Visualizing Dynamic Clustered Data Using Area-proportional Maps

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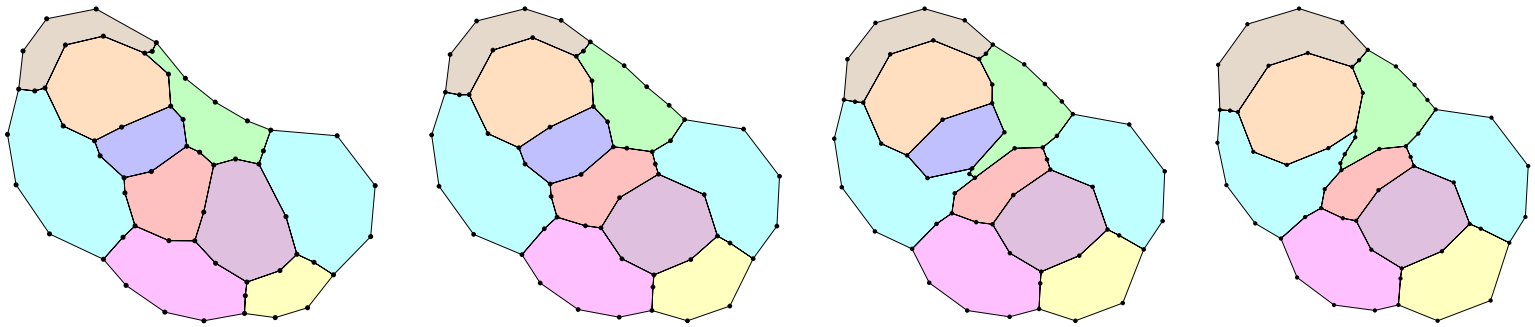
Agenda

- Introduction
  - Problem Statement
  - Motivation
- Visualizing Static Input Graphs
- Visualizing Dynamic Input Graphs
- Evaluation

Problem Statement

- Visualize clustered graph as a map
  - Each country represents a cluster in the original graph
  - Countries have area close to proportional to cluster size
  - Dynamic setting: input graph changes over time $\rightarrow$ map needs to adapt



Motivation

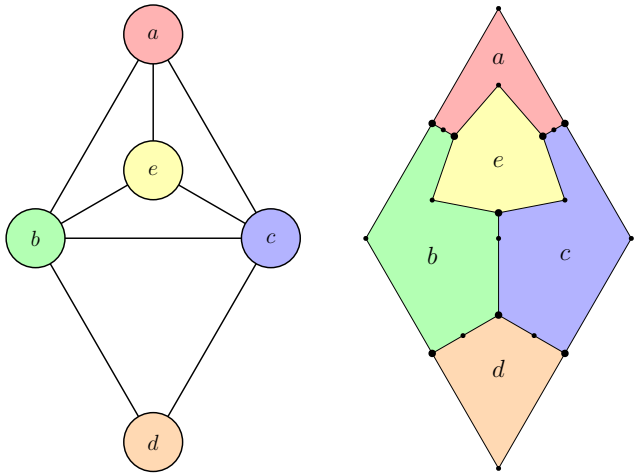
- Clustered data appears naturally
- Map metaphor helps us make sense of data
- Dynamic data appears naturally: preserving mental map is crucial
- Area is a strong visual variable

Agenda

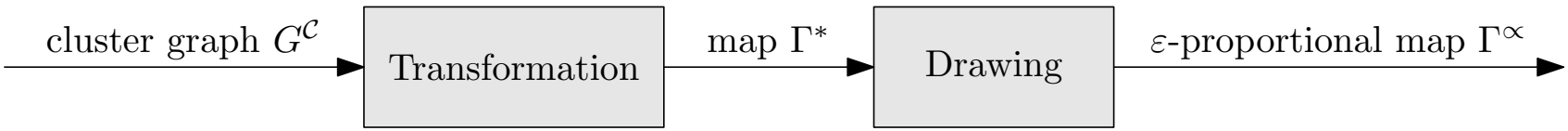
- Introduction
- Visualizing Static Input Graphs
  - Definitions
  - Algorithmic Pipeline
  - Transformation to Dual
  - Drawing the Polygonal Dual
- Visualizing Dynamic Input Graphs
- Evaluation

Definitions

- Polygonal contact representation
  - Contact representation in which all regions are simple polygons
  - No holes
  - No duplicate adjacencies
- Polygonal dual of graph G
  - Polygonal contact representation of G



