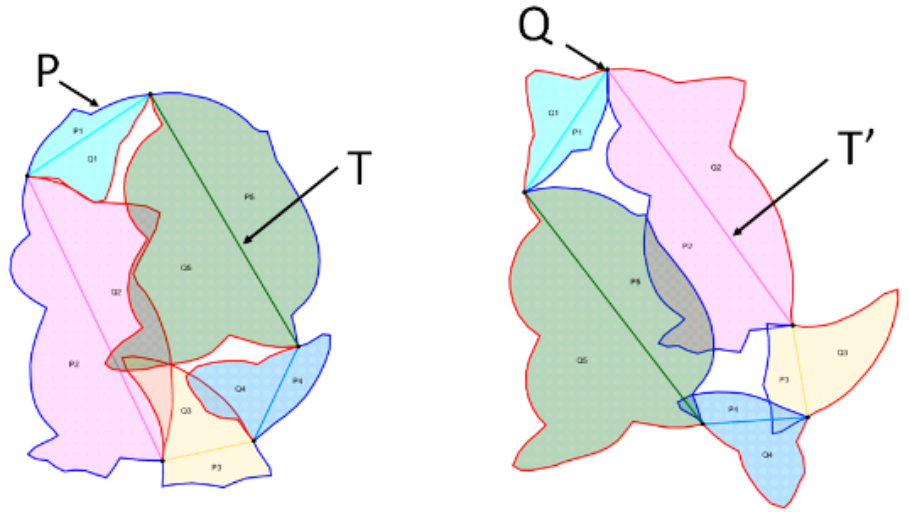
Problem Recap

Input: a shape P and its trunk T, shape Q as the riot of P, and its trunk T’.

Target: to fabricate common pieces of P and Q, which can be assembled along a chain, so that rotating the chain clockwise forms one figure and counter-clockwise forms the other figure.

Problem: The red exterior contour Q (Right figure) is split by T’ into curves, forming the red interior curves of P (Left figure). Each piece, denoted as {Qi} in the following figure, is represented by a red boundary curve and a polygon edge. In the left figure, they may have overlaps which would cause piece conflictions after fabrication. The **target** is to deform the boundary curves in {Qi} to eliminate overlaps in P, and minimize gaps, while preserving the curve details as much as possible, so that when we reverse P to Q (Right figure), the shape Q is still recognizable.

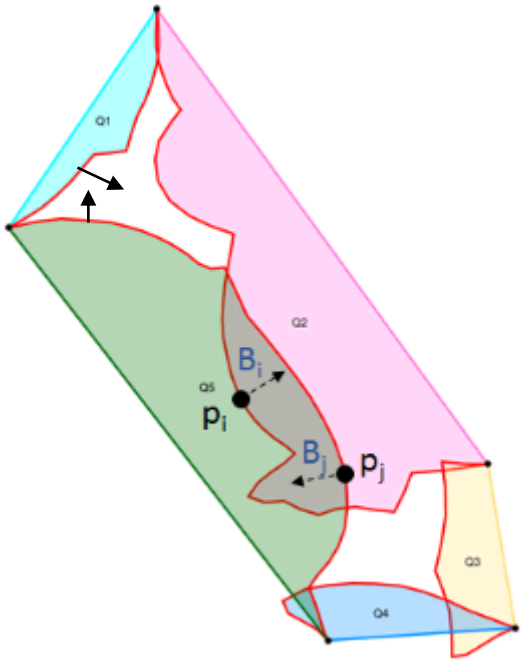


Boundary deformation

1. Deformation method - Laplacian editing is used for deforming boundary curves while preserving curve details.
   Refer : [Laplacian Surface Editing. O. Sorkine, D. Cohen-Or, Y. Lipman, M. Alexa, C. Roessl, and H.-P. Seidel. Proc. SGP 2004]

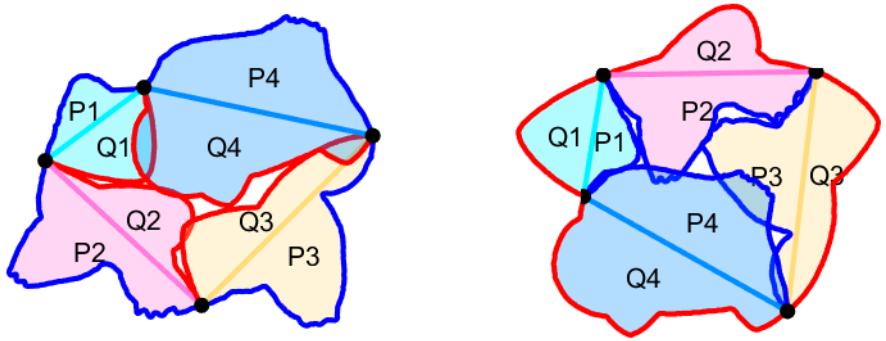
2. Moving directions – Attraction-Repulsion force is applied to both overlap and gaps. Each curve has a set of sample points, and the force is defined between points from two nearby curves.
   Take the following figure for example, to eliminate the overlaps, we should pull the green part along p_j direction, and red part along p_i direction.

   Refer: Organic Labyrinths and Mazes, H. Pedersen, K. Singh, NPAR 06
   And a brief description can be found from my previous document:
   https://docs.google.com/document/d/1Ew4pw0Arjmo31uNVXHfO5A1IDfwZYxYSnbLcbG8p_H

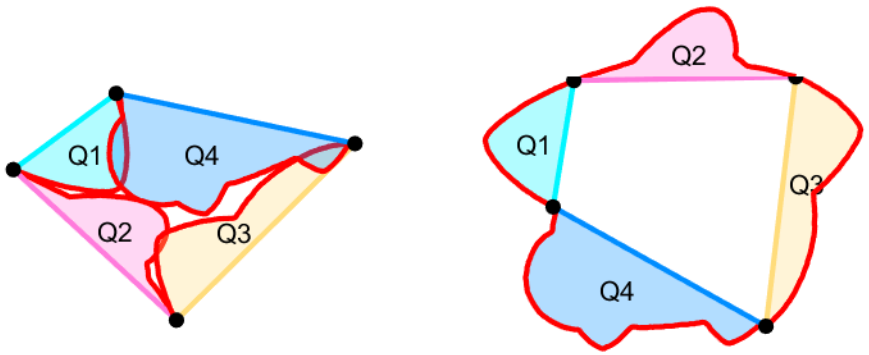


3. Iteratively compute the moving vectors (step) of each point on a curve, select the largest step, and apply Laplacian deformation to the curve.

