Confidence Intervals

Instructions for this Minitab macro:

Save the macro file "CI.mac" from
  www.engr.mun.ca/~ggeorge/4421/demos/CI.mac .
Note where you have saved the macro file.
Ensure that all folder names in the path to the file have no spaces;
(so *don't* save it under 'My Documents':   Minitab doesn't like spaces in folder names!)

If necessary, use the 'View' menu to make the 'Command Line' pane visible at the right edge of the Minitab window.
Click in the 'Command Line' pane and type

% [drive]:/[folder path]/CI

where [drive] is the drive letter (C for the computer's hard drive, often D or E for a USB stick, etc.)   For example, if the macro is saved on the root of a USB stick on the E drive, then the command is
`% E:/CI`
If your macro is stored in the default location for macros, then all you need to type is
`%CI`
then click on the 'Run' button.

The user will be asked to input the size of each sample,
then asked to input the number of trials (random samples)

Cell C7(1) displays an update of how many random samples have been processed so far.

What the macro does:

Random quantity X is drawn from a normal distribution $X \sim N(100, 5^2)$
Random samples of size n are drawn m times from this distribution and sample mean $\bar{x}$ and sample standard deviation s calculated each time.
The user chooses the sample size n and the number m of samples.
Confidence intervals for the population mean are constructed, on the basis of not knowing the population variance.

The boundaries of each 95% confidence interval are $\bar{x} \pm t_{.025,\, n-1} \times (\text{s.e.})$

The true mean for $\bar{X}$ is μ (mu) .   The sample standard error is $\text{s.e.} = \dfrac{s}{\sqrt{n}}$

The boundaries (low, high) of each confidence interval and whether they bracket the true value of the mean (1=yes, 0=no) are recorded.
The boundaries are also plotted using a time series plot.

The overall percentage of confidence intervals that include the true value of the population mean μ is reported in the output pane.

On the time series plot one can identify the confidence intervals that fail to capture the true value of μ. By hovering the cursor on one end of any interval, one can identify the corresponding row in the data (worksheet) pane, in which the mean and standard error can also be viewed.

One simulation for 1,000 random samples each of size 16 produced this plot:
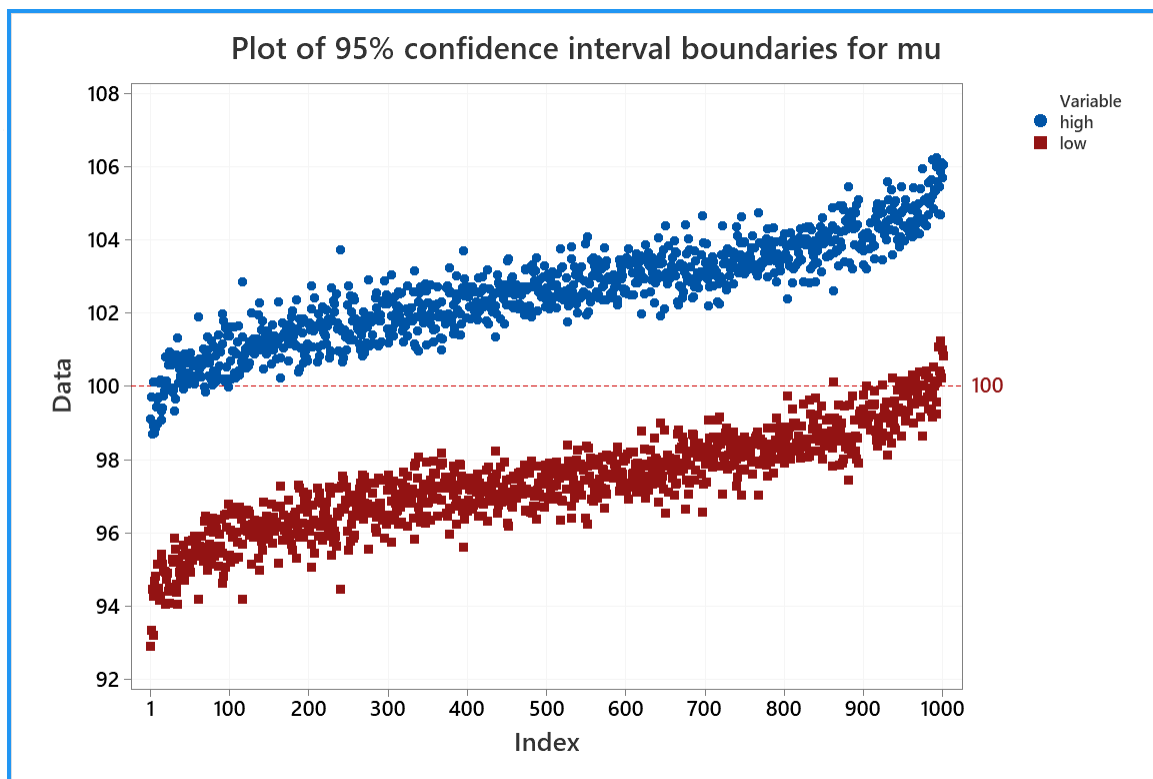
On the left end some confidence intervals are entirely below the true mean (100).
On the right end some confidence intervals are entirely above the true mean.
94.6% of these 1,000 confidence intervals do capture the true value of the mean.

