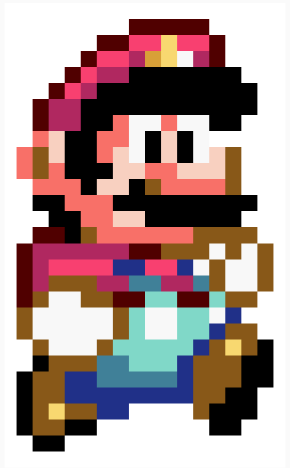
Depixelizing

Pixel Art



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Pixel Art

http://www.pixeljoint.com/forum/forum_posts.asp?TID=11299

Use of Pixel Art

- Computer Games
- Advertising
- Icons

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YAHOO! SPORTS
YAHOO! careers.yahoo.com
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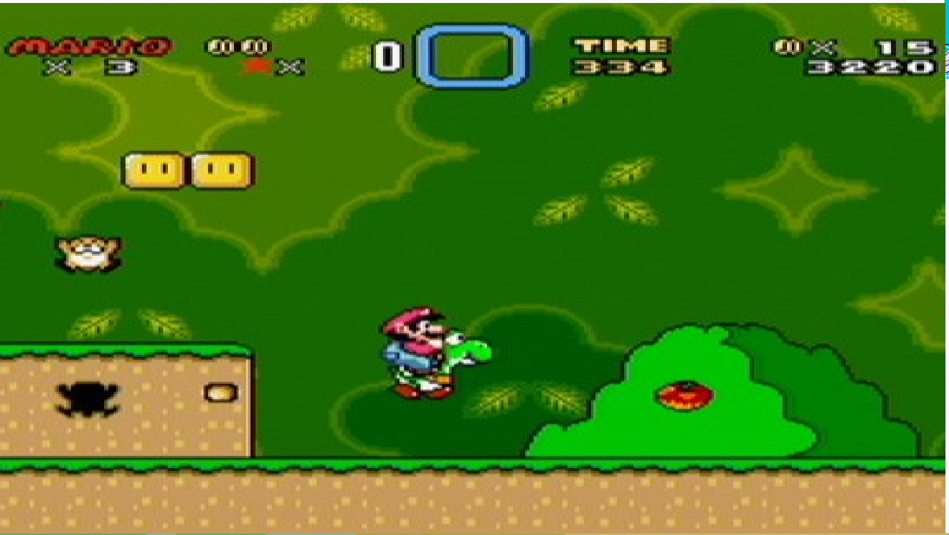
http://www.cuded.com/2012/01/pixel-art-by-eboy/

http://research.microsoft.com/en-us/um/people/kopf/pixelart/supplementary/multi_comparison.html

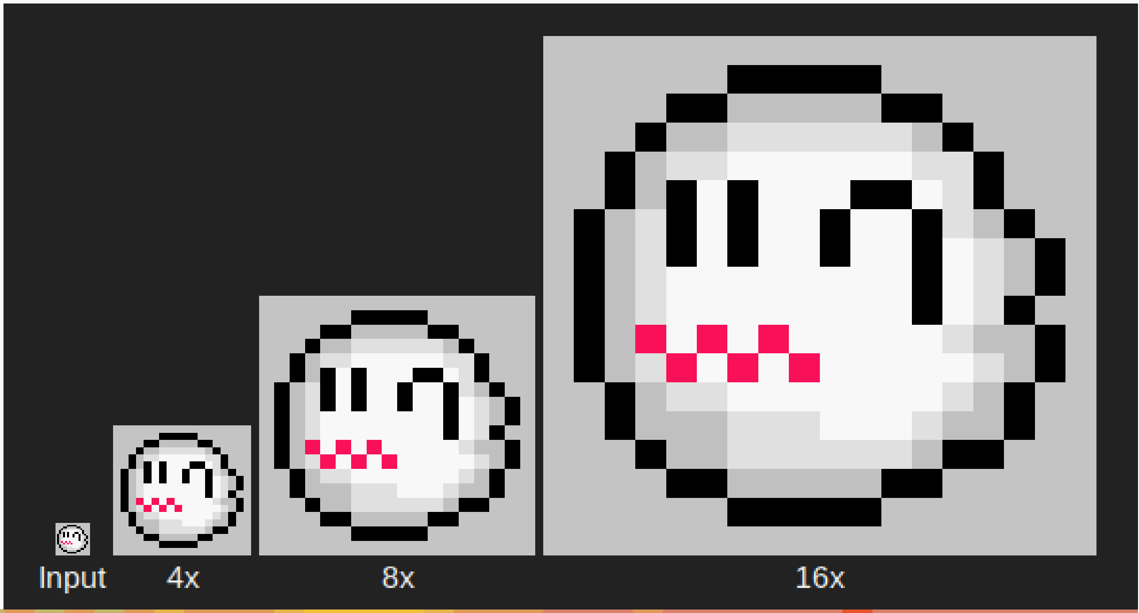


http://www.toy-tma.com/electronic-toys/video-games/10-games-play-thanksgiving/

To Increase Resolution

Upscaling Pixel Art :

- Mostly done by Nearest Neighbour
  - Blocky.

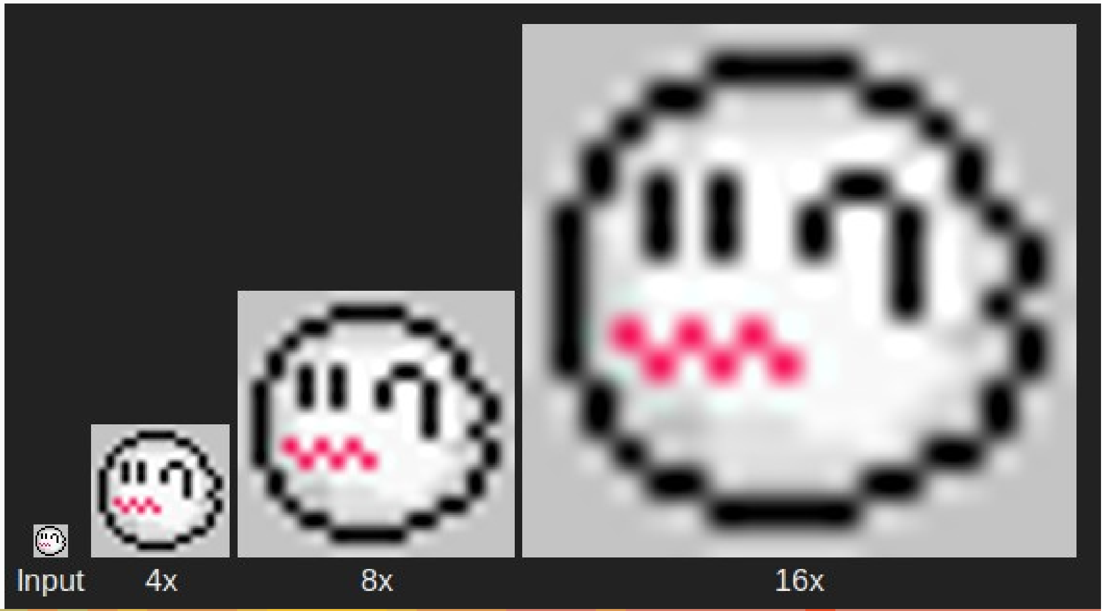


http://research.microsoft.com/en-us/um/people/kopf/pixelart/supplementary/multi_comparison.html

To Increase Resolution

Upscaling Pixel Art :

- Using *Classical* Image filtering techniques
  - Bilinear, Bicubic ... Interpolation
  - Blurring ...