Some Results

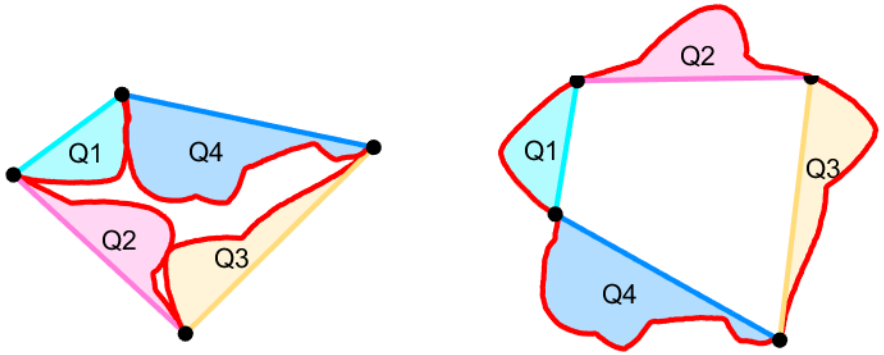


RIOT 1



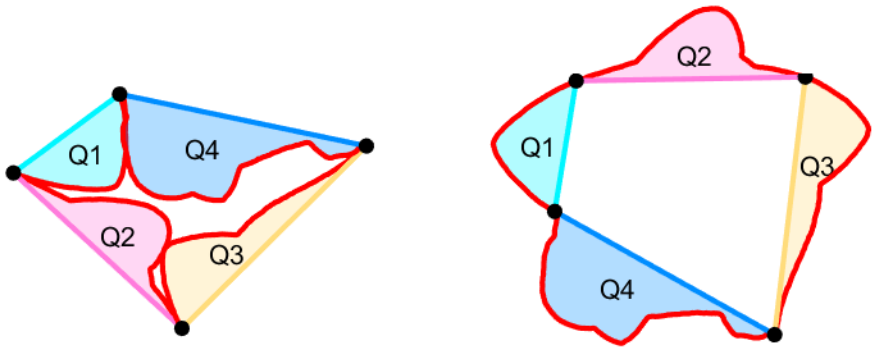
Original P

Iter8: overlap-area:-0.0001875, gap-area:0.1216



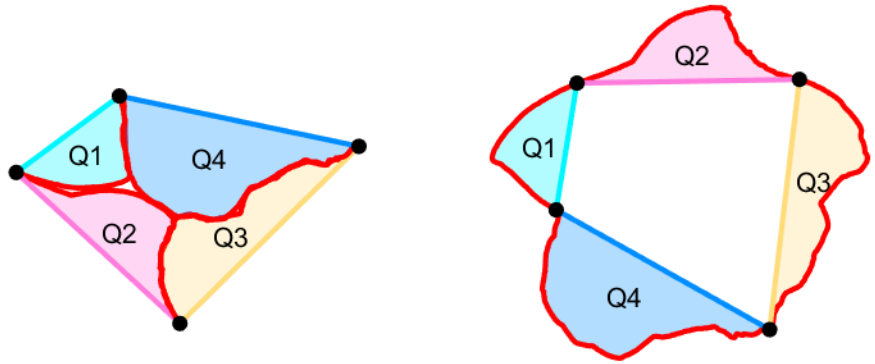
After eliminating overlaps

Iter1: overlap-area:0, gap-area:0.11323

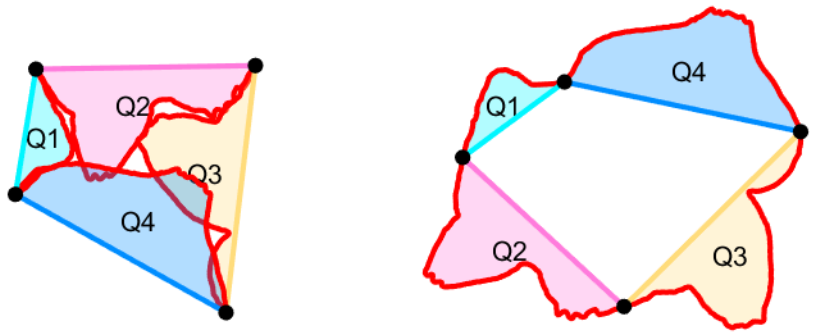


Minimizing gaps – Iter 1

Iter12: overlap-area:-1.25e-05, gap-area:0.01286

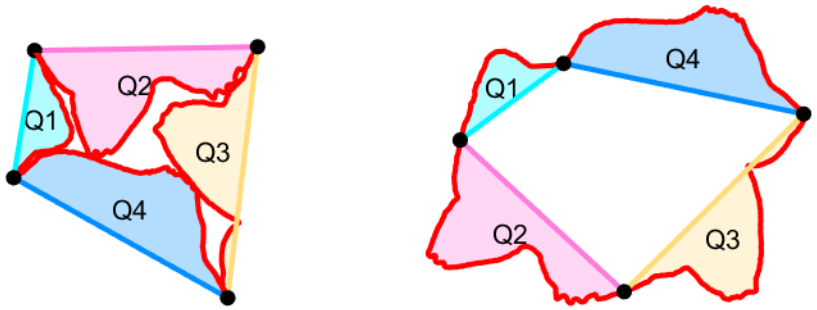


Minimizing gaps – Iter 12



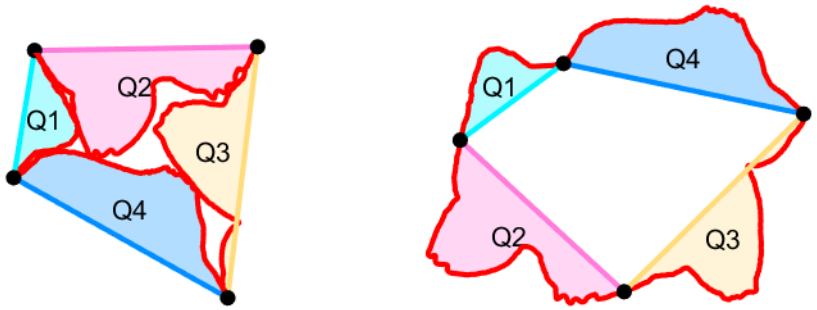
Original Q

Iter3: overlap-area:-7.5e-05, gap-area:0.08645



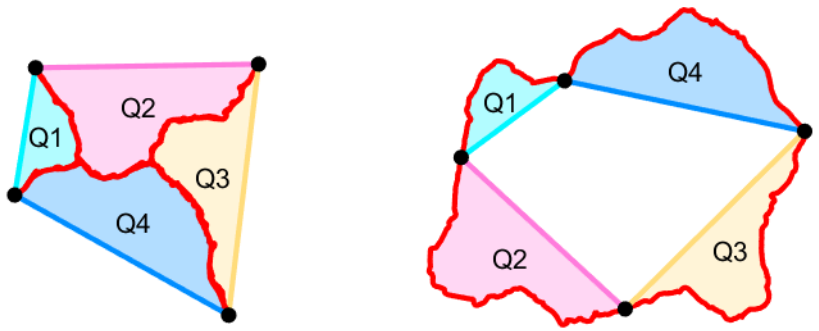
After eliminating overlaps

Iter1: overlap-area:-0.000225, gap-area:0.07698

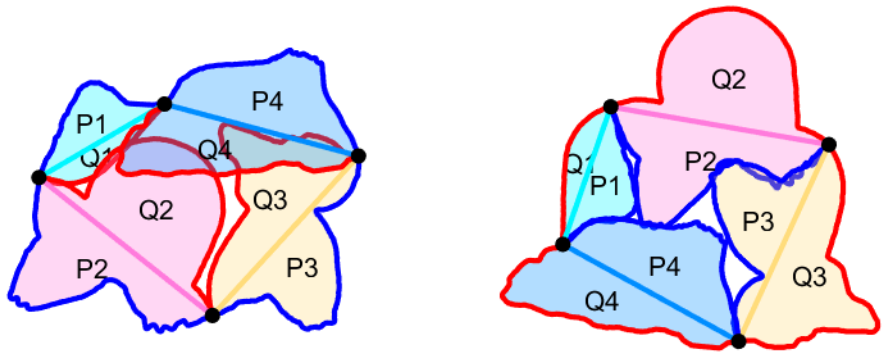


Minimizing gaps – Iter 1

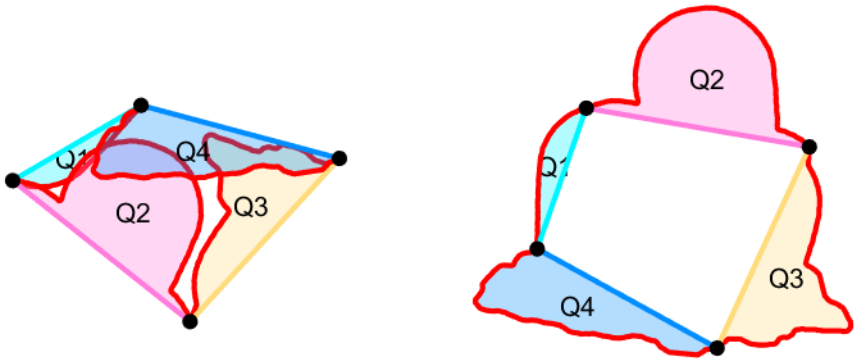
Iter12: overlap-area:0, gap-area:0.0062125



