

nag_arma_time_series (g05hac)

1. Purpose

nag_arma_time_series (g05hac) generates an autoregressive moving average (ARMA) time series with normally distributed errors (or residuals). It initialises the series to a stationary position and sets up a reference vector enabling the function to be called repeatedly, adding terms to the previous series at each call.

2. Specification

```
#include <nag.h>
#include <nagg05.h>

void nag_arma_time_series(Boolean start, Integer p, Integer q,
                          double phi[], double theta[], double mean, double vara,
                          Integer n, double w[], double ref[], NagError *fail)
```

3. Description

An ARMA model, denoted by $\text{ARMA}(p, q)$, is a mixture of an autoregressive process of order p (AR) and a moving average (MA) process of order q and can be written as

$$(x_n - \mu) = \phi_1(x_{n-1} - \mu) + \dots + \phi_p(x_{n-p} - \mu) + a_n - \theta_1 a_{n-1} \dots - \theta_q a_{n-q}$$

where x_n are the realization of the series, μ is the mean of the series and a_n are the errors (or residuals, also often called the white noise) which are independently distributed as normal with mean zero and variance σ^2 . The parameters ϕ_i are the autoregressive parameters and the parameters θ_i are the moving average parameters.

The function sets up initial values corresponding to a stationary position using the method described by Tunnicliffe-Wilson (1979). It generates n terms of the time series by first calculating the next term in the autoregressive series and then applying the moving-average summation and storing the result.

4. Parameters

start

Input: **start** must be **TRUE** if a new series is to begin, if **start** is **FALSE** a previously generated series will be continued. If **start** is **FALSE** then the scalar parameters **p**, **q**, **mean** and **vara** and the contents of the array parameters, **phi** and **theta** must not be changed.

p

Input: the number of autoregressive coefficients supplied.
Constraint: $p \geq 0$.

q

Input: the number of moving-average coefficients supplied.
Constraint: $q \geq 0$.

phi[p]

Input: the autoregressive coefficients of the model, if any, **phi**[$i - 1$] must contain ϕ_i for $i = 1, 2, \dots, p$.

theta[q]

Input: the moving-average coefficients of the model, if any, **theta**[$i - 1$] must contain θ_i for $i = 1, 2, \dots, q$.

mean

Input: the mean of the time series.

vara

Input: the variance of the errors, σ^2 .
Constraint: **vara** > 0.0.

- n**
Input: the number of observations to be generated.
Constraint: $n \geq 1$.
- w[n]**
Output: the realization of the time series.
- ref [5*MAX(p,q)+7]**
Output: the reference vector and the recent history of the series.
- fail**
The NAG error parameter, see the Essential Introduction to the NAG C Library.

5. Error Indications and Warnings

NE_INT_ARG_LT

- On entry, **p** must not be less than 0: **p** = *<value>*.
- On entry, **q** must not be less than 0: **q** = *<value>*.
- On entry, **n** must not be less than 1: **n** = *<value>*.

NE_REAL_ARG_LE

- On entry, **vara** must not be less than or equal to 0.0: **vara** = *<value>*.

NE_STATIONARITY

- The input series does not constitute a stationary time-series model.

NE_START_P_Q

- The function has been called either with **start** = **FALSE** the first time or at least one of **p** or **q** has been changed in a subsequent call with **start** = **FALSE**.

NE_REF_VEC

- The reference vector set up by the previous call of this function has become corrupt.

6. Further Comments

None.

6.1. References

- Knuth D E (1981) *The Art of Computer Programming (Vol 2)*. (2nd Edn) Addison-Wesley.
- Tunncliffe Wilson G (1979) Some Efficient Computational Procedures for High Order ARMA Models. *J. Stat. Comput. Simul.* **8** 301–309.

7. See Also

None.

8. Example

The program below shows two calls of nag_arma_time_series. In the first call an ARMA series is generated. In the second call terms are added to the already existing series.

8.1. Program Text

```
/* nag_arma_time_series(g05hac) Example Program
 *
 * Copyright 1994 Numerical Algorithms Group.
 *
 * Mark 3, 1994.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagg05.h>
```

```
#define NA 3
#define NB 2
#define NR 20
#define NW 10

main()
{
  Integer i, ip, iq, n;
  double phi[NA], theta[NB], w[NW];
  double mean, vara;
  double ref[NR];
  Boolean start;
  Integer seed = 0;

  Vprintf("g05hac Example Program Results\n\n");

  g05cbc(seed);
  ip = 2;
  iq = 0;
  n = NW;
  phi[0] = 0.4;
  phi[1] = 0.2;
  mean = 0.0;
  vara = 2.0;

  /* Generate an ARMA series with 5 terms */
  start = TRUE;
  g05hac(start, ip, iq, phi, theta, mean, vara, (Integer)5, w, ref,
        NAGERR_DEFAULT);

  /* Add further 5 terms to the previous series*/
  start = FALSE;
  g05hac(start, ip, iq, phi, theta, mean, vara, (Integer)5, &w[5], ref,
        NAGERR_DEFAULT);
  for (i = 0; i < n; ++i)
    Vprintf("%12.4f \n", w[i]);
  exit(EXIT_SUCCESS);
}
```

8.2. Program Data

None.

8.3. Program Results

g05hac Example Program Results

```
3.4060
1.6952
3.5042
1.1311
0.0640
0.5834
0.5352
-1.7206
-0.4964
1.6448
```
