

## Additional Materials

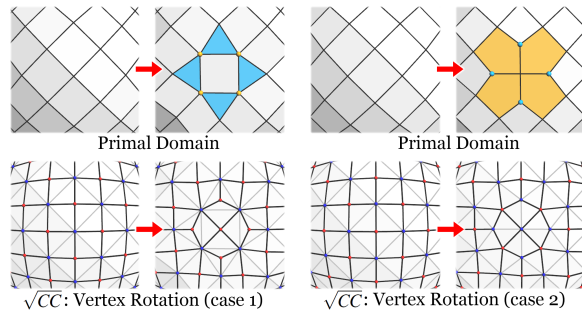


Figure 17: The two possible outcomes (depending on the p-vertex/d-vertex labeling) in the primal domain by applying a vertex rotation operation [TPC\*10] in the  $\sqrt{CC}$  domain.

In Figure 12a and Figure 12b we show both the primal and the  $\sqrt{CC}$  domains of pair-wise irregular element movements. These figures are too tall to be included in the main paper. Figure 13 shows a triple cancellation operation of irregular elements.

In Figure 14 we compare the three input meshes (the vertex positions are initialized by Laplacian smoothing with back projection) and their optimizations by fairness (an approximation of angle deviation optimization) and planarity for the Yas-Island example. The input meshes are already reasonably planar thus the planarity optimizations do not change the shapes by much.

In Figure 16 we show a closer look of the histograms and visualizations for the T-junction editing example.

In Figure 15 we edit an input pure quad mesh of Bunny to convert all irregular vertices to irregular faces using odd numbers of pair-wise irregular element movements. The movement paths are chosen such that sharp features are not crossed over. The result is a  $QD$  mesh without irregular vertices that still preserves the sharp features. In comparison, taking the dual would also produce a mesh without irregular vertices. However, the sharp features are distorted, i.e. chiseled, because each sharp edge now becomes a dual face.

In Figure 17 we show the two possible outcomes in the primal domain by performing a vertex rotation operation (proposed in [TPC\*10] in the  $\sqrt{CC}$  domain. In Figure 18 we show that region-wise primal-dual conversions are possible by applying GP operators [BLK11] in the  $\sqrt{CC}$  domain.

