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Explorable.com, Lyndsay T Wilson120.4K reads

The Mann-Whitney-Wilcoxon (MWW) or Wilcoxon Rank-Sum Test

Non-parametric tests are basically used in order to work around the underlying assumption of normality in parametric tests. Quite general assumptions regarding the population are used in these tests.

A good example of a non-parametric test is the Mann-Whitney U-test (Also known as the Mann-Whitney-Wilcoxon (MWW) or Wilcoxon Rank-Sum Test). Unlike its parametric counterpart, the t-test for two samples, this test does not assume that the difference between the samples is normally distributed, or that the variances of the two populations are equal.

Thus when the validity of the assumptions of the t-test are not certain, the Mann-Whitney U-Test can be used instead and therefore has wider applicability.

The Method

The Mann-Whitney U-test [1] is used to test whether two independent samples [2] of observations are drawn from the same or identical distributions. An advantage with this test is that the two samples under consideration do not necessarily need to have the same number of observations or instances.

This test is based on the idea that when 'm' number of X random variables and 'n' number of Y random variables are arranged together in increasing order of magnitude, the pattern they exhibit provides information about the relationship between their parent populations.

The Mann-Whitney test criterion is based on the magnitude of the Ys in relation to the Xs, i.e. the position of Ys in the combined ordered sequence. A sample pattern of arrangement where most of the Ys are greater than most of the Xs or vice versa would be evidence against random mixing. This would tend to discredit the null hypothesis [3] of identical distribution.

Assumptions

The test has two important assumptions. The first is that the two samples under consideration are random, and are independent of each other, as are the observations within each sample. The second is that the observations are numeric or ordinal (i.e. arranged in ranks/orders).

How to Calculate the Mann-Whitney U

In order to calculate the U statistics, the combined set of data is first arranged in ascending order with tied scores receiving a rank equal to the average position of those scores in the ordered sequence (in other words, add the two tying scores and divide by two to give a shared rank for both).

Let T denote the sum of ranks for the first sample. The Mann-Whitney test statistic is then calculated using U = n1 n2 + {n1 (n1 + 1)/2} - T , where n1 and n2 are the sizes of the first and second samples respectively.

An Example

An example can help clarify the process. Consider the following samples.

Sample A							
Observation	25	25	19	21	22	19	15
Rank	15.5	15.5	9.5	13	14	9.5	3.5

Sample B									
Observation	18	14	13	15	17	19	18	20	19
Rank	6.5	2	1	3.5	5	9.5	6.5	12	9.5

Here, T = 80.5, n1 = 7, n2 = 9.Hence, U = (7 * 9) + [{7 * (7+1)}/2] - 80.5 = 10.5.

We next compare the value of the calculated U with the value given in the Tables of Critical Values for the Mann-Whitney U-test. Here, the critical values are provided for given n1 and n2, and accordingly we accept or reject the null hypothesis [3]. Even though the distribution of U is known, the normal distribution [4] provides a good approximation in case of large samples.

Hypothesis on Equality of Medians

Often this statistic is used to compare a hypothesis regarding equality of medians [5]. The logic is simple - since the U statistic tests if two samples are drawn from identical populations, we can also use it to test whether two group medians are equal.

As a Counterpart of T-Test

The Mann-Whitney U test is truly the non parametric counterpart of the two sample t-test. To see this, one needs to recall that the t-test [6] tests for equality of means when the underlying assumptions of normality and equality of variance [7] are satisfied. Thus the t-test determines if the two samples have been drawn from identical normal populations. The Mann-Whitney U test is its generalization [8].

Links
[1] http://www.statisticssolutions.com/resources/directory-of-statistical-analyses/mann-whitney-u-test
[2] https://explorable.com/sample-group
[3] https://explorable.com/null-hypothesis
[4] https://explorable.com/normal-probability-distribution
[5] https://explorable.com/calculate-median
[6] https://explorable.com/students-t-test-2
[7] https://explorable.com/statistical-variance
[8] https://explorable.com/what-is-generalization