5)
ApproxQuantile(x, c(.05, .95))
```
**ScaleHistogram**

<table>
<thead>
<tr>
<th>ScaleHistogram</th>
<th>Scale Histogram Counts</th>
</tr>
</thead>
</table>

**Description**

Scales the counts of the provided histograms by the provided factor and returns a new histogram.

**Usage**

`ScaleHistogram(x, factor)`

**Arguments**

- `x`: A "histogram" object (created by `hist`) representing a dataset summarized by binning.
- `factor`: A number value to scale the bucket counts by. Defaults to `1/Count(x)` to normalize the sum of counts of the histogram to 1.

**Author(s)**

Murray Stokely <mstokely@google.com>

**See Also**

`histogramtools-package`, `hist`.

**Examples**

```r
x <- runif(100)
h <- hist(x, plot=FALSE)
plot(ScaleHistogram(h, 10))
```

**SubsetHistogram**

<table>
<thead>
<tr>
<th>Subset a histogram by removing some of the buckets.</th>
</tr>
</thead>
</table>

**Description**

SubsetHistogram creates a histogram by zooming in on a portion of a larger histogram and discarding tail buckets.

**Usage**

`SubsetHistogram(x, minbreak=NULL, maxbreak=NULL)`
Arguments

x A histogram object (created by \texttt{hist}).

minbreak If non-NULL, specifies a new minimum breakpoint for the returned histogram. Must be one of the existing breakpoints of \(x\).

maxbreak If non-NULL, specifies a new maximum breakpoint for the returned histogram. Must be one of the existing breakpoints of \(x\).

Details

This function provides a way to "zoom-in" on a histogram by setting new minimum and maximum breakpoints and returning a histogram of only the interior part of the distribution. At least one of \texttt{minbreak} or \texttt{maxbreak} should be set, otherwise the original histogram is returned unmodified.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

\texttt{histogramtools-package} and \texttt{hist}.

Examples

\begin{verbatim}
hist.1 <- hist(c(1,2,3), breaks=c(0,1,2,3,4,5,6,7,8,9), plot=FALSE)
hist.2 <- SubsetHistogram(hist.1, maxbreak=6)

hist.1
hist.2
\end{verbatim}

\begin{verbatim}
trimsparse
\end{verbatim}

\begin{verbatim}
trimsparse
\end{verbatim}

\textit{Trim the tails of a sparse histogram.}

Description

Removes empty consecutive buckets at the tails of a histogram.

Usage

\texttt{TrimHistogram(x, left=TRUE, right=TRUE)}

Arguments

x A histogram object (created by \texttt{hist}).

left If \texttt{TRUE}, consecutive buckets in the left tail of the histogram without any elements will be removed from the returned histogram.

right If \texttt{TRUE}, consecutive buckets in the right tail of the histogram without any elements will be removed from the returned histogram.
Details

Many data analysis pipelines write out histogram protocol buffers with thousands of buckets so as to be applicable in a wide range of contexts. This function provides a way to transform the histogram into one with fewer buckets by removing sparseness in the tails.

Author(s)

Murray Stokely <mstokely@google.com>

See Also

histogramtools-package and hist.

Examples

```r
hist.1 <- hist(c(1,2,3), breaks=c(0,1,2,3,4,5,6,7,8,9), plot=FALSE)
length(hist.1$counts)
sum(hist.1$counts)

hist.trimmed <- TrimHistogram(hist.1)
length(hist.trimmed$counts)
sum(hist.trimmed$counts)
```
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