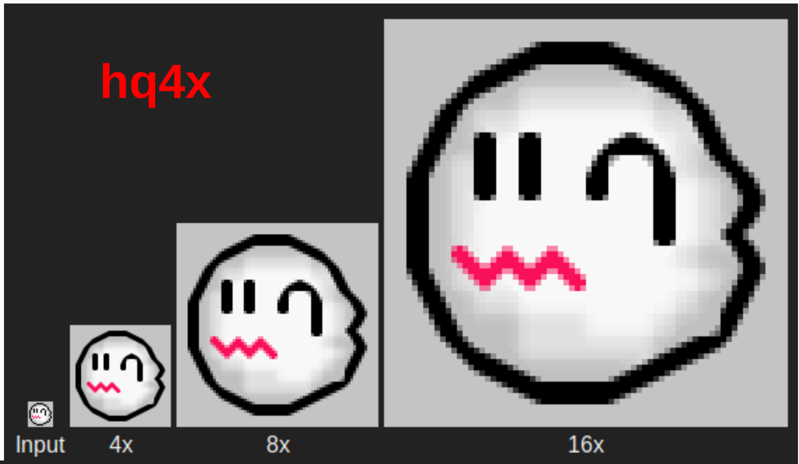


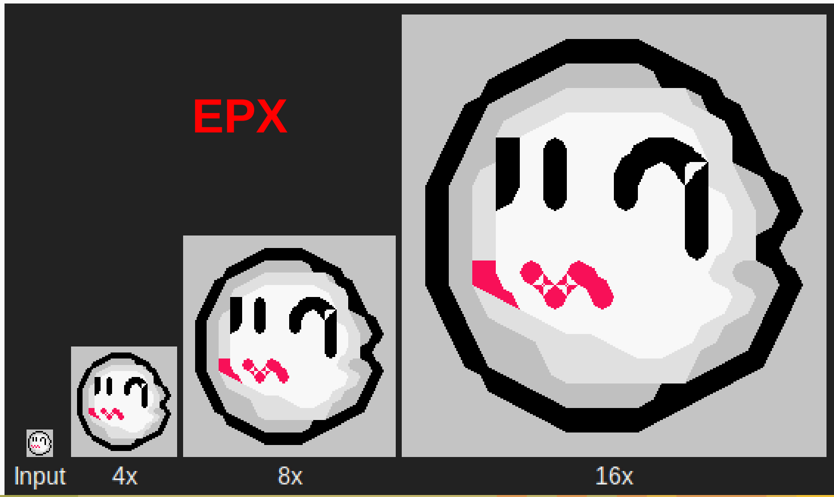
http://research.microsoft.com/en-us/um/people/kopf/pixelart/supplementary/multi_comparison.html

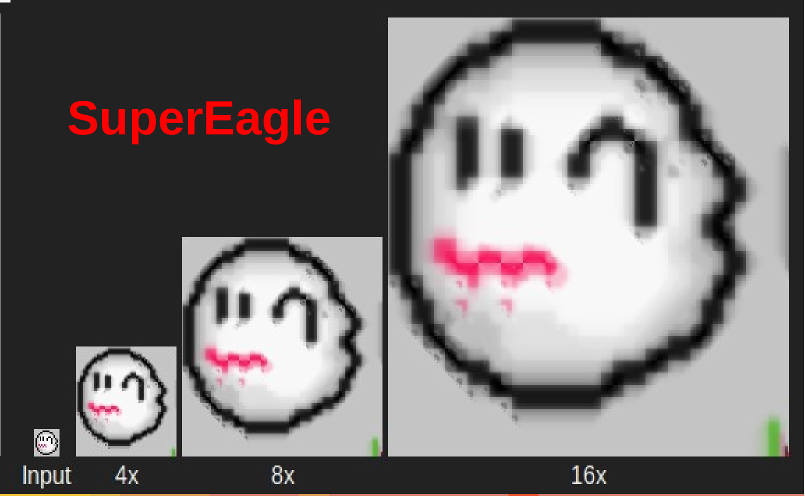
To Increase Resolution

Upscaling Pixel Art :

- Using *Pixel Art upscaling* techniques
  - SuperEagle, EPX, hqx family..
  - Good result upto a certain limit







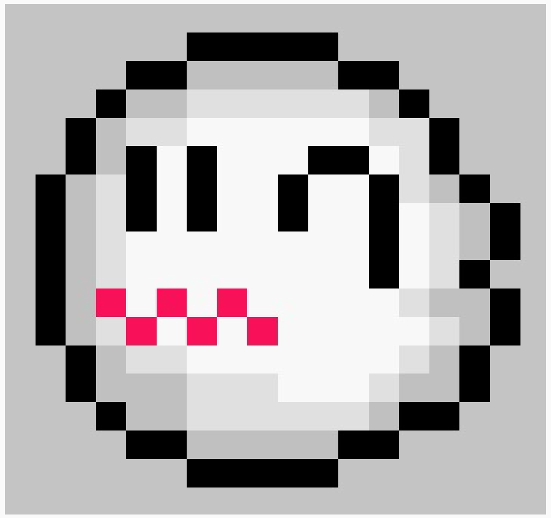
http://research.microsoft.com/en-us/um/people/kopf/pixelart/supplementary/multi_comparison.html

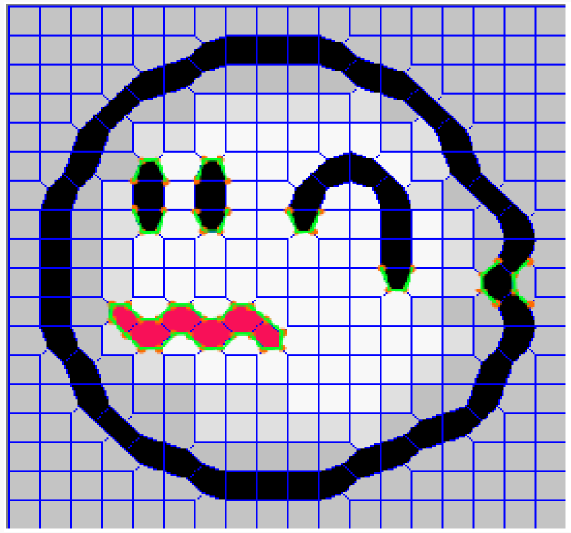
To Increase Resolution

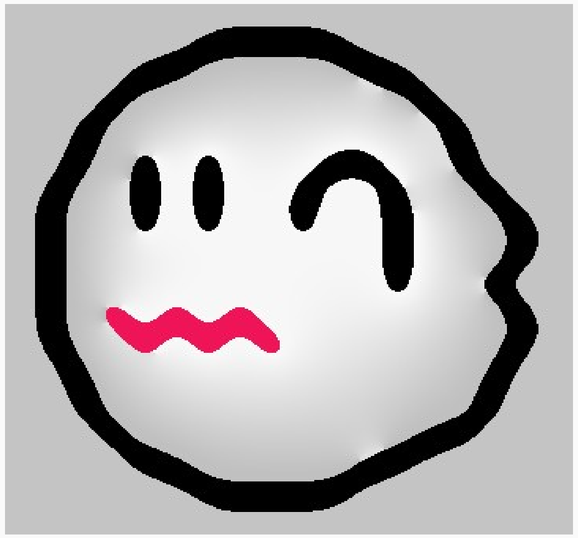
Vectorize Image

- Algorithms for automatic vectorization of raster images
- Based on image segmentation/edge detection
- Tiny features of pixel art vanishes on such filters

