Learning the Central Limit Theorem: A Step-by-Step Guide Using the TI-84 Calculator

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The Foundational Role of the Central Limit Theorem (CLT)

The Central Limit Theorem (CLT) is arguably the most fundamental concept in inferential statistics. It provides the essential bridge between descriptive analysis and making broad conclusions about a population based solely on sample data. Understanding the CLT is crucial for any researcher or student aiming to perform reliable statistical inference.

In essence, the theorem asserts that if you draw sufficiently large, independent random samples from virtually any population distribution, the distribution of the resultant sample means will approach a normal distribution. This phenomenon occurs regardless of the original population's shape--be it skewed, uniform, or bimodal--provided the sample size (denoted as **n**) is adequate, typically accepted as $n \geq 30$.

This remarkable property allows statisticians to treat the sampling distribution as normal. This transformation is immensely powerful because it permits the utilization of established parametric tests and standard probability calculations, simplifying complex analyses that would otherwise be impossible if the population distribution was unknown or non-normal.

Defining the Parameters of the Sampling Distribution

When the Central Limit Theorem is satisfied (i.e., $n \geq 30$), the new distribution of sample means acquires highly predictable characteristics directly derived from the original population parameters. These characteristics are essential for accurately calculating the probability associated with any given sample mean.

The CLT precisely defines how the mean and variability of the sampling distribution relate to the population mean (mu) and the population standard deviation ($sigma$). These two relationships form the core mathematical framework for all subsequent probability calculations:

The mean of the sampling distribution ($mu_{bar{x}}$) is guaranteed to be equal to the mean of the population distribution (mu). This property highlights that the sample mean serves as an unbiased estimator of the true population mean.

$$x = \mu$$

The standard deviation of the sampling distribution, conventionally termed the standard error of the mean, quantifies the average deviation of the sample means from the population mean. It is calculated by dividing the population standard deviation ($sigma$) by the square root of the sample size ($sqrt{n}$). As the sample size increases, the standard error decreases, reflecting the reduced variability and increased precision of the estimates.

$$s = \sigma / \sqrt{n}$$

Executing Probability Calculations Using normalcdf() on the TI-84

To determine probabilities concerning a sample mean derived using the CLT, users of the TI-84 calculator must employ the **normalcdf()** function. This powerful tool computes the cumulative distribution function (CDF), effectively giving the area under the standardized normal curve between two specified boundary values.

When applying this function in the context of the sampling distribution, it is absolutely essential to use the correct parameters. The mean parameter must be the population mean (mu), and the standard deviation parameter must be the standard error ($sigma/sqrt{n}$). Failure to use the standard error will result in an incorrect calculation, as the variability of the sampling distribution is always smaller than the population's variability.

The standard syntax structure required for the **normalcdf()** function on the TI-84 calculator is:

normalcdf(lower value, upper value, x, s/√n)

The specific parameters required for input correspond to the following statistical definitions:

x: Represents the true mean of the population (mu).
s: Represents the population standard deviation ($sigma$).
n: Represents the size of the random sample drawn.

To access the distribution menu and locate the **normalcdf()** function on your TI-84 calculator, press the 2nd button, followed immediately by the VARS key, which functions as the DISTR shortcut. Scroll down the listed distributions until you find normalcdf(and press ENTER to select it.

The subsequent examples illustrate the precise application of this function to solve three common types of probability questions encountered when applying the Central Limit Theorem.

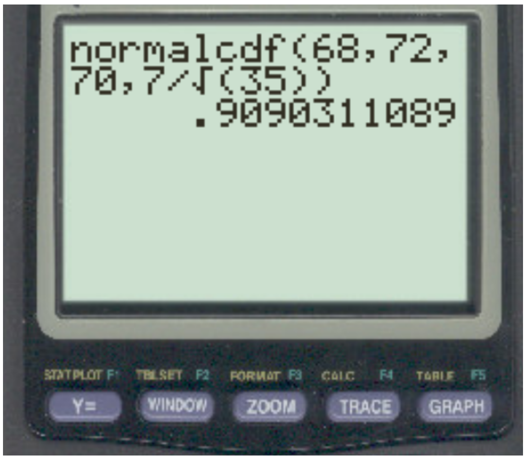
Example 1: Calculating Probability Between Two Values

Consider a population characterized by a mean (mu) of 70 and a standard deviation ($sigma$) of 7. If a random sample of size **n = 35** is selected, what is the probability that the resulting sample mean ($bar{x}$) will fall within the range of 68 and 72? We are solving for the area P(68 < $bar{x}$ < 72).

