NAG Library Function Document  

nag_summary_stats_onevar (g01atc)

1 Purpose

nag_summary_stats_onevar (g01atc) calculates the mean, standard deviation, coefficients of skewness and kurtosis, and the maximum and minimum values for a set of (optionally weighted) data. The input data can be split into arbitrary sized blocks, allowing large datasets to be summarised.

2 Specification

```c
#include <nag.h>
#include <nagg01.h>

void nag_summary_stats_onevar (Integer nb, const double x[],
                              const double wt[], Integer *pn, double *xmean, double *xsd,
                              double *xskew, double *xkurt, double *xmin, double *xmax,
                              double rcomm[], NagError *fail)
```

3 Description

Given a sample of \( n \) observations, denoted by \( x = \{x_i : i = 1, 2, \ldots, n\} \) and a set of non-negative weights, \( w = \{w_i : i = 1, 2, \ldots, n\} \), nag_summary_stats_onevar (g01atc) calculates a number of quantities:

(a) Mean

\[
\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{W}, \quad \text{where} \quad W = \sum_{i=1}^{n} w_i.
\]

(b) Standard deviation

\[
s_2 = \sqrt{\frac{\sum_{i=1}^{n} w_i (x_i - \bar{x})^2}{d}}, \quad \text{where} \quad d = W - \frac{\sum_{i=1}^{n} w_i^2}{W}.
\]

(c) Coefficient of skewness

\[
s_3 = \frac{\sum_{i=1}^{n} w_i (x_i - \bar{x})^3}{ds_2^3}.
\]

(d) Coefficient of kurtosis

\[
s_4 = \frac{\sum_{i=1}^{n} w_i (x_i - \bar{x})^4}{ds_2^4} - 3.
\]

(e) Maximum and minimum elements, with \( w_i \neq 0 \).

These quantities are calculated using the one pass algorithm of West (1979).

For large datasets, or where all the data is not available at the same time, \( x \) and \( w \) can be split into arbitrary sized blocks and nag_summary_stats_onevar (g01atc) called multiple times.
4 References

5 Arguments
1: nb – Integer
   Input
   On entry: $b$, the number of observations in the current block of data. The size of the block of data
   supplied in $x$ and $wt$ can vary; therefore $nb$ can change between calls to
   nag_summary_stats_onevar (g01atc).
   Constraint: $nb \geq 0$.

2: x[nb] – const double
   Input
   On entry: the current block of observations, corresponding to $x_i$, for $i = k + 1, \ldots, k + b$, where $k$
   is the number of observations processed so far and $b$ is the size of the current block of data.

3: wt[nb] – const double
   Input
   On entry: if $wt$ is not NULL, $wt$ must contain the user-supplied weights corresponding to
   the block of data supplied in $x$, that is $w_i$, for $i = k + 1, \ldots, k + b$.
   If $wt$ is NULL, $w_i = 1$ for all $i$.
   Constraint: $wt[i - 1] \geq 0$, for $i = 1, 2, \ldots, nb$.

4: pn – Integer*
   Input/Output
   On entry: the number of valid observations processed so far, that is the number of observations
   with $w_i > 0$, for $i = 1, 2, \ldots, k$. On the first call to nag_summary_stats_onevar (g01atc), or when
   starting to summarise a new dataset, $pn$ must be set to 0.
   If $pn \neq 0$, it must be the same value as returned by the last call to nag_summary_stats_onevar
   (g01atc).
   On exit: the updated number of valid observations processed, that is the number of observations
   with $w_i > 0$, for $i = 1, 2, \ldots, k + b$.
   Constraints:
   
   $pn \geq 0$;
   if $rcomm$ is NULL, $pn = 0$.

5: xmean – double*
   Output
   On exit: $\bar{x}$, the mean of the first $k + b$ observations.

6: xsd – double*
   Output
   On exit: $s_2$, the standard deviation of the first $k + b$ observations.

7: xskew – double*
   Output
   On exit: $s_3$, the coefficient of skewness for the first $k + b$ observations.

8: xkurt – double*
   Output
   On exit: $s_4$, the coefficient of kurtosis for the first $k + b$ observations.

9: xmin – double*
   Output
   On exit: the smallest value in the first $k + b$ observations.
10: xmax – double *  
   \textit{Output} 
   \textit{On exit:} the largest value in the first \(k + b\) observations.

   \textit{Communication Array} 
   \textit{On entry:} communication array, used to store information between calls to \texttt{nag_summary_stats_onevar} (g01atc). If \(pn = 0\), \texttt{rcomm} need not be initialized, otherwise it must be unchanged since the last call to this function.

   If \texttt{rcomm} is NULL, \texttt{rcomm} is not referenced and all the data must be supplied in one go.