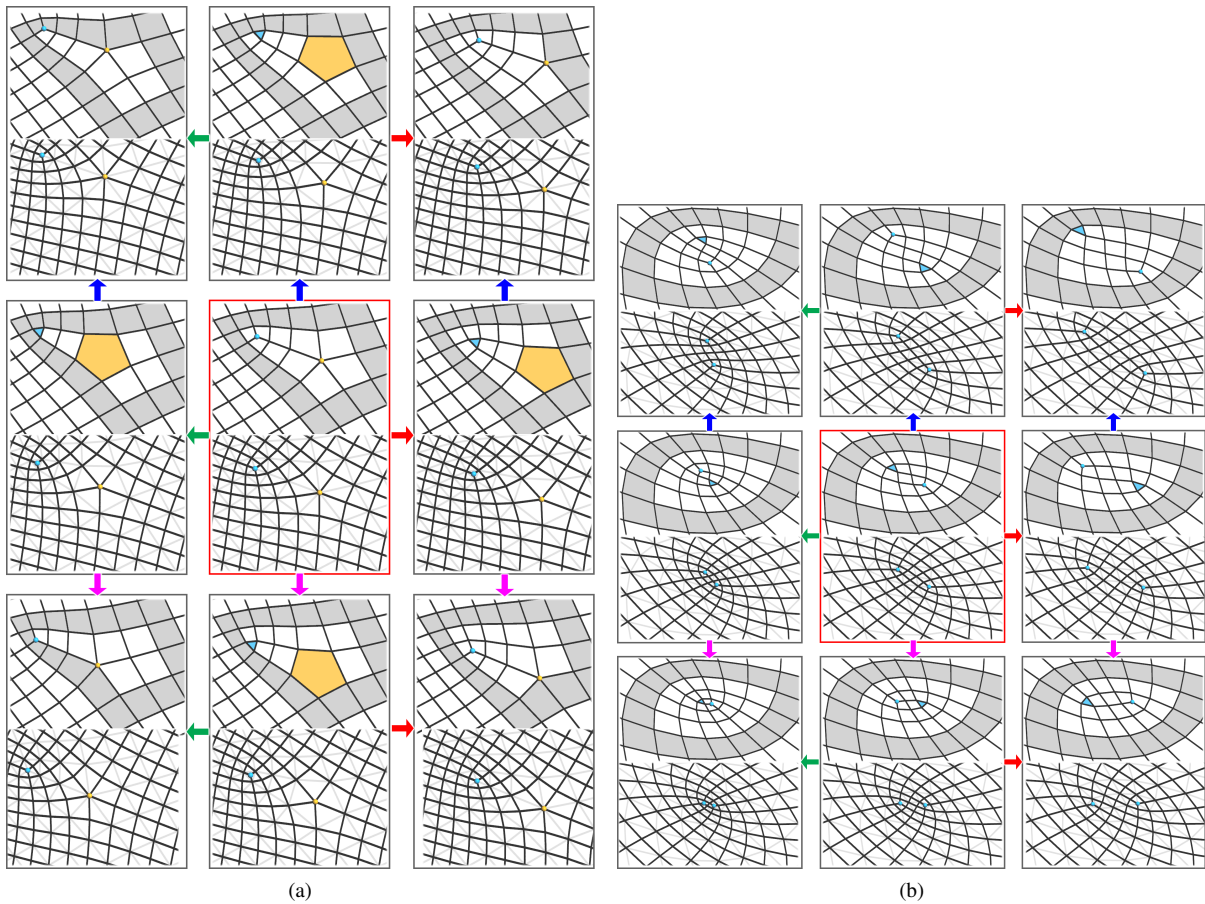


Figure 12: (a) A  $v_3$ - $f_5$  pair can be moved in the left (green arrows), right (red arrows), up (blue arrows), and down (purple arrows) directions. Note that a single step would switch their types, thus a type-preserving movement can be realized by two consecutive steps. Both primal (top) and  $\sqrt{CC}$  (bottom) domains are shown for each mesh. (b) A  $v_3$ - $v_3$  pair can be moved in the scaling closer (green arrows), scaling farther (red arrows), rotating counter-clockwise (blue arrows), and rotating clockwise (purple arrows) directions. Both primal (top) and  $\sqrt{CC}$  (bottom) domains are shown for each mesh. The gray faces are marked for ease of inspection.