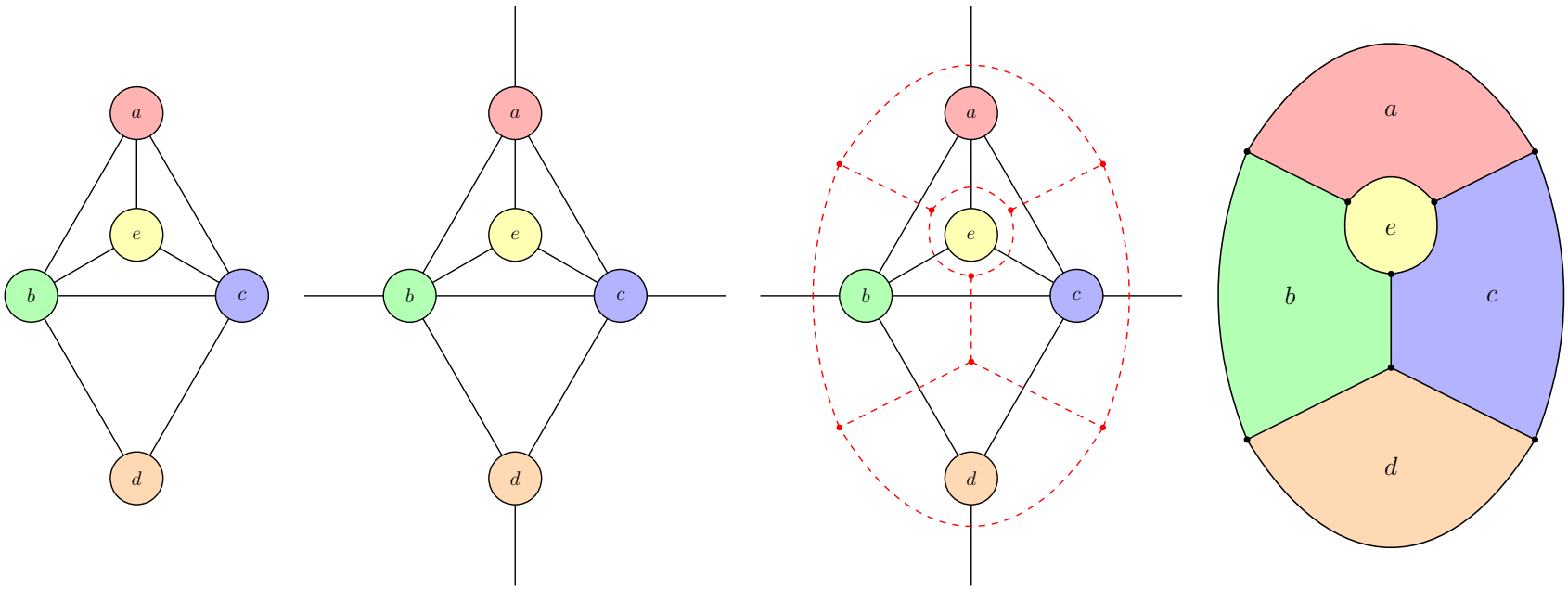
Algorithmic Pipeline



Transformation to Dual

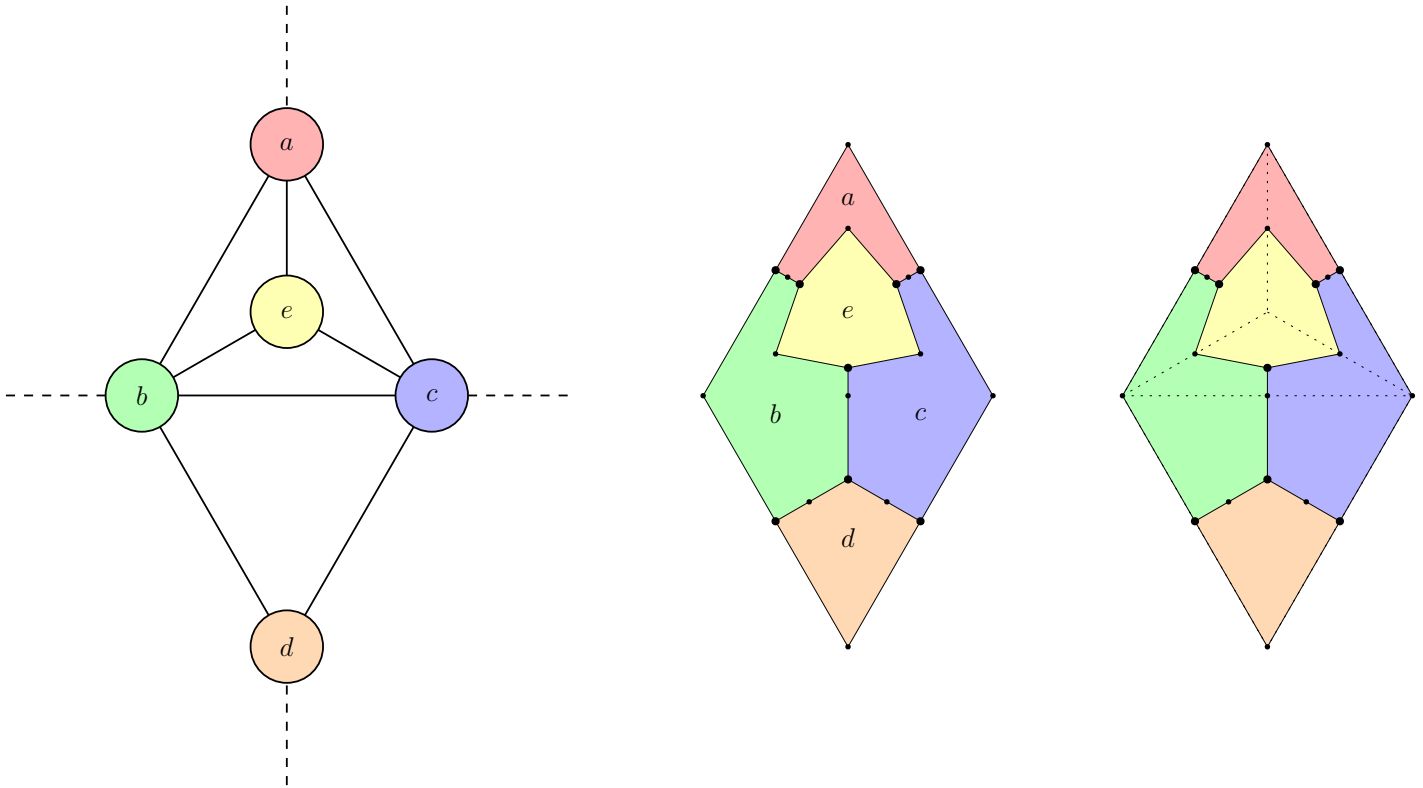
Definition: Augmented Dual G^+

1. Add helper vertex in outer face and connect to all vertices on outer face
2. Form "normal" dual



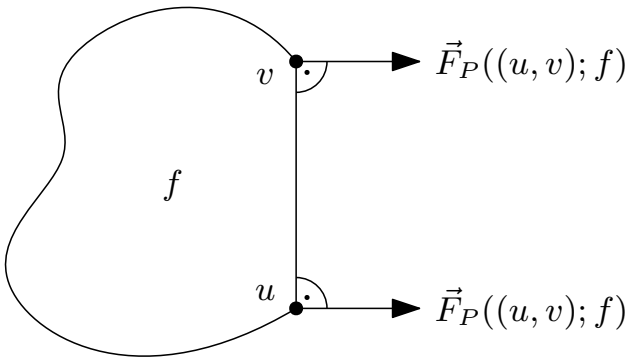
Transformation to Dual

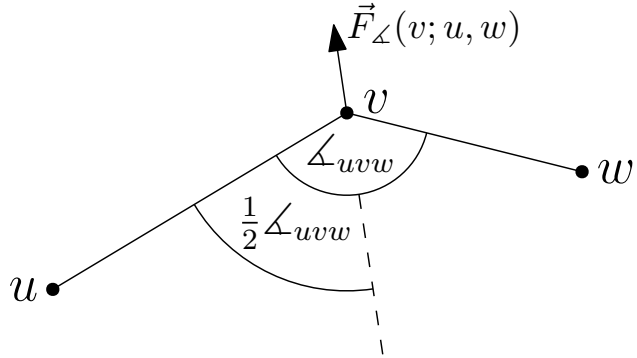
Construction



Drawing the Polygonal Dual

- Force-directed graph drawing
  - Air pressure
  - Angular resolution
  - Vertex-vertex repulsion
  - Vertex-edge repulsion
- Preserve edge crossing and combinatorial properties: ImPrEd (Simonetto et al.)