Since the sample size (n=35) is greater than 30, we confirm that the sampling distribution is approximately normal, and we can proceed with the CLT. First, we calculate the standard error: $7/sqrt{35}$. The lower boundary for the calculation is 68, and the upper boundary is 72. The TI-84 function requires these boundaries along with the population mean and the standard error.

The accurate syntax to be entered into the TI-84 for this calculation is:

normalcdf(68, 72, 70, 7/√35)



Upon execution, the probability that the sample mean lies between 68 and 72 is calculated to be approximately **0.909**, indicating a high likelihood that the sample mean will fall close to the true population mean.

Example 2: Finding Probability Greater Than a Specific Value

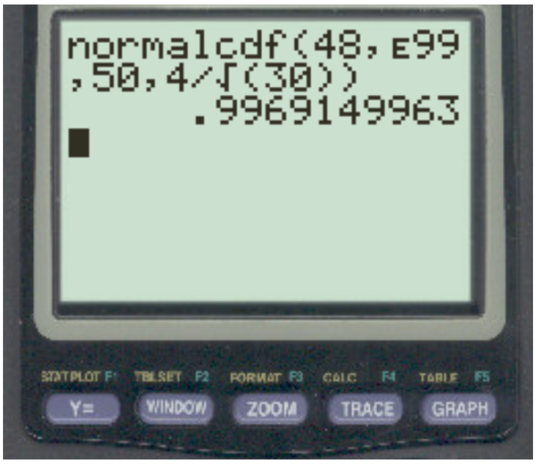
Suppose a population has a mean (mu) of 50 and a population standard deviation ($sigma$) of 4. If we take a sample of size **n = 30**, we need to determine the probability that the sample mean ($bar{x}$) is greater than 48. This is represented as P($bar{x}$ > 48).

To calculate the probability for a range extending infinitely to the right (positive infinity), we set the lower boundary to the specific value (48). The upper boundary must be represented by a sufficiently large number. On the TI-84 calculator, this value is input using scientific notation as **E99** (10^{99}). The standard error for this problem is $4/sqrt{30}$.

We combine the calculated standard error, the population mean, and the defined boundaries into the function:

normalcdf(48, E99, 50, 4/√30)

Note: To input the "E" symbol (representing scientific notation, 10^x) on the TI-84 calculator, press the 2nd button followed by the , button.



The resulting probability that the sample mean is greater than 48 is determined to be a high value of **0.9969**, reflecting that 48 is two units below the population mean of 50.

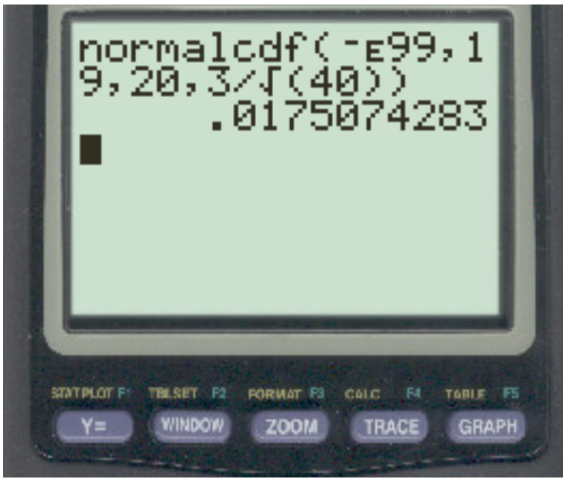
Example 3: Determining Probability Less Than a Specific Value

Finally, let us analyze a distribution with a mean (mu) of 20 and a standard deviation ($sigma$) of 3. If a sample size **n = 40** is drawn, what is the probability that the sample mean ($bar{x}$) is less than 19? We are seeking P($bar{x}$ < 19).

When calculating probabilities that extend toward negative infinity, the upper boundary is set as the specified value (19). The lower boundary must be represented by negative infinity, or **-E99**, on the calculator. The standard error required for this computation is $3/sqrt{40}$.

The necessary input structure for the TI-84 calculator, incorporating the standard error and the infinite lower bound, is:

normalcdf(-E99, 19, 20, 3/√40)



The resulting calculation shows that the probability that the sample mean is less than 19 is **0.0175**. This low probability is expected since 19 is one unit below the population mean of 20, and the large sample size results in a small standard error, concentrating the means tightly around 20.

Additional Resources for Statistical Computation

Understanding the Central Limit Theorem is the gateway to applying advanced statistical methods, including constructing confidence intervals and performing hypothesis tests. Mastery of the **normalcdf()** function using the standard error is a crucial skill for accurate probability determination in introductory and advanced statistics courses.