   \textit{On exit:} the updated communication array. The first five elements of \texttt{rcomm} hold information that may be of interest with

\[
\begin{align*}
\text{rcomm}[0] &= \sum_{i=1}^{k+b} w_i \\
\text{rcomm}[1] &= \left( \sum_{i=1}^{k+b} w_i \right)^2 - \sum_{i=1}^{k+b} w_i^2 \\
\text{rcomm}[2] &= \sum_{i=1}^{k+b} w_i (x_i - \bar{x})^2 \\
\text{rcomm}[3] &= \sum_{i=1}^{k+b} w_i (x_i - \bar{x})^3 \\
\text{rcomm}[4] &= \sum_{i=1}^{k+b} w_i (x_i - \bar{x})^4
\end{align*}
\]

   the remaining elements of \texttt{rcomm} are used for workspace and so are undefined.

12: fail – NagError *  
   \textit{Input/Output} 
   The NAG error argument (see Section 3.6 in the Essential Introduction).

6 Error Indicators and Warnings

NE_ALLOC_FAIL
   Dynamic memory allocation failed.
   See Section 3.2.1.2 in the Essential Introduction for further information.

NE_BAD_PARAM
   On entry, argument \texttt{value} had an illegal value.

NE_CASES_ONE
   On exit we were unable to calculate \texttt{xsd}, \texttt{xskew} or \texttt{xkurt}. A value of 0 has been returned.

NE_CASES_ZERO
   On entry, the number of valid observations is zero.

NE_ILLEGAL_COMM
   \texttt{rcomm} has been corrupted between calls.

NE_INT
   On entry, \texttt{nb} = \texttt{value}.
   Constraint: \texttt{nb} \geq 0.
   On entry, \texttt{pn} = \texttt{value}.
   Constraint: if \texttt{rcomm} is NULL then \texttt{pn} = 0.
On entry, \(pn = \langle value\rangle\).
Constraint: \(pn \geq 0\).

**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 contact NAG for assistance.
An unexpected error has been triggered by this function. Please contact NAG.
See Section 3.6.6 in the Essential Introduction for further information.

**NE_NEG_WEIGHT**
On entry, \(wt[\langle value\rangle] = \langle value\rangle\).
Constraint: if \(wt\) is not NULL then \(wt[i - 1] \geq 0\), for \(i = 1, 2, \ldots, nb\).

**NE_NO_LICENCE**
Your licence key may have expired or may not have been installed correctly.
See Section 3.6.5 in the Essential Introduction for further information.

**NE_PREV_CALL**
On entry, \(pn = \langle value\rangle\).
On exit from previous call, \(pn = \langle value\rangle\).
Constraint: if \(pn > 0\), \(pn\) must be unchanged since previous call.

**NE_ZERO_VARIANCE**
On exit we were unable to calculate \(xskew\) or \(xkurt\). A value of 0 has been returned.

7 Accuracy
Not applicable.

8 Parallelism and Performance
\texttt{g01atc} is threaded by NAG for parallel execution in multithreaded implementations of the NAG Library.

Please consult the X06 Chapter Introduction for information on how to control and interrogate the OpenMP environment used within this function. Please also consult the Users’ Note for your implementation for any additional implementation-specific information.

9 Further Comments
Both \texttt{g01atc} and \texttt{g01auc} consolidate results from multiple summaries. Whereas the former can only be used to combine summaries calculated sequentially, the latter combines summaries calculated in an arbitrary order allowing, for example, summaries calculated on different processing units to be combined.

10 Example
This example summarises some simulated data. The data is supplied in three blocks, the first consisting of 21 observations, the second 51 observations and the last 28 observations.
10.1 Program Text

/* nag_summary_stats_onevar (g01atc) Example Program. */
/* Copyright 2014 Numerical Algorithms Group. */
/* Mark 24, 2013. */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg01.h>

int main(void)
{
  /* Integer scalar and array declarations */
  Integer b, i, ierr, iwt, nb, pn;
  Integer exit_status = 0;

  /* NAG structures and types */
  NagError fail;

  /* Double scalar and array declarations */
  double xkurt, xmax, xmean, xmin, xsd, xskew;
  double rcomm[20];
  double *wt = 0, *x = 0;

  /* Initialise the error structure */
  INIT_FAIL(fail);

  printf("nag_summary_stats_onevar (g01atc) Example Program Results\n\n");

  /* Skip heading in data file */
  #ifdef _WIN32
    scanf_s("%*[\n ] ");
  #else
    scanf("%*[\n ] ");
  #endif

  /* Initialise the number of valid observations processed so far */
  pn = 0;

  /* Loop over each block of data */
  for (b = 0;; )
  {
    /* Read in the number of observations in this block and a flag indicating
     whether weights have been supplied (iwt = 1) or not (iwt = 0) */
    #ifdef _WIN32
      ierr = scanf_s("%"NAG_IFMT"%"NAG_IFMT"", &nb, &iwt);
    #else
      ierr = scanf("%"NAG_IFMT"%"NAG_IFMT"", &nb, &iwt);
    #endif
    if (ierr == EOF || ierr < 2) break;
    #ifdef _WIN32
      scanf_s("%*[\n ] ");
    #else
      scanf("%*[\n ] ");
    #endif

    /* Keep a running total of the number of blocks of data */
    b++;

