Creating grid refinement data files

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The purpose of this document is to provide instructions on how to create a data file containing the relevant refinement data that the user wishes to apply to a coarse mesh in order to obtain finer grid spacings capable of capturing turbulent flow physics. Note that this refinement strategy was developed due to the issues encountered when attempting to fit finely-spaced meshes with control points at the beginning of an optimization. This procedure is not necessary if one is only attempting a flow solve, as the mesh fitting is not performed. I have included a standard 12-block coarse flat plate mesh with this document, along with its associated grid.refine file. I highly recommend familiarizing yourself with this fairly simple example before moving on to make your own for any larger, more complicated grids.

1 Instructions:

1. Select the desired off-wall tolerance and off-wall refinement factor. All spacings in the normal direction (typically $di = 3$) that are coarser than the tolerance will be refined by the given factor. Typical values used are $1e-4$ for the tolerance and 0.0005 for the refinement factor. Note that if a more specific set of off-wall refinement factors is desired (i.e. different levels of refinement in different areas), one can set the tolerance to 0.0 and proceed to include the desired off-wall refinement data with the data for the tangential directions.

2. Draw the upper and lower surfaces of the wing and its neighbouring block surfaces; label the block numbers for each surface.

3. Decide which edges are to be refined; keep in mind that the level of refinement must be consistent at block interfaces, or you run the risk of creating a poor-quality mesh.

If, after the mesh is refined, the flow solver doesn't converge, it could be an indication that there is a problem with the set-up of the refinement.

4. Note the definitions of $dx1$ and $dx2$ for the edges that will be refined. For increasing indices j (in direction $it1$) and k (in direction $it2$), $dx1$ starts at the low side and $dx2$ at the high side.

5. Note the di and edge indices for the edges to be refined (see the diagram below).

6. Input all refinement data into a file titled "grid.refine" as shown in the 12-block flat plate example. The data should include the block number (blk) direction index (di), edge index ($edge$), which end of the edge is being refined ($dx1/dx2$), and the refinement factor to be applied at each location (fac). It is good practice to have each column strictly increasing (e.g. blk goes from 1 to 12, $edge$ goes from 1 to 4, etc.). Make sure that the number listed under "number of edges" at the top of the file matches the number of entries.

2 Definition of direction and edge indices

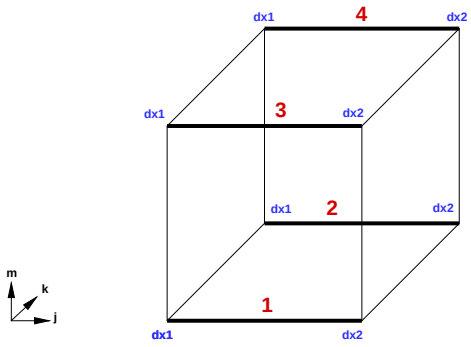
Table 1 shows how the edges are numbered for the three possible directional orientations. For example, if $di = 1$, then the edges we are looking at to refine (shown in bold) are in the j direction. From the data in the table, we see that edge 1 will be at a minimum in directions $it1$ (k) and $it2$ (m), edge 2 will be at a maximum in $it1$ and a minimum in $it2$, edge 3 will be at a minimum in $it1$ and a maximum in $it2$, and edge 4 will be at a maximum in both $it1$ and $it2$. The $dx1$ spacings are at the minimum indices of $it1$ and $it2$, while the $dx2$ spacings are at the maximum indices. Similar conventions are shown for $di = 2$ and $di = 3$. These conventions are illustrated in Figure 1.

di=1	it1=2	it2=3
edg = 1	1	1
edg = 2	max	1
edg = 3	1	max
edg = 4	max	max

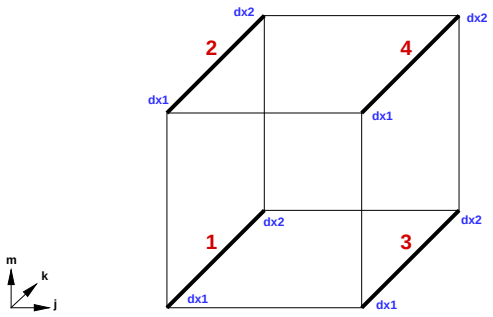
di=2	it1=3	it2=1
edg = 1	1	1
edg = 2	max	1
edg = 3	1	max
edg = 4	max	max