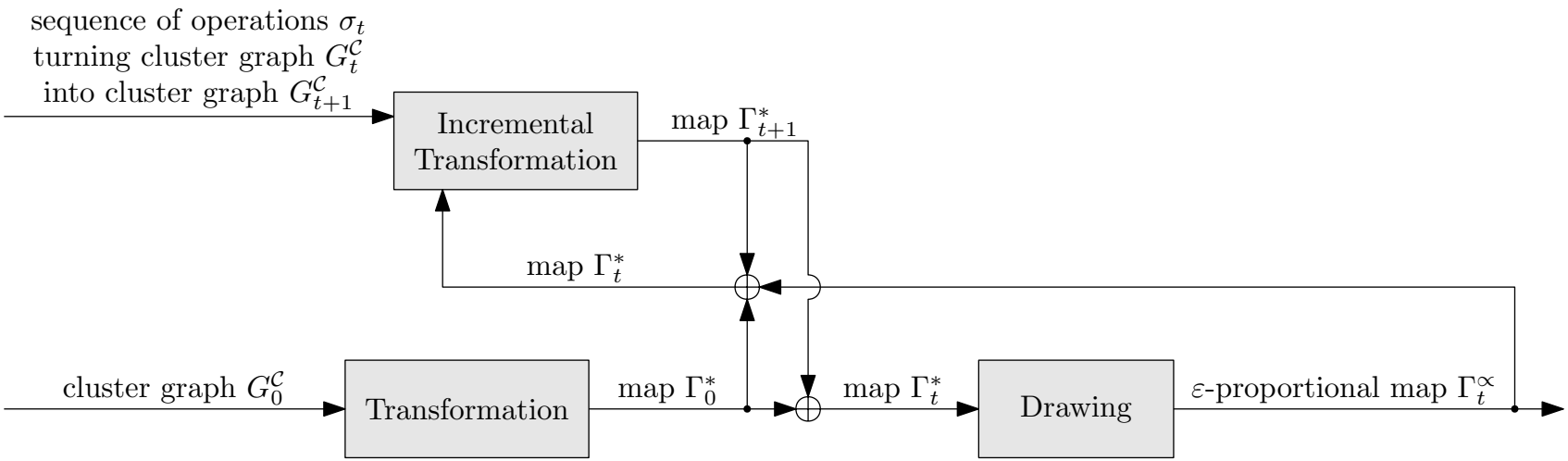




Agenda

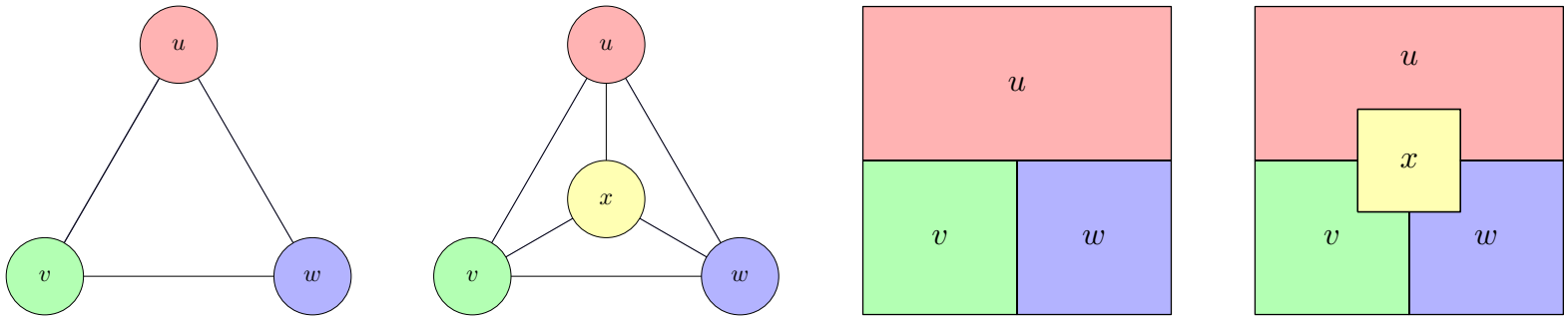
- Introduction
- Visualizing Static Input Graphs
- Visualizing Dynamic Input Graphs
  - Algorithmic Pipeline
  - Incremental Transformation
    - Weight Changes
    - Inserting Vertices
    - Removing Vertices
    - Flipping Edges
- Evaluation

Algorithmic Pipeline



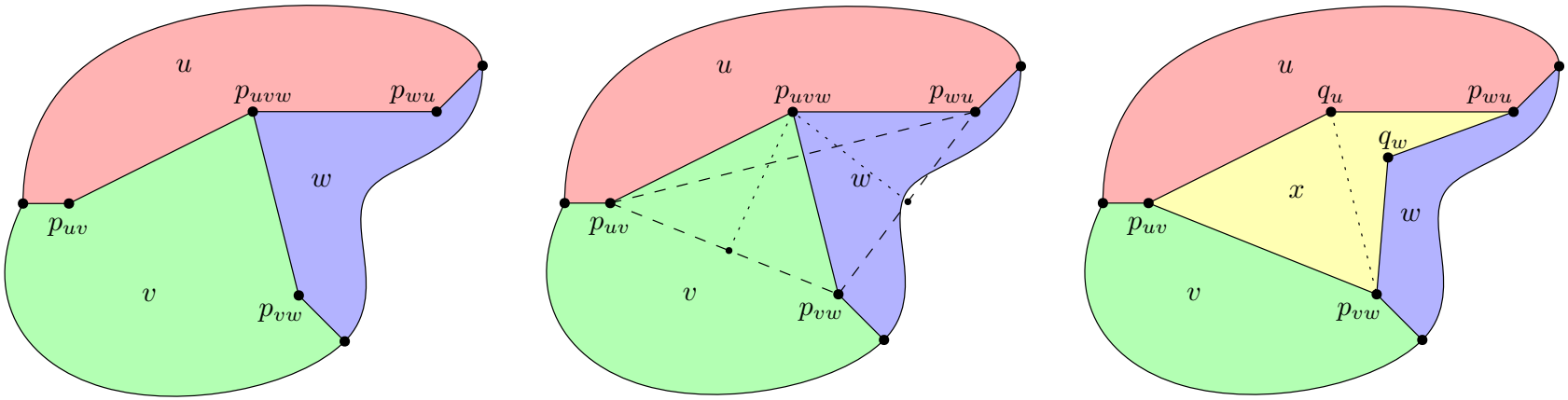
Incremental Transformation
Inserting Vertices

- Internal faces in primal are triangles
- No preconditions
- Idea: insert new face in dual at point where three existing faces meet