Overview of the Algorithm



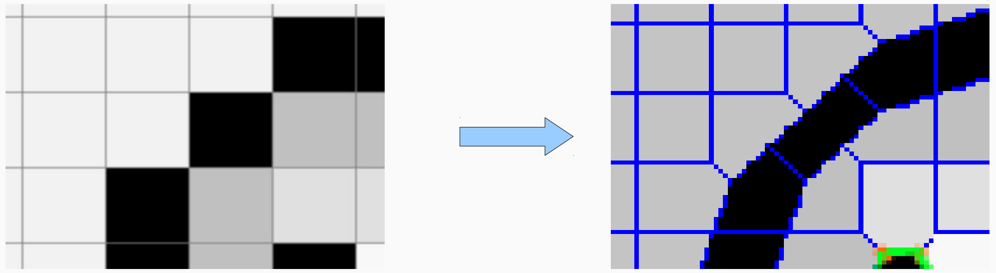




Input

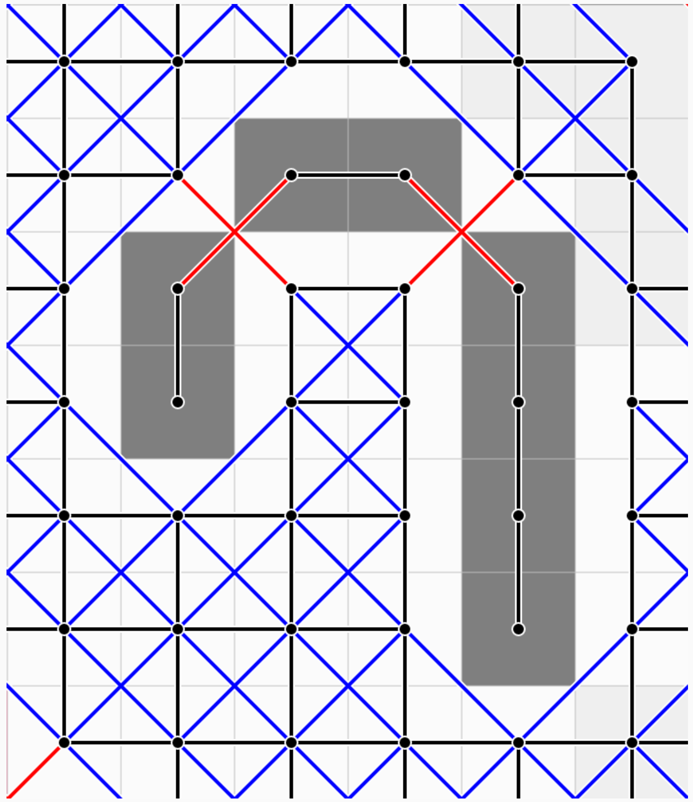
Reshaped pixels

B Splines fit

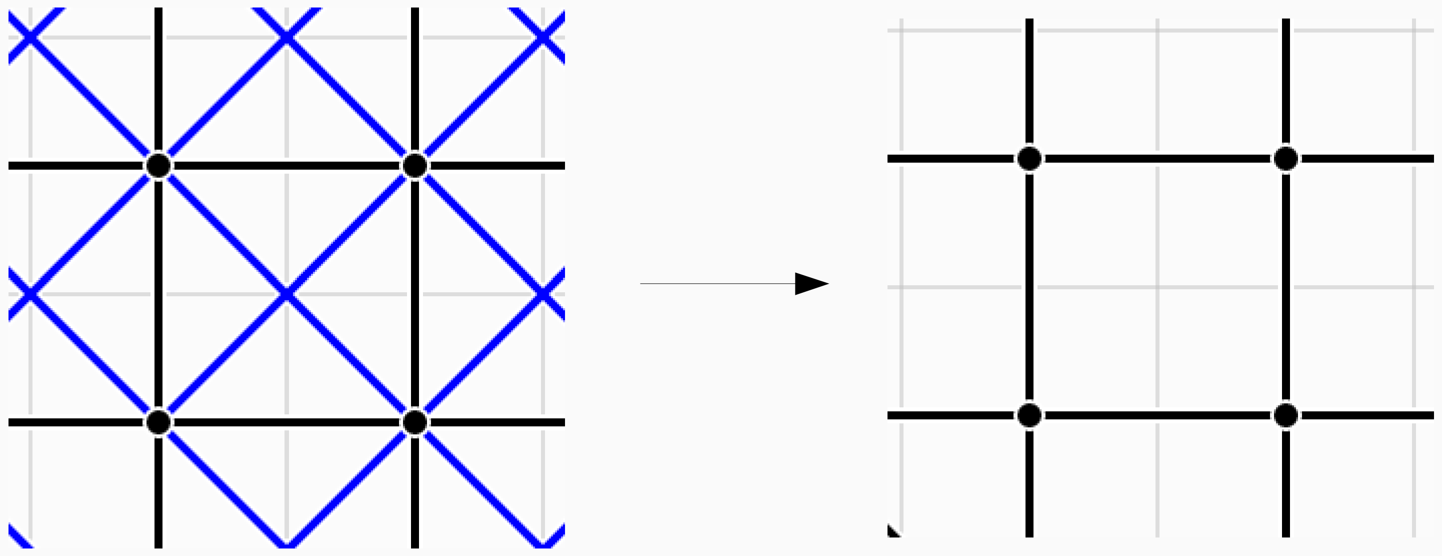


Similarity Graph

- Graph with each pixel as node.
- Edges between pixels which have similar colors.
- Remove extra and conflicting edges

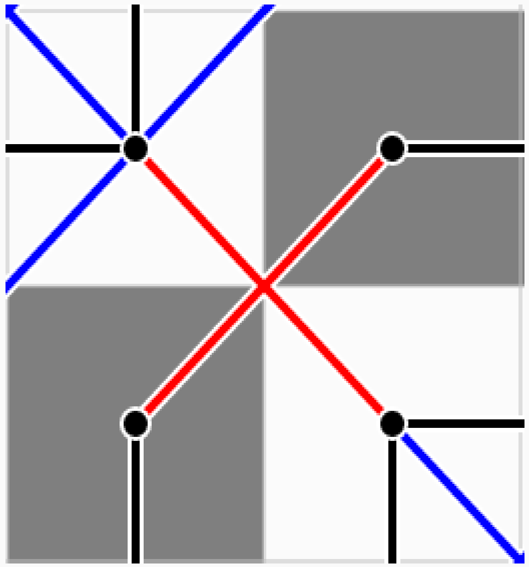


Normal Case



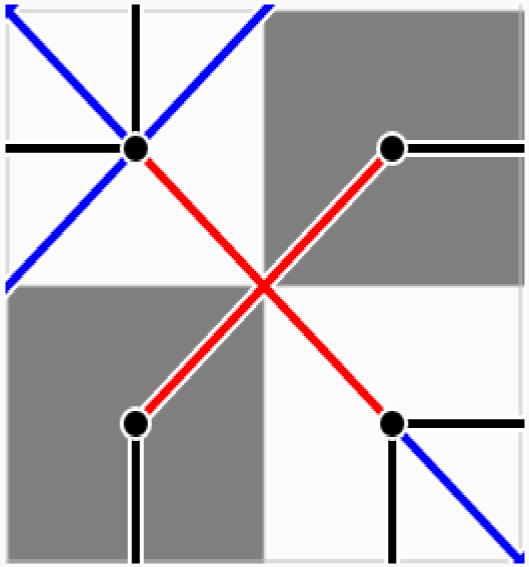
Remove unnecessary connections

Resolving Ambiguity



Can we figure out which connection to keep?

Resolving Ambiguity



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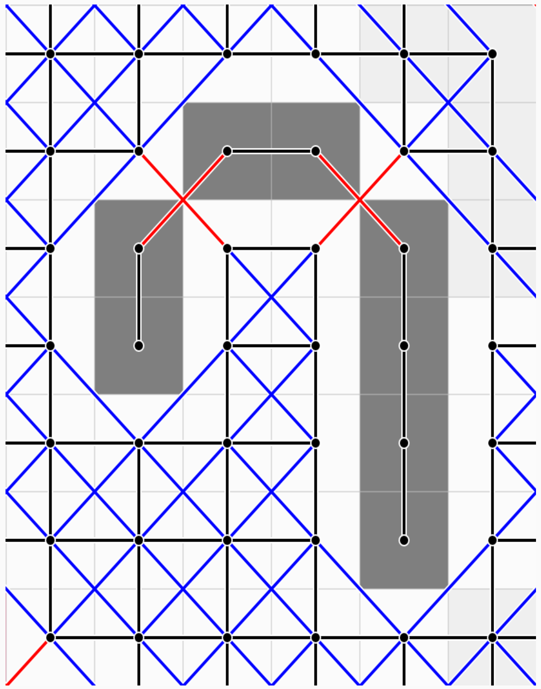