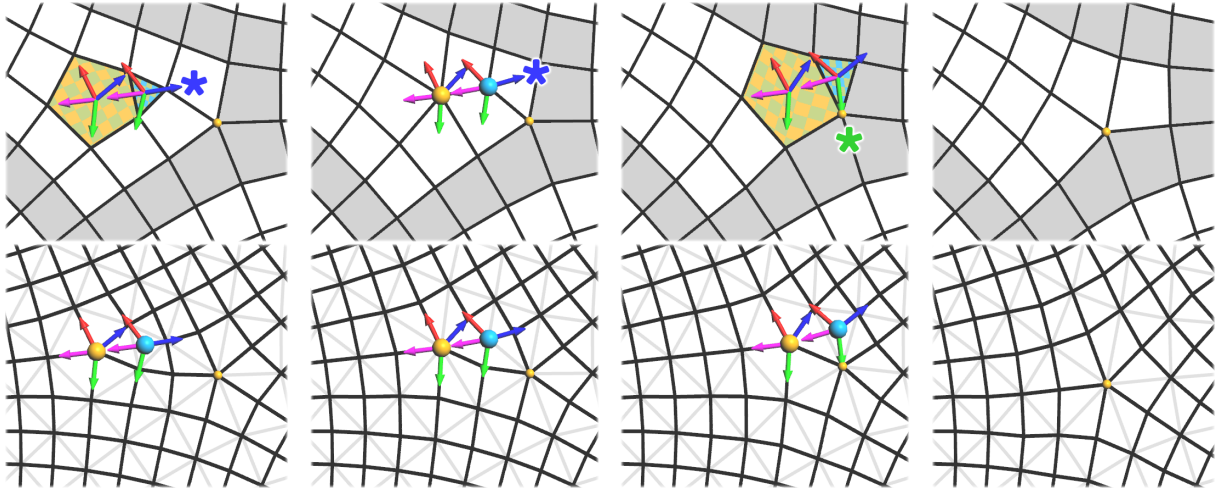


Figure 13: A triple cancellation. The  $f_3$  of the  $f_3$ - $f_5$  pair in the primal domain is collided with the  $v_5$  by taking three steps of pair-wise movements (marked by stars with matching colors). The result is a single remaining  $v_5$ . The operation is realized in the  $\sqrt{CC}$  domain as a triple irregular vertex cancellation operation.

