Code_Aster

Titre : Opérateur GENE_FONC_ALEA
Responsable : ZENTNER Irmela

Version default

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Operator GENE_FONC_ALEA

1 Goal

To generate a trajectory of a multivariate process stochastic monodimensional (i.e with several components and indexed on only one variable), stationary, of worthless average starting from its matrix of spectral concentration (matrix interspectrale). The trajectories of the stochastic process are temporal functions which make it possible to carry out a transitory dynamic calculation then.

The trajectories obtained have a matrix interspectrale which converges on average towards the matrix interspectrale target and are the achievements of a process asymptotically Gaussian (i.e when the number of pullings tends towards the infinite one). The algorithm used is an algorithm of simulation per trigonometrical series with phase random and transformed of opposite fast Fourier.

The produced temporal functions are deposited in a structure of data interspectre . Each function is located by its sequence number. It can be extracted by using the operator RECU_FONCTION [U4.32.03].

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2 Syntax

```
vf [interspectre] = GENE_FONC_ALEA

        (  ♦  INTE_SPEC       =  intf          [interspectre]

           ◊  NUME_VITE_FLUI  =  nk            [I]

                  # Case with authorized interpolation:
           ◊  /  ◊  Interpol      =  'YES'  ,      [DEFECT]
                  ◊  DUREE_TIRAGE =  duration      [R]
                  ◊  FREQ_INIT    =  fi            [R]
                  ◊  FREQ_FIN     =  FF            [R]

                  # Case with interpolation not - authorized:
              /  ◊  INTERPOL      =  'NOT'  ,

           ◊  NB_POIN         =  nb_poin       [I]

           ◊  NB_TIRAGE       =  /  NT         [I]
                                 /  1          [DEFECT]

           ◊  INIT_ALEA       =  nor           [I]

           ◊  INFORMATION        =  /  1              [DEFECT]
                                    /  2

           ◊  TITLE           =  title         [l_Kn]

        )   ;
```

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3 Operands

3.1 Operand INTE_SPEC

♦ INTE_SPEC = intf   [interspectre]

Name of the matrix interspectrale towards which the matrix interspectrale of the generated signals must tend.

The matrix interspectrale is a complex matrix, whose each term is written $S_{XY}(f) = \int_{-\infty}^{+\infty} E[X(t)Y(t-\tau)]e^{-2i\pi f\tau}d\tau$ where $E[\cdot]$ is the expectation, and where X and Y are two stationary random processes (for example two components of a loading in two points distinct from a grid).

Note:

| *To be physical, the matrix interspectrale must be a definite-positive square matrix.*

This matrix interspectrale is generated mainly by the operators:

DEFI_INTE_SPEC, LIRE_INTE_SPEC and CALC_INTE_SPEC.

For further information on the direction of the parameters, the reader is invited to consult the documentation of the order DEFI_INTE_SPEC [U4.36.02].

3.2 Operand NUME_VITE_FLUI

◊ NUME_VITE_FLUI = nk   [I]

This sequence number corresponds at a rate of flow if the interspectres model, via the operators CALC_FLUI_STRU and DEFI_SPEC_TURB, a turbulent excitation induced by a fluid flow.

3.3 Operand Interpol

◊ Interpol =

                    / 'YES'   [DEFECT]

One authorizes to interpolate the functions in frequency constituting the terms of the matrix interspectrale. In particular, the new discretization will depend on the duration of the signal to generate (keyword DUREE_TIRAGE) and amongst points of the FFT (keyword NB_POIN).

                    / 'NOT'

The values of the interspectre used are only the existing values (not interpolation used).

Caution:

| *If INTERPOL=' NON' , it is necessary that:*
| • *the various terms of the matrix interspectrale have exactly the same discretization and with a constant step in frequency. If the number of points of discretization of the interspectre is not a power of 2, and/or is not compatible with the interspectre one or of alarms are emitted and a power of 2 ad hoc is chosen,*

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- *the interspectres are sufficiently finely discretized to allow a generation of temporal with sufficient moments.*

3.4 Operand DUREE_TIRAGE

◊ DUREE_TIRAGE = duration   [R]

Lasted of the signal to generate, for each pulling (the total duration will be thus $NT \times$ duration).

If the keyword DUREE_TIRAGE is not present, the duration of the signal to be generated is calculated by durée $= \frac{1}{\Delta f}$ where Δf is the step in frequency of the interspectre (not minimum of origin of the interspectre, or not calculated starting from the keywords FREQ_INIT, FREQ_FIN and NB_POIN).

Note:

The generated signals start at moment 0. with a zero value.

