**Defining the Problem**

Bootstrapping is a statistical resampling distribution method used to gather an unbiased statistic from a large enough parent distribution. It was introduced in 1979 by Bradley Efron as an extension to an older resampling method known as the “jackknife”. Although its coding is relatively simple compared to other sampling methods, it does require the use of multiple statistical techniques such as mean sampling and histogram dynamics.

*General Process of Bootstrapping:*

1. A quantitative parent distribution/sample must be present before bootstrapping takes place. This sample can have values ranging from negative to positive infinity and theoretically can have a sample size of infinity.
2. The list is then randomly sorted from the range of the parent distribution. There can be as many random lists based on the parent distribution as the bootstrapper chooses. Each randomly generated list, however, must have the same sample size as the parent distribution. The number of random child distributions is equal to the number of iterations in bootstrapping.
3. The bootstrapper then chooses to take a statistical value from each random child distribution. Whichever statistical value is to be found must be the same for every random distribution created.
4. Once each statistical value has been found from each random child distribution, the statistical values are then plotted on a histogram with a frequency of one.
5. According to the central limit theorem and the rules of sampling proportion, the histogram should form a Gaussian shape- which indicates a normal distribution- if the number of iterations satisfies the conditions of the theorem. This is the basis of bootstrapping.
6. Since the distribution is based on a sample mean, a further practical use would be to calculate the differences in the sample mean/proportion to the known population mean or parameter.

As the study of statistics continues, bootstrapping is in more of a need to be readily accessible to students and statisticians alike. The problem is finding a readily accessible device capable of performing this process.

**Specifications**

1. The program will start up on command and through the previous entry command.
2. It will utilize all the default available lists and matrices of the TI device.
3. It will create as many random child distributions and support any parent distributions as long as it does not exceed the calculator’s limitations.
4. It will properly exit through prompt or through a interrupted runtime.
5. It will present no errors during runtime (with the exception of the break error due to user interference).
6. It will go through the general process of bootstrapping through the use of the statistical value of means and sample means.
7. It will display the histogram with the expected results through the central limit theorem.
8. The user can choose whether to delete all data created by program or not in order to view the data outside of the program.

**Programming Language used**: TI-BASIC

**Device used to program**: TI-84 Plus CE (Texas Instruments)

**Total number of lines (without comments)**: 433

Notes:

* Commands involving parentheses and quotations do not need end quotations and/or parentheses.
* In TI-BASIC, comments are marked with a :“[comment]” next to the command (quotations included; brackets excluded).
* By default, the calculator does not allow full lowercase typing unless through the use of a computer or system app that allows access.
* The TI-84 Plus CE/CSE supports a 26x10 character display matrix. The code below will not be displayed correctly if executed with non-color TI graphing calculators.
* Labels can be up to two characters long, from 00 to ZZ.

**Bibliography:**

The following sources was used for the research of bootstrapping:

Hand, Nick. "Bootstrap Resampling." *YouTube*. YouTube, 13 Dec. 2012. Web. 20 Mar. 2016. <https://www.youtube.com/watch?v=ZCXg64l9R\_4>.

Taylor, Courtney. "What Is Bootstrapping in Statistics?" *About.com Statistics*. About, 16 Dec. 2014. Web. 20 Mar. 2016. <http://statistics.about.com/od/Applications/a/What-Is-Bootstrapping.htm>.

https://en.wikipedia.org/wiki/Bootstrapping\_(statistics)

**Source Code:**

PROGRAM:BOOTSTRP

ClrHome

rand

Output(1,1,"--------------------------

Output(2,1,"BOOTSTRAPPING PROGRAM "

Output(3,1,"--------------------------

Output(5,1,"BY NEELOY GOMES

Output(7,1,"A RESAMPLING DISTRIBUTION

Output(8,1,"PROGRAM

Output(10,1,"PRESS ENTER TO CONTINUE

Pause

Lbl 99

ClrHome

Menu("MAIN MENU:","USE USER SAMPLE",1,"USE GIVEN SAMPLE",2,"EXIT",3)

Lbl 1

ClrHome

Menu("WHICH LIST HAS SAMPLE?","L₁",11,"L₂",12,"L₃",13,"L₄",14,"L₅",15,"L₆",16,"BACK...",99)

Lbl 2

Menu("WHICH TYPE OF SAMPLE?","SYMMETRIC UNIMODAL",C5,"SYMMETRIC BIMODAL",C6,"RIGHT-SKEWED",C7,"LEFT-SKEWED",C8,"UNIFORM",C9,"BACK...",99)

