Package ‘benchr’

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Title    High Precise Measurement of R Expressions Execution Time
Version  0.2.5
Description Provides infrastructure to accurately measure and compare the execution time of R expressions.

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**benchmark**

*High Precise Measurement of R Expressions Execution Time*

**Description**

`benchmark` serves as a more accurate replacement of the often seen `system.time(replicate(1000, expr))` expression. It tries hard to accurately measure only the time it takes to evaluate `expr`. To achieve this, the sub-millisecond (supposedly nanosecond) accurate timing functions most modern operating systems provide are used. Additionally all evaluations of the expressions are done in C++ code to minimize any measurement error.

**Usage**

```r
benchmark(
  ..., 
  times = 100L, 
  order = c("random", "inorder", "block"), 
  envir = parent.frame(), 
  progress = TRUE, 
  gcFirst = TRUE, 
  gcDuring = FALSE 
)
```

**Arguments**

- `...` Captures any number of unevaluated expressions passed to `benchmark` as named or unnamed arguments.
- `times` Integer. Number of times to evaluate each expression.
- `order` Character. The order in which the expressions are evaluated.
- `envir` The environment in which the expressions will be evaluated.
- `progress` Logical. Show progress bar during expressions evaluation.
- `gcFirst` Logical. Should a garbage collection be performed immediately before the timing?
- `gcDuring` Logical. Should a garbage collection be performed immediately before each iteration, as produced by `times`? (very slow)
Details

Before evaluating each expression, the overhead of calling the timing functions and the C++ function call overhead are estimated. This estimated overhead is subtracted from each measured evaluation time. Should the resulting timing be negative, a warning is thrown and the respective value is replaced by 0. If the timing is zero, a warning is also raised. Should all evaluations result in one of the two error conditions described above, an error is raised.

Value

Object of class benchmark, which is a data.frame with a number of additional attributes and contains the following columns:

- `expr`: The deparsed expression as passed to `benchmark` or the name of the argument if the expression was passed as a named argument.
- `time`: The measured execution time of the expression in seconds. The order of the observations in the data frame is the order in which they were executed.

An object of class benchmark also contains the following attributes:

- `precision`: Timer precision in seconds.
- `error`: Timer error (overhead) in seconds.
- `units`: Units for time intervals (by default, "s" – seconds).
- `times`: Number of repeats for each measurement.
- `order`: Execution regime.
- `gc`: Whether garbage collection took place before each execution.

The order in which the expressions are evaluated

- "random" (the default) randomizes the execution order
- "inorder" executes each expression in order
- "block" executes all repetitions of each expression as one block.

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See Also

- `summary.benchmark()`
- `mean.benchmark()`
- `print.benchmark()`
- `plot.benchmark()`
- `boxplot.benchmark()`

Examples

```r
## Measure the time it takes to dispatch a simple function call
## compared to simply evaluating the constant NULL
f <- function() NULL
res <- benchmark(NULL, f(), times = 1000L)

## Print results:
```
print(res)

## Plot results
boxplot(res)

---

**benchr**

*High Precise Measurement of R Expressions Execution Time*

**Description**

Package **benchr** provides an infrastructure (framework) for precise measurement of R expressions execution time.

**Details**

To measure execution time, **benchr** provides function **benchmark()**, as well as a number of additional methods for analysis and representation of results.

For precise time measurement we use a cross-platform monotone clock, provided by C++11 standard in header file **chrono**. The timer accuracy depends on the implementation by the compiler in use, the OS and the hardware. Most commonly, the precision is one micro- or nanosecond. We provide the opportunity to get the timer accuracy (time interval between two consecutive timer ticks) via function **timer_precision()**. This accuracy is also listed in the output of implicit or explicit print call.

We estimate the timer overhead before the actual measurement by running multiple (2*10^5 by default) calls to an empty function. By doing that, we not only estimate the overhead, but also produce a warm-up effect on the processor, taking it out from idle state. After the actual measurement results are adjusted by the timer overhead.

Time intervals are measured in seconds and stored as long double, which lets us capture a wide range of possible values from `.Machine$double.xmin` to `.Machine$double.xmax`. This is quite enough to operate both within very small (nanoseconds) and very big time frames (e.g. the maximum time interval possible is `.Machine$double.xmax / 3600` hours).

It should be noted that the R session is not an isolated container with strictly bounded resources, therefore the execution time can be influenced by various factors, which may lead to outliers. In order to increase measurement reliability, we repeat executions multiple times (100 repetitions for each expression by default). This approach allows to collect enough data for statistical analysis in time difference.

