

Determination of a Straight Skeleton from a Motorcycle Graph

May 9, 2024

Below is the starting point, a motorcycle graph of a polygon. As is noted elsewhere, a motorcycle graph can be generated from a triangulation of an n -sided polygon [order $n \cdot \log(n)$], ray tracing of v convex vertices in the triangulation [order $v \cdot \sqrt{n}$] and brute force intersection of motorcycle paths [order $v \cdot v$]. Note that each of the motorcycle regions is a convex polygon.

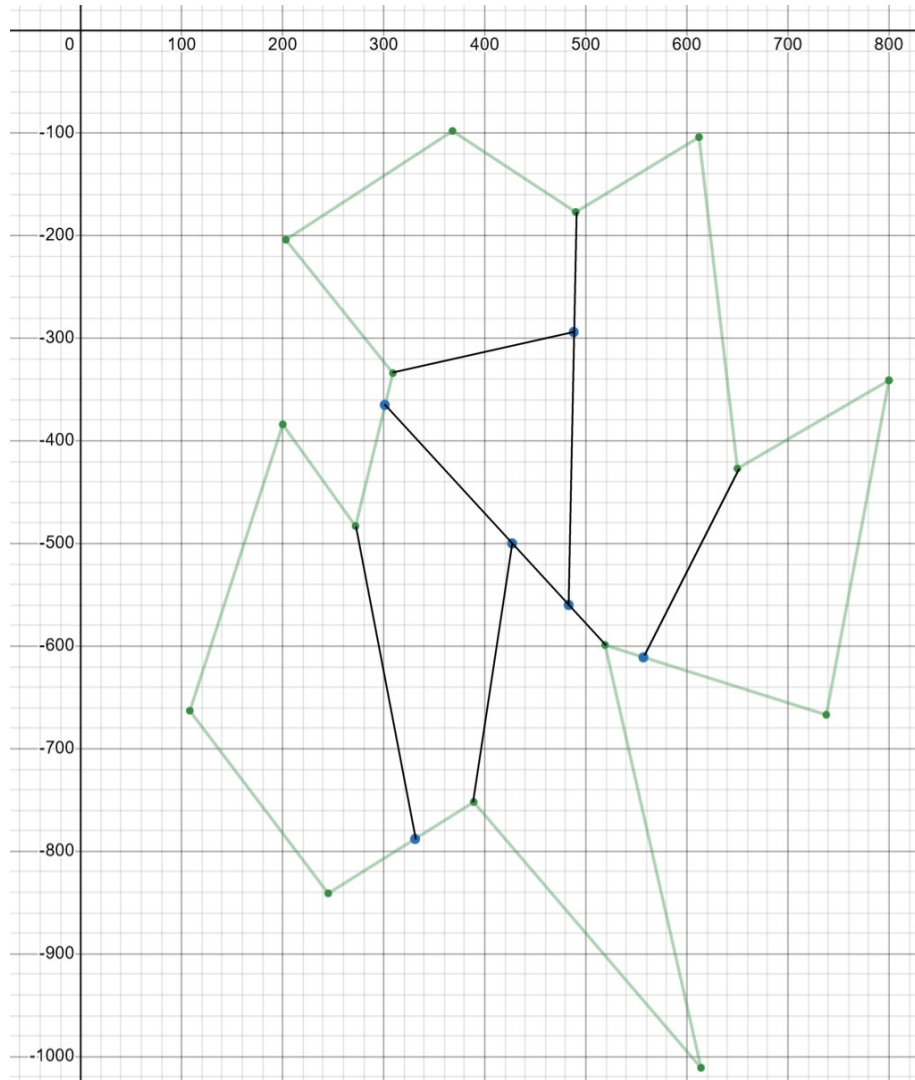


Fig. 1

The next step is to identify those regions having two or more adjacent sides on the boundary. Skeletons for these regions can be immediately determined. The skeleton ends on encountering a side with vertex/target points, as shown below. Where a node has four or more attached segments, the node is complete; if not, the node is incomplete. In the figure below there are five incomplete nodes having two attached segments. The incomplete node from vertex 14 has one attached segment. We will next show how to complete the incomplete nodes.