Minimizing gaps – Iter 12

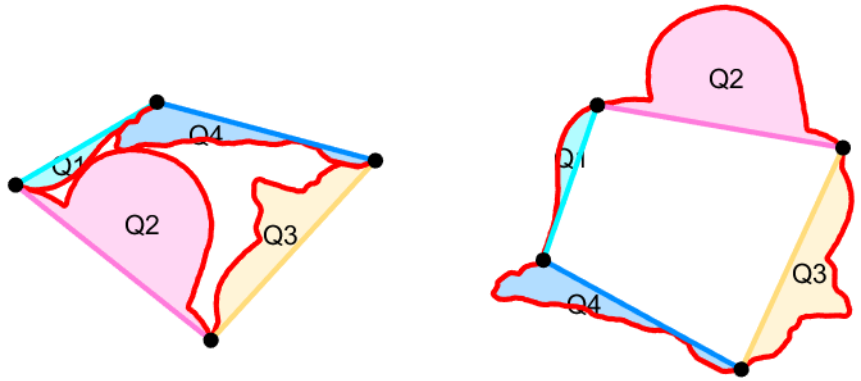


RIOT 2



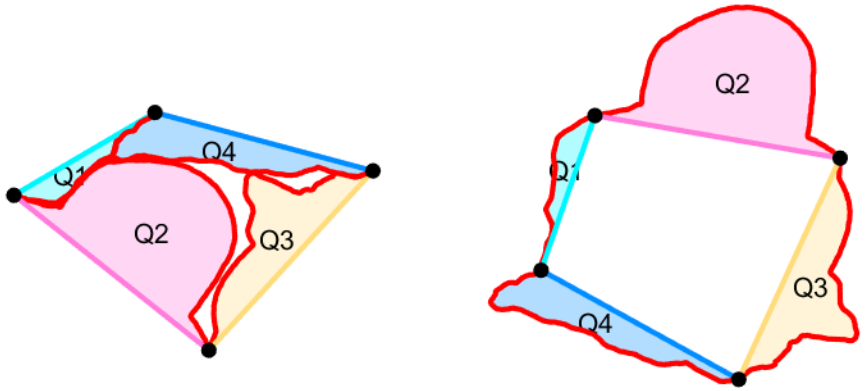
Original P

Iter4: overlap-area:0, gap-area:0.13761



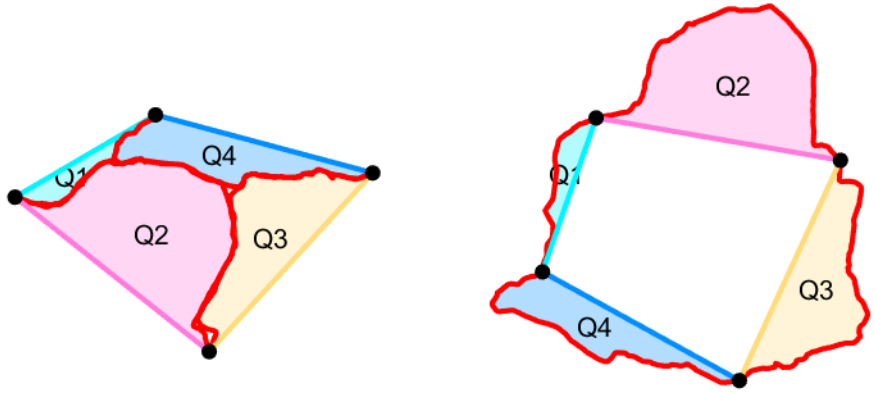
After eliminating overlaps

Iter1: overlap-area:-3.75e-05, gap-area:0.055675

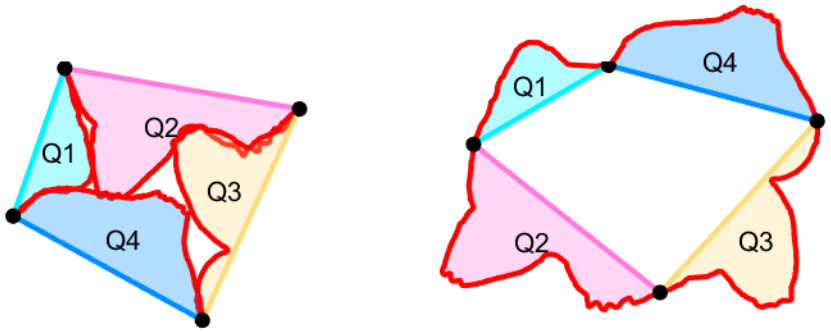


Minimizing gaps – Iter 1

Iter8: overlap-area:0, gap-area:0.007775

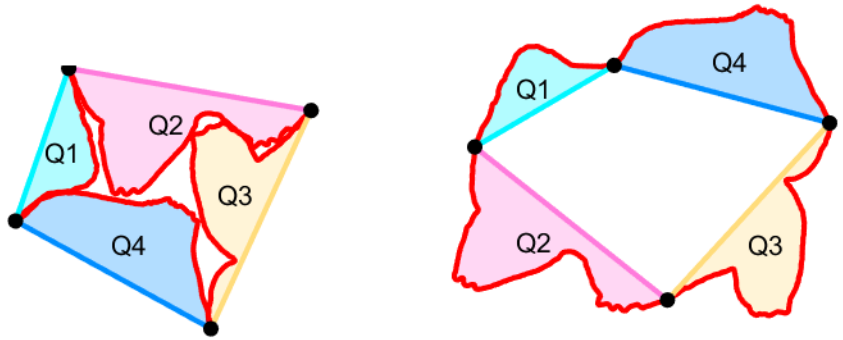