    /* Reallocation X to the required size */
    NAG_FREE(x);
    if (!x = NAG_ALLOC(nb, double))
    {
      printf("Allocation failure\n");
      exit_status = -1;
      goto END;
    }

    /* ... (remaining code) */
  }

  printf("End of program\n");
  return 0;
}

END:
/* Read in the data for this block */
if (iwt)
{
    /* Weights supplied, so reallocate WT to the required size */
    NAG_FREE(wt);
    if (!(wt = NAG_ALLOC(nb, double)))
    {
        printf("Allocation failure\n");
        exit_status = -2;
        goto END;
    }
    for (i = 0; i < nb; i++)
    {
        #ifdef _WIN32
            scanf_s("%lf%lf", &x[i], &wt[i]);
        #else
            scanf("%lf%lf", &x[i], &wt[i]);
        #endif
    }
    #ifdef _WIN32
        scanf_s("%*[^\n] ");
    #else
        scanf("%*[^\n] ");
    #endif
    /* Call nag_summary_stats_onevar (g01atc) to update the summaries for
    this block of data */
    nag_summary_stats_onevar(nb, x, wt, &pn, &xmean, &xsd, &xskew, &xkurt,
        &xmin, &xmax, rcomm, &fail);
    if (fail.code != NE_NOERROR && fail.code != NE_CASES_ONE &&
        fail.code != NE_ZERO_VARIANCE && fail.code != NE_CASES_ZERO)
    {
        printf("Error from nag_summary_stats_onevar (g01atc).\n", fail.message);
        exit_status = 1;
        goto END;
    }
}
else
{
    /* No weights */
    NAG_FREE(wt);
    wt = 0;
    for (i = 0; i < nb; i++)
    {
        #ifdef _WIN32
            scanf("%lf", &x[i]);
        #else
            scanf("%lf", &x[i]);
        #endif
    }
    #ifdef _WIN32
        scanf("%*[^\n] ");
    #else
        scanf("%*[^\n] ");
    #endif
    /* Display the results */
    printf(" Data supplied in %"NAG_IFMT" blocks\n", b);
    if (fail.code == NE_CASES_ZERO)
    {
        printf(" No valid observations supplied. All weights are zero.\n");
    }
    else
    {
        printf(" %"NAG_IFMT" valid observations\n", pn);
        printf(" Mean %13.2f\n", xmean);
        if (fail.code == NE_CASES_ONE)
        {
            printf(" Unable to calculate the standard deviation,"\n");
            printf(" skewness or kurtosis\n");
        }
        else
        {
            printf(" Std devn %13.2f\n", xsd);
            if (fail.code == NE_ZERO_VARIANCE)
                printf(" Unable to calculate the skewness and kurtosis\n");
            else
                printf("\n");
        }
    }
}
{ printf(" Skewness %13.2f\n", xskew);
 printf(" Kurtosis %13.2f\n", xkurt);
}
printf(" Minimum %13.2f\n", xmin);
printf(" Maximum %13.2f\n", xmax);
}
END:
NAG_FREE(x);
NAG_FREE(wt);
return(exit_status);

10.2 Program Data

nag_summary_stats_onevar (g01atc) Example Program Data

```c
21 1 :: nb,iwt (1st block)
  -0.62 4.91 -1.92 0.25
  -1.72 3.90 -6.35 3.75
  2.00 1.17  7.65 3.19
  6.15 2.66  3.81 0.02
  4.87 3.59 -0.51 3.63
  6.88 4.83 -5.85 3.72
 -0.72 1.72  0.66 0.78
  2.23 4.74 -1.61 1.72
 -0.15 3.94 -1.15 1.33
 -8.74 0.51 -3.94 2.40
  3.61 3.90 :: End of x,wt for 1st block
 51 0 :: n,iwt (2nd block)
 -0.66 -2.39 -6.25 1.23  2.27 -2.27
 10.12 8.29 -2.99  8.71 -0.74  0.02
  1.22 1.70  4.30  2.99 -0.83 -1.00
  6.57 2.32 -3.47 -1.41 -5.26  0.53
  1.80 4.79 -3.04  1.20 -3.21 -3.75
  0.86 1.27 -5.95 -5.27  1.63  3.59
 -0.01 -1.38 -4.71 -4.82  3.55  0.46
  2.57 1.76 -4.05  1.23 -1.99  3.20
 -0.65  8.42 -6.01 :: End of x for 2nd block
 28 0 :: n,iwt (3rd block)
  1.13 -8.86  5.92 -1.71 -3.99  6.57
 -2.01 -2.29 -1.11  7.14  4.84 -4.44
 -3.32 10.25 -2.11  8.02 -7.31  2.80
 -1.20  1.01  1.37 -2.28  1.28 -3.95
  3.43 -0.61  4.85 -0.11 :: End of x for 3rd block
```

10.3 Program Results

nag_summary_stats_onevar (g01atc) Example Program Results

```
Data supplied in 3 blocks
100 valid observations
Mean 0.51
Std devn 4.24
Skewness 0.18
Kurtosis -0.59
Minimum -8.86
Maximum 10.25
```