We have also implemented several execution regimes in order to minimize the probability of systematic errors in measurements. By default, a random order of execution is being used. There is also a block order of execution, when the first expression is repeated a fixed number of times, then the second and so on. In such regime one can decrease the influence of allocators and garbage collection, since the memory is allocated only at the beginning of each block. The third option is to execute expressions in the order, provided by the user.

Note that we do not make any checks regarding return objects, i.e. one can compare not only algorithms with the same result, but also the same algorithm with different input parameters (e.g. input data sets of different size).

We also do not check whether the expressions are language objects (see **is.language()**) and do not coerce to that type.
**Package options**

accessible through function arguments. We allow to modify these parameters via package options. We have tried to set optimal default values, which you may consider changing in some cases. Here’s a complete list of package options:

‘benchr.warmup’ Number of iterations for timer overhead estimation (2*10^5 by default).

‘benchr.print_details’ Whether additional information on the measurement parameters should be displayed (FALSE by default).

‘benchr.use_ggplot’ Whether ggplot2 package should be used to produce plots, if the package is installed (TRUE by default).

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**See Also**

Useful links:

- https://gitlab.com/artemklevtsov/benchr
- Report bugs at https://gitlab.com/artemklevtsov/benchr/issues

**Examples**

```r
# Benchmark expressions
res <- benchmark(
  rep(1:10, each = 10),
  rep.int(1:10, rep.int(10, 10))
)
# Aggregated statistics
mean(res)
summary(res)
# Plot results
boxplot(res)
```

---

**Description**

Displays measurement results as box plots, with R expressions on X axis and execution time on Y axis.
Usage

```r
## S3 method for class 'benchmark'
boxplot(
  x,
  units = "auto",
  log = TRUE,
  xlab,
  ylab,
  horizontal = FALSE,
  violin = FALSE,
  ...
)
```

Arguments

- `x`: An object of class `benchmark`.
- `units`: Character. The units to be used in printing the timings. The available units are nanoseconds ("ns"), microseconds ("us"), milliseconds ("ms"), seconds ("s").
- `log`: Logical. Should times be plotted on log scale?
- `xlab`: Character. X axis label.
- `ylab`: Character. Y axis label.
- `horizontal`: Logical. If set to `TRUE`, X and Y axes will be switched. Defaults to `FALSE`.
- `violin`: Logical. Use `ggplot2::geom_violin()` instead of `ggplot2::geom_boxplot()` for the ggplot plots.
- `...`: Arguments passed on to `boxplot.default()`.

Details

If `ggplot2` package is available, it will be used. In order to switch to default `boxplot` from the `graphics` package set option `benchr.use_ggplot` to `FALSE`: `options(benchr.use_ggplot = FALSE)`.

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See Also

- `plot.benchmark()`

Examples

```r
timings <- benchmark(  
  rchisq(100, 0), rchisq(100, 1), rchisq(100, 2),  
  rchisq(100, 3), rchisq(100, 5),  
  times = 1000L  
)
boxplot(timings)
```
mean.benchmark

Mean method for the benchmark timings.

Description

This method computes aggregated statistics (sample mean and confidence intervals) for each expression.

Usage

```r
## S3 method for class 'benchmark'
mean(x, trim = 0.05, conf.level = 0.95, relative = "mean", ...)
```

Arguments

- `x`: An object of class `benchmark`.
- `trim`: Numeric. The fraction (0 to 0.5) of observations to be trimmed before the mean is computed.
- `conf.level`: Numeric. Confidence level of the interval.
- `relative`: Character. The name or index of the column whose values will be used to compute relative timings.
- `...`: Not currently used.

Value

The method returns a `data.frame` with additional attributes, which contains these columns:

- `expr`: The deparsed expression as passed to `benchmark` or the name of the argument if the expression was passed as a named argument.
- `mean`: Sample mean for timing results.
- `trimmed`: Truncated sample mean for timing results. A fraction of observations is defined by the argument `trim`.
- `lw.ci`: Lower boundary for the confidence level (confidence level is specified by the argument `conf.level`).
- `up.ci`: Upper boundary for the confidence level (confidence level is specified by the argument `conf.level`).
- `relative`: Relative difference across expressions compared to a minimal value in the column, specified by the argument `relative`.

Additional attributes:

- `units`: Units for time intervals.
- `conf.level`: Confidence level.
- `trim`: Fraction of observations that was trimmed before the trimmed mean was computed.
plot.benchmark

Author(s)

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See Also

summary.benchmark()

Examples

timings <- benchmark(
  rchisq(100, 0), rchisq(100, 1), rchisq(100, 2),
  rchisq(100, 3), rchisq(100, 5),
  times = 1000L
)
mean(timings)

plot.benchmark  Plot method for the benchmark timings.