Now it is clear

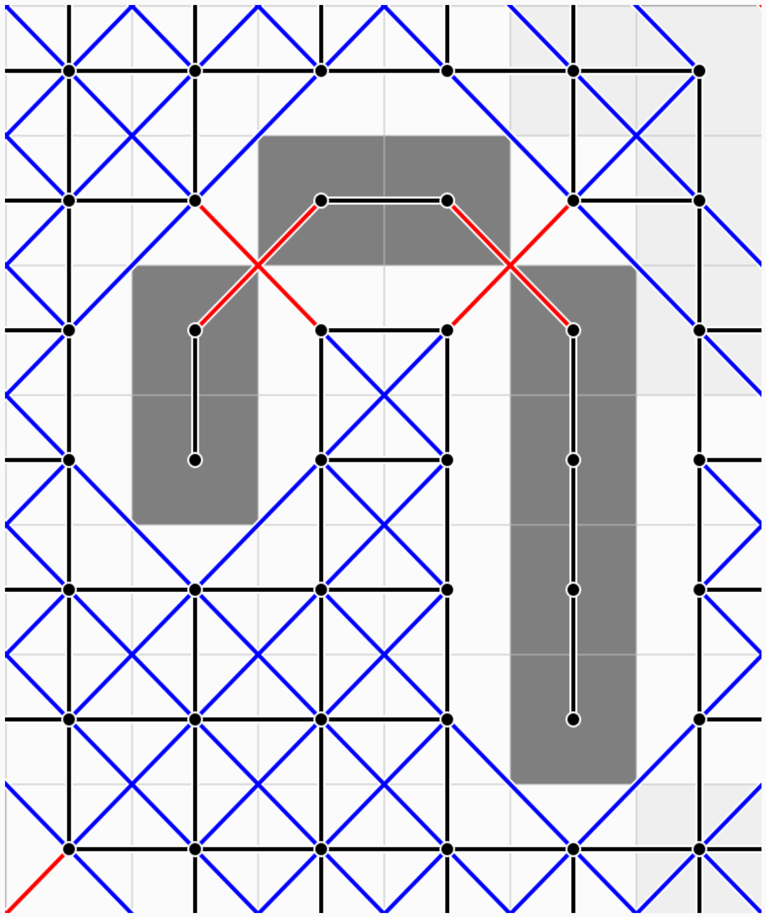
Heuristics to resolve ambiguities

Curves:

• Features likely to contain long lines.

• Find out length of longest straight line(without junctions) containing each diagonal.

•Select the longer length.



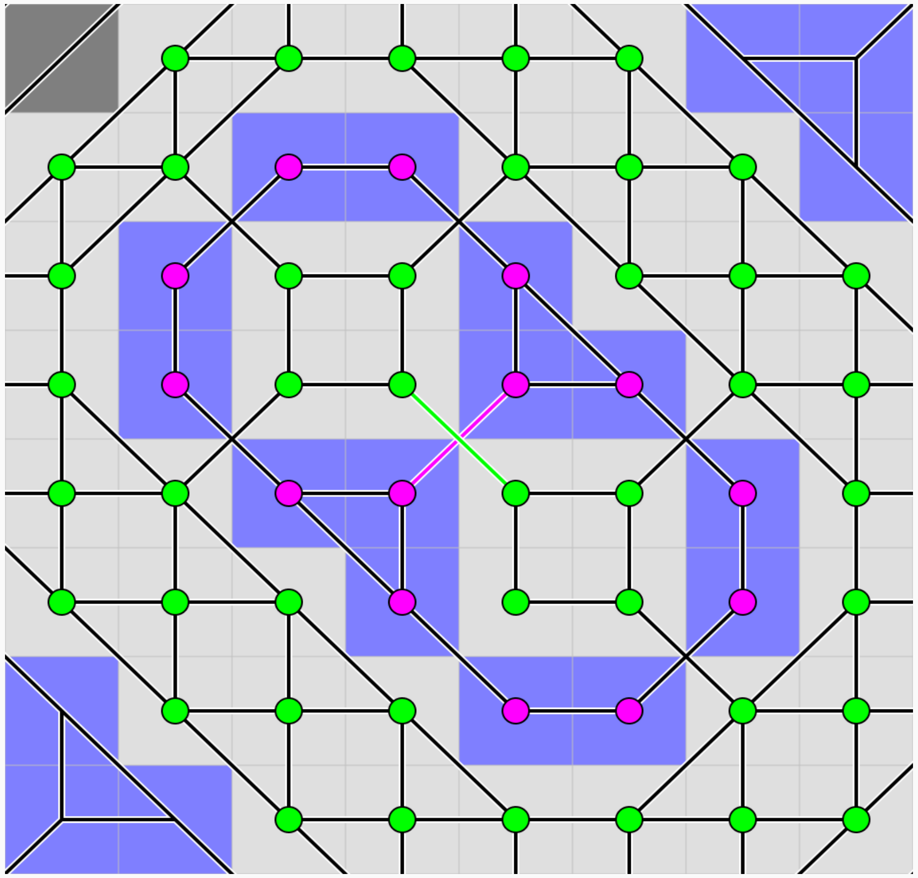
Heuristics to resolve ambiguities

Sparse Pixels:

• Foreground pixels more likely to be a part of feature.

• Find out lengths of connected components for both diagonals.

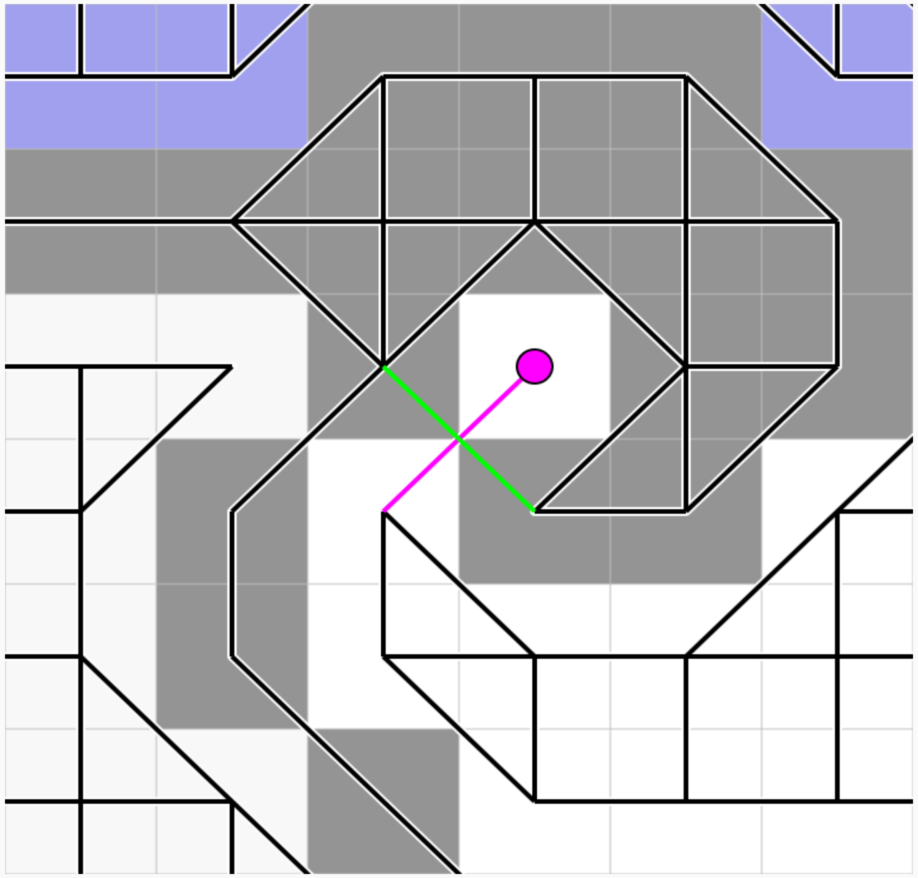
•Select one with lesser value.



