A small R library which computes precision of descriptive statistics from measurement precision:

A companion to "How many decimals?"

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Loading the library

The exact computations to round descriptive statistics are found in the main text under Table 1. The equations are all simple; however, there are a lot of formulas to remember. To assist in rounding descriptive statistics, I have designed a small R library called `MeasurementPrecision` (no space and two capital letters) which resides on GitHub. To upload it, first install the `devtools` library from CRAN (Wickham, Hester & Chang, 2019). Then prior to the first use, issue the commands

```
devtools::install_github("dcousin3/MeasurementPrecision")
library(MeasurementPrecision)
```

On subsequent sessions, you can only use

```
library(MeasurementPrecision)
```

A basic use

Let's assume the following two sets of observations

```
sample1 <- c(83, 58, 79, 50, 49, 53, 62, 79, 66)
sample2 <- c(71, 62, 83, 93, 56, 82, 66, 69, 82, 86, 74, 61, 59, 101,
94, 86, 75)
```

To get a rounded descriptive statistic, use a command named `roundMP.`*`statistic`*. For example, to round the mean of the first sample, use:

```
roundMP.mean(fromData = sample1, deltax=0.5)
```

where `deltax`, a mandatory argument, is the precision of the instrument. The command returns a one-line data frame with four columns:

```
# machine.precision extrinsic systematic non.systematic
#          64.33333        64       64.3           64.3
```

where `machine.precision` is the unrounded result, `extrinsic` is the extrinsic precision-based rounding; `systematic` is the result assuming systematic measurement error and `non.systematic` is the result assuming non-systematic measurement error.

In any of the commands, you can use `fromData` if you want to specify raw data or `fromStatistics` to provide already-calculated descriptive statistics (provide them with all the precision you can). For example,

```
roundMP.mean(
     fromStatistics = list(mean = 64.333333, sd = 13.20982, n = 9),
     deltax = 0.5
)
```

returns the same results as above. If you issue this command with an empty list of statistics, an error message will let you know which statistics are required.

Getting rounded statistics beyond the mean

You can also round the standard deviation (`sd`), the standard error of the mean (`semean`) and the confidence interval of the mean (`cimean`):

```
roundMP.sd(fromData =sample1, deltax = 0.5)
roundMP.semean(fromData =sample1, deltax = 0.5)
roundMP.cimean(fromData =sample1, deltax = 0.5)
```

In `roundMP.cimean`, add `gamma =` for a different coverage. For example, `gamma = 0.80` will round a 80% confidence interval of the mean.

A one-sample *t*-test requires the null hypothesis for the mean, provided with `mu0,` for example:

```
roundMP.t.test(fromData = sample2, mu0 = 65, deltax = 0.5)
```

where 65 kg is the average planetary body weight for humans.

For statistics on two independent samples, you can use

```
roundMP.meandiff(fromData = list(sample2, sample1), deltax = 0.5)
roundMP.sdpool(fromData = list(sample2, sample1), deltax = 0.5)
roundMP.cohen.d(fromData = list(sample2, sample1), deltax = 0.5)
```

The argument `fromData` accepts vectors, matrices, data frames or a list of vectors (as illustrated here).

The non-systematic estimates are by default obtained from the simplifying assumptions described in Appendix B of the main paper. To use the full expression (non-parametric solution), add `assumptions=FALSE` to any of the commands, for example

```
roundMP.t.test(fromData = list(sample2, sample1),
     deltax=0.5, assumptions = FALSE
)
```

Generally, there is not much differences whether the simplified or the full expression are used.

Specifying the desired scenario as default

By default, all the `roundMP` functions output 4 different results, following four approaches to rounding: `"machine.precision"`, `"extrinsic"`, `"systematic"`, and `"non.systematic"`. It is possible to select only one or a few scenarios among this list by setting the global option `roundMP.selectedScenario`. For example,

```
options(roundMP.selectedScenario = c("extrinsic", "systematic"))
roundMP.mean(fromData = sample1, 0.5, verbose = T)
```

will display results only for two scenario (rounding assuming `extrinsic` and on `systematic` measurement error).

Arguments fromData, fromStatistics and fromObject

Regarding `t.test`, it is also possible to get a rounded result from a t.test object directly using the argument `fromObject` instead (instead of `fromData` or `fromStatistics`). The input has to contain a t-test, not a Welch test (so use `var.equal = TRUE` for two-samples):

```
res <- t.test(sample1, sample2, var.equal = TRUE)
roundMP.t.test(fromObject = res, deltax = 0.5)
```

Note that the library `MeasurementPrecision` must be declared prior to use the `t.test` function as it is redefined by `MeasurementPrecision`.

Detailed output

Finally, to obtain more details on the computations, and see the exact precision, you can add the option `verbose=TRUE` to any command. For example,

```
roundMP.mean(fromData = list(sample1), deltax = 0.5, verbose = TRUE)
```

returns

```
------------------------------------------------------------------------
mean of input is:                           64.33333
delta x of instrument is:                   0.5
EXTRINSINC PRECISION:  (result based on standard error of the mean)
  - precision for mean is:                  4.403282
  - rounded mean of input is:               64
SYSTEMATIC ERROR INTRINSINC PRECISION: (result assumption-free)
  - precision for mean is:                  0.50005
  - rounded mean of input is:               64.3
NON-SYSTEMATIC ERROR INTRINSINC PRECISION: (result assumption-free)
  - precision for mean is:                  0.1666833
  - rounded mean of input is:               64.3
------------------------------------------------------------------------
  machine.precision extrinsic systematic non.systematic
1          64.33333        64       64.3           64.3
```

The last two lines are identical to the solution provided earlier, but detailed information returns the precision for each scenario, whether a simplifying assumption was used, and the resulting rounded result.