Lbl C5

1→M

ClrHome

1→E

50→F

Goto D2

Lbl C6

2→M

ClrHome

1→E

50→F

Goto D2

Lbl C7

3→M

ClrHome

1→E

50→F

Goto D2

Lbl C8

4→M

ClrHome

1→E

50→F

Goto D2

Lbl C9

0→M

ClrHome

1→E

50→F

Lbl D2

ClrHome

Menu("OVERWRITE WHICH LIST?","L₁",21,"L₂",22,"L₃",23,"L₄",24,"L₅",25,"L₆",26)

End

Lbl 21

Disp "OVERWRITING LIST..."

{0}→L₁

(E+F)/2→U

If M=1

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→L₁

End

If M=2

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊B

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊C

augment(⌊B,⌊C)→L₁

End

If M=3

Then

iPart(E+Frand(30))→L₁

End

If M=4

Then

iPart(E+F√(rand(30)))→L₁

End

If M=0

Then

randInt(E,F,30)→L₁

End

1→B

Goto C1

Lbl 22

Disp "OVERWRITING LIST..."

{0}→L₂

(E+F)/2→U

If M=1

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→L₂

End

If M=2

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊B

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊C

augment(⌊B,⌊C)→L₂

End

If M=3

Then

iPart(E+Frand(30))→L₂

End

If M=4

Then

iPart(E+F√(rand(30)))→L₂

End

If M=0

Then

randInt(E,F,30)→L₂

End

2→B

Goto C1

Lbl 23

Disp "OVERWRITING LIST..."

{0}→L₃

(E+F)/2→U

If M=1

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→L₃

End

If M=2

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊B

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊C

augment(⌊B,⌊C)→L₃

End

If M=3

Then

iPart(E+Frand(30))→L₃

End

If M=4

Then

iPart(E+F√(rand(30)))→L₃

End

If M=0

Then

randInt(E,F,30)→L₃

End

3→B

Goto C1

Lbl 24

Disp "OVERWRITING LIST..."

{0}→L₄

(E+F)/2→U

If M=1

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→L₄

End

If M=2

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊B

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊C

augment(⌊B,⌊C)→L₄

End

If M=3

Then

iPart(E+Frand(30))→L₄

End

If M=4

Then

iPart(E+F√(rand(30)))→L₄

End

If M=0

Then

randInt(E,F,30)→L₄

End

4→B

Goto C1

Lbl 25

Disp "OVERWRITING LIST..."

{0}→L₅

(E+F)/2→U

If M=1

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→L₅

End

If M=2

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊B

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊C

augment(⌊B,⌊C)→L₅

End

If M=3

Then

iPart(E+Frand(30))→L₅

End

If M=4

Then

iPart(E+F√(rand(30)))→L₅

End

If M=0

Then

randInt(E,F,30)→L₅

End

5→B

Goto C1

Lbl 26

Disp "OVERWRITING LIST..."

{0}→L₆

(E+F)/2→U

If M=1

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→6

End

If M=2

Then

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊B

iPart(randNorm(U,√((F-U)²+(E-U)²),30))→⌊C

augment(⌊B,⌊C)→L₆

End

If M=3

Then

iPart(E+Frand(30))→L₆

End

If M=4

Then

iPart(E+F√(rand(30)))→L₆

End

If M=0

Then

randInt(E,F,30)→L₆

End

6→B

Goto C1

Lbl C1

ClrHome

Disp "THE LIST HAS BEEN","OVERWRITTEN."

Pause

ClrHome

Menu("NEXT STEP?","BOOTSTRAP IMMEDIATELY",1,"CHECK THE SAMPLE CREATED",C2)

Lbl C2

ClrHome

Disp "CHECK THE SAMPLE BY GOING","TO STAT AND EDIT."," "

Disp "RESTART THE ","PROGRAM TO USE THE SAMPLE."

Stop

End

Lbl 3

Menu("SAVE GRAPH AND LIST DATA?","YES",4,"NO",0)

Lbl 4

ClrHome

Disp "GRAPHS AND LISTS SAVED FOR","FURTHER VIEWING."," ","PRESS ENTER TO CLOSE THE","PROGRAM AND ZOOMSTAT TO","DISPLAY THE GRAPH."