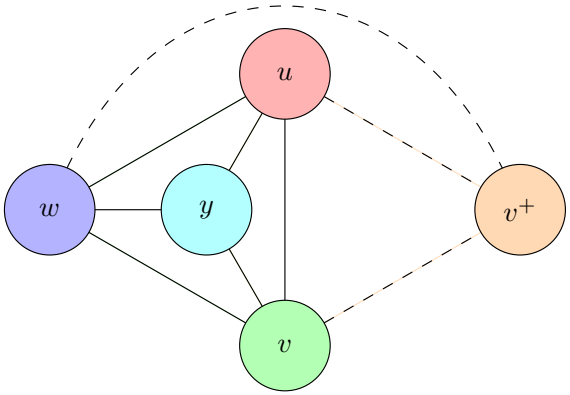
Incremental Transformation

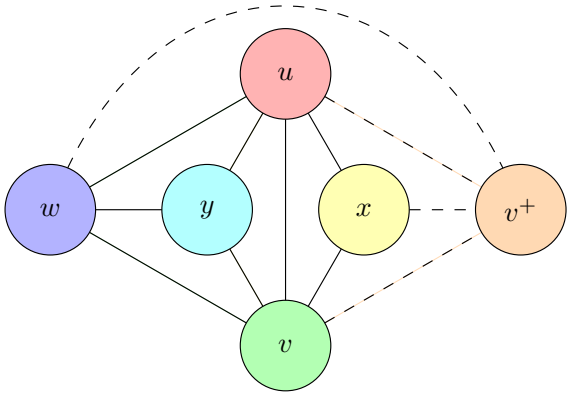
Inserting Vertices — Construction

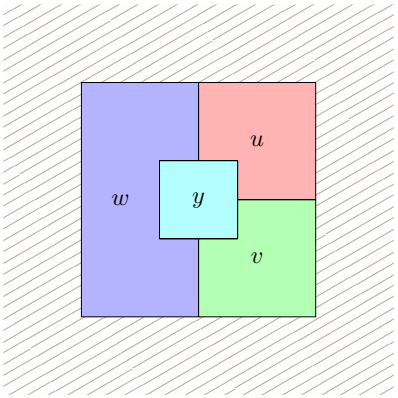


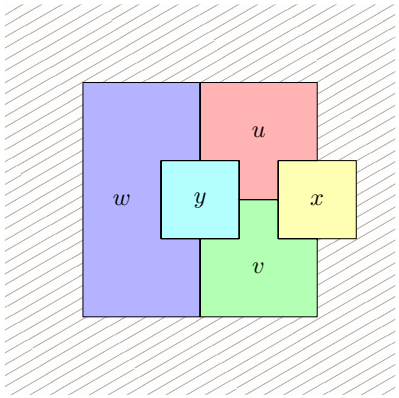
Incremental Transformation

Inserting Vertices — Implicit Outer Face



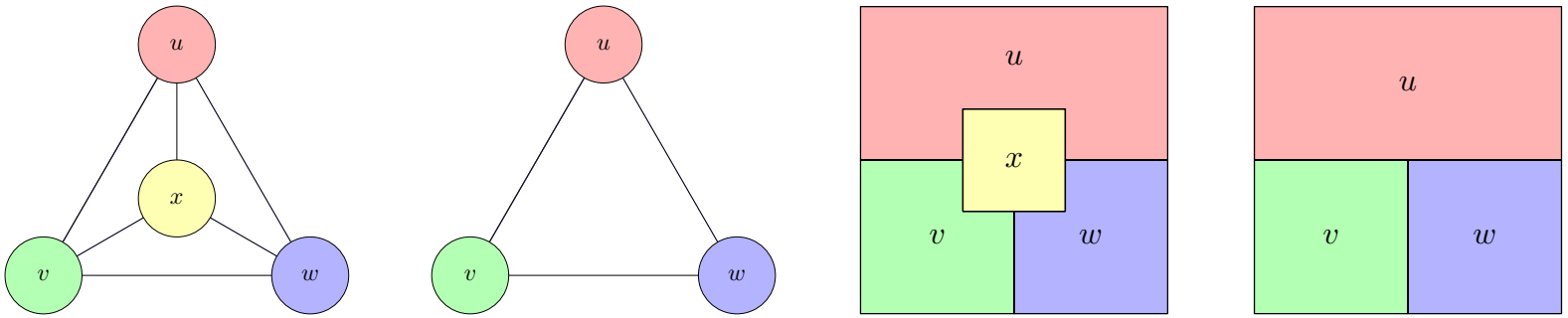






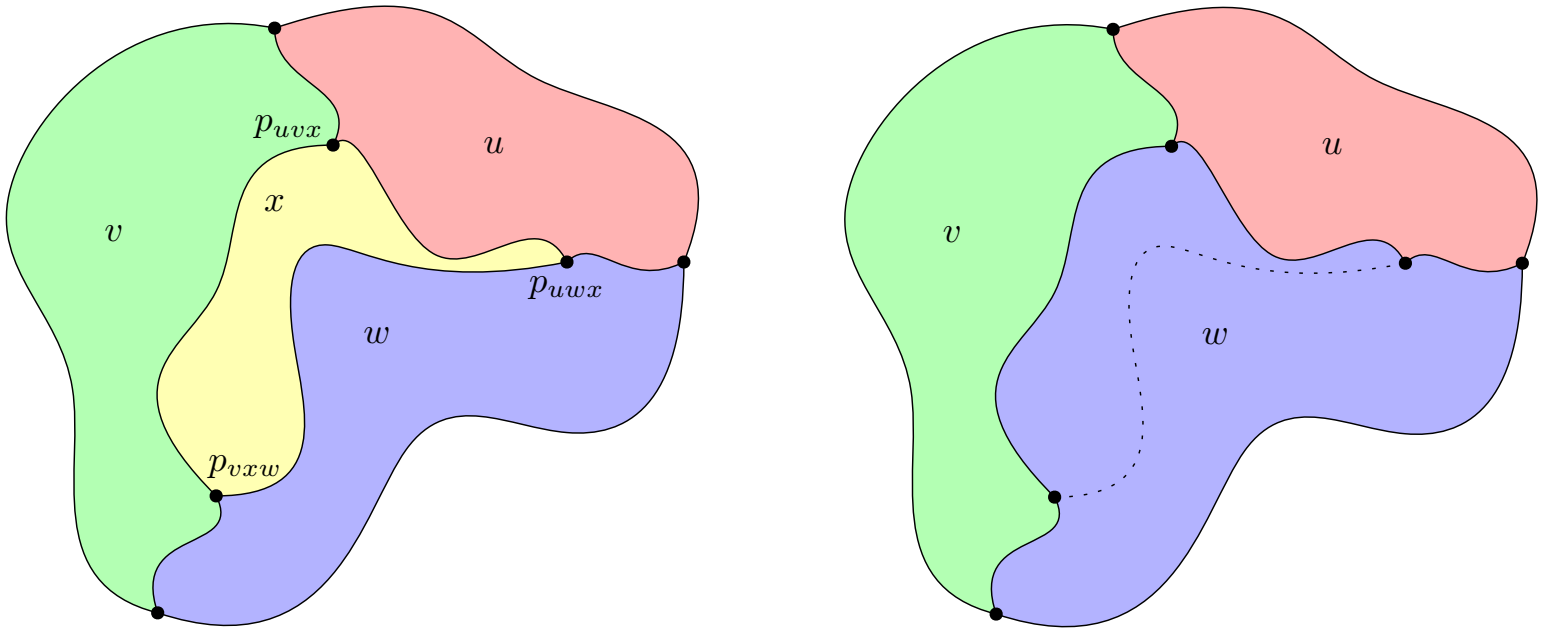
Incremental Transformation
Removing Vertices

- Primal must remain internally triangulated
- Vertex to be removed must have degree 3
- Idea: remove boundary with one adjacent region