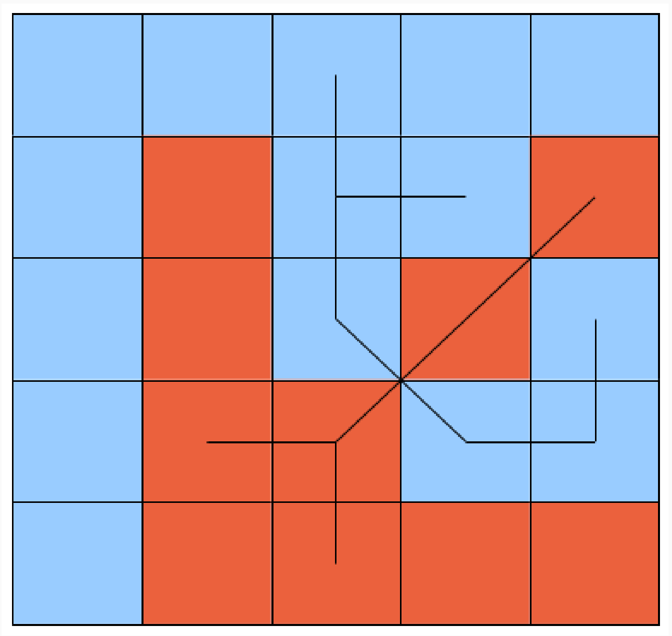
Heuristics to resolve ambiguities

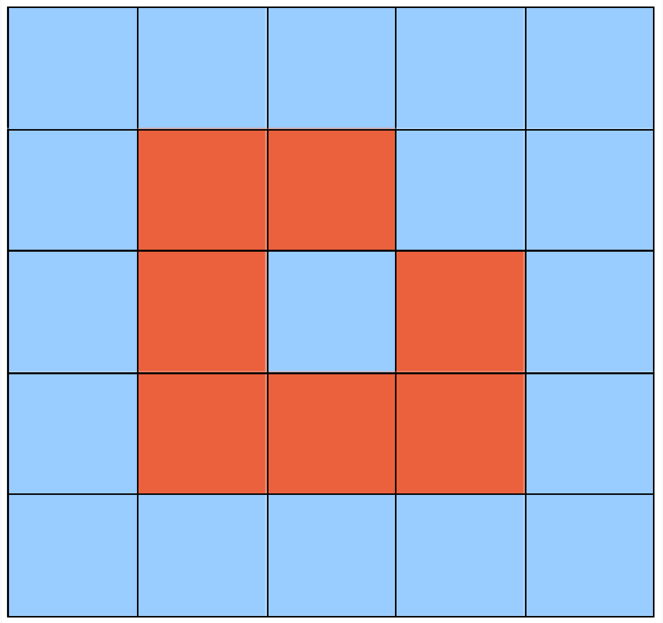
Island Pixels:

- Pixels with only one connection
- Retain, to avoid fragmentation



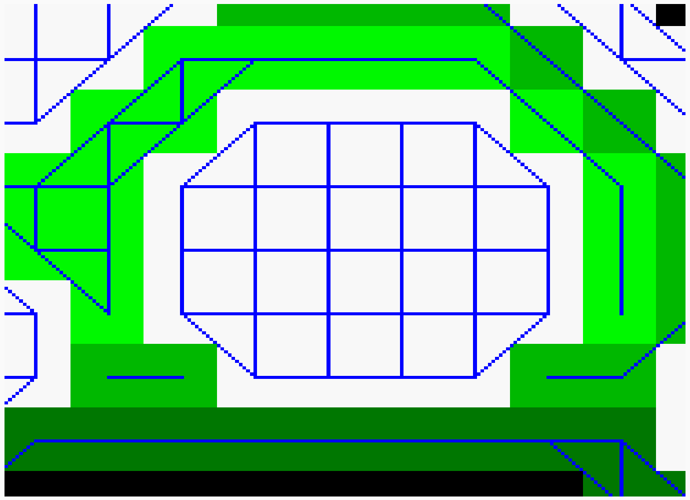
Heuristics to resolve ambiguities





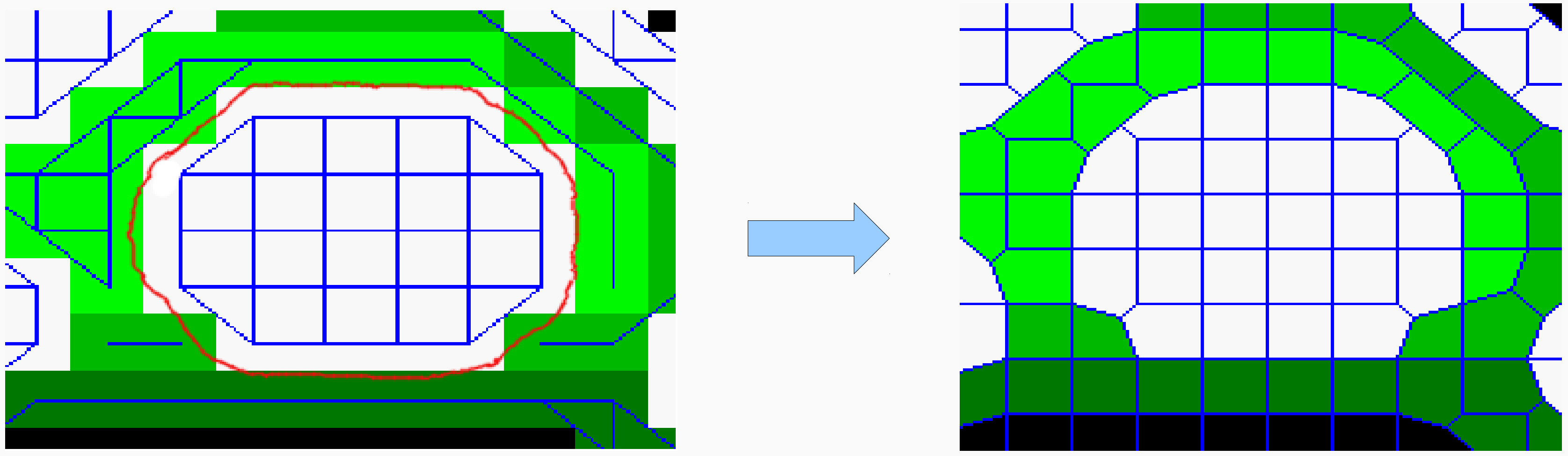
- All heuristics dont always give correct answer.
- So take weighted average.

How to reshape pixels



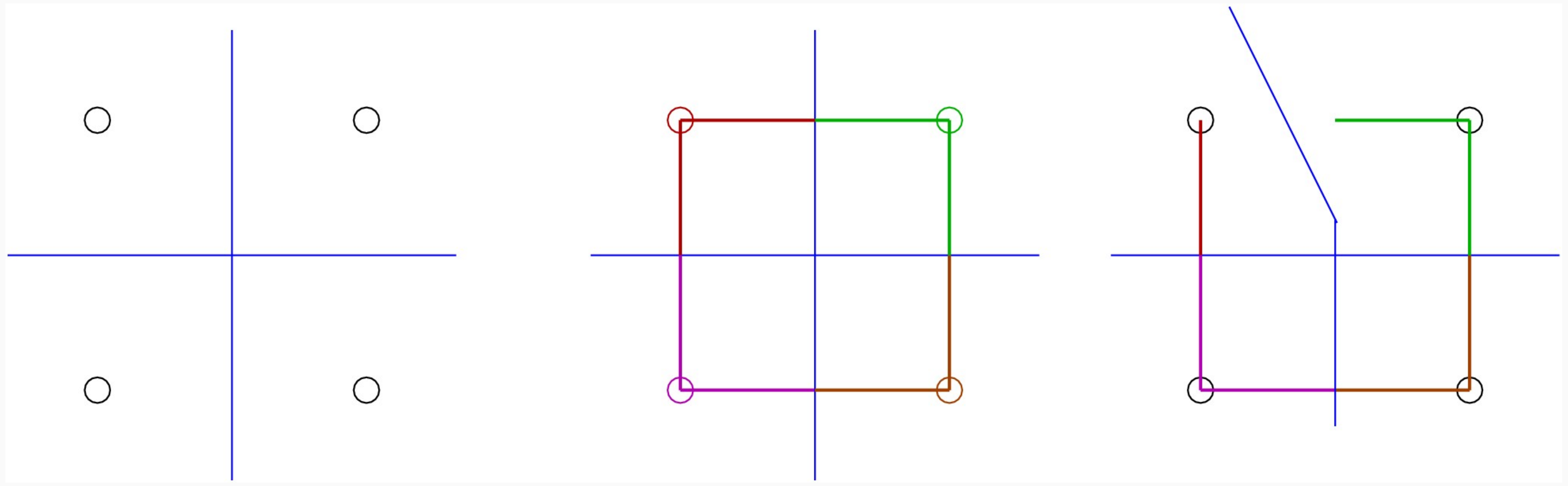
Need to define a boundary to seperate different features