Minimizing gaps – Iter 8



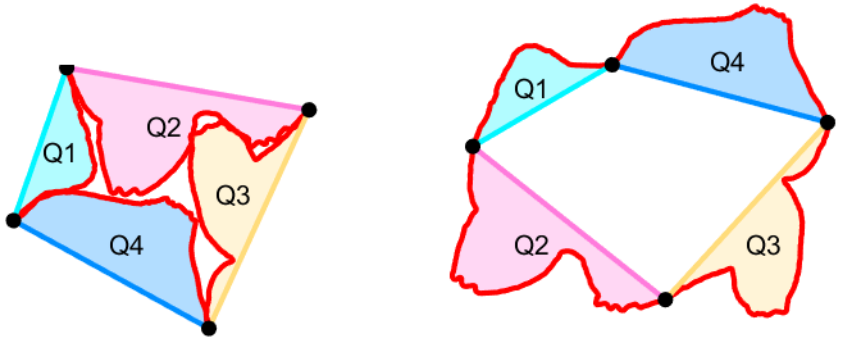
Original Q

Iter4: overlap-area:-1.25e-05, gap-area:0.07385



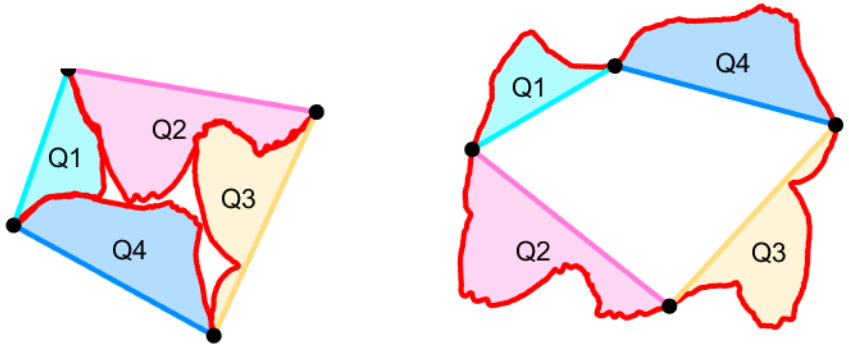
After eliminating overlaps

Iter1: overlap-area:-0.0001625, gap-area:0.0666

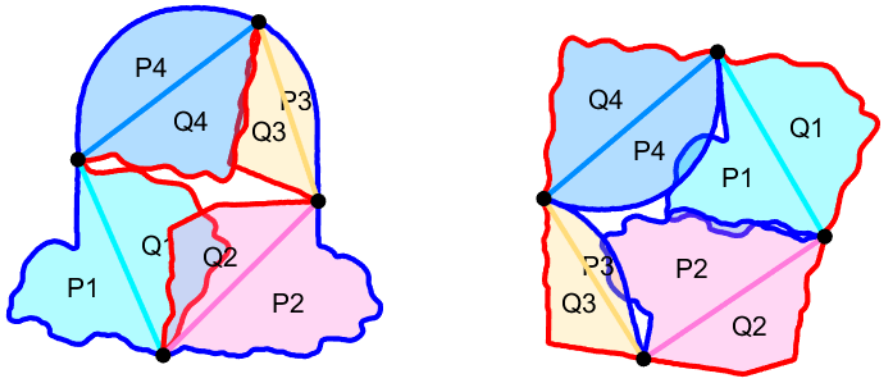


Minimizing gaps – Iter 1

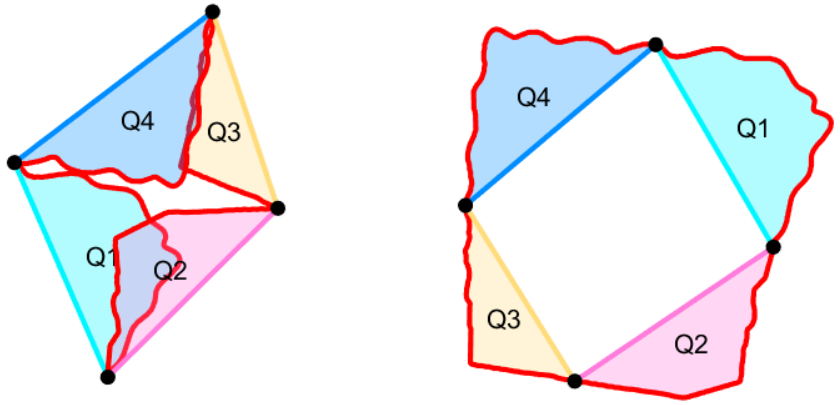
Iter12: overlap-area:-2.5e-05, gap-area:0.0463