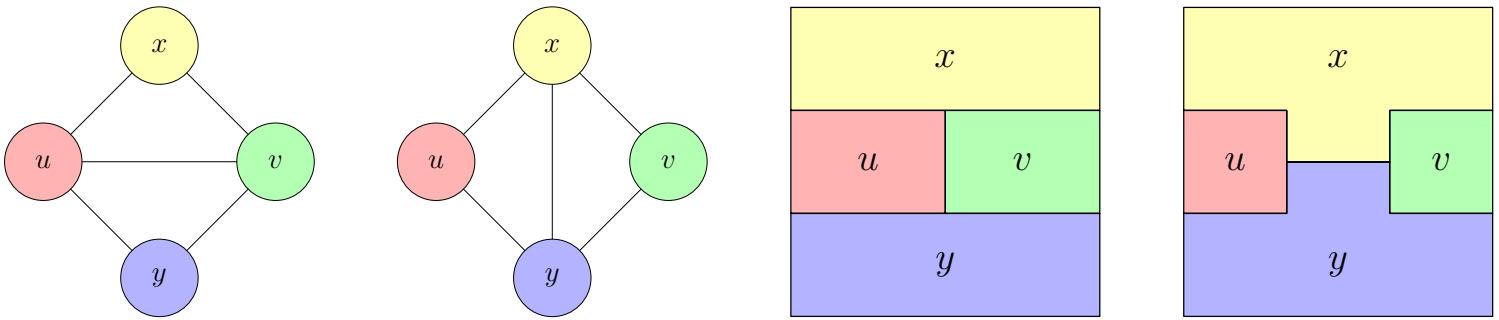
Incremental Transformation

Removing Vertices — Construction



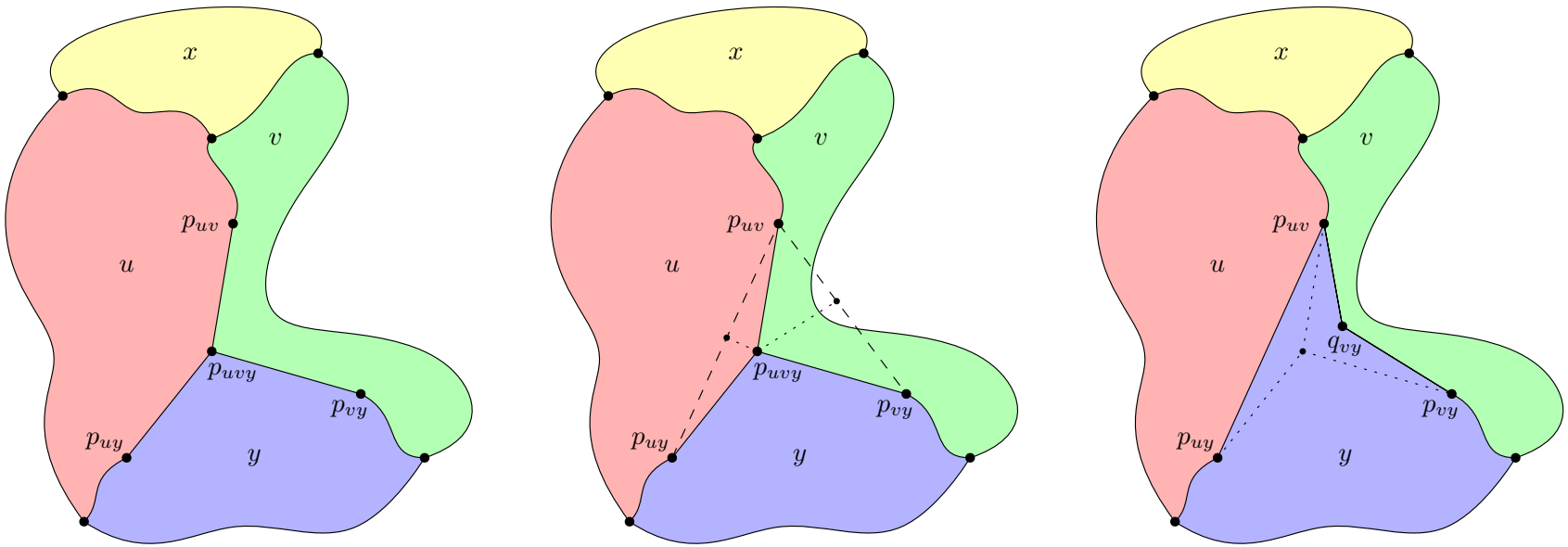
Incremental Transformation
Flipping Edges

- Internal edge is incident to two triangular faces
- Edge can only be flipped if vertices on either side aren't already adjacent
- Idea
  - Contact boundary to be removed into single point
  - Create boundary in opposing direction