How to reshape pixels



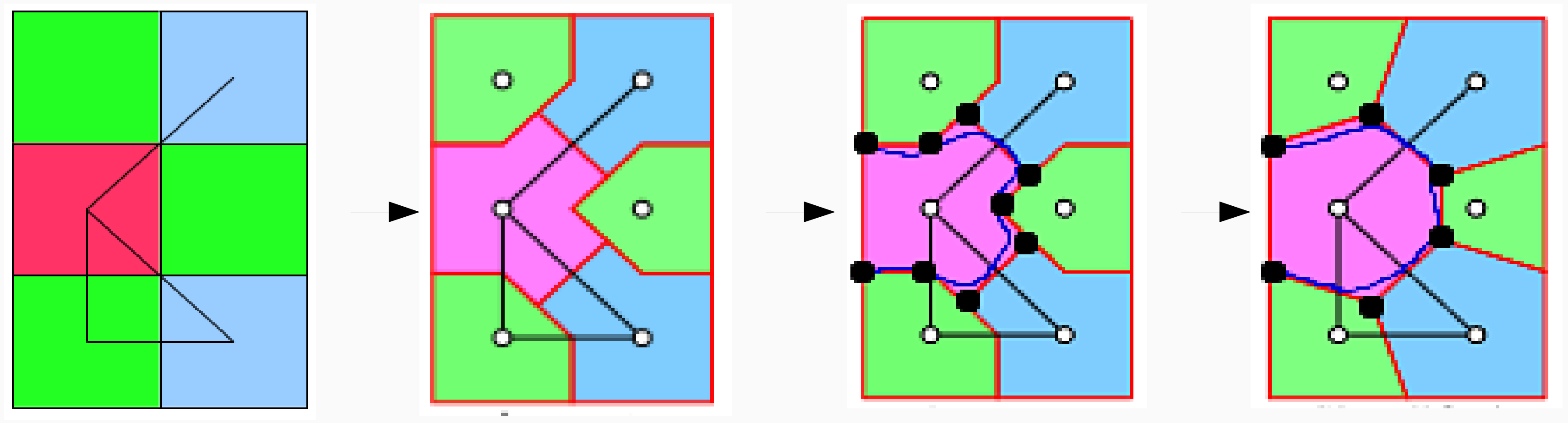
Divide the region such that each half is associated with the corresponding graph

Voronoi Diagram



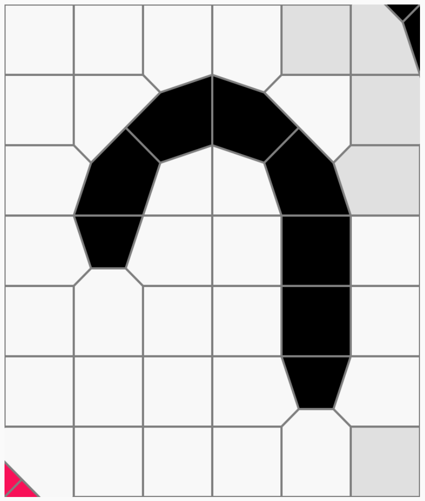
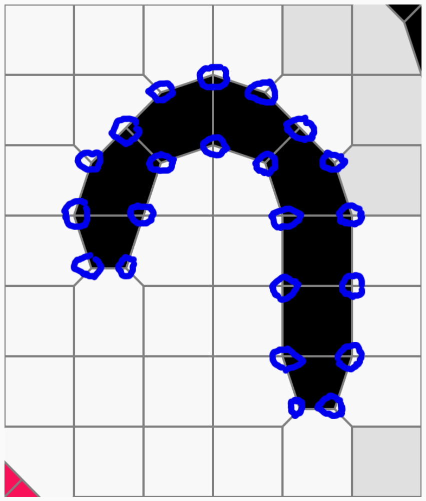
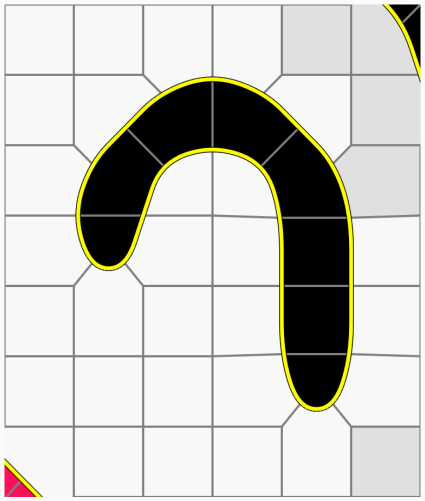
The partitioning of a plane with n points into convex polygons such that each polygon contains exactly one generating point and every point in a given polygon is closer to its generating point than to any other.

Problems with Voronoi Diagram



- Too many bends caused along cell walls.
- Leads to wavy splines, which will cause artifacts.
- Remove unnecessary bend along cell walls.

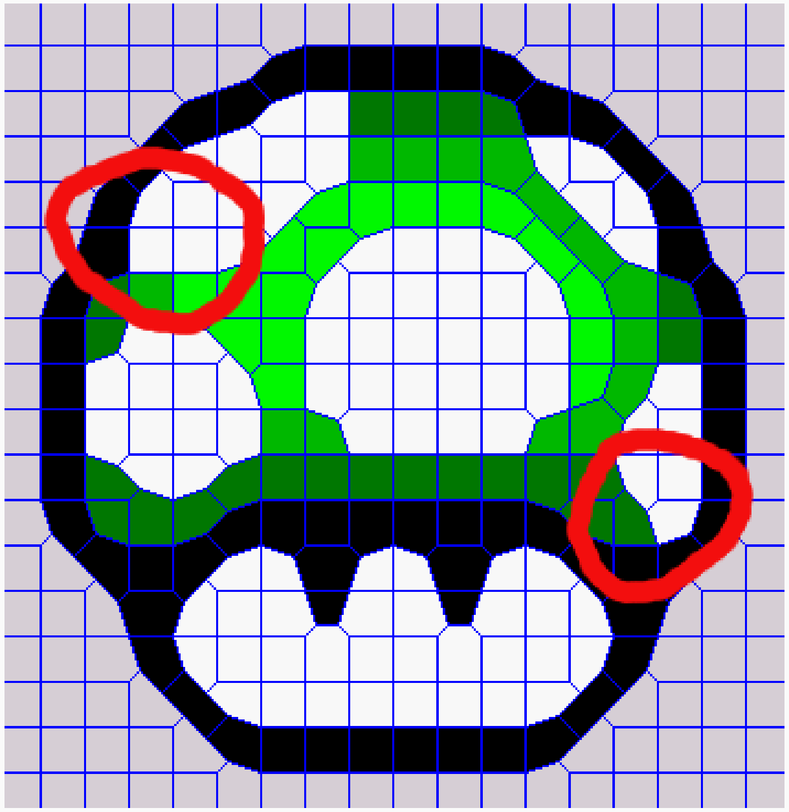
Extracting Spline Curves

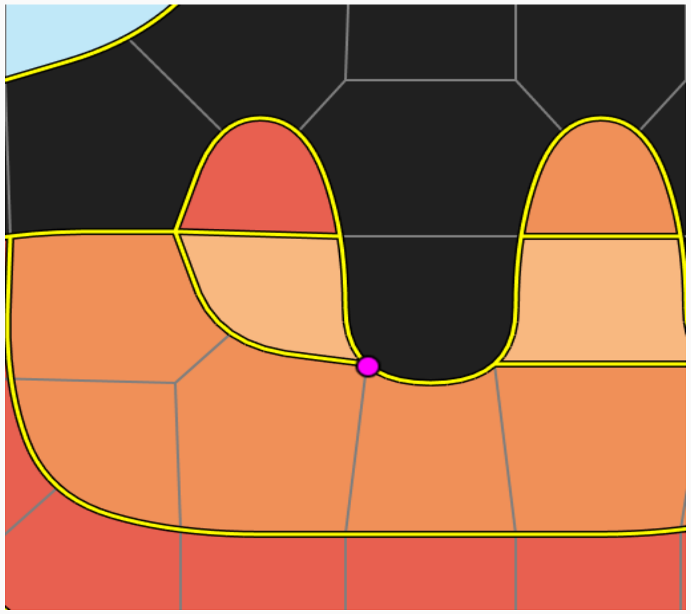
- Visible edges identified.
- Splines made out of end points of visible edges.