Minimizing gaps – Iter 12

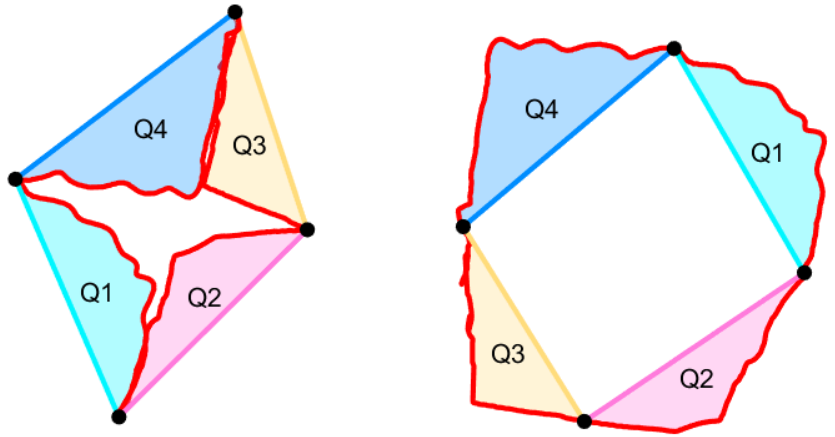


RIOT 3



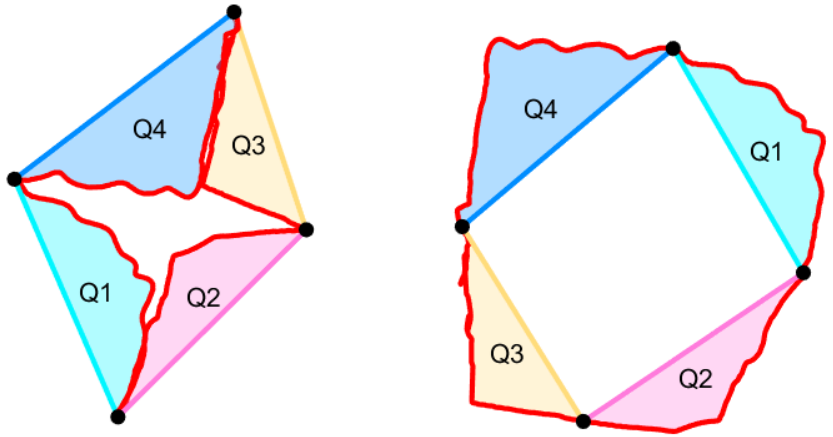
Original P

Iter5: overlap-area:-1.25e-05, gap-area:0.1064



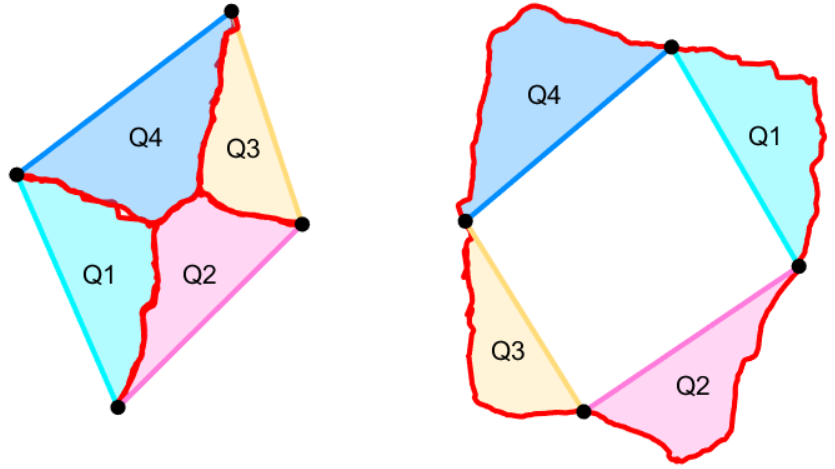
After eliminating overlaps

Iter1: overlap-area:-1.25e-05, gap-area:0.1052

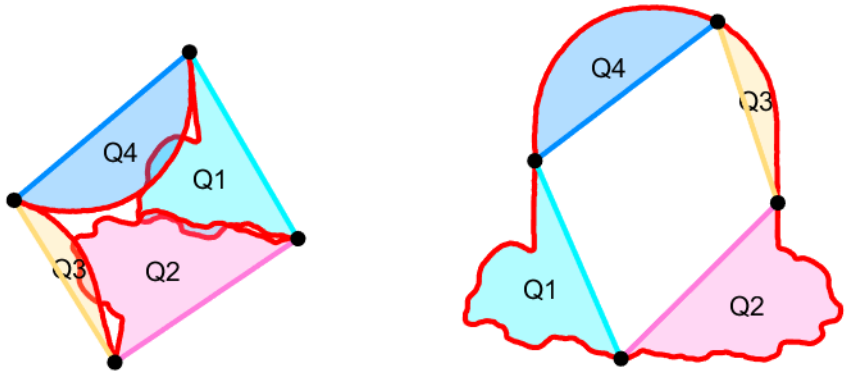


Minimizing gaps – Iter 1

Iter12: overlap-area:0, gap-area:0.0056375

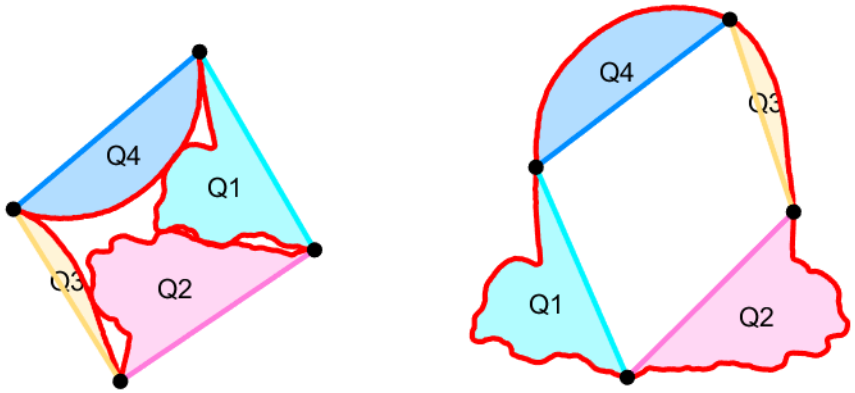


Minimizing gaps – Iter 12



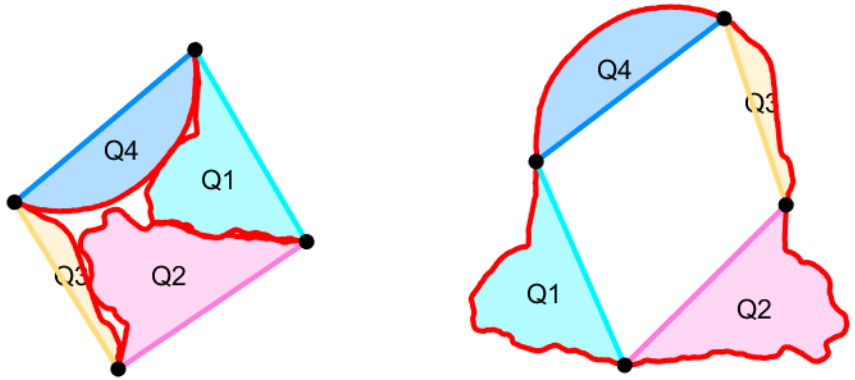
Original Q

Iter3: overlap-area:-0.000125, gap-area:0.076262



