Code_Aster

Version default

Titre : Opérateur PROJ_MESU_MODAL
Responsable : ANDRIAMBOLOLONA Harinaivo

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Operator `PROJ_MESU_MODAL`

1   Goal

To extrapolate experimental measurements on a digital model in dynamics.

The experimental data can be displacements, speeds, accelerations, strains or stresses. They are defined as a function of time or the frequency, or in the form of list.

It is a question of calculating the generalized coordinates of measurement relative to a base of expansion defined on the digital model. This base of expansion (deformed, forced or deformations) is calculated as a preliminary according to a concept of the type `mode_meca`. The basic vectors are then restricted with the measured degrees of freedom. Space association between the points of measurement and the nodes of the digital grid can be carried out manually ou/et automatically. The calculation of the generalized coordinates is carried out by resolution of a problem of minimization of the least type squares, possibly regularized according to the method of Tikhonov.

Is applicable to any type of model (1D, 2D and 3D).

Product a structure of data of the type `tran_gene`, `harm_gene` or `mode_gene`.

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2   Syntax

```
repgene [*_gene] = PROJ_MESU_MODAL
    (  ♦   MODELE_CALCUL=
            _F (   ♦   BASE   = bases
            [mode_meca]
                   ♦  MODEL  = mocalc                          [model]
                   ),
       ♦    MODELE_MESURE =
            _F (   ♦   MEASUREMENT  = measurement               /
            [dyna_trans]
                                                        /      [dyna_harmo]
                                                        /      [mode_meca]
                                                        /      [mode_meca_c]

                   ♦   MODEL  = mostru                          [model]
                   ◊   NOM_CHAM = |  'DEPL'                     [DEFECT]
                                  |  'QUICKLY'
                                  |  'ACCE'
                                  |  'SIEF_NOEU'
                                  |  'EPSI_NOEU'
                   ),
       ◊   NOM_PARA  =  will lpara                             [l_Kn]
       ◊   CORR_MANU =
            _F (   ♦  NOEU_MESURE  = no1                       [node]
                   ♦  NOEU_CALCUL  = no2                       [node]
                   ),
       ◊   RESOLUTION   =
            _F (   ◊  METHOD =  /  'LU'                        [DEFECT]
                               /  'SVD'
                   If METHOD = 'SVD'  then:
                                  ◊   EPS = /  0.              [DEFECT]
                                            /  eps             [R]
                   ◊  REGUL  =  /  'NOT'                       [DEFECT]
                               /  'NORM_MIN'
                               /  'TIK_RELA'
                   If REGUL! = 'NOT'  then :
                                  ◊  /  COEF_PONDER  =  /  0. [DEFECT]
                                                       /  W   [l_R]
                                     /  COEF_PONDER_F=  w_f   [l_fonction]
                   ),
    )



        If measurement = [dyna_trans]    then repgene = [tran_gene]
        If measurement = [dyna_harmo]    then repgene = [harm_gene]
        If measurement = [mode_meca]     then repgene = [mode_gene]
        If measurement = [mode_meca_c]   then repgene = [mode_gene]
```

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3 Operands

3.1 Keyword factor MODELE_CALCUL

This keyword factor gathers the characteristics of the digital model on which one wants to extrapolate measurement. It should appear only once.

3.1.1 Operand MODEL

♦ MODEL = mocalc

Name of the digital model on which the base of expansion is built.

3.1.2 Operand BASE

♦ BASE = bases

Name of the base of expansion. This base is of type mode_meca. This concept was possibly enriched, via the order CALC_CHAMP, by the fields of strains and/or modal stresses calculated with the nodes.

3.2 Keyword factor MODELE_MESURE

This keyword factor gathers information on the measured field (observed) that one wishes to extrapolate on the digital model. It should appear only once.

3.2.1 Operand MODEL

♦ MODEL = mostru

Name of the model associated with the observation.

3.2.2 Operand MEASUREMENT

♦ MEASUREMENT = measurement

Name of the measured field.

This keyword determines the type of concept produced by the operator PROJ_MESU_MODAL. If measurement is of type dyna_trans, the produced concept is of type tran_gene. If measurement is of type dyna_harmo, the produced concept is of type harm_gene. If measurement is of type mode_meca, or mode_meca_c, the produced concept is of type mode_gene.

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3.2.3 Operand NOM_CHAM

◊   NOM_CHAM = | 'DEPL'   [DEFECT]
                 | 'QUICKLY'
                 | 'ACCE'
                 | 'SIEF_NOEU'
                 | 'EPSI_NOEU'

This keyword makes it possible to choose the fields to be read and extrapolate. The components of the field considered are those which were measured (observed) and were read in measurement. For the moment, one does not affect a weighting coefficient on the various components of the field: each component has the same weight during the inversion.

3.3   Operand NOM_PARA

◊   NOM_PARA =   will lpara

List of the reference symbols of the parameters of the measured data which one wishes to transmit to the generalized model.