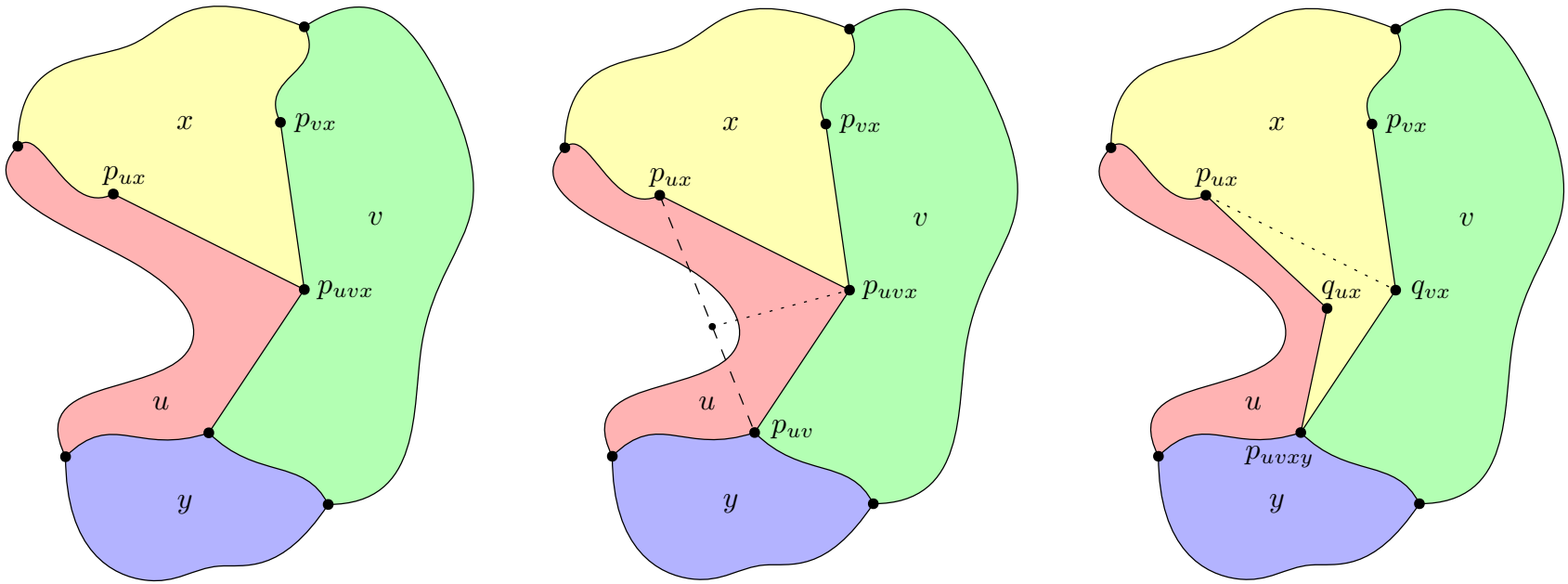
Incremental Transformation

Flipping Edges — Construction — Contract u-v-Boundary



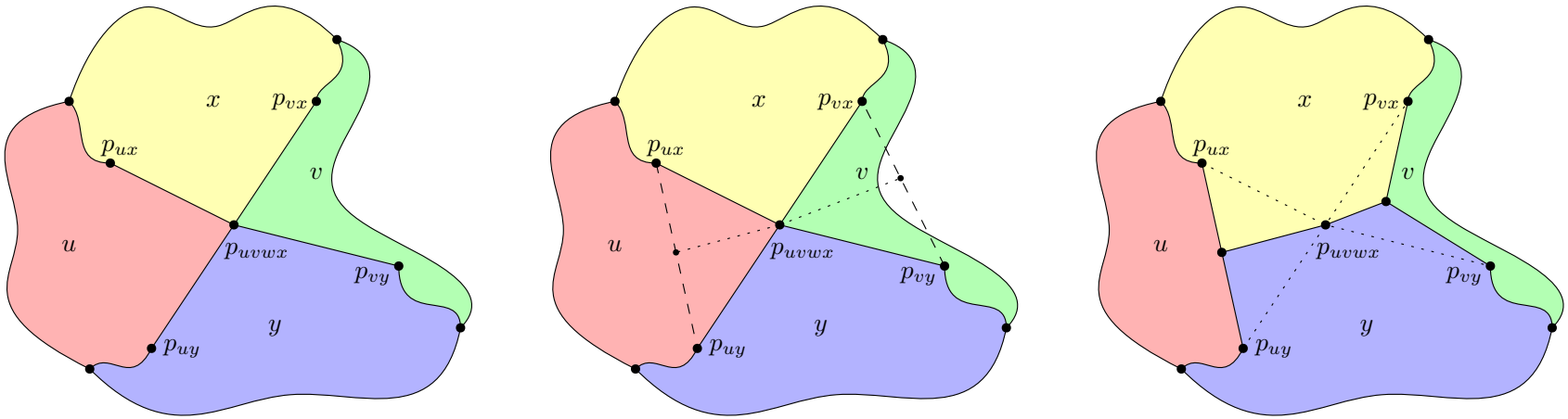
Incremental Transformation

Flipping Edges — Construction — Contract u-v-Boundary



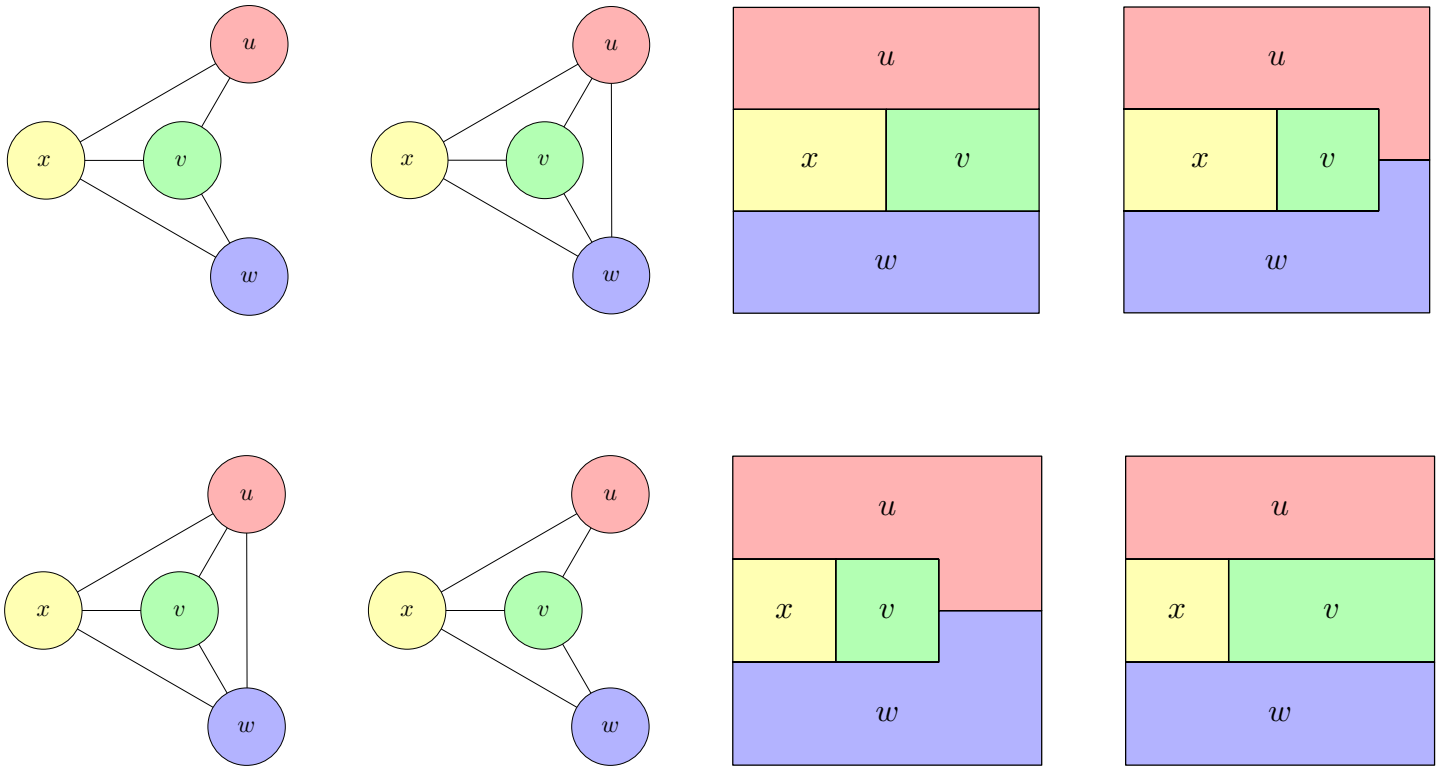
Incremental Transformation

Flipping Edges — Construction — Create x-y-Boundary



Incremental Transformation

Flipping Edges — Inserting and Removing Edges



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- Introduction
- Visualizing Static Input Graphs
- Visualizing Dynamic Input Graphs
- Evaluation
  - Research Questions
  - Quality Metrics
  - Evaluation Results
  - Examples