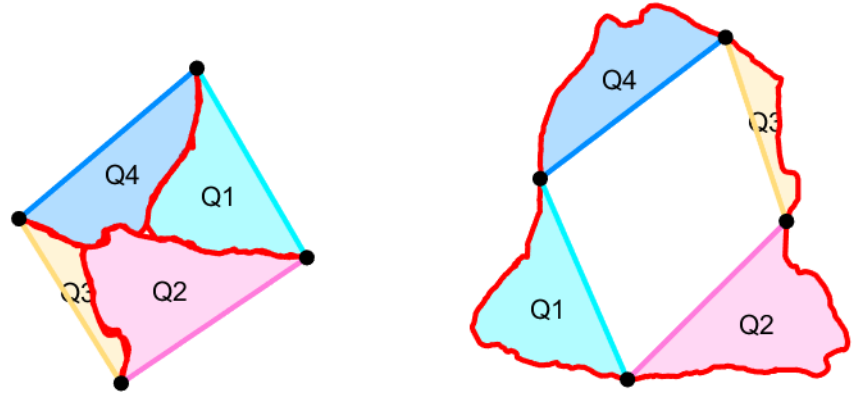
After eliminating overlaps

Iter1: overlap-area:-0.00015, gap-area:0.044737

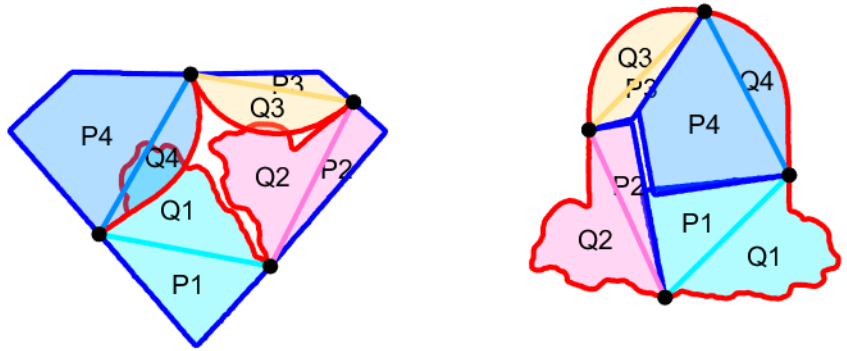


Minimizing gaps – Iter 1

Iter12: overlap-area:-1.25e-05, gap-area:0.0071

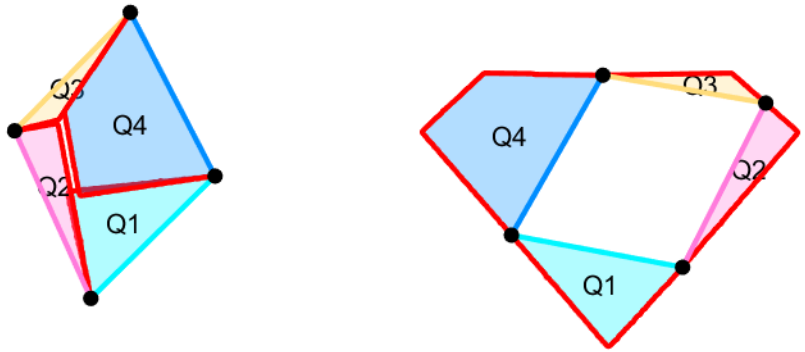


Minimizing gaps – Iter 12



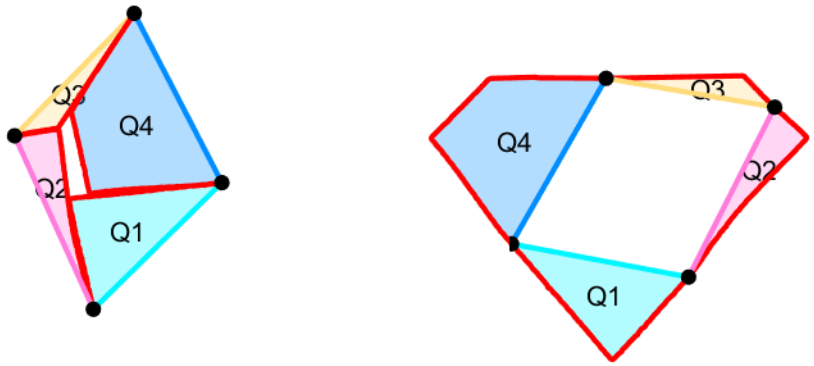
RIOT 4

To Do: In the case that boundary curves are straight lines, the curve deformation cannot handle it well, maybe we should take it as a special case to solve, such as vertices merge.