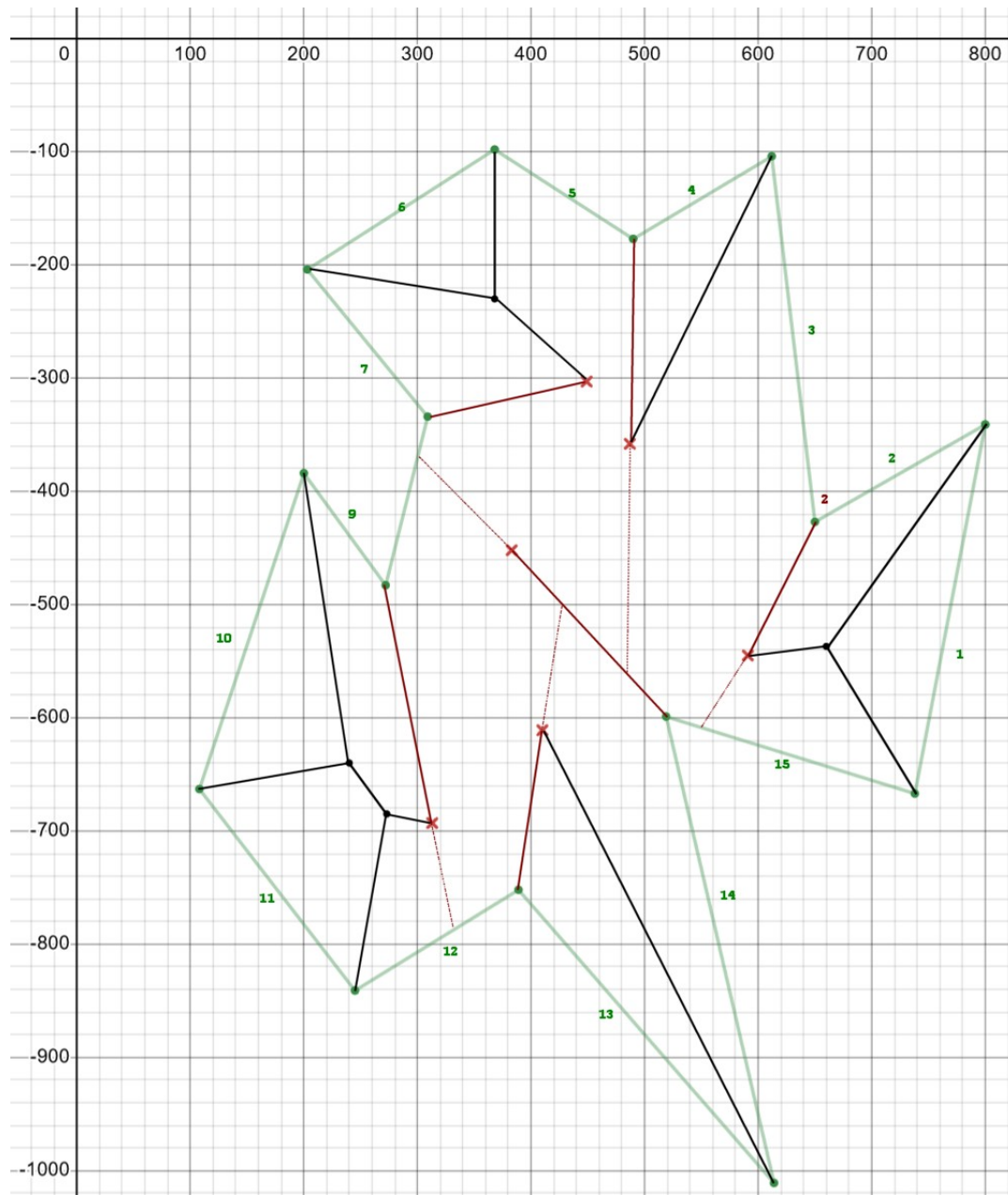


Fig. 2

At this point we will relink the motorcycle regions by removing links at target points except for those with a through path not associated with a peripheral region. Note that the through path from vertex point 14 divides the polygon into parts: a clockwise traversal in the lower part, a counter-clockwise in the upper. This results in the paths around the interior of the polygon, as shown in the figure below (not all of the arrows are shown).