Research Questions

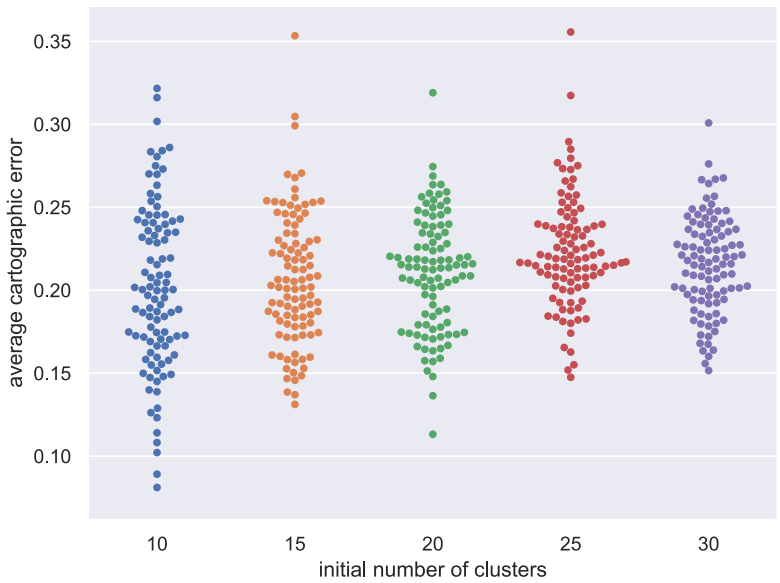
1. Which quantitative measures best capture the quality of the maps generated by our algorithm in terms of
   - accuracy?
   - our understanding of locally fat regions?
2. What is the quality of the maps generated by our algorithm according to these quality metrics?
   - How does this quality change based on the size and other properties of the input graph?
   - How does this quality change over time as dynamic updates are incorporated?

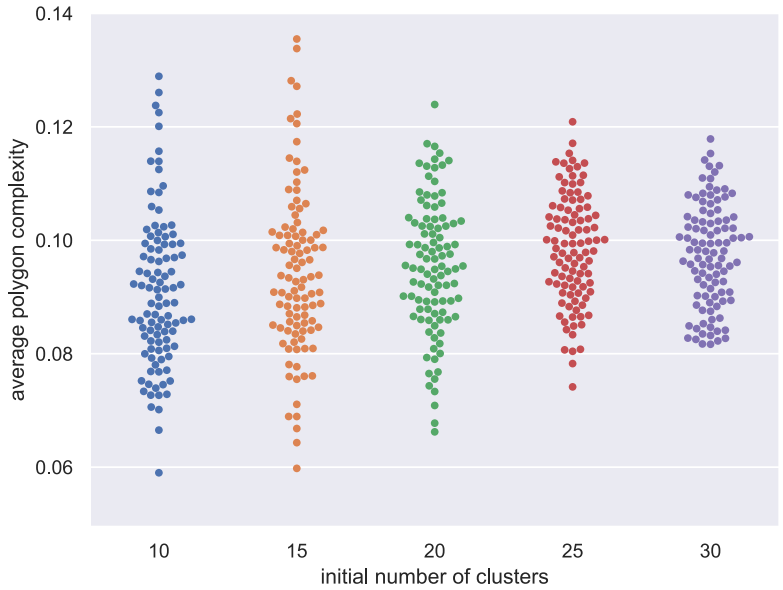
Quality Metrics

- Cartographic error
  - How much do the actual region areas differ from the prescribed ones?
- Polygon complexity
  - How convex is the polygon?
  - What's the frequency and amplitude of the "vibration" on the polygon's boundary?