Description

Displays measurement results as a scatter plot, with R expressions on X axis and execution time on Y axis. Each expression is highlighted by its own colour.

Usage

## S3 method for class 'benchmark'
plot(x, units = "auto", log = TRUE, xlab, ylab, ...)

Arguments

x  An object of class benchmark.
units  Character. The units to be used in printing the timings. The available units are nanoseconds ("ns"), microseconds ("us"), milliseconds ("ms"), seconds ("s").
log  Logical. Should times be plotted on log scale?
xlab  Character. X axis label.
ylab  Character. Y axis label.
...  Not currently used.

Details

If ggplot2 package is available, it will be used. In order to switch to default boxplot from the graphics package set option benchr.use_ggplot to FALSE: options(benchr.use_ggplot = FALSE).
print.benchmark

Author(s)
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See Also
boxplot.benchmark()

Examples

timings <- benchmark(
  rchisq(100, 0), rchisq(100, 1), rchisq(100, 2),
  rchisq(100, 3), rchisq(100, 5),
  times = 1000L
)
plot(timings)

print.benchmark

Print method for the benchmark timings.

Description
This is universal method of measurement results representation, which can be called either implicitly or explicitly. The method uses summary method to compute aggregated statistics for benchmarking results. print also provides additional information about the timer precision and overhead, the execution regime and the number of repeats.

Usage

## S3 method for class 'benchmark'
print(
  x,
  units = "auto",
  order = "none",
  relative = "median",
  details = FALSE,
  ...
)

## S3 method for class 'summaryBenchmark'
print(x, units = "auto", order = "none", ...)

Arguments

x An object of class benchmark, summaryBenchmark or meanBenchmark.
units Character. The units to be used in printing the timings. The available units are nanoseconds ("ns"), microseconds ("us"), milliseconds ("ms"), seconds ("s").
order Character. Order results according to this column of the output.
**summary.benchmark**

- **relative**
  Character. The name or index of the column whose values will be used to compute relative timings.

- **details**
  Logical. Show additional details about measurement process.

- **...**
  Arguments passed on to `print.data.frame()`.

### Value

Apart from the table output produced by `summary`, the method also prints additional information about the benchmarking process (with `details = TRUE`):

- **Timer precision**
  Timer precision in seconds.

- **Timer error**
  Timer error (overhead) in seconds.

- **Replications**
  Number of repeats for each expression.

- **Expressions order**
  Execution regime.

- **Garbage collection**
  Whether garbage collection took place before each execution.

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### See Also

- `summary.benchmark()`, `mean.benchmark()`

### Examples

```r
a1 <- a2 <- a3 <- a4 <- numeric(0)
res <- benchmark(
  a1 <- c(a1, 1),
  a2 <- append(a2, 1),
  a3[length(a3) + 1] <- 1,
  a4[[length(a4) + 1]] <- 1
)
print(res)
```

---

**summary.benchmark**

*Summary method for the benchmark timings.*

### Description

This method computes aggregated statistics (quantiles, means and sums) for each expression.
Usage

```r
## S3 method for class 'benchmark'
summary(object, relative = "median", ...)
```

Arguments

- `object` An object of class `benchmark`.
- `relative` Character. The name or index of the column whose values will be used to compute relative timings.
- `...` Not currently used.

Value

The method returns a `data.frame` with additional attributes, which contains these columns:

- `expr` The deparsed expression as passed to `benchmark` or the name of the argument if the expression was passed as a named argument.
- `n.eval` Number of successful measurements.
- `min` Minimal timing measurement for this expression.
- `lw.qu` First quartile of measurements for this expression.
- `mean` Sample mean of measurements for this expression.
- `median` Sample median of measurements for this expression.
- `up.qu` Third quartile of measurements for this expression.
- `max` Maximal timing measurement for this expression.
- `total` Total (summed) measured time for this expression.
- `relative` Relative difference across expressions compared to a minimal value in the column, specified by the argument `relative`.

Additional attributes:

- `units` Units for time intervals.

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See Also

- `mean.benchmark()`

Examples

```r
timings <- benchmark(
  rchisq(100, 0), rchisq(100, 1), rchisq(100, 2),
  rchisq(100, 3), rchisq(100, 5),
  times = 1000L
)
summary(timings)
```
**timer_precision**

Get timer precision.

### Description
Get timer precision.

### Usage

```
timer_precision()
```

### Value
Number of seconds from one clock tick to the next.
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