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T-Test (Statistical methods)

A t-test is a type of inferential statistic used to determine if there is a significant difference between the means of two groups, which may be related in certain features. It is mostly used when the data sets, like the data set recorded as the outcome from flipping a coin 100 times, would follow a normal distribution and may have unknown variances. A t-test is used as a hypothesis testing tool, which allows testing of an assumption applicable to a population.

A t-test looks at the t-statistic, the t-distribution values, and the degrees of freedom to determine the statistical significance. To conduct a test with three or more means, one must use an analysis of variance.

Explaining the T-Test

Essentially, a t-test allows us to compare the average values of the two data sets and determine if they came from the same population. In the above examples, if we were to take a sample of students from class A and another sample of students from class B, we would not expect them to have exactly the same mean and standard deviation. Similarly, samples taken from the placebo-fed control group and those taken from the drug prescribed group should have a slightly different mean and standard deviation.

Mathematically, the t-test takes a sample from each of the two sets and establishes the problem statement by assuming a null hypothesis that the two means are equal. Based on the applicable formulas, certain values are calculated and compared against the standard values, and the assumed null hypothesis is accepted or rejected accordingly.

If the null hypothesis qualifies to be rejected, it indicates that data readings are strong and are probably not due to chance. The t-test is just one of many tests used for this purpose. Statisticians must additionally use tests other than the t-test to examine more variables and tests with larger sample sizes. For a large sample size, statisticians use a z-test. Other testing options include the chi-square test and the f-test.

There are three types of t-tests, and they are categorized as dependent and independent t-tests.

Key Takeaways

- A t-test is a type of inferential statistic used to determine if there is a significant difference between the means of two groups, which may be related in certain features.
- The t-test is one of many tests used for the purpose of hypothesis testing in statistics.
- Calculating a t-test requires three key data values. They include the difference between the mean values from each data set (called the mean difference), the standard deviation of each group, and the number of data values of each group.
- There are several different types of t-test that can be performed depending on the data and type of analysis required.

Ambiguous Test Results

Consider that a drug manufacturer wants to test a newly invented medicine. It follows the standard procedure of trying the drug on one group of patients and giving a placebo to another group, called the control group. The placebo given to the control group is a substance of no intended therapeutic value and serves as a benchmark to measure how the other group, which is given the actual drug, responds.

After the drug trial, the members of the placebo-fed control group reported an increase in average life expectancy of three years, while the members of the group who are prescribed the new drug report an increase in average life expectancy of four years. Instant observation may indicate that the drug is indeed working as the results are better for the group using the drug. However, it is also

possible that the observation may be due to a chance occurrence, especially a surprising piece of luck. A t-test is useful to conclude if the results are actually correct and applicable to the entire population.

In a school, 100 students in class A scored an average of 85% with a standard deviation of 3%. Another 100 students belonging to class B scored an average of 87% with a standard deviation of 4%. While the average of class B is better than that of class A, it may not be correct to jump to the conclusion that the overall performance of students in class B is better than that of students in class A. This is because there is natural variability in the test scores in both classes, so the difference could be due to chance alone. A t-test can help to determine whether one class fared better than the other.

T-Test Assumptions

1. The first assumption made regarding t-tests concerns the scale of measurement. The assumption for a t-test is that the scale of measurement applied to the data collected follows a continuous or ordinal scale, such as the scores for an IQ test.
2. The second assumption made is that of a simple random sample, that the data is collected from a representative, randomly selected portion of the total population.
3. The third assumption is the data, when plotted, results in a normal distribution, bell-shaped distribution curve.
4. The final assumption is the homogeneity of variance. Homogeneous, or equal, variance exists when the standard deviations of samples are approximately equal.

Calculating T-Tests

Calculating a t-test requires three key data values. They include the difference between the mean values from each data set (called the mean difference), the standard deviation of each group, and the number of data values of each group.

The outcome of the t-test produces the t-value. This calculated t-value is then compared against a value obtained from a critical value table (called the T-Distribution Table). This comparison helps to determine the effect of chance alone on the difference, and whether the difference is outside that chance range. The t-test questions whether the difference between the groups represents a true difference in the study or if it is possibly a meaningless random difference.

T-Distribution Tables

The T-Distribution Table is available in one-tail and two-tails formats. The former is used for assessing cases which have a fixed value or range with a clear direction (positive or negative). For instance, what is the probability of output value remaining below -3, or getting more than seven when rolling a pair of dice? The latter is used for range bound analysis, such as asking if the coordinates fall between -2 and +2.

The calculations can be performed with standard software programs that support the necessary statistical functions, like those found in MS Excel.

T-Values and Degrees of Freedom

The t-test produces two values as its output: t-value and degrees of freedom. The t-value is a ratio of the difference between the mean of the two sample sets and the variation that exists within the sample sets. While the numerator value (the difference between the mean of the two sample sets) is straightforward to calculate, the denominator (the variation that exists within the sample sets) can become a bit complicated depending upon the type of data values involved. The denominator of the ratio is a measurement of the dispersion or variability. Higher values of the t-value, also called t-score, indicate that a large difference exists between the two sample sets. The smaller the t-value, the more similarity exists between the two sample sets.

- A large t-score indicates that the groups are different.
- A small t-score indicates that the groups are similar.

Degrees of freedom refers to the values in a study that has the freedom to vary and are essential for assessing the importance and the validity of the null hypothesis. Computation of these values usually depends upon the number of data records available in the sample set.