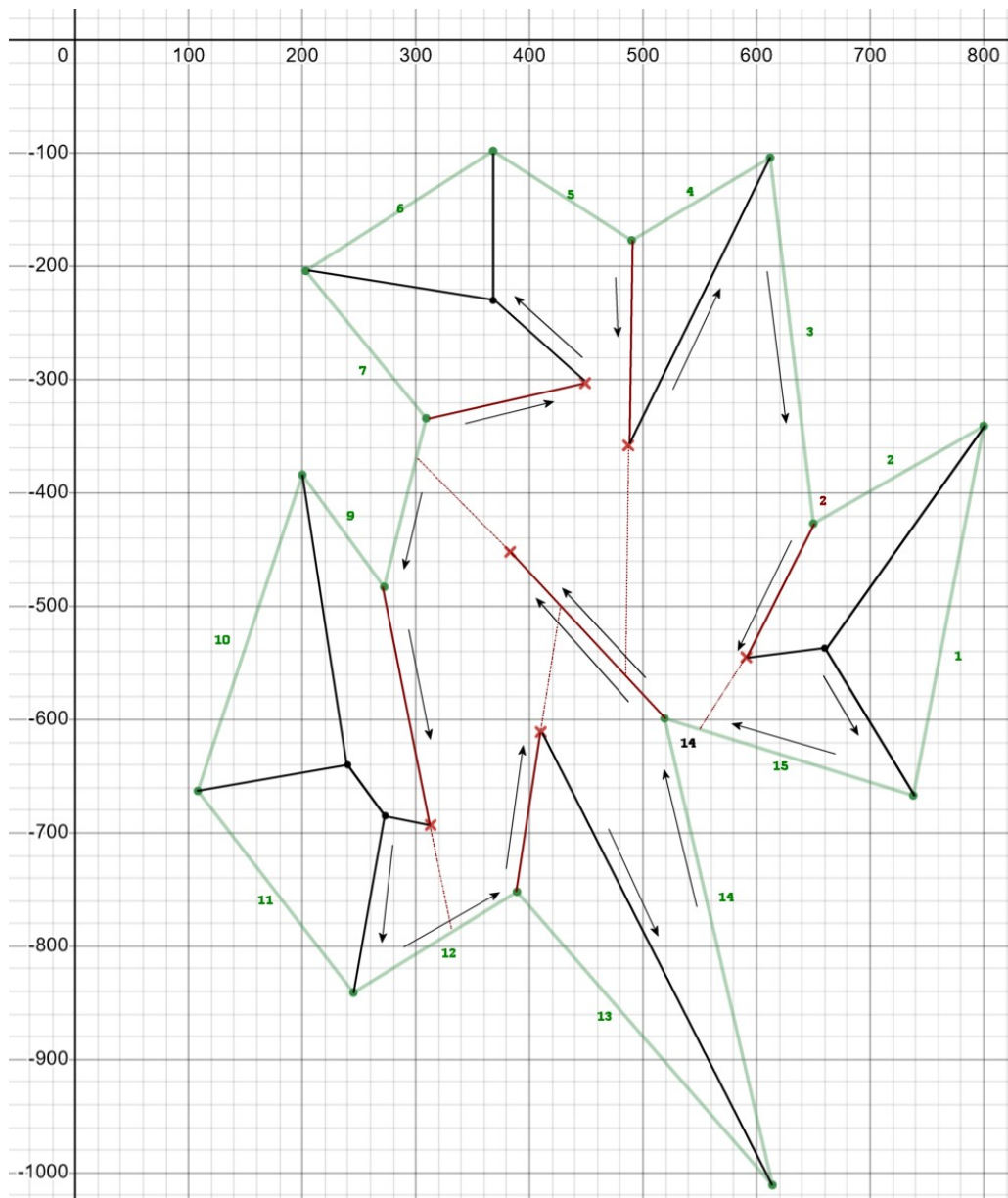


Fig. 3

The internal connections of the incomplete nodes can now be shown. From the target side of the bisector of the vertex at point 14 (point A), we develop two vectors from point B, one to the left and one on the right by traversing the paths determined by the relinking just described. The traversal ends when an incomplete point is encountered. For the traversal to the left, that end point is marked with an X. The one to the right with Y. Vectors connect B with X and B with Y.