3.4   Keyword factor CORR_MANU

This keyword factor makes it possible to the user to manually define (to overload) the correspondence between the node of observation and the similar node of the digital model. This keyword factor is optional, but it can appear as many times as necessary. On the other hand, the operands under this keyword factor go per pair: one NOEU_MESURE must have sound NOEU_CALCUL associated.
If this keyword factor is absent, space association between the points of measurement and the nodes of the digital grid is carried out automatically by using the function of form of the element of the digital model to determine the value of the field on the point of measurement.

3.4.1   Operand NOEU_MESURE

♦   NOEU_MESURE = no1

This keyword informs the name of the node of observation which one wishes to associate with the node of the digital model no2. In certain cases, the file of grid associated with measurement is with the universal format (Ideas format), one cannot thus know a priori the name Aster associated with the node. It is thus necessary, in this case, of reading the grid resulting from PRE_IDEAS, by LIRE_MAILLAGE in order to be able to name of the node.

3.4.2   Operand NOEU_CALCUL

♦   NOEU_CALCUL = no2

This keyword informs the name of the node of the digital model which one wishes to associate with the node observation no1.

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3.5 Keyword factor RESOLUTION

One defines here the method of resolution to be used and the parameters associated with this method.

3.5.1 Operand METHOD

◊   METHOD =   / 'LU'
               / 'SVD'

One proposes the method LU (decomposition as a LU Lower-Upper) and method SVD (decomposition in singular values) for calculation of the opposite matrix. For the method SVD, the number of singular values to take into account depends on the value on eps that the user informs under the operand EPS. By default, one adopts the method LU.

3.5.2 Operand EPS

This keyword is used if method SVD is chosen.

◊   EPS =   / 0.
             / eps

This keyword gives the value from which a singular value is regarded as worthless. It determines the number of singular values thus to exploit at the time of the resolution. One eps equal to zero means that all the singular values are to be taken into account. eps equal to 1 means that one considers only the greatest singular value. By default, one chooses EPS = 0.

3.5.3 Operand REGUL

◊   REGUL =   / 'NOT'
               / 'NORME_MIN'
               / 'TIK_RELA'

REGUL allows to specify the method of regularization which one wants to use. By default, one does not add a regularization (not additional constraint on the solution: REGUL = 'NOT').
Currently, two types of regularization are available (minimal standard: REGUL = 'NORM_MIN' or Tikhonov of order 0 and "relative" Tikhonov: REGUL = 'TIK_RELA').
One seeks to minimize, for each sequence number of the measured field, the following functional calculus compared to η :

$$|q_{\exp} - \bar{\Phi}_{num} \eta|^2 + \alpha |\eta - \eta_{priori}|^2$$

with:

- η : generalized coordinates relating to the base of expansion $\bar{\Phi}_{num}$.
- $q_{\exp}$: measured field following the degrees of freedom of observation.
- $\bar{\Phi}_{num}$: base expansion restricted with the degrees of freedom of observation.
- α : weighting coefficients allowing to specify the affected weight with information a priori on the solution.

According to the method used, the parameters of the preceding functional calculus are declined as follows:
Without regularization: $\alpha = 0$
Minimal standard (NORM_MIN): $\eta_{priori} = 0$
"Relative" Tikhonov (TIK_RELA): η_{priori} : solution found with the preceding sequence number

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It is disadvised using this keyword when the measured field (measurement) is of mode_meca type.

3.5.4   Operands COEF_PONDER and COEF_PONDER_F

This keyword corresponds to the affected weight with information a priori, α . It is used if one applies a regularization to the solution η .

◊   /   COEF_PONDER   = coeff

List of the weighting coefficients on the solution a priori (method of regularization of Tikhonov) [bib3].

/   COEF_PONDER_F= coef_f

List of the weight functions on the solution a priori (method of regularization of Tikhonov). The variables of these functions are the same ones as those of the measured field (measurement). If the number of coefficients or weight functions given is lower than the number of basic vectors used in the base of expansion, the coefficients or weight functions of the additional vectors are taken equal to the last coefficient or the last function of the list.

4   Phase of checking and execution

4.1   Calculation of the base of expansion restricted with the measured degrees of freedom

Initially, the grid of measurement is project on the grid of the digital model. One determines then the participation of the nodes of the digital model for each node of measurement via the function of form of the element which contains the node of measurement. The correspondence obtained between the nodes is provided in the file MESSAGE study Aster.

The second treatment consists in calculating the component of the field (expansion bases) to the node of measurement according to the measured degrees of freedom.