Ideally, 95% of these 95% confidence intervals would include the true value of the mean.

The macro is also on the final two pages of this document.

:

```
gmacro
CI
### Simulation to construct (k1) 95% confidence intervals from random
### samples, each of size (k2) from a normal distribution of mean (k3)
### and standard deviation (k4).   The proportion of intervals that
### capture the true value of the population mean is reported.
### Macro created 2015 02 17 and last modified 2021 02 18 by G.H. George

mtitle "Confidence Interval Simulation"   #keep all output in one pane
  erase c1-c10          # needed to ensure clear space in the worksheet
### Constants:
### k1 = number of random samples
### k2 = sample size for each sample
let k3 = 100             # population mean
let k4 = 5               # population standard deviation (must be positive)
### k5 = loop counter; index number of current random sample
### k6 = half-width of confidence interval
### k7 = proportion of 95% CI that capture the true mean
### k8 = tail area = 2.5% for 95% two-tailed CI
### k9 = critical t-value at 95% confidence (2-tailed) for (k2-1) deg.
freedom
### k10 = number of degrees of freedom = k2 - 1

### Columns:
  name c1 'sample'      # all values in the current random sample
  name c2 'mean'        # sample means for all (k1) random samples
  name c3 's.e.'        # standard errors for all (k1) random samples
  name c4 'low'         # lower boundary of each confidence interval
  name c5 'high'        # upper boundary of each confidence interval
  name c6 'capture'     # = 1 if true mean inside confidence interval
  name c7 'sample size' # temporary column for input of k2
  name c8 'alpha/2'     # tail area = 2.5% for 95% two-tailed CI
  name c9 't_crit'      # critical t-value
  name c10 'sampleNo'   # current sample number

### Note that keyboard data entry must be into columns, not constants:
  note Enter sample size (must be an integer > 2):
  set 'sample size';
    file "terminal";
    nobs 1.
  copy 'sample size' k2

  note Enter number of samples (must be a positive integer):
  set 'sampleNo';
    file "terminal";
    nobs 1.
  copy 'sampleNo' k1
  let 'sampleNo'(2) = k1
```

```
### Calculate and store the critical t-value (k9)
  let k10 = k2 - 1
  let 'alpha/2'(1) = 0.025
  InvCDF 'alpha/2' 't_crit';
    T k10.
  copy 't_crit' k9

### Draw the (k1) random samples, each of size (k2) in column c1:
  do k5=1:k1              # conduct the (k1) simulations
      let 'sampleNo'(1) = k5   # display current sample number
      random k2 'sample';
        Normal k3 k4.    # X ~ N(k3, (k4)^2)  in column c1
      let 'mean'(k5) = mean('sample')
      let 's.e.'(k5) = stdev('sample')/sqrt(k2)
      let k6 = abs(k9*'s.e.'(k5))
      let 'low'(k5) = 'mean'(k5) - k6
      let 'high'(k5) = 'mean'(k5) + k6
      let 'capture'(k5) = 0
      if (k3 > 'low'(k5)) and (k3 < 'high'(k5))   # mu inside CI?
          let 'capture'(k5) = 1
      endif
  enddo

### Calculate and report the proportion of 95% CI that capture mu.
  let k7 = sum('capture') / k1
  note The percentage of 95% confidence intervals that capture
  note the true value of the population mean is
  print k7;
    format (%7.2).

### Plot all the confidence interval boundaries in ascending order
### of sample mean
  Sort 'mean'-'capture'  'mean'-'capture';
    By 'mean'.
  Tsplot high low;
    Overlay;
    Index;
    Legend;
      Section 1;
    Reference 2 k3;
    Symbol;
    Grid 2;
    Footnote;
      FPanel;
    Title "Plot of 95% confidence interval boundaries for mu";
    NoDTitle.

endmtitle
endmacro
```