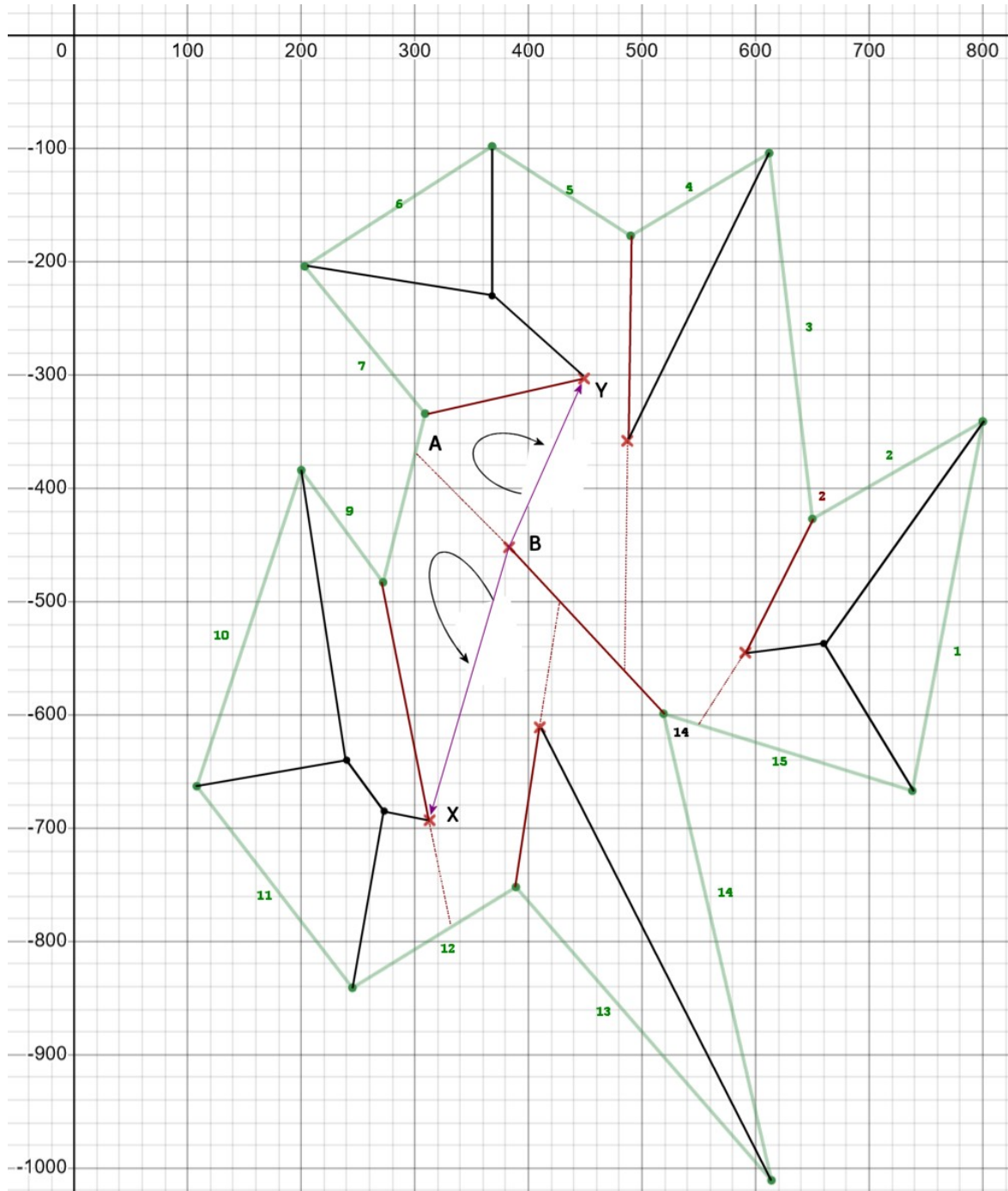


Fig. 4

Next we will consider the three regions having more than two adjacent boundary segments, shown below. We traverse the path from the incomplete node toward the target side of the vertex, stopping when an incomplete node is encountered. A vector is placed between the two incomplete nodes, as shown below.