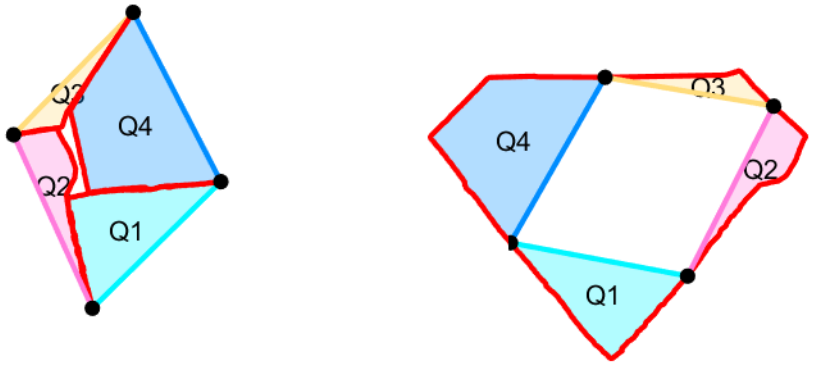
Original Q

Iter6: overlap-area:-8.75e-05, gap-area:0.0321



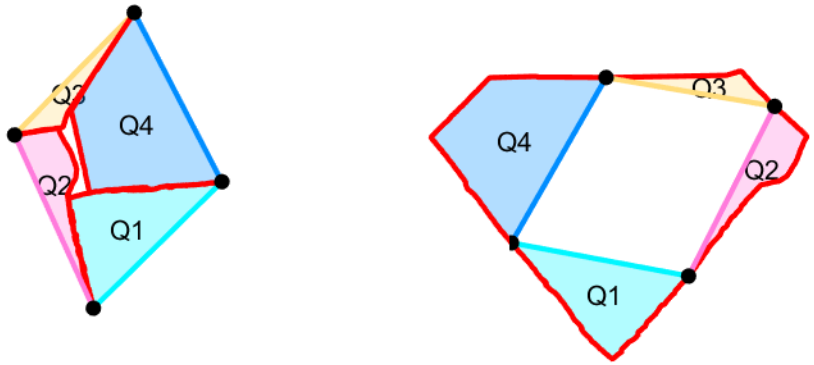
After eliminating overlaps

Iter1: overlap-area:-5e-05, gap-area:0.020025

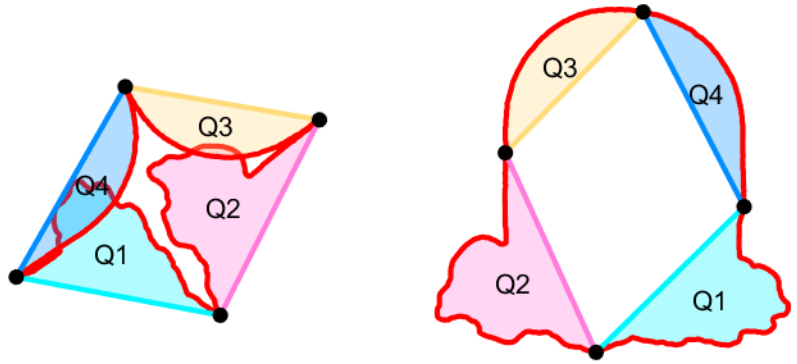


Minimizing gaps – Iter 1

Iter2: overlap-area:5.5511e-17, gap-area:0.019

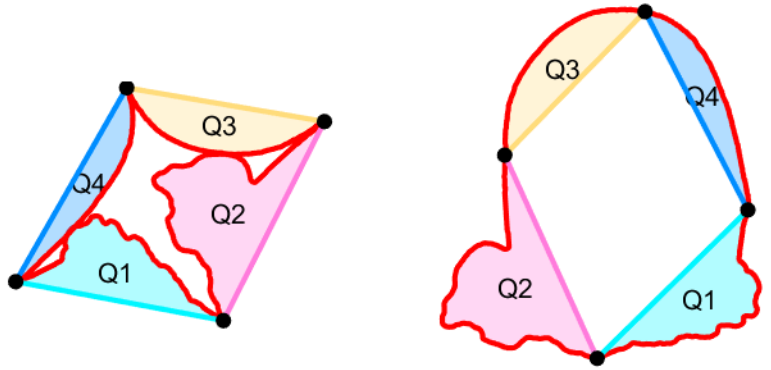


Minimizing gaps – Iter 2



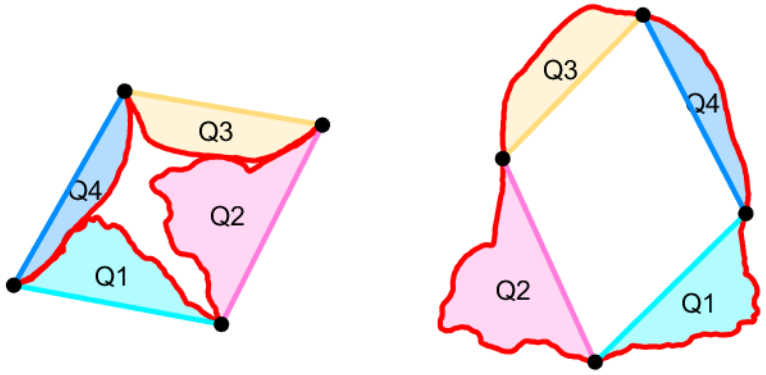
Original P

Iter3: overlap-area:-5e-05, gap-area:0.12286



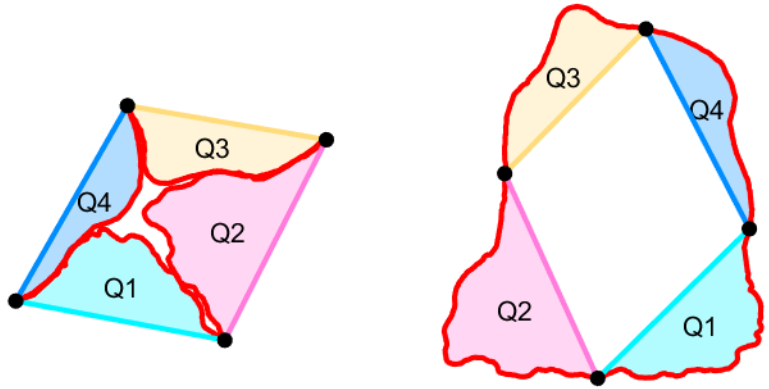
After eliminating overlaps

Iter1: overlap-area:-0.0001625, gap-area:0.1019

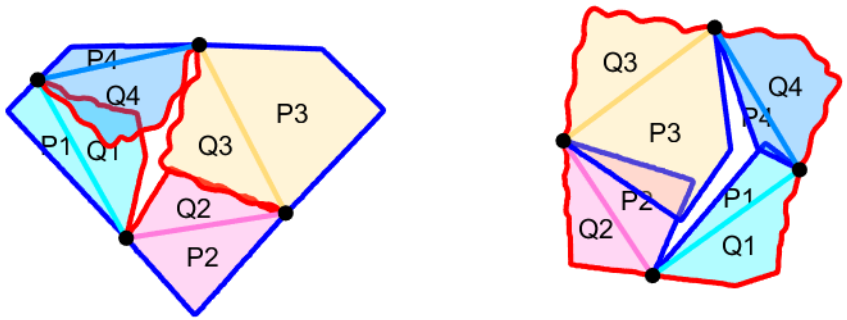


Minimizing gaps – Iter 1

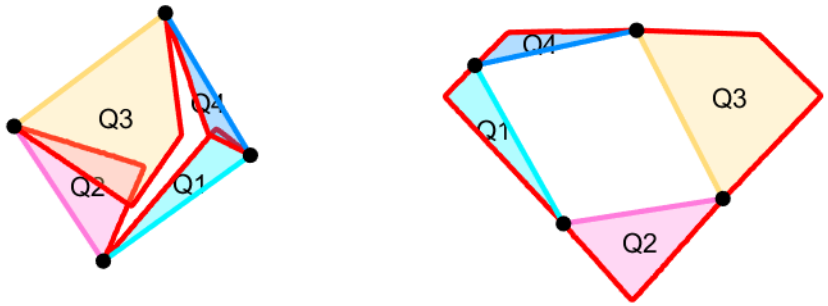
Iter12: overlap-area:-1.25e-05, gap-area:0.041925