Note:

To obtain the desired duration, the algorithm of generation adjusts the number of points used in the FFT (cf [§3.6] Operand NB_POIN) and the interspectre beyond the frequencies min and max by zero values prolongs if need be.

3.5 Operands FREQ_INIT / FREQ_FIN

◊ FREQ_INIT = fi   [R]
◊ FREQ_FIN = FF   [R]

First and last values of frequency for which the interspectre will be taken into account.

The presence of these keywords causes to truncate the interspectre. If the keywords are not present, in fact the values of minimal and maximum frequency of the interspectre are used.

3.6 Operand NB_POIN

◊ NB_POIN = nb_poin   [I]

Many points of discretization of the interspectre to be used in the algorithm of generation.

This number must be a power of 2 because it corresponds to the number of points of the fast transform of Fourier reverses used by the algorithm of generation. If such is not the case, it is the power of 2 immediately above than nb_poin who is retained.

If the keyword NB_POIN is not present, the number of points is calculated so that the theorem of Shannon is respected, i.e. that $\frac{1}{\Delta t} > 2 \cdot f_{max}$, where Δt is the step in time of the signal to generate (which depends on NB_POIN and of DUREE_TIRAGE) and where f_{max} is the maximum frequency selected of the interspectre.

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Suggestion:

It is advised not to specify the number of points, the coded algorithm choosing in this case automatically the optimal value. In particular, if the keyword DUREE_TIRAGE and NB_POIN are not present, then one is assured that the generated signal is coherent at the same time with the step of discretization of the interspectre and with the maximum frequency. However, if the user wants to specify NB_POIN, the two remarks which follow must help there.

Note:

If the keyword DUREE_TIRAGE and NB_POIN are present then one a: $\Delta t = \frac{1}{2} \times \frac{\text{durée}}{\text{nb\_poin}}$ In this case, if nb_poin is too small compared to duration so that the theorem of Shannon is respected; then an alarm is emitted and it is the minimum number of points allowing the respect of the theorem of Shannon which is retained. The value specified by NB_POIN is thus taken into account only when it is higher than the value minimum. By imposing a number of points raised, one can force the signal to have a step of discretization in time smaller than that by default. It is necessary then to be conscious that the discretization of temporal is finer than the maximum frequency of the interspectre allows it theoretically.

Note:

If INTERPOL=' NON' and if nb_poin is not compatible with the interspectre, an alarm is emitted and a power of 2 ad hoc is selected.

Note:

The number of points constituting the generated signals is equal to twice the number of points of discretization of the interspectre, and thus to twice nb_poin when the keyword is indicated. This number of points is useful to know for a posterior use in CALC_INTE_SPEC [U4.36.03] (cf [§ 3.9] " Operand INFORMATION "and [§ 6] " Examples ").

3.7 Operand NB_TIRAGE

◊ NB_TIRAGE = NT   [I]

Many pullings which must contain the generated temporal signals. The signals results will contain NT end to end put statistically independent pullings.

One can then post-treat the results got starting from these signals generated with the operator CALC_INTE_SPEC [U4.36.03], cf [§6] "Examples".

Caution:

If the keyword DUREE_TIRAGE is present, the total duration of signal will be NT $\times$ duration. However, it is not of course equivalent to generate 1 pulling of duration NT $\times$ durée_tirage and NT pullings of duration durée_tirage put end to end. There is statistical independence between the various sections of duration D in the second case and not in the first.

3.8 Operand INIT_ALEA

◊ INIT_ALEA = nor   [I]

Cause initialization with sound nor**ième** term of the continuation of pseudo-random numbers employed for the generation of the signals.

If the keyword INIT_ALEA is absent, the terms used of the continuation are those immediately consecutive with those already used. If no term were still used, the continuation is initialized in its first term.

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Suggestion:

With less than one particular use, it is advised not to inform the keyword INIT_ALEA *in the following operators:* GENE_FONC_ALEA, GENE_VARI_ALEA *and* GENE_MATR_ALEA. *In this case, with the first call to the one of these operators, the continuation of pseudo-random numbers is initialized in its first term. The omission of the keyword* INIT_ALEA *to each call of these operators in the command file the statistical independence of the pseudo-random numbers used guarantees.*

Note:

The germ of the continuation remains identical of one execution to the other of Code_Aster; the results thus remain rigorously identical (one can thus test to it not regression of not converged statistical results). If one wishes to generate results statistically independent from one execution to another, then the keyword should be used INIT_ALEA *with values raising the number of terms used in the former executions.*

Caution:

The generator of random variable used is that of the module "random" of Python. It depends on the version of Python exploited by Code_Aster. Not statistically converged results can thus vary from one version to another of Code_Aster or platform to another, if the version of Python is not the same one and that between the two versions the module random evolved (case between Python 2.1 and 2.3).