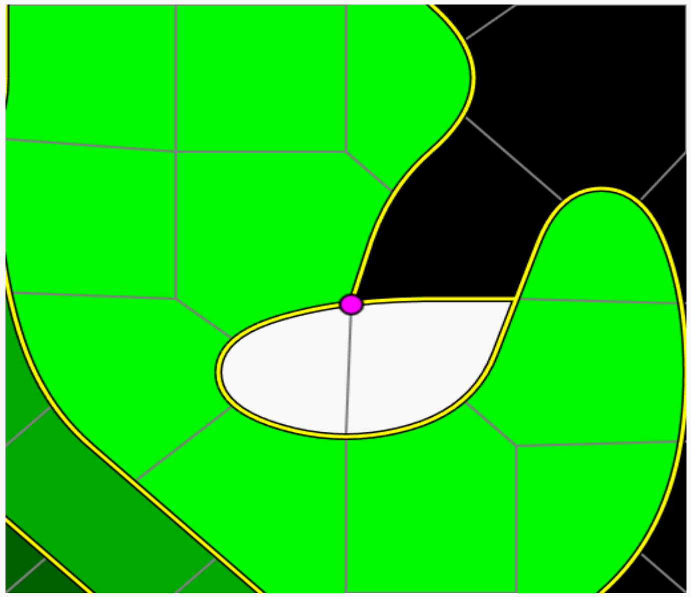
Extracting Spline Curves

- Different boundaries meet, resulting in T junctions
- Initially three different splines formed
- Later two of them merged.
- Which two to merge?



Resolving Ambiguities



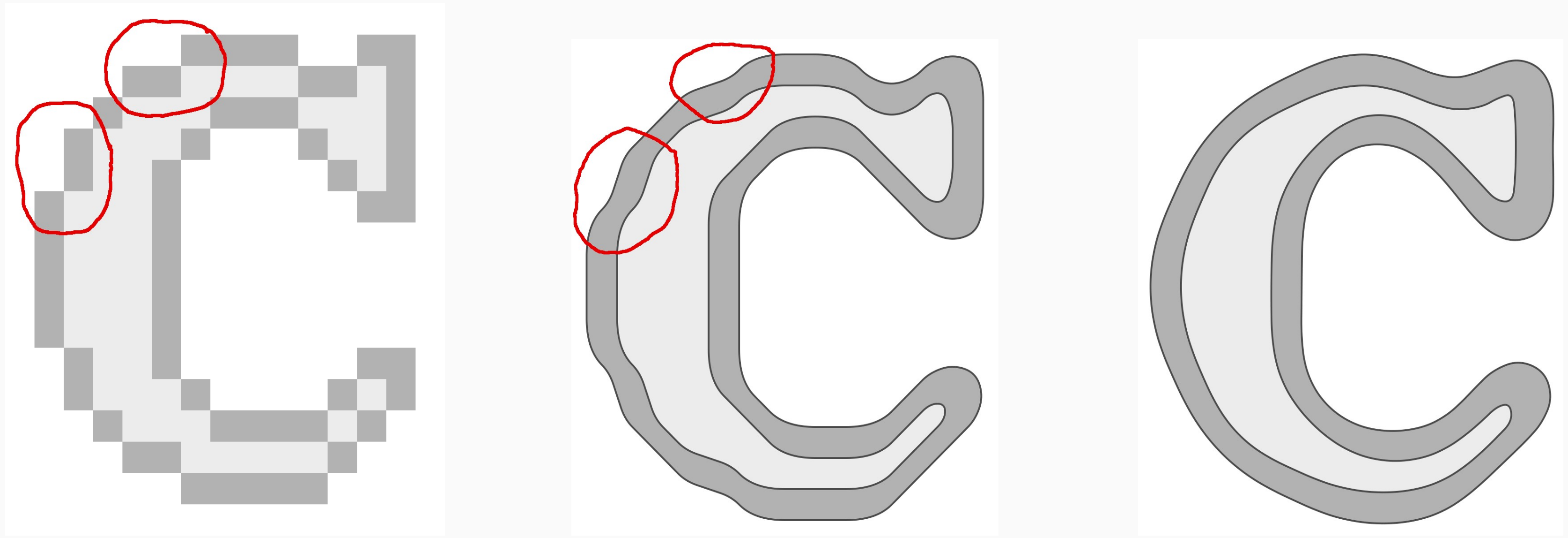


Ignoring the spline which connects regions of similar color.

Picking the pair splines which make an angle closer to 180 with each other.

Optimizing control points

Due to large number of control points, staircasing artifacts seen.



Optimizing control points

- Smoothness is measured by absence of curvature
  -- Minimize the curvature

$$E_s^{(i)} = \int_{s \in r(i)} |\kappa(s)| ds$$

- Control points must not shift much
  -- Penalty for high position shift

$$E_p^{(i)} = ||p_i - \hat{p}_i||^4$$

- Final energy equation

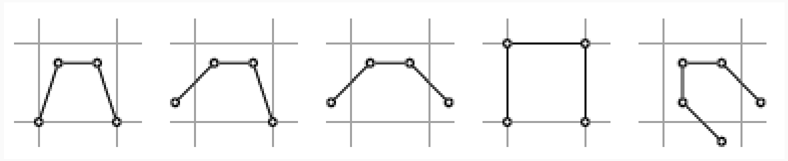
$$E^{(i)} = E_p^{(i)} + E_s^{(i)}$$

- Optimization problem

$$\arg\min_{\{p_i\}} \sum_i E^{(i)}$$

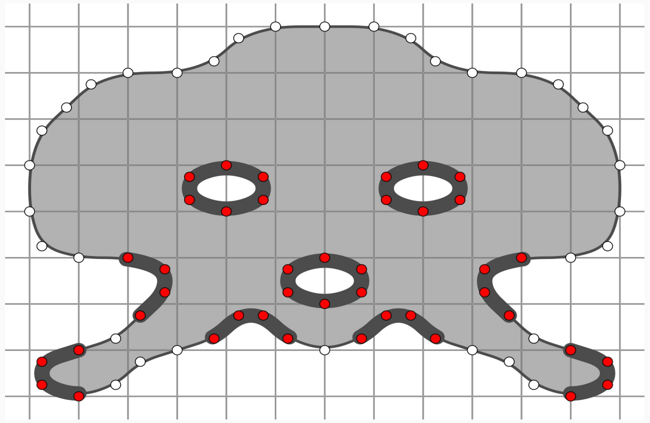
- Solution by relaxation

Corner points

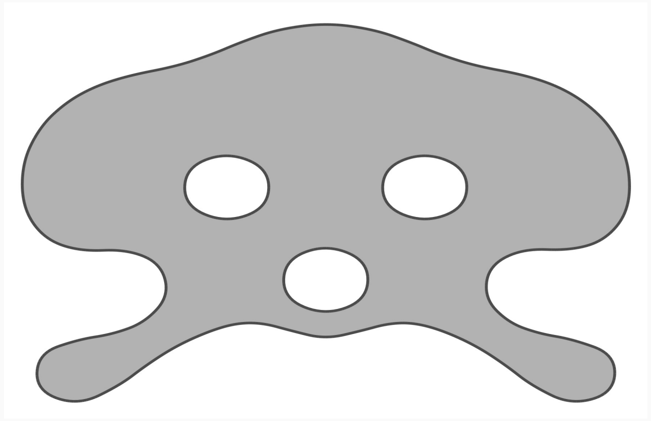


- Certain sharp turns in the B-splines, which are a part of features.
- Shape may get destroyed.

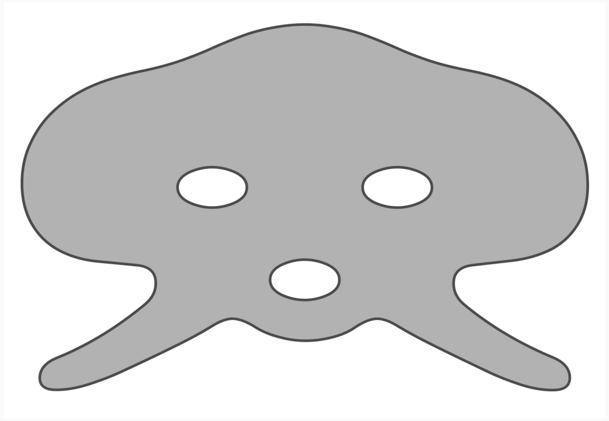
  ---- optimization is avoided on these points.