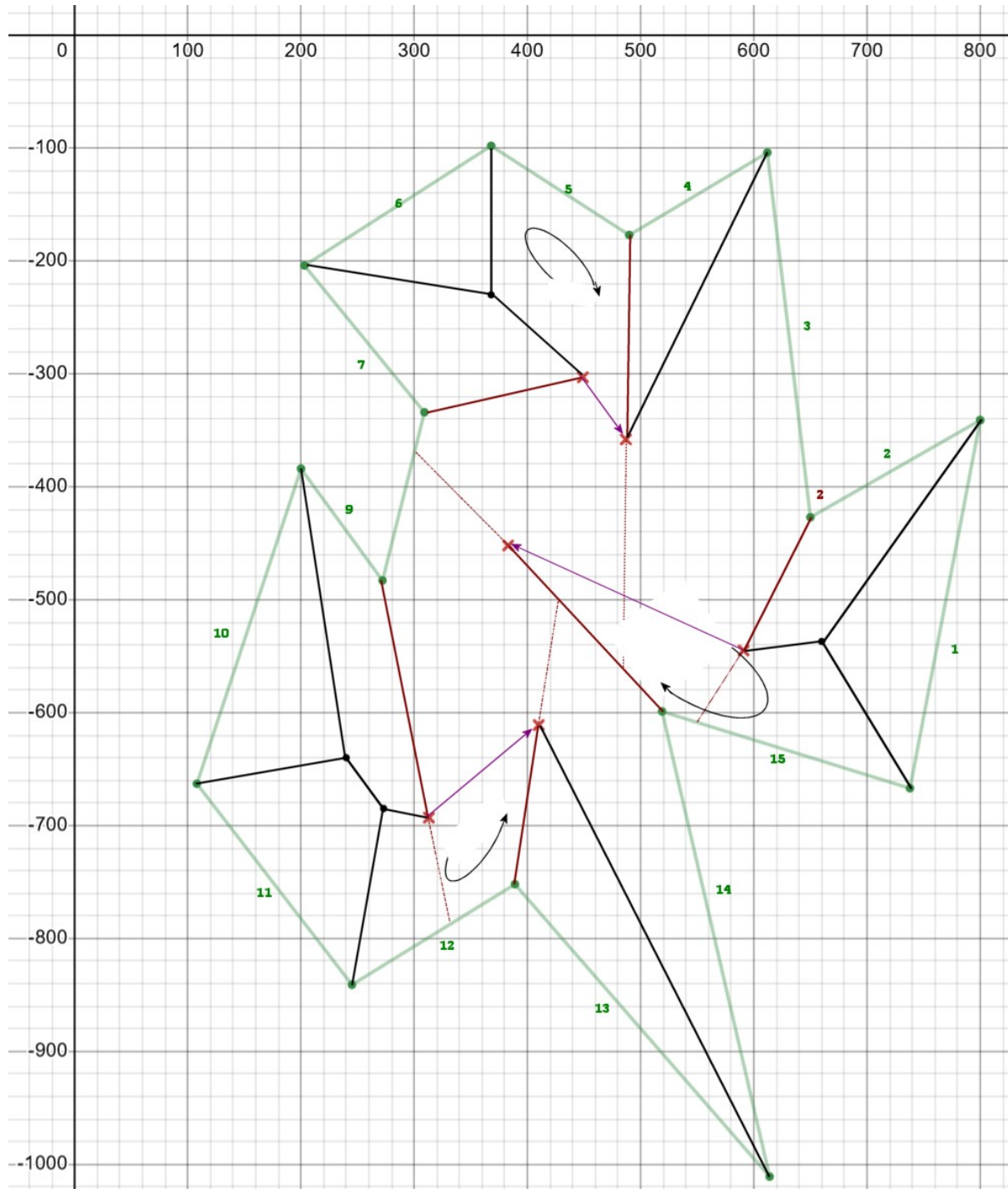


Fig. 5

The diagram is plotted on a coordinate grid with the x-axis ranging from 0 to 800 and the y-axis from -100 to -1000. It features a network of lines and points:

- Black Lines:** Form several interconnected polygons. Key points labeled include A, B, C, f, s, U, V, and W.
- Green Lines:** Labeled 1 through 15, forming a larger, more complex boundary around the black structures.
- Red Lines:** Connect specific points, including a segment from 'f' to 's' and another from 's' to 'f'. Some red lines are solid, while others are dotted.
- Points:** Marked with black dots at vertices and red 'x' marks at specific locations (e.g., f, s, U, V, W).
- Curved Arrow:** Located near point C, indicating a clockwise rotation.

Fig. 6

In the figure below we bring together all of the vectors shown in Figures 4 through 6: Green is from Fig. 4; blue from Fig. 5; and orange from Fig. 6. Note that the previously incomplete nodes now all have at least four attached segments. We can see that two regions are formed, holes (or cycles) where skeletons need to be defined. The lower hole has three sides, the upper four.