Note:

In version Python 2.3, the period of the generator is of 2 ** 19937-1.

3.9   Operand INFORMATION

◊   INFORMATION =

/   1:   pas d' impression.

/   2:   impression of the step of time, initial time, the final time of the generated signals, and

amongst points used in the transform of fast Fourier opposite.

Note:

INFO=2 allows to know the number of points constituting the generated signals (it is twice the number of points used in the fast transform of Fourier reverses.) It is to better use this number of points then in the operator CALC_INTE_SPEC *keyword* NB_POIN *(cf [§ 6] " Examples ").*

3.10 Operand TITLE

◊   TITLE = title

title is the title of calculation to be printed at the top of the results [U4.03.01].

4   Phase of checking

Various checks are carried out to ensure that the data are coherent (nb_poin sufficient large compared to the maximum frequency and the duration to be generated, lasted sufficiently large compared to the discretization of the interspectre, etc…). Alarms are emitted if necessary.

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If the keyword NB_POIN is present, then one checks that the value given is a power of 2. In the contrary case, an alarm is emitted and the value is modified.
If INTERPOL=' NON', it is checked that the various terms of the matrix interspectrale have the same discretization with a constant step in frequency.

5   Produced concept

The produced temporal functions are deposited in a structure of data interspectre. Each function is located by its sequence number. It can be extracted by using the operator RECU_FONCTION [U4.32.03].

6   Examples

```
The purpose of # This example is only to give an idea of syntax and
# of the operators associated useful (for recovery with the functions
# generated and their possible checking).
# the interspectre used does not have meaning. There is not
# of use of the functions generated (with a dyna_tran_modal by
# example).
# the cases test zzzz180a and sdll107a provide more complete examples

# Definition of the interspectre
spect11 = DEFI_FONCTION (
                    NOM_PARA = 'FREQ',
                    VALE_C =  (
                                0.    ,  10.,  0. ,
                                50.0  ,  10.,  0. ,
                                150.  ,  0.1,  0. ,
                            )
                    )

spect12 = DEFI_FONCTION (
                    NOM_PARA = 'FREQ',
                    VALE_C =  (
                                0.    ,  0.5,  0.8,
                                150.  ,  0.5,  0.8,
                            )
                    )

spect22 = DEFI_FONCTION (
                    NOM_PARA = 'FREQ'
                    VALE_C =  (
                                0.    ,  1. ,  0. ,
                                150.  ,  1. ,  0. ,
                            )
                    )

mat_int = DEFI_INTE_SPEC (
                    DIMENSION = 2,
                    PAR_FONCTION =   ( _F (  NUME_ORDRE_I = 1,
                                        NUME_ORDRE_J = 1,
                                        FUNCTION = sp11),
                                    _F (  NUME_ORDRE_I = 1,
                                        NUME_ORDRE_J = 2,
                                        FUNCTION = sp12),
                                    _F (  NUME_ORDRE_I = 2,
```

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```
                                                    NUME_ORDRE_J = 2,
                                                    FUNCTION = sp22)
                                )
                    )

    # Generation of the two temporal functions via the structure of data
    # interspectre
    vect = GENE_FONC_ALEA (INTE_SPEC =  mat_int,
                           DUREE_TIRAGE =  5. ,
                           NB_TIRAGE =  10,
                           )

    # Recovery of the two functions for example for a IMPR_FONCTION
    FONC1 = RECU_FONCTION (INTE_SPEC = vect,
                           NUME_ORDRE = 1)

    FONC2 = RECU_FONCTION (INTE_SPEC = VECT1,
                           NUME_ORDRE = 2)

    # Checking: Calculation of the interspectre of the generated functions
    # Attention: the value given to NB_POIN is important. It is
    # desirable to take it equalizes with the constituent number of points
    # the functions (2*nb_fft if coming from GENE_FONC_ALEA).
    INTERS=CALC_INTE_SPEC (INST_INIT=0.,
                           INST_FIN=50.,
                           DUREE_ANALYSE=5.,
                           DUREE_DECALAGE=5.,
                           NB_POIN=2048,
                           FONCTION= (FONC1,  FONC2,))

    # Recovery of the auto--spectrum of FONC1 for comparison with spetc11
    F11  =RECU_FONCTION (INTE_SPEC=INTERS,
                         NUME_ORDRE_I=1,
                         )
```