NAG Library Function Document

nag_dggbak (f08wjc)

1 Purpose

nag_dggbak (f08wjc) forms the right or left eigenvectors of the real generalized eigenvalue problem $Ax = \lambda Bx$, by backward transformation on the computed eigenvectors given by nag_dtgevc (f08ykc). It is necessary to call this function only if the optional balancing function nag_dggbal (f08whc) was previously called to balance the matrix pair (A, B).

2 Specification

```
#include <nag.h>
#include <nagf08.h>
void nag_dggbak (Nag_OrderType order, Nag_JobType job, Nag_SideType side,
     Integer n, Integer ilo, Integer ihi, const double lscale[],
     const double rscale[], Integer m, double v[], Integer pdv,
     NagError *fail)
```

3 Description

If the matrix pair has been previously balanced using the function nag_dggbal (f08whc) then nag_dggbak (f08wjc) backtransforms the eigenvector solution given by nag_dtgevc (f08ykc). This is usually the sixth and last step in the solution of the generalized eigenvalue problem.

For a description of balancing, see the document for nag_dggbal (f08whc).

4 References

Ward R C (1981) Balancing the generalized eigenvalue problem *SIAM J. Sci. Stat. Comp.* **2** 141–152

5 Arguments

1: **order** – Nag_OrderType *Input*

On entry: the **order** argument specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order** = Nag_RowMajor. See Section 3.2.1.3 in the Essential Introduction for a more detailed explanation of the use of this argument.

Constraint: **order** = Nag_RowMajor or Nag_ColMajor.

2: **job** – Nag_JobType *Input*

On entry: specifies the backward transformation step required.

job = Nag_DoNothing
No transformations are done.

job = Nag_Permute
Only do backward transformations based on permutations.

job = Nag_Scale
Only do backward transformations based on scaling.

job = Nag_DoBoth
Do backward transformations for both permutations and scaling.

Note: this must be the same argument **job** as supplied to nag_dggbal (f08whc).

Constraint: **job** = Nag_DoNothing, Nag_Permute, Nag_Scale or Nag_DoBoth.

3: **side** – Nag_SideType *Input*

On entry: indicates whether left or right eigenvectors are to be transformed.

side = Nag_LeftSide
The left eigenvectors are transformed.

side = Nag_RightSide
The right eigenvectors are transformed.

Constraint: **side** = Nag_LeftSide or Nag_RightSide.

4: **n** – Integer *Input*

On entry: n, the order of the matrices A and B of the generalized eigenvalue problem.

Constraint: $\mathbf{n} \geq 0$.

5: **ilo** – Integer *Input*
6: **ihi** – Integer *Input*

On entry: i_{lo} and i_{hi} as determined by a previous call to nag_dggbal (f08whc).

Constraints:

if $\mathbf{n} > 0$, $1 \leq \mathbf{ilo} \leq \mathbf{ihi} \leq \mathbf{n}$;
if $\mathbf{n} = 0$, $\mathbf{ilo} = 1$ and $\mathbf{ihi} = 0$.

7: **lscale**[dim] – const double *Input*

Note: the dimension, *dim*, of the array **lscale** must be at least $\max(1, \mathbf{n})$.

On entry: details of the permutations and scaling factors applied to the left side of the matrices A and B, as returned by a previous call to nag_dggbal (f08whc).

8: **rscale**[dim] – const double *Input*

Note: the dimension, *dim*, of the array **rscale** must be at least $\max(1, \mathbf{n})$.

On entry: details of the permutations and scaling factors applied to the right side of the matrices A and B, as returned by a previous call to nag_dggbal (f08whc).

9: **m** – Integer *Input*

On entry: m, the required number of left or right eigenvectors.

Constraint: $0 \leq \mathbf{m} \leq \mathbf{n}$.

10: **v**[dim] – double *Input/Output*

Note: the dimension, *dim*, of the array **v** must be at least

$\max(1, \mathbf{pdv} \times \mathbf{m})$ when **order** = Nag_ColMajor;
$\max(1, \mathbf{n} \times \mathbf{pdv})$ when **order** = Nag_RowMajor.

The (i, j)th element of the matrix V is stored in

$\mathbf{v}[(j-1) \times \mathbf{pdv} + i - 1]$ when **order** = Nag_ColMajor;
$\mathbf{v}[(i-1) \times \mathbf{pdv} + j - 1]$ when **order** = Nag_RowMajor.

On entry: the matrix of right or left eigenvectors, as returned by nag_dggbal (f08whc).

On exit: the transformed right or left eigenvectors.

11: **pdv** – Integer *Input*

On entry: the stride separating row or column elements (depending on the value of **order**) in the array **v**.

Constraints:

if **order** = Nag_ColMajor, **pdv** $\geq \max(1, \mathbf{n})$;
if **order** = Nag_RowMajor, **pdv** $\geq \max(1, \mathbf{m})$.

12: **fail** – NagError * *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 ⟨*value*⟩ had an illegal value.

NE_INT

On entry, **n** = ⟨*value*⟩.
Constraint: **n** ≥ 0.

On entry, **pdv** = ⟨*value*⟩.
Constraint: **pdv** > 0.

NE_INT_2

On entry, **m** = ⟨*value*⟩ and **n** = ⟨*value*⟩.
Constraint: $0 \leq \mathbf{m} \leq \mathbf{n}$.

On entry, **pdv** = ⟨*value*⟩ and **m** = ⟨*value*⟩.
Constraint: **pdv** $\geq \max(1, \mathbf{m})$.

On entry, **pdv** = ⟨*value*⟩ and **n** = ⟨*value*⟩.
Constraint: **pdv** $\geq \max(1, \mathbf{n})$.

NE_INT_3

On entry, **n** = ⟨*value*⟩, **ilo** = ⟨*value*⟩ and **ihi** = ⟨*value*⟩.
Constraint: if **n** > 0, $1 \leq$ **ilo** $\leq$ **ihi** $\leq$ **n**;
if **n** $= 0$, **ilo** $= 1$ and **ihi** $= 0$.

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_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.

7 Accuracy

The errors are negligible, compared with the previous computations.

8 Parallelism and Performance

nag_dggbak (f08wjc) is not threaded by NAG in any implementation.

nag_dggbak (f08wjc) makes calls to BLAS and/or LAPACK routines, which may be threaded within the vendor library used by this implementation. Consult the documentation for the vendor library for further information.

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

The number of operations is proportional to n^2.

The complex analogue of this function is nag_zggbak (f08wwc).

10 Example

See Section 10 in nag_dhgeqz (f08xec) and nag_dtgevc (f08ykc).