AxesOn

Pause

ClrHome

Stop

Lbl 0

PlotsOff

ClrDraw

DelVar ⌊A

DelVar ⌊B

DelVar ⌊C

DelVar ⌊BOOT

DelVar ⌊FREQ

DelVar ⌊θ

–10→Xmin

10→Xmax

–10→Ymin

10→Ymax

ClrDraw

ClrHome

Disp "GRAPHS AND LISTS CREATED","BY THIS PROGRAM HAVE BEEN","ERASED."

AxesOn

Stop

Lbl 11

If dim(L₁)=0

Then

ClrHome

Disp "THERE IS NO DATA IN THIS","SAMPLE.

Pause

Goto 99

Else

L₁→A

dim(L₁)→L

1→B

Goto A1

End

Lbl 12

If dim(L₂)=0

Then

Disp "THERE IS NO DATA IN THIS","SAMPLE.

Pause

Goto 99

Else

L₂→A

dim(L₂)→L

2→B

Goto A1

End

Lbl 13

If dim(L₃)=0

Then

Disp "THERE IS NO DATA IS THIS","SAMPLE.

Pause

Goto 99

Else

L₃→A

dim(L₃)→L

3→B

Goto A1

End

Lbl 14

If dim(L₄)=0

Then

Disp "THERE IS NO DATA IN THIS","SAMPLE.

Pause

Goto 99

Else

L₄→A

dim(L₄)→L

4→B

Goto A1

End

Lbl 15

If dim(L₅)=0

Then

Disp "THERE IS NO DATA IN THIS","SAMPLE.

Pause

Goto 99

Else

L₅→A

dim(L₅)→L

5→B

Goto A1

End

Lbl 16

If dim(L₆)=0

Then

Disp "THERE IS NO DATA IN THIS","SAMPLE.

Pause

Goto 99

Else

dim(L₆)→L

L₆→A

6→B

Goto A1

End

Lbl A1

{0}→⌊BOOT

{0}→⌊θ

ClrHome

Disp "RESAMPLE SIZE: ","(1-999)"

Prompt R

If R<1 or R>999

Then

Output(5,1,"THE CALCULATOR CANNOT

Output(6,1,"HANDLE THIS SAMPLE SIZE.

Output(7,1,"PLEASE INPUT A SAMPLE SIZE

Output(8,1,"WITHIN RANGE."

Pause

Goto A1

Else

Disp "PLEASE WAIT..."

R→dim(⌊θ)

End

Lbl 98

Disp " ","HOW MANY ITERATIONS?","(1-999)

Prompt I

If I<1 or I>999

Then

ClrHome

Disp "THE CALCULATOR CANNOT","HANDLE THIS MANY","ITERATIONS.","PLEASE INPUT A NUMBER","WITHIN RANGE."

Pause

ClrHome

Goto 98

Else

Disp "PLEASE WAIT..."

I→dim(⌊BOOT)

End

1→X

Lbl 50

ClrHome

Output(1,1,"SAMPLE LIST:

If B=1

Then

Output(1,14,"L₁

End

If B=2

Then

Output(1,14,"L₂

End

If B=3

Then

Output(1,14,"L₃

End

If B=4

Then

Output(1,14,"L₄

End

If B=5

Then

Output(1,14,"L₅

End

If B=6

Then

Output(1,14,"L₆

End

Output(2,1,"SAMPLE SIZE:

Output(2,14,L

Output(3,1,"ITERATIONS:

Output(3,13,I

Output(4,1,"RESAMPLE SIZE:"

Output(4,16,R

Output(6,1,"ARE YOU SATISFIED WITH

Output(7,1,"THESE SETTINGS?"

Pause

Menu("SATISFIED?","YES",70,"NO",99)

Lbl 70

ClrHome

Disp "BOOTSTRAPPING..."

1→Y

Output(3,1,"THIS MAY TAKE SEVERAL

Output(4,1,"MINUTES DEPENDING ON THE

Output(5,1,"SAMPLE SIZE AND THE NUMBER

Output(6,1,"OF ITERATIONS.

Output(9,1,"ITERATIONS COMPLETE:

Output(10,4,"/"

Output(10,5,I

Output(10,1,"0"

While Y≤I

1→Z

While Z≤R

randInt(1,L)→K

⌊A(K)→⌊θ(Z)

Z+1→Z

End

mean(⌊θ)→⌊BOOT(Y)

Output(10,1,Y

Y+1→Y

End

ClrDraw

AxesOn

Plot1(Histogram,⌊BOOT,1,BLUE)

Lbl 5

ZoomStat

DispGraph

Pause

ClrHome

Menu("START OVER?","YES",99,"NO",3,"DISPLAY GRAPH AGAIN",5)