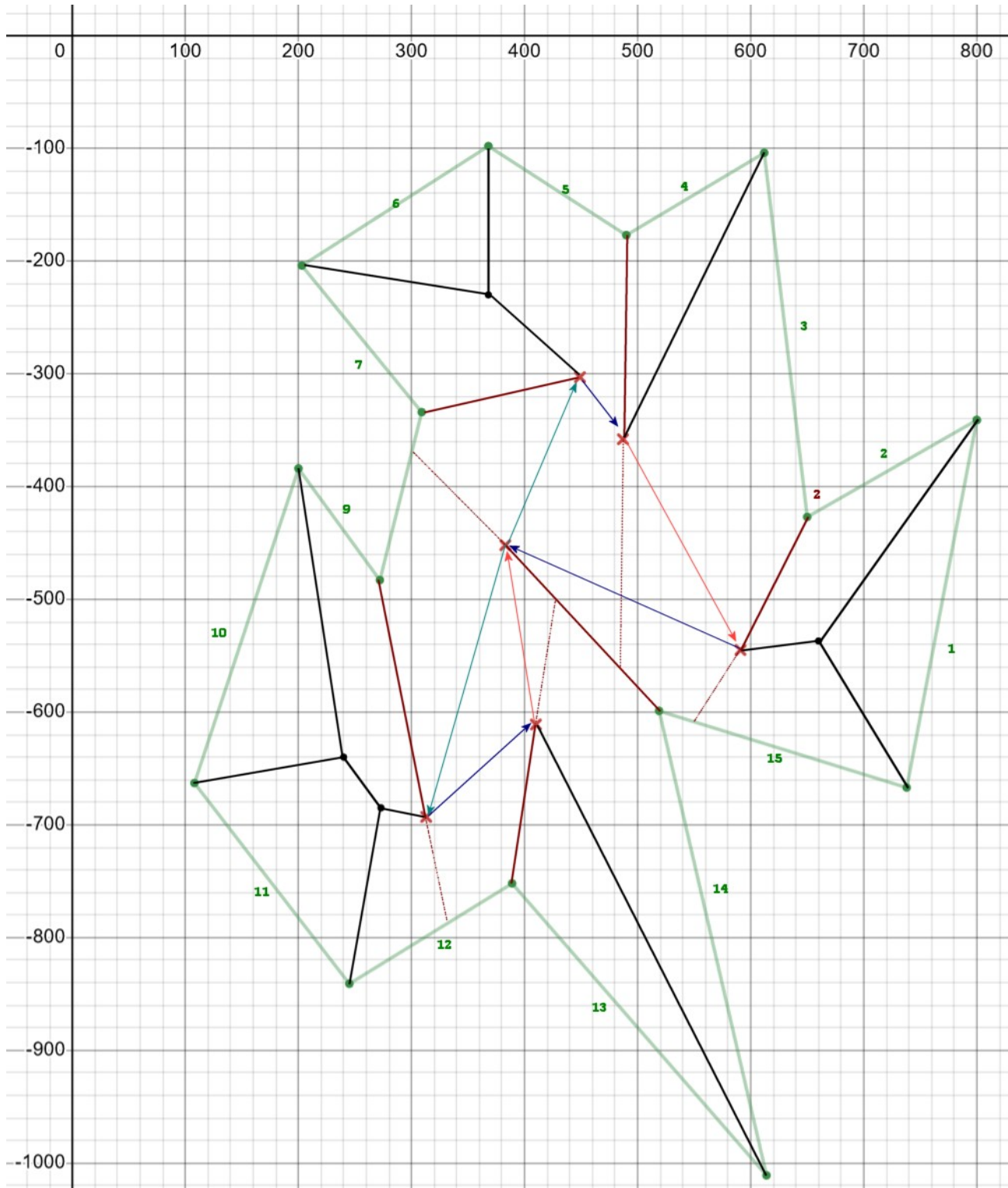


Fig. 7

The two convex holes contain points higher than along any edge of the area. In the case of the lower triangular area, the triangulation of the area indicates a high point is the incenter of the edges 8, 12 and 14. This incenter of these edges is shown as a dot in the triangular region. Note that this incenter is not the same as the center of the skeleton of the region.

To find triple connection points of the four-sided upper area, the upper node of its skeleton corresponds to sides 8, 5 and 3, while the lower area associates sides 8, 15 and 3. The two sides that join these two incenters are 8 and 3. The two incenters thus determined are shown as dots in this region.