Minimizing gaps – Iter 12

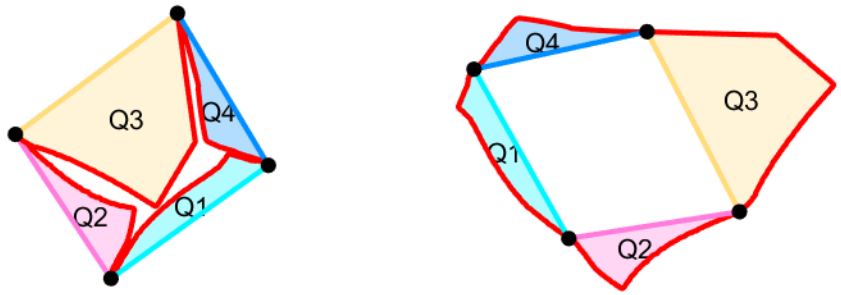


RIOT 5



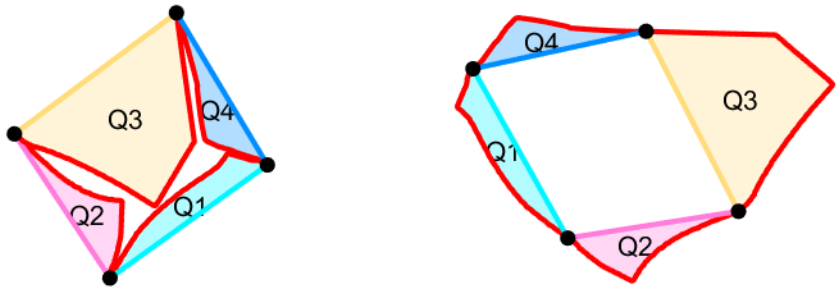
Original Q

Iter2: overlap-area:-3.75e-05, gap-area:0.0864



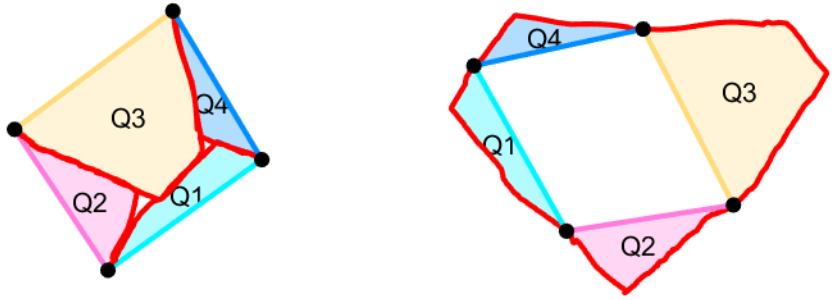
After eliminating overlaps

Iter1: overlap-area:-2.5e-05, gap-area:0.09238

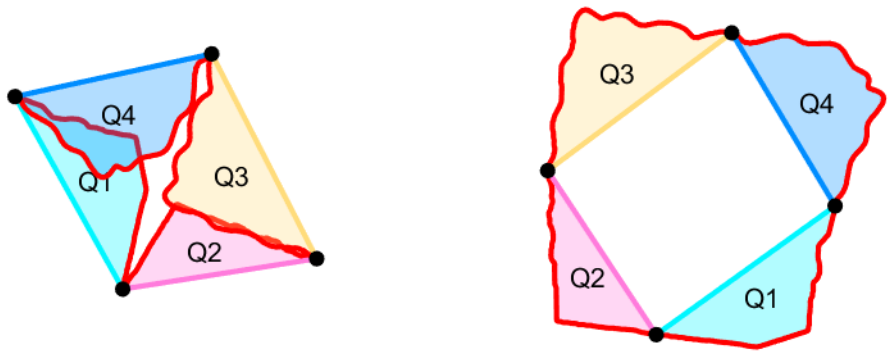


Minimizing gaps – Iter 1

Iter12: overlap-area:-0.0001375, gap-area:0.0

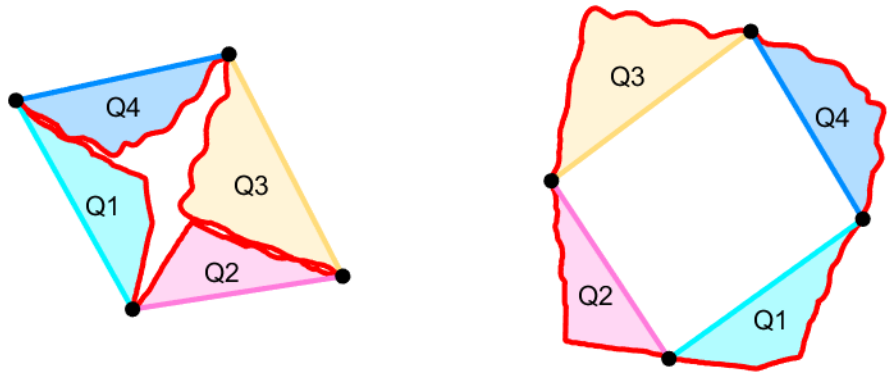


Minimizing gaps – Iter 5



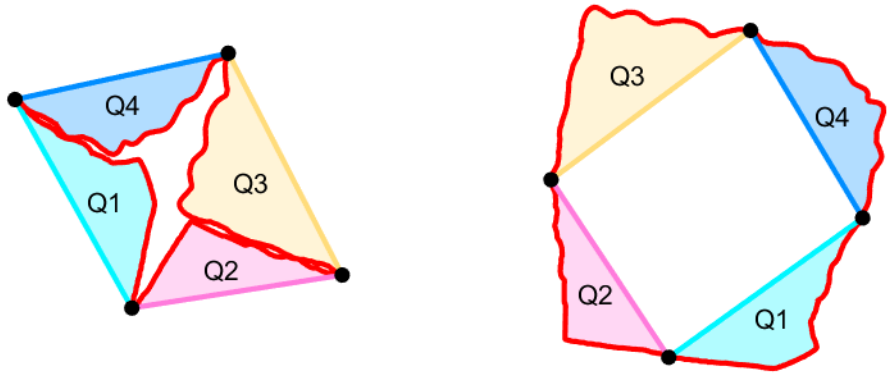
Original P

Iter4: overlap-area:-7.5e-05, gap-area:0.101



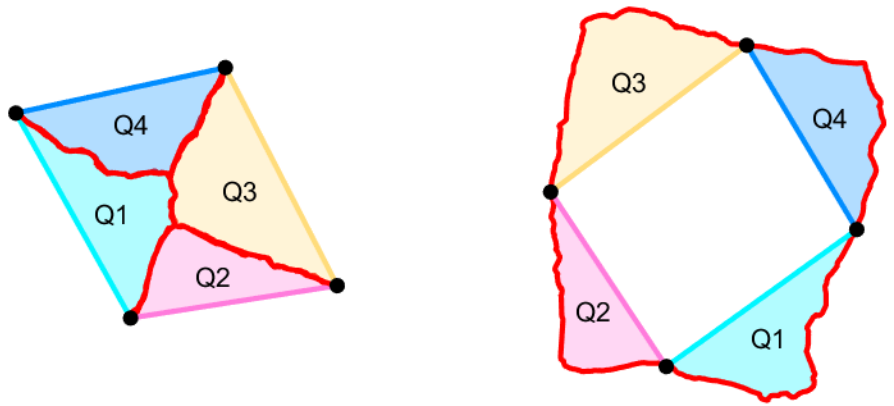
After eliminating overlaps

Iter1: overlap-area:-7.5e-05, gap-area:0.0961



Minimizing gaps – Iter 1

Iter12: overlap-area:-1.25e-05, gap-area:0.00473



Minimizing gaps – Iter 12