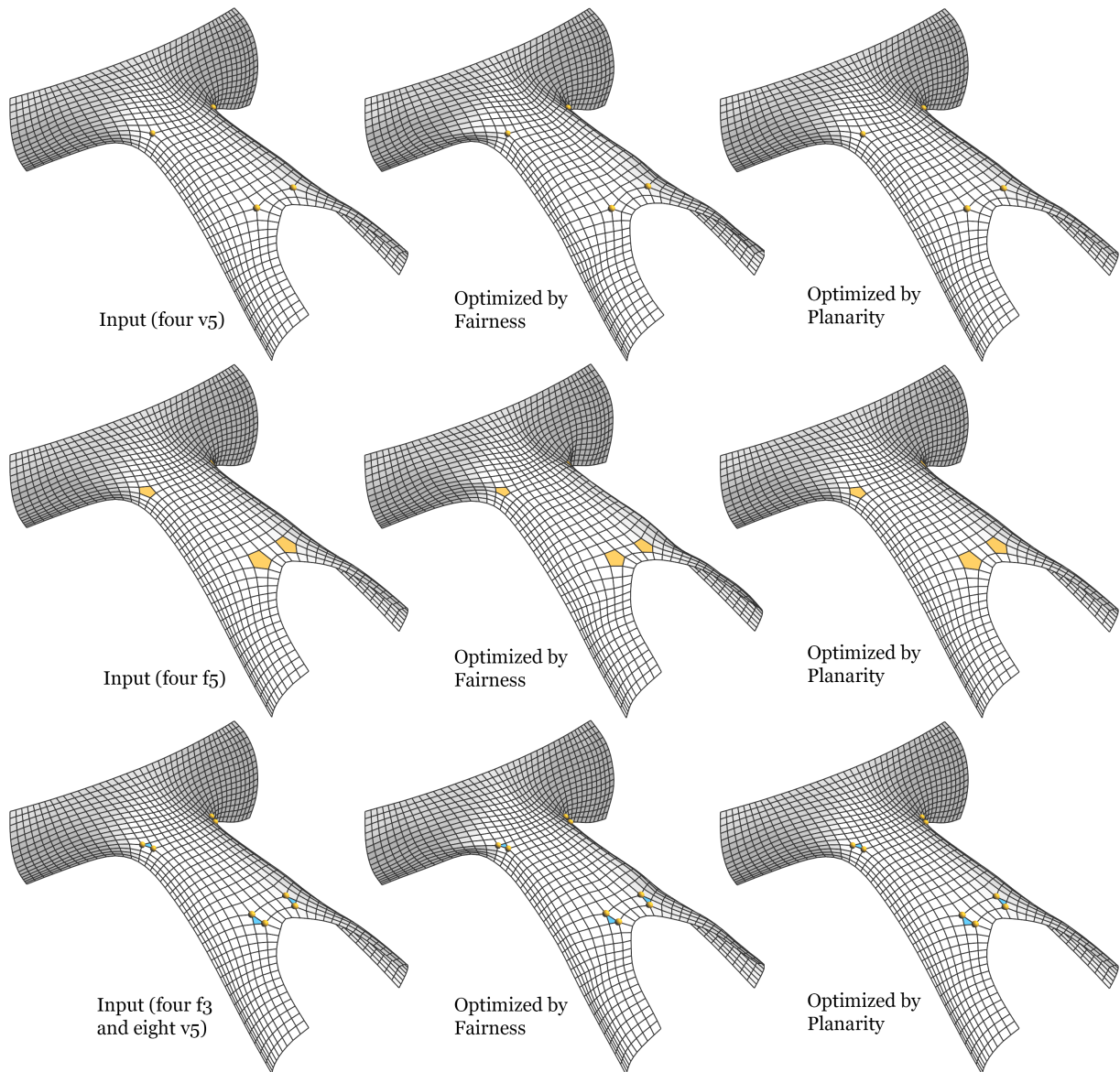


Figure 14: The three input meshes and their optimizations by fairness (an approximation of the angle-deviation optimization) and planarity for the Yas-Island example.

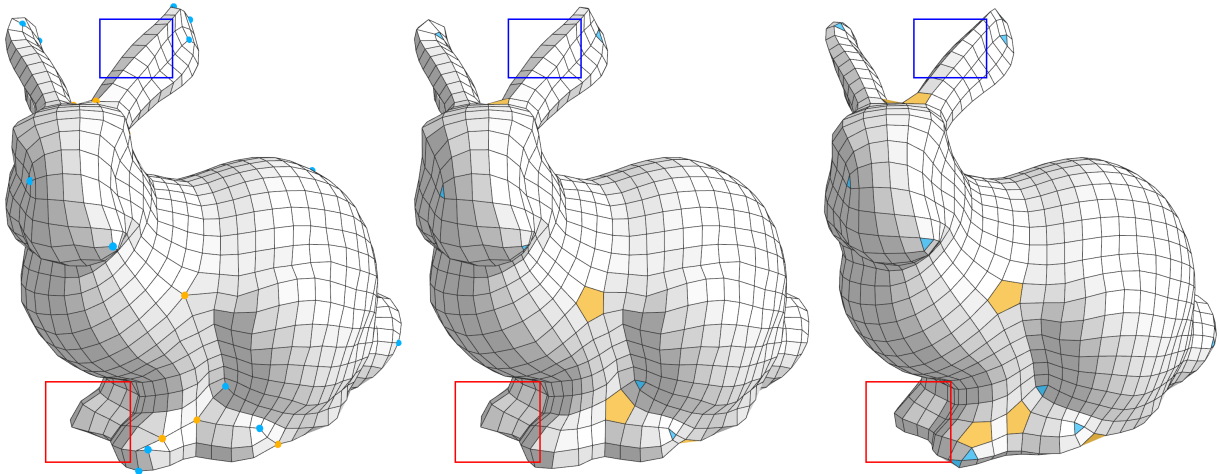


Figure 15: (Left) An input quad mesh of Bunny. (Middle) An edited version with all irregular vertices converted to irregular faces by taking odd numbers of pair-wise irregular element movements. The movements are applied in a way that sharp features are preserved. (Right) The dual of the input mesh. While it also has no irregular vertices, the sharp features are distorted, i.e. chiseled, due to the nature of dual meshes.

