

NAG Toolbox for MATLAB

d06cc

1 Purpose

d06cc rennumbers the vertices of a given mesh using a Gibbs method, in order the reduce the bandwidth of Finite Element matrices associated with that mesh.

2 Syntax

```
[nnz, coor, edge, conn, irow, icol, ifail] = d06cc(nnzmax, coor, edge,
conn, itrace, 'nv', nv, 'nelt', nelt, 'nedge', nedge)
```

3 Description

d06cc uses a Gibbs method to renumber the vertices of a given mesh in order to reduce the bandwidth of the associated finite element matrix A . This matrix has elements a_{ij} such that:

$$a_{ij} \neq 0 \Rightarrow i \text{ and } j \text{ are vertices belonging to the same triangle.}$$

This function reduces the bandwidth m , which is the smallest integer such that $a_{ij} \neq 0$ whenever $|i - j| > m$ (see Gibbs *et al.* 1976 for details about that method). d06cc also returns the sparsity structure of the matrix associated with the renumbered mesh.

This function is derived from material in the MODULEF package from INRIA (Institut National de Recherche en Informatique et Automatique).

4 References

Gibbs N E, Poole W G Jr and Stockmeyer P K 1976 An algorithm for reducing the bandwidth and profile of a sparse matrix *SIAM J. Numer. Anal.* **13** 236–250

5 Parameters

5.1 Compulsory Input Parameters

1: **nnzmax** – int32 scalar

the maximum number of nonzero entries in the matrix based on the input mesh. It is the dimension of the arrays **irow** and **icol** as declared in the (sub)program from which d06cc is called.

Constraint: $4 \times \mathbf{nelt} + \mathbf{nv} \leq \mathbf{nnzmax} \leq \mathbf{nv}^2$.

2: **coor(2,nv)** – double array

coor(1,i) contains the x co-ordinate of the i th input mesh vertex, for $i = 1, \dots, \mathbf{nv}$; while **coor(2,i)** contains the corresponding y co-ordinate.

3: **edge(3,nedge)** – int32 array

The specification of the boundary or interface edges. **edge(1,j)** and **edge(2,j)** contain the vertex numbers of the two end points of the j th boundary edge. **edge(3,j)** is a user-supplied tag for the j th boundary or interface edge: **edge(3,j)** = 0 for an interior edge and has a nonzero tag otherwise.

Constraint: $1 \leq \mathbf{edge}(i,j) \leq \mathbf{nv}$ and $\mathbf{edge}(1,j) \neq \mathbf{edge}(2,j)$, for $i = 1, 2$ and $j = 1, 2, \dots, \mathbf{nedge}$.

4: **conn(3,nelt) – int32 array**

The connectivity of the mesh between triangles and vertices. For each triangle j , **conn**(i,j) gives the indices of its three vertices (in anticlockwise order), for $i = 1, 2, 3$ and $j = 1, \dots, \mathbf{nelt}$.

Constraint: $1 \leq \mathbf{conn}(i,j) \leq \mathbf{nv}$ and $\mathbf{conn}(1,j) \neq \mathbf{conn}(2,j)$ and $\mathbf{conn}(1,j) \neq \mathbf{conn}(3,j)$ and $\mathbf{conn}(2,j) \neq \mathbf{conn}(3,j)$, for $i = 1, 2, 3$ and $j = 1, 2, \dots, \mathbf{nelt}$.

5: **itrace – int32 scalar**

The level of trace information required from d06cc.

itrace ≤ 0

No output is generated.

itrace = 1

Information about the effect of the renumbering on the finite element matrix are output. This information includes the half bandwidth and the sparsity structure of this matrix before and after renumbering.

itrace > 1

The output is similar to that produced when **itrace** = 1 but the sparsities (for each row of the matrix, indices of nonzero entries) of the matrix before and after renumbering are also output.

5.2 Optional Input Parameters

1: **nv – int32 scalar**

Default: The dimension of the array **coor**.

the total number of vertices in the input mesh.

Constraint: $\mathbf{nv} \geq 3$.

2: **nelt – int32 scalar**

Default: The dimension of the array **conn**.

the number of triangles in the input mesh.

Constraint: $\mathbf{nelt} \leq 2 \times \mathbf{nv} - 1$.

