NAG C Library Function Document

nag_sign_test (g08aac)

1 Purpose

nag_sign_test (g08aac) performs the Sign test on two related samples of size n.

2 Specification

```
#include <nag.h>
#include <nagg08.h>

void nag_sign_test (Integer n, const double x[], const double y[], Integer *s,
          double *p, Integer *non_tied, NagError *fail)
```

3 Description

The Sign test investigates the median difference between pairs of scores from two matched samples of size n, denoted by $\{x_i, y_i\}$, for $i = 1, 2, \ldots, n$. The hypothesis under test, H_0, often called the null hypothesis, is that the medians are the same, and this is to be tested against a one- or two-sided alternative H_1 (see below).

nag_sign_test computes:

(a) the test statistic S, which is the number of pairs for which $x_i < y_i$;

(b) the number n_1 of non-tied pairs $(x_i \neq y_i)$;

(c) the lower tail probability p corresponding to S (adjusted to allow the complement $(1 - p)$ to be used in an upper one-tailed or a two-tailed test). p is the probability of observing a value $\leq S$ if $S < \frac{1}{2}n_1$; or of observing a value $< S$ if $S > \frac{1}{2}n_1$, given that H_0 is true. If $S = \frac{1}{2}n_1$, p is set to 0.5.

Suppose that a significance test of a chosen size α is to be performed (i.e., α is the probability of rejecting H_0 when H_0 is true; typically α is a small quantity such as 0.05 or 0.01). The returned value of p can be used to perform a significance test on the median difference, against various alternative hypotheses H_1, as follows:

(i) H_1: median of $x \neq$ median of y. H_0 is rejected if $2 \times \min(p, 1 - p) < \alpha$.

(ii) H_1: median of $x >$ median of y. H_0 is rejected if $p < \alpha$.

(iii) H_1: median of $x <$ median of y. H_0 is rejected if $1 - p < \alpha$.

4 Parameters

1: **n** – Integer *Input*

On entry: the size of each sample, n.

Constraint: $\mathbf{n} \geq 1$.

2: **x[n]** – const double *Input*
3: **y[n]** – const double *Input*

On entry: $\mathbf{x}[i-1]$ and $\mathbf{y}[i-1]$ must be set to the ith pair of data values, $\{x_i, y_i\}$, for $i = 1, 2, \ldots, n$.

4: **s** – Integer * *Output*

On exit: the Sign test statistic, S.

5: **p** – double * *Output*

On exit: the lower tail probability, p, corresponding to S.

6: **non_tied** – Integer * *Output*

On exit: the number of non-tied pairs, n_1.

7: **fail** – NagError * *Input/Output*

The NAG error parameter (see the Essential Introduction).

5 Error Indicators and Warnings

NE_INT_ARG_LT

On entry, **n** must not be less than 1: **n** = <*value*>.

NE_G08AA_NON_TIED

On exit, the number of **non_tied** pairs, **non_tied** = 0, i.e., the samples are identical.

NE_INTERNAL_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please consult NAG for assistance.

6 Further Comments

The time taken by the routine is small, and increases with n.

6.1 Accuracy

The tail probability, p, is computed using the relationship between the binomial and beta distributions. For $n_1 < 120$, p should be accurate to at least 4 significant figures, assuming that the machine has a precision of 7 or more digits. For $n_1 \geq 120$, p should be computed with an absolute error of less than 0.005. For further details see nag_prob_beta_dist (g01eec).

6.2 References

Siegel S (1956) *Non-parametric Statistics for the Behavioral Sciences* McGraw-Hill

7 See Also

nag_prob_beta_dist (g01eec)

8 Example

This example is taken from page 69 of Siegel (1956). The data relate to ratings of ‘insight into paternal discipline’ for 17 sets of parents, recorded on a scale from 1 to 5.

8.1 Program Text

```
/* nag_sign_test (g08aac) Example Program.
 *
 * Copyright 2000 Numerical Algorithms Group.
 *
 * Mark 6, 2000.
 */
```

```
#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg08.h>

int main (void)
{
  double p, *x=0, *y=0;
  Integer i, s, n, non_tied;
  Integer exit_status=0;
  NagError fail;

  INIT_FAIL(fail);
  Vprintf("g08aac Example Program Results\n");

/*  Skip heading in data file */
  Vscanf("%*[^\n]");

  n=17;
  if (!(x=NAG_ALLOC(n, double))
      || !(y=NAG_ALLOC(n, double)))
    {
      Vprintf("Allocation failure\n");
      exit_status = -1;
      goto END;
    }

  for (i=1; i<=n; i++)
    Vscanf("%lf", &x[i-1]);

  for (i=1; i<=n; i++)
    Vscanf("%lf", &y[i-1]);

  Vprintf("\n%s\n\n", "Sign test");
  Vprintf("%s\n\n", "Data values");
  for (i=1; i<=n; i++)
    Vprintf("%3.0f%s", x[i-1], i%n?"":"\n");
  Vprintf("\n");

  for (i=1; i<=n; i++)
    Vprintf("%3.0f%s", y[i-1], i%n?"":"\n");
  Vprintf("\n");

  g08aac(n, x, y, &s, &p, &non_tied, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from g08aac.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }

  Vprintf("%s%5ld\n", "Test statistic   ", s);
  Vprintf("%s%5ld\n", "Observations     ", non_tied);
  Vprintf("%s%5.3f\n", "Lower tail prob. ", p);
 END:
  if (x) NAG_FREE(x);
  if (y) NAG_FREE(y);
  return exit_status;
}
```

8.2 Program Data

```
g08aac Example Program Data
 4 4 5 5 3 2 5 3 1 5 5 5 4 5 5 5 5
 2 3 3 3 3 3 3 3 2 3 2 2 5 2 5 3 1
```

8.3 Program Results

```
g08aac Example Program Results

Sign test

Data values

  4   4   5   5   3   2   5   3   1   5   5   5   4   5   5   5   5

  2   3   3   3   3   3   3   3   2   3   2   2   5   2   5   3   1

Test statistic       3
Observations        14
Lower tail prob. 0.029
```