AUTOMATIC INITIAL MESH GENERATION BY A GRID-BASED TEMPLATE

Soyoung AHN [1] and Philsu KIM [1]

1) *Department of Mathematics, Kyungpook National University, Daegu, KOREA*

Corresponding Author : Soyoung Ahn, ckskan@kaist.ac.kr

ABSTRACT

A grid-based approach is considered to generate the initial mesh. This paper describes the technique of generating a mesh template and how it can be used systematically for automatic mesh generation for the multiply connected bounded polygonal domain.

INTRODUCTION

A grid-based approach is proposed by Thacker *et al.*(see [1]) and general grid-based algorithm follows three steps :

(1) The grid is superimposed on the object.
(2) The grid cells that fall outside the object are removed.
(3) The grid cells that intersect the object boundary are adjusted or trimmed so that they fit into the object.

This method is sometimes called as Contour adjustment method due to the step 3.

An advantage of this method is that the constraint of nearly equilateral elements can be satisfied because construction begins with exactly equilateral elements, and neighboring points can be systematically identified because the initial grid is regular, and it could be implemented in most finite element software.

Then there are several requirements. The Step 2 requires to recognize which points are exterior and which are interior because the exterior points are excluded, in order to obtain the zigzag grid. Also, it needs the standard of choosing the zigzag boundary and the method for renumbering the interior and boundary points. In the Step 3, the method for adjusting the zigzag boundary to the boundary of the object has to be considered.

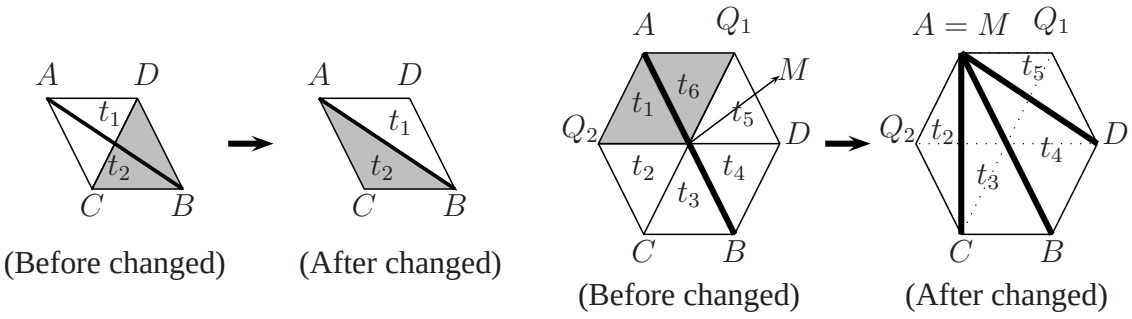
However, in most of past papers these requirements are conducted manually, otherwise are not concretely shown how they are able to be satisfied systematically.

This paper describes the automatic mesh generation for the multiply connected bounded polygonal domain by the technique of generating a mesh template.

AUTOMATIC INITIAL MESH GENERATION

Our main algorithm is as follows :

(1) The equilateral mesh template is superimposed on the object (Fig. 2(a)).
(2) The closest grid points to the array of the given boundary points are founded, of which the pseudo-boundary consists (Fig. 2(c)). If two boundary points are corresponded to the same



(a) E_2-type (b) E_3-type

Figure 1. C1 and C2 operations

grid points, then the later point in order which is called as a non-matched point is excluded in advance.

(3) Two types $C1$ and $C2$ of modifying operations are conducted (see Fig. 1), and the zigzag boundary, the interior points consisting of triangles with one or two boundary points, is founded (Fig. 2(d)).
(4) Adjust the boundary points to the corresponding grid points (Fig. 2(e)).
(5) The non-matched boundary points are connected again according to the first given order (Fig. 2(f)).
(6) Conduct smoothing processes using Laplacian smoothing [2] and aspect ratios to improve the poorly-shaped interior grid cells near to the boundary (Fig. 2(g)).
(7) Keep the interior points (Fig. 2(h)).

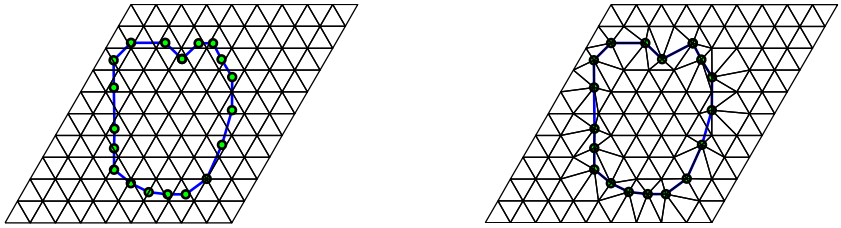
STRUCTURE OF AN EQUILATERAL GRID-BASED TEMPLATE