di=3	it1=1	it2=2
edg = 1	1	1
edg = 2	max	1
edg = 3	1	max
edg = 4	max	max

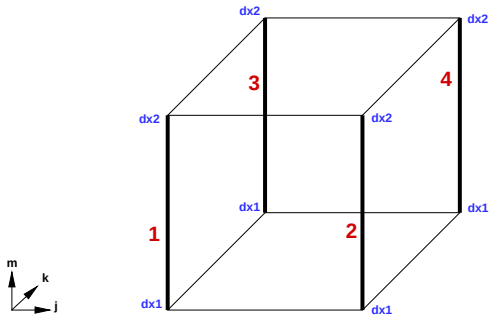
Table 1: Direction and edge index labelling convention



(a) Edge indices for di = 1



(b) Edge indices for di = 2



(c) Edge indices for di = 3

Figure 1: Illustration of edge index labelling convention

3 Example: 12-block flat plate

Figures 2 and 3 show the block layout diagram for the 12-block flat plate grid provided with this document as an example case. The block numbers are shown in black, while the direction and edge indices are shown in red. Due to a lack of space, I did not include the labels for blocks 2, 5, 8, and 11; note, however, that they follow the same convention as their neighbouring blocks. I have shown on blocks 1 and 4 that the node indices j and k start at a minimum in the lower left-hand corner of each block. This is true of all of the blocks and will provide the user with a reference as to how to label the spacings $dx1$ and $dx2$.

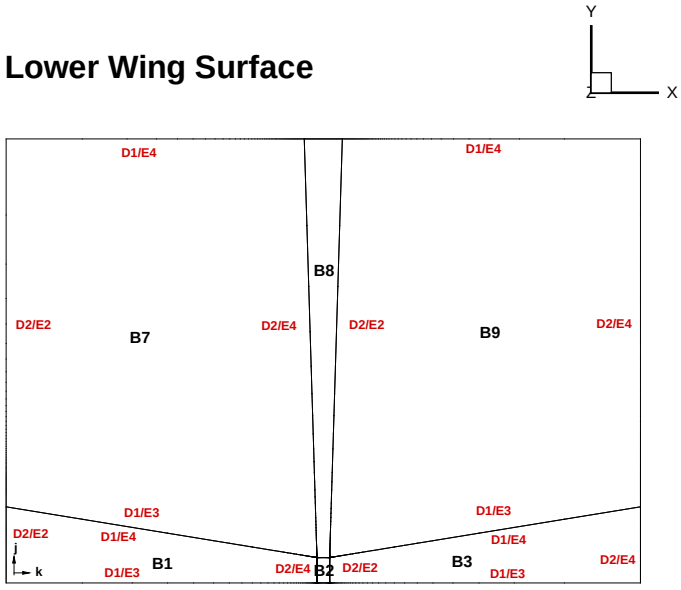


Figure 2: Lower surface block/di/edge labelling

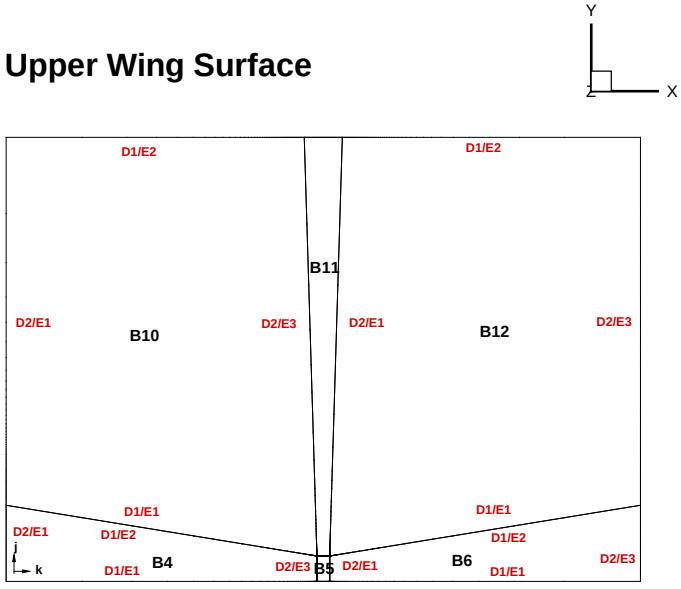


Figure 3: Upper surface block/di/edge labelling