Corner Points



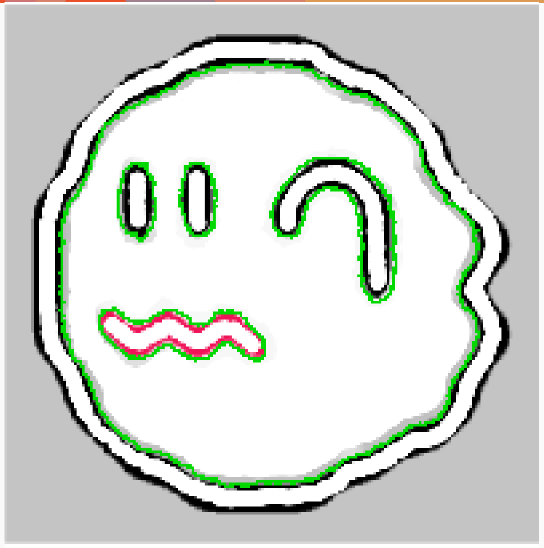
Optimization done on corners

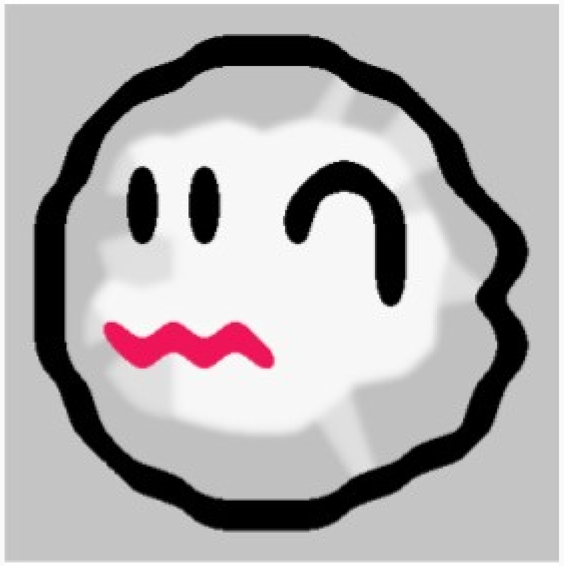


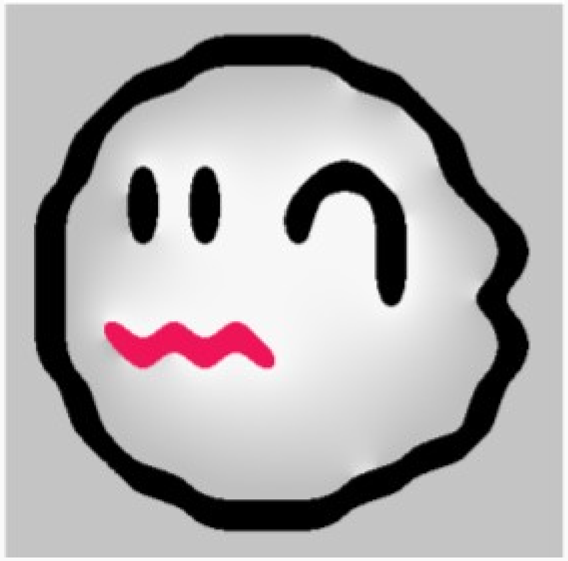
Optimization not done on corners

Rendering

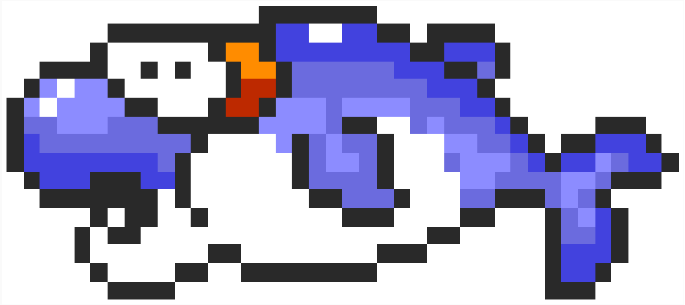
- Rasterization
- Color Diffusion



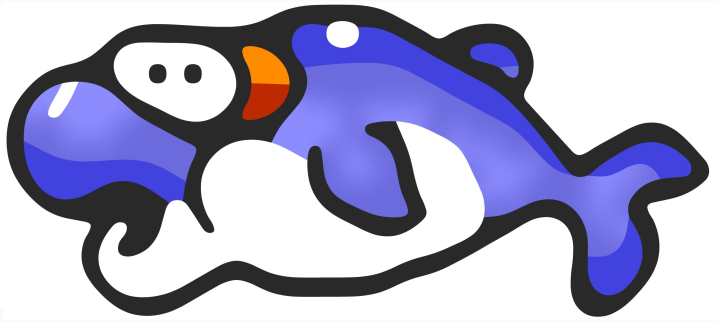




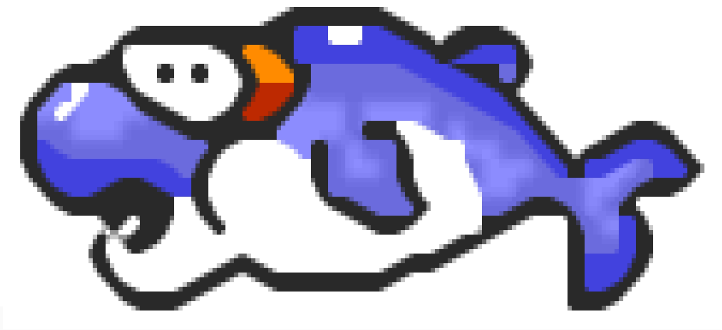
Results



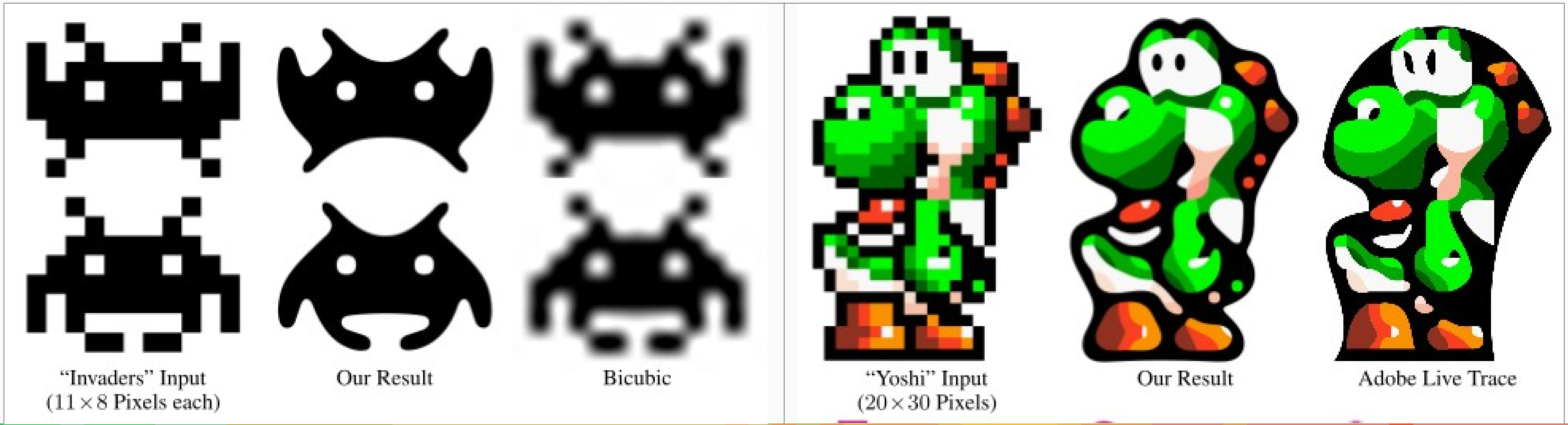
Nearest Neighbour



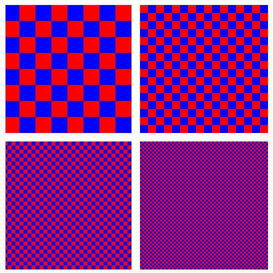
Our Result