3: **nedge – int32 scalar**

Default: The dimension of the array **edge**.

the number of the boundary edges in the input mesh.

Constraint: $\mathbf{nedge} \geq 1$.

5.3 Input Parameters Omitted from the MATLAB Interface

iwork, liwork, rwork, lrwork

5.4 Output Parameters

1: **nnz – int32 scalar**

The number of nonzero entries in the matrix based on the input mesh.

2: **coor(2,nv) – double array**

coor(1, i) will contain the x co-ordinate of the i th renumbered mesh vertex, for $i = 1, \dots, \mathbf{nv}$; while **coor**(2, i) will contain the corresponding y co-ordinate.

3: **edge(3,nedge) – int32 array**

The renumbered specification of the boundary or interface edges.

4: **conn(3,nelt) – int32 array**

The renumbered connectivity of the mesh between triangles and vertices.

5: **irow(nnzmax) – int32 array**

6: **icol(nnzmax) – int32 array**

The first **nnz** elements contain the row and column indices of the nonzero elements supplied in the finite element matrix *A*.

7: **ifail – int32 scalar**

0 unless the function detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

ifail = 1

On entry, **nv** < 3,
or **nelt** > 2 × **nv** – 1,
or **nedge** < 1,
or **nnzmax** < 4 × **nelt** + **nv** or **nnzmax** > **nv**²
or **conn**(*i,j*) < 1 or **conn**(*i,j*) > **nv** for some *i* = 1, 2, 3 and *j* = 1, ..., **nelt**,
or **conn**(1,*j*) = **conn**(2,*j*) or **conn**(1,*j*) = **conn**(3,*j*) or
conn(2,*j*) = **conn**(3,*j*) for some *j* = 1, ..., **nelt**,
or **edge**(*i,j*) < 1 or **edge**(*i,j*) > **nv** for some *i* = 1, 2 and *j* = 1, ..., **nedge**,
or **edge**(1,*j*) = **edge**(2,*j*) for some *j* = 1, ..., **nedge**,
or **liwork** < max(**nnzmax**, 20 × **nv**),
or **lrwork** < **nv**.

ifail = 2

A serious error has occurred during the computation of the compact sparsity of the finite element matrix or in an internal call to the renumbering function. Check the input mesh, especially the connectivity between triangles and vertices (the parameter **conn**). If the problem persists, contact NAG.

7 Accuracy

Not applicable.

8 Further Comments

Not applicable.

9 Example

```
nnzmax = int32(3000);
coor = zeros(2, 250);
```

```
coor(1, 1) = 1;  
coor(1, 2) = 0.987688;  
coor(1, 3) = 0.951057;  
coor(1, 4) = 0.891007;  
coor(1, 5) = 0.809017;  
coor(1, 6) = 0.707107;  
coor(1, 7) = 0.587785;  
coor(1, 8) = 0.45399;  
coor(1, 9) = 0.309017;  
coor(1, 10) = 0.156434;  
coor(1, 11) = 6.123030000000001e-17;  
coor(1, 12) = -0.156434;  
coor(1, 13) = -0.309017;  
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coor(1, 25) = -0.809017;  
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coor(1, 27) = -0.587785;  
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coor(1, 29) = -0.309017;  
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coor(1, 33) = 0.309017;  
coor(1, 34) = 0.45399;  
coor(1, 35) = 0.587785;  
coor(1, 36) = 0.707107;  
coor(1, 37) = 0.809017;  
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coor(1, 73) = -0.362968;  
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coor(1, 79) = -0.515679;  
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coor(2, 32) = -0.987688;  
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conn(3, 400) = 144;
conn(3, 401) = 42;
conn(3, 402) = 155;
itrace = int32(1);
[nnz, coorOut, edgeOut, connOut, irow, icol, ifail] = ...
    d06cc(nnzmax, coor, edge, conn, itrace)

```

```

nnz =
    1556
coorOut =
    array elided
edgeOut =
    array elided
connOut =
    array elided
irow =
    array elided
icol =
    array elided
ifail =
    0
INITIAL HALF-BAND-WIDTH: 234    INITIAL PROFILE: 18233
FINAL HALF-BAND-WIDTH : 28    FINAL PROFILE : 4038

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