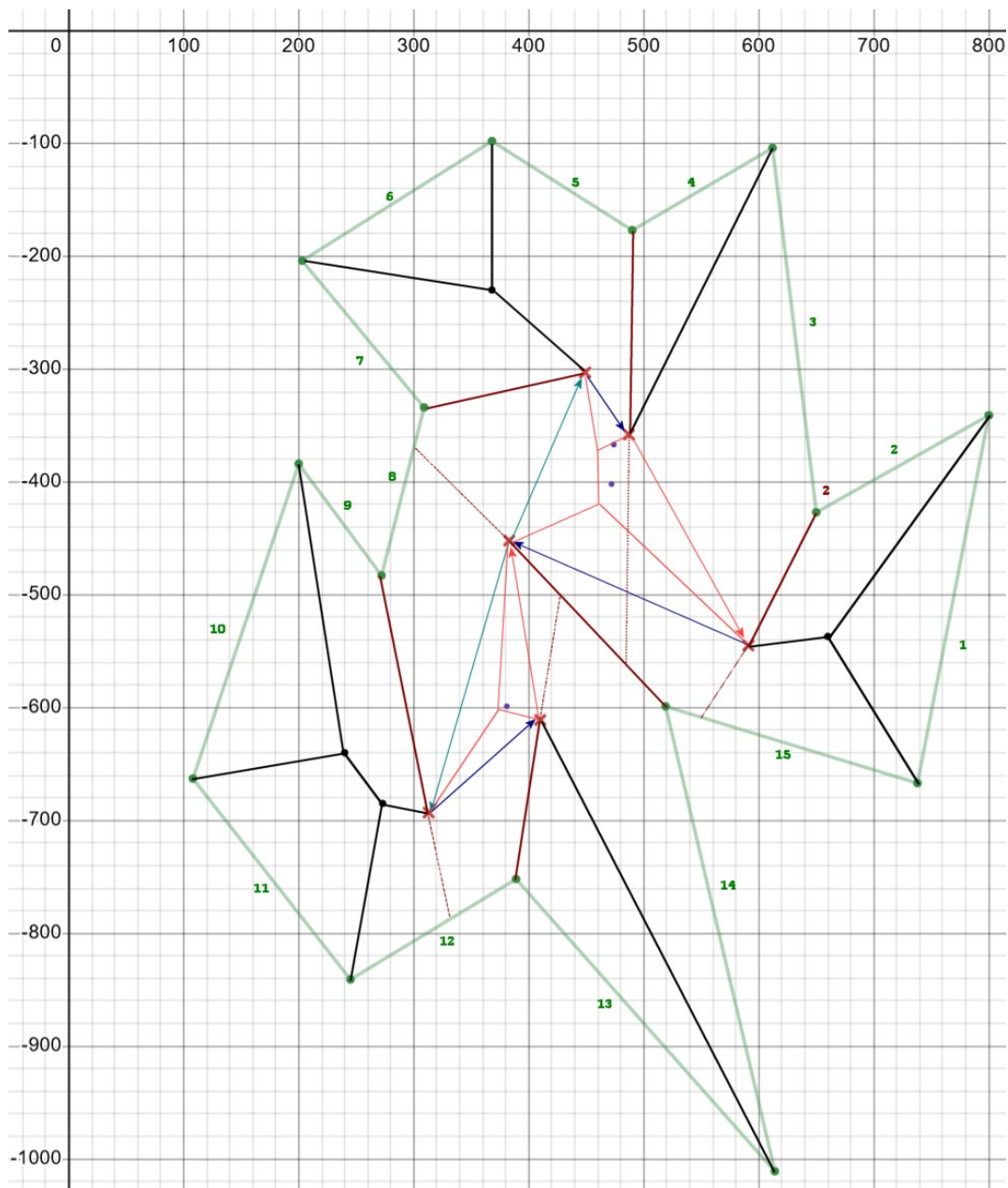


Fig. 8

Now, replace the region outlines and their internal skeletons with the incenters of the determining sides, and create lines from these points to the corners of the region. This replacement, shown below, is the result skeleton.