4.2   Calculation of the generalized coordinates

The solution of the equation of minimization is given by:

$$\eta(0) \quad = \quad \left[\bar{\bar{\Phi}}_{num}^T \bar{\bar{\Phi}}_{num}\right]^{-1} \bar{\bar{\Phi}}_{num}^T q_{\exp}(0)$$

$$\eta(i) \quad = \quad \left[\bar{\bar{\Phi}}_{num}^T \bar{\bar{\Phi}}_{num} + \alpha(i)\right]^{-1} \left(\bar{\bar{\Phi}}_{num}^T q_{\exp}(i) + \alpha(i)\eta_{priori}\right)$$

With:

- $\eta(i)$: coordinates generalized for the sequence number I (T_I or F_I),
- $q_{\exp}(i)$: measurement with the sequence number I,
- $\bar{\bar{\Phi}}_{num}$: base expansion restricted with the degrees of freedom of measurement,
- $\alpha(i)$: coefficients allowing to specify the affected weight with information a priori with the sequence number I. These variables or functions are defined by the user in the operands COEF_PONDER or COEF_PONDER_F keyword factor RESOLUTION. They are introduced in the form of a list of realities or functions and correspond, term in the long term, with each vector of the base of expansion selected.

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According to the method used, the preceding parameters are declined as follows:

Without regularization: $\alpha = 0$

Minimal standard (NORM_MIN): $\eta_{priori} = 0$

"Relative" Tikhonov (TIK_RELA): $\eta_{priori} = \eta_{i-1}$

Notice 1:

If a weighting coefficient is negative, the treatment stops in fatal error.

Notice 2:

If all the weighting coefficients are worthless for a given sequence number and that the number of measurements is strictly lower than the number of basic vectors, a message of alarm is transmitted to prevent risk of singular matrix (indeed, in this case, there is not unicity of the solution).

At the conclusion of calculation, the identified generalized coordinates are derived in order to calculate corresponding speeds and accelerations.

The result of the inversion is a concept of the type tran_gene, harm_gene or mode_gene.

5   Example of use of PROJ_MESU_MODAL

For the examples of use, it is highly advised to refer to the cases tests SDLD104 and SDLV122.

One presents in this paragraph the various stages for the expansion of measurement on the digital model.

- Reading of the grid made up of the points of measurement:
  This operation aims to read the position of the points of measure to a file of type grid. The format of this file must be readable by *Code_Aster* (format GIBI, universal (I-deas) or soon MED). Meshs connecting the nodes of measurement can have been defined. They do not have obviously any physical meaning but will possibly make it possible to display the results at the time of the phase of postprocessing.
  In the majority of the cases, the grid is resulting from a code of experimental measurement which provides a file to the universal format (I-deas format). To transform it into format Aster, the operator is used PRE_IDEAS.

```
PRE_IDEAS (UNITE_IDEAS = 19, UNITE_MAILLAGE = 21,)
mailmesu = LIRE_MAILLAGE (UNIT = 21,)
```

- Assignment of a mechanical model to the grid:
  This operation aims to define the model of the support of the nodes of the grid made up of the points of measurement. Two cases can be considered: assignment of a modeling DIS_T (discrete in translation => 3 degrees of freedom per node: DX, DY and DZ) or assignment of a modeling DIS_TR (discrete in translation - rotation => 6 degrees of freedom per node: DX, DY, DZ, DRX, DRY MARTINI and DRZ) if measurements of rotation are carried out.

```
modlmesu = AFFE_MODELE (  GRID  = mailmesu,
                        AFFE = _F ( GROUP_NO  = 'noeumesu',
                               MODELING  = 'DIS_T',
                               PHENOMENON  = 'MECHANICAL',),
                        )
```

- Reading of measurement:
  Measurement can be read via the operator LIRE_RESU. This operator allows to read a file with the universal format (dataset 58). He recovers the component of the field observed and assigns it to the corresponding model.

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```
measurement = LIRE_RESU (  FORMAT = 'IDEAS_DS58',
                           UNIT = 33,
                           GRID = mailmesu,
                           TYPE_RESU = 'DYNA_TRANS',
                           NOM_CHAM = 'SIEF_NOEU',)
```

- Definition of the base of expansion:
  The base of expansion must be of the type mode_meca. This concept can result from CALC_MODES or of DEFI_BASE_MODALE.
  If one wants to extrapolate a field of strain or stress, the base must be enriched, via the order CALC_CHAMP, by the fields of strain or stress calculated with the nodes.

- Calculation of the generalized coordinates:
  The calculation of the generalized coordinates relating to the base of expansion is ensured by the operator PROJ_MESU_MODAL.

```
repgene = PROJ_MESU_MODAL  (
             MODELE_CALCUL   =  _F (  MODEL = modlcalc,
                     BASE = bases,),
             MODELE_MESURE   =  _F (  MODEL = modlmesu,
                     MEASUREMENT = measurement,
                     NOM_CHAM = 'SIEF_NOEU',),
             CORR_MANU       =  _F (  NOEU_MESURE = 'no1',
                     NOEU_CALCUL = 'no2',),
             RESOLUTION      =  _F (  METHOD = 'SVD',
                     EPS = 1.E-4,),
             )
```

- Expansion on the digital model:
  This expansion consists in calculating on all the nodes of the digital model, the field compatible with the field observed on the measured degrees of freedom. This expansion is carried out by the order REST_GENE_PHYS.

```
answer = REST_GENE_PHYS ( RESU_GENE = repgene,
                          TOUT_CHAM = 'YES',)
```

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