In the equilateral mesh template the indices of the grid points and the grid cells are orderly numbered from left to right and from bottom to top, respectively. Then it can be shown that the indices of the grid points and the grid cells around a given point A, which are placed on the local template $T_{24}(A)$ (Fig. 1), are easily calculated by the index of A and a characterized array CM by $\mathtt{lx}$, the number of diagonal lines with the slope $\sqrt{3}$ in the mesh template as follows :

$$CM = \begin{pmatrix} -\mathtt{lx} & -\mathtt{lx}+1 & 1 & \mathtt{lx} & \mathtt{lx}-1 & -1 \\ -\mathtt{lx}+1 & 1 & \mathtt{lx} & \mathtt{lx}-1 & -1 & -\mathtt{lx} \\ -1 & -\mathtt{lx} & -\mathtt{lx}+1 & 1 & \mathtt{lx} & \mathtt{lx}-1 \\ -\mathtt{lx}-1 & -2\mathtt{lx}+1 & -\mathtt{lx}+2 & \mathtt{lx}+1 & 2\mathtt{lx}-1 & \mathtt{lx}-2 \\ -\mathtt{lx} & -1 & \mathtt{lx}-1 & \mathtt{lx} & 1 & -\mathtt{lx}+1 \\ -2\mathtt{lx}+2 & -2\mathtt{lx}+3 & -2\mathtt{lx}+4 & 1 & 0 & -1 \\ -2\mathtt{lx}+1 & -4\mathtt{lx}+6 & -2\mathtt{lx}+5 & 2 & 2\mathtt{lx}-3 & -2 \\ -2\mathtt{lx}+1 & -\mathtt{lx}+2 & \mathtt{lx}+1 & 2\mathtt{lx}-1 & \mathtt{lx}-2 & -\mathtt{lx}-1 \\ -2\mathtt{lx}+3 & -2\mathtt{lx}+4 & 1 & 0 & -1 & -2\mathtt{lx}+2 \\ -4\mathtt{lx}+5 & -4\mathtt{lx}+8 & 3 & 2\mathtt{lx}-2 & 2\mathtt{lx}-5 & -2\mathtt{lx} \\ -4\mathtt{lx}+6 & -2\mathtt{lx}+5 & 2 & 2\mathtt{lx}-3 & -2 & -2\mathtt{lx}+1 \end{pmatrix}. \quad (1)$$

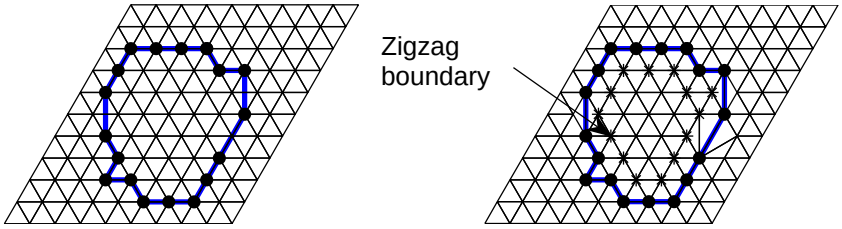
Therefore, these properties make it easy to exclude the exterior and keep the interior

Then, there exist three types according to the locations of B and for the types E_2 and E_3 the following modifying operations are applied (Fig. 2) if A and B are the closest points to two consecutive boundary points. Then, we can automatically determine which grid points are inside of the domain and what their indices are.



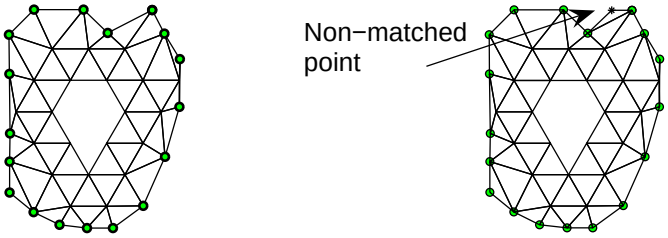
(a) Template superimposed on the domain

(b) Template adjusted to the boundary



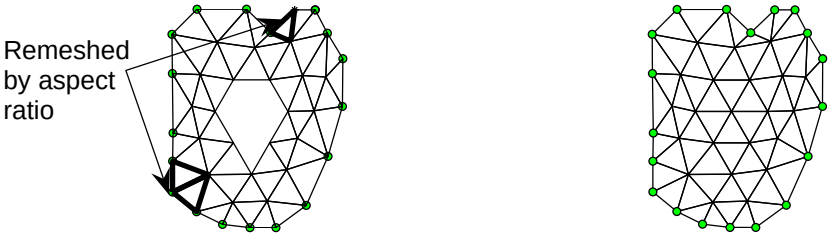
(c) Pseudo boundary for the input data

(d) C1 and C2 operation and zigzag boundary



(e) Grid cells near the zigzag boundary

(f) Adding the non−matched input data



(g) Remeshing

(h) Complete mesh

Figure 2. Process of mesh generation based on Contour adjust method

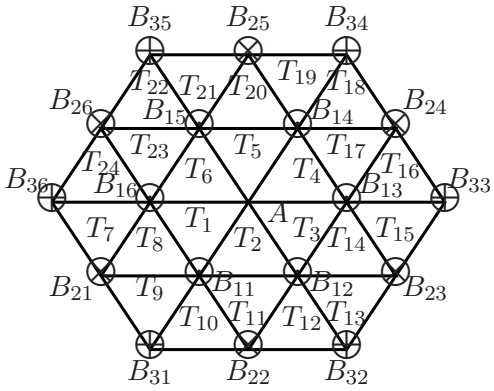


Figure 3. Local template $T_{24}(A)$:Three cases of location of B in $T_{24}(A)$; E_1 type case: $\odot$, B_{1i}; E_2 type case: $\otimes$, B_{2i}; E_3 type case: $\oplus$, B_{3i}

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