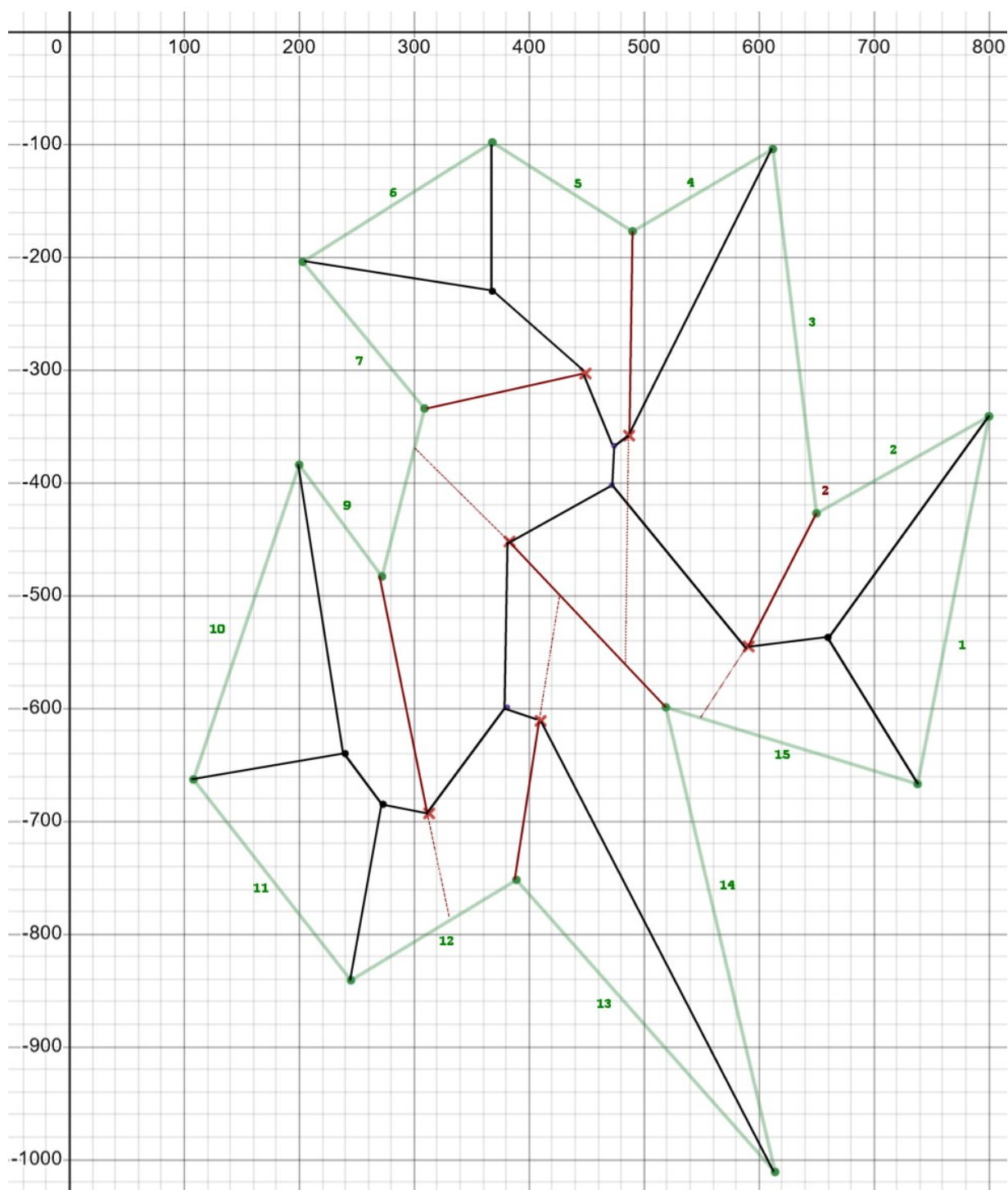


Fig. 9

For comparison, below is a medial axis skeleton of the same polygon.

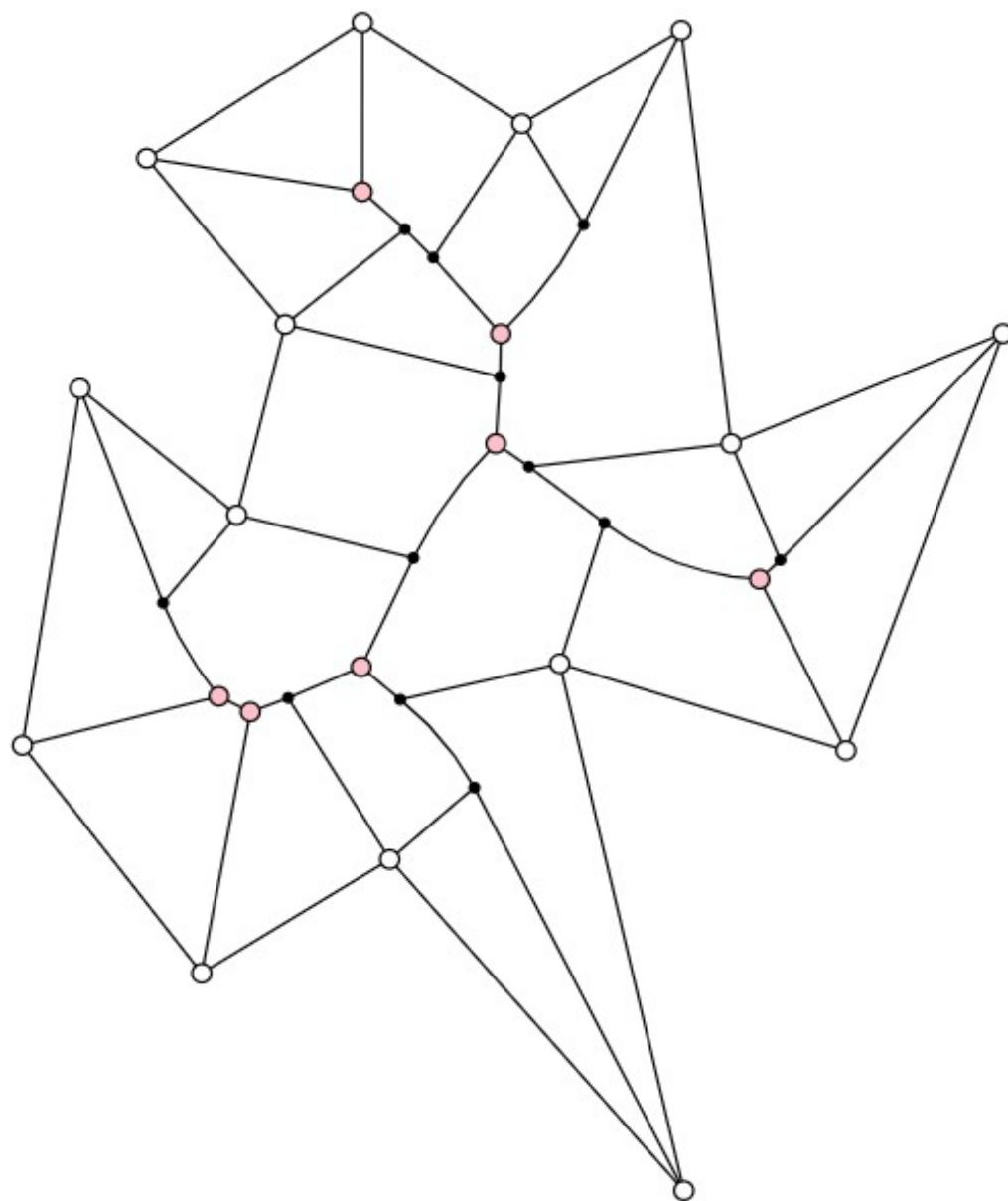


Fig. 10