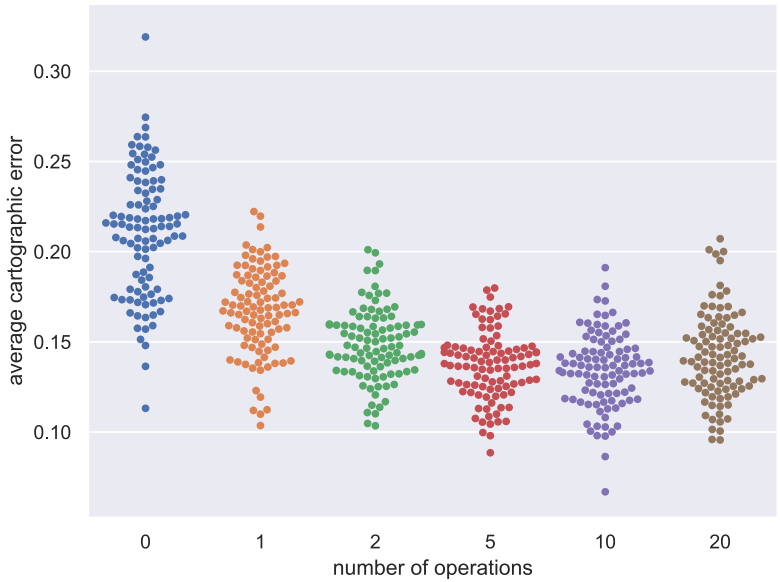
Evaluation Results

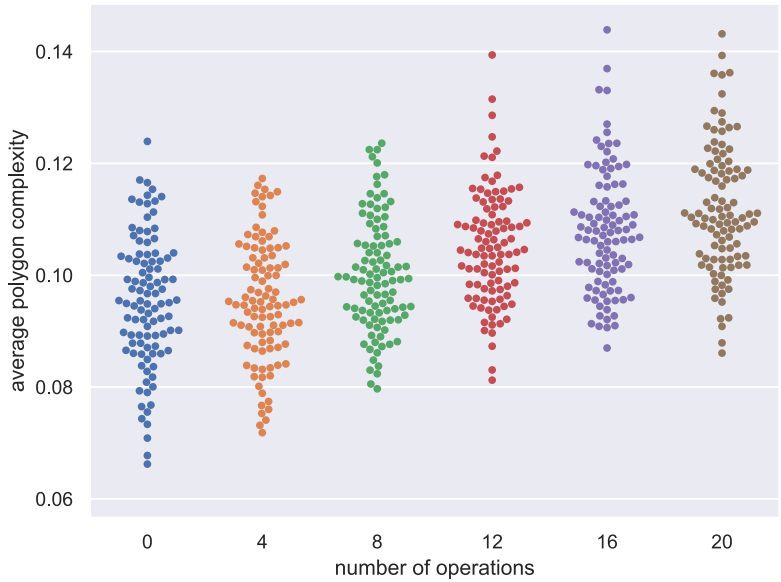
Effect of initial number of clusters





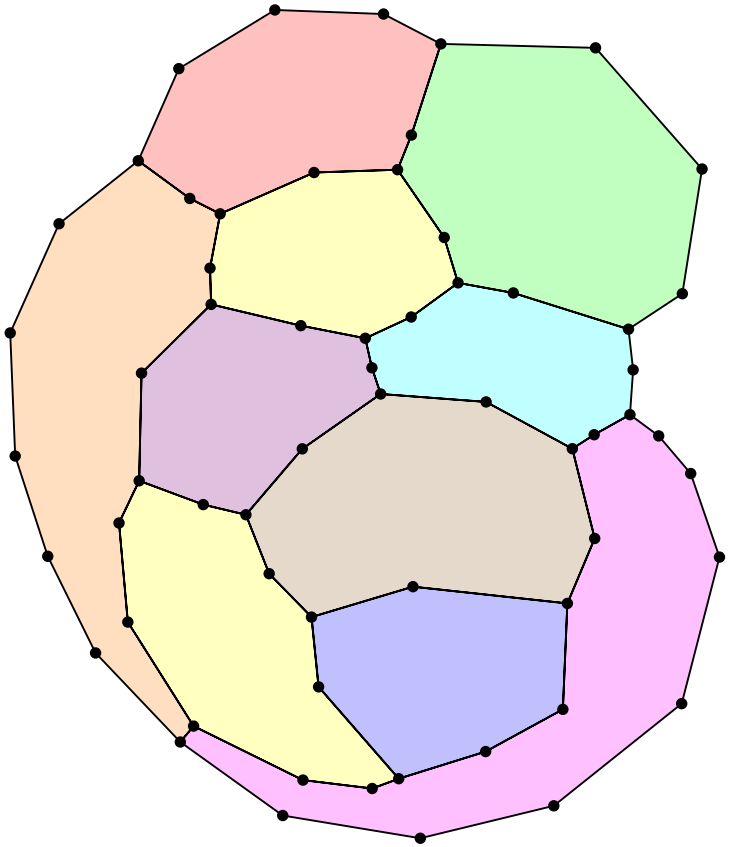
Evaluation Results
Effect of number of operations

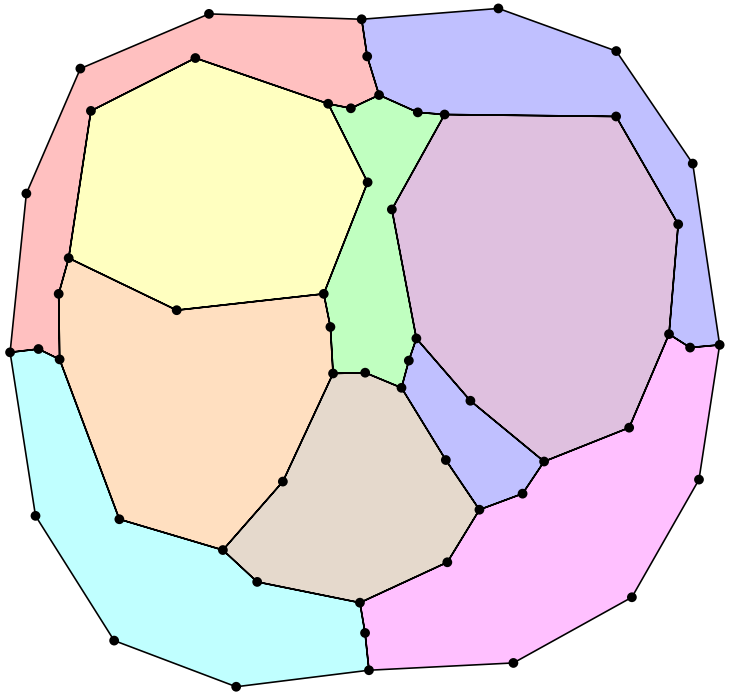




Examples

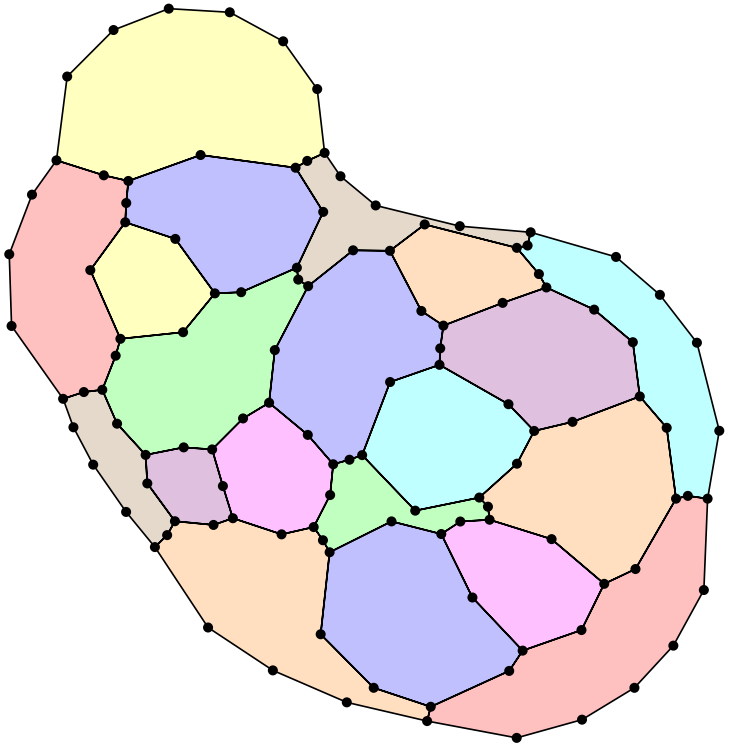
Maps with $n = 10$

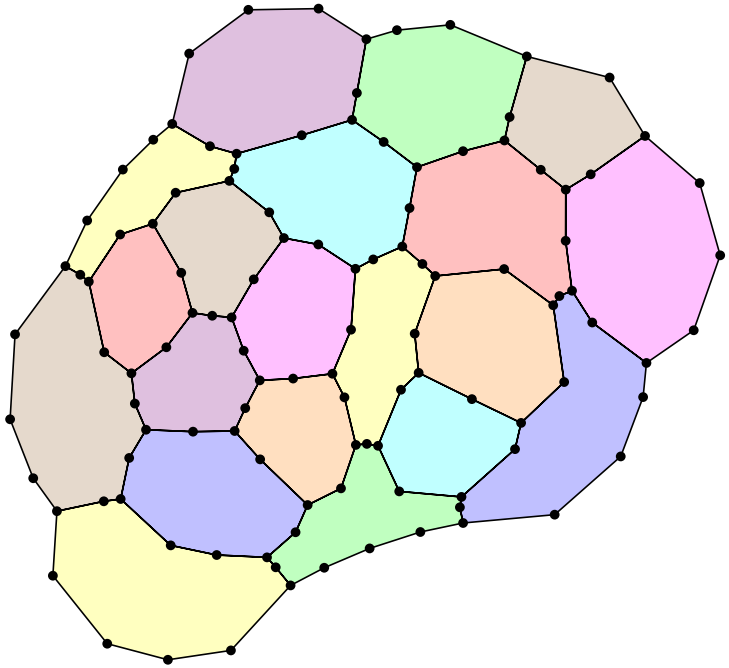




Examples

Maps with $n = 20$





Examples

Maps with $n = 30$