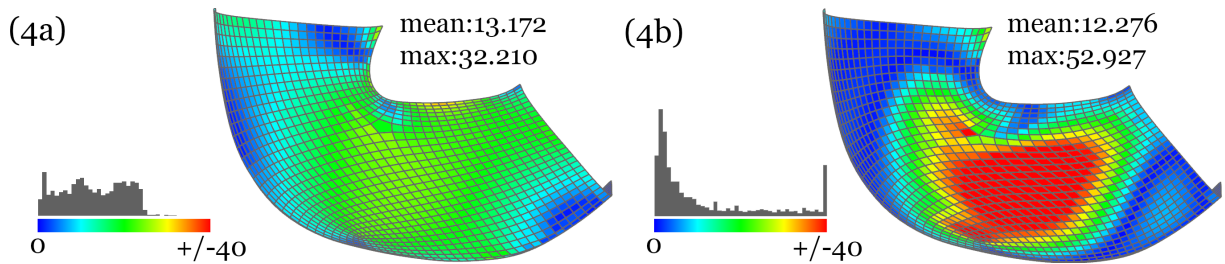


Figure 16: A closer look at the histograms of angles and the visualizations of the angle deviations for the T-junction editing example.

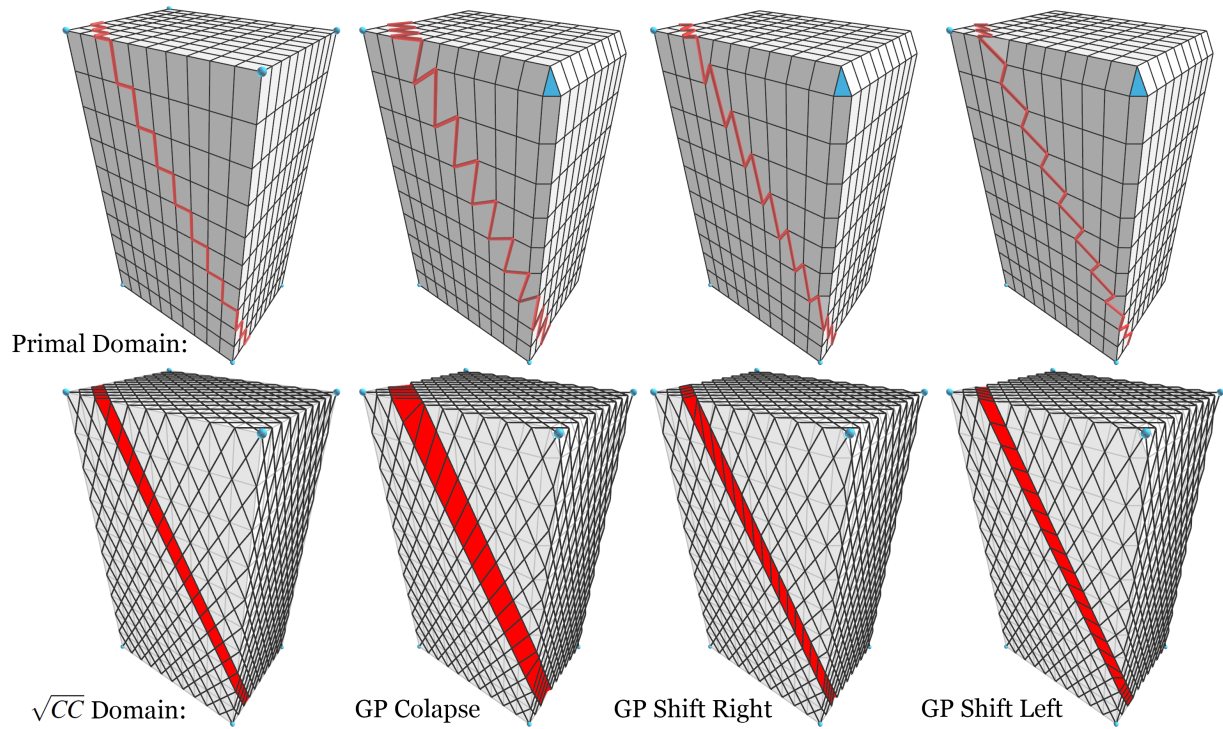


Figure 18: By applying a GP collapse, GP shift right, or GP shift left operation [BLK11] (red quad strips) in the  $\sqrt{CC}$  domain, we can perform primal-dual conversion to a local region (the upper-right part of the mesh) in different ways. Red edges in the primal domain correspond to the quads directly affected by the GP operators in the  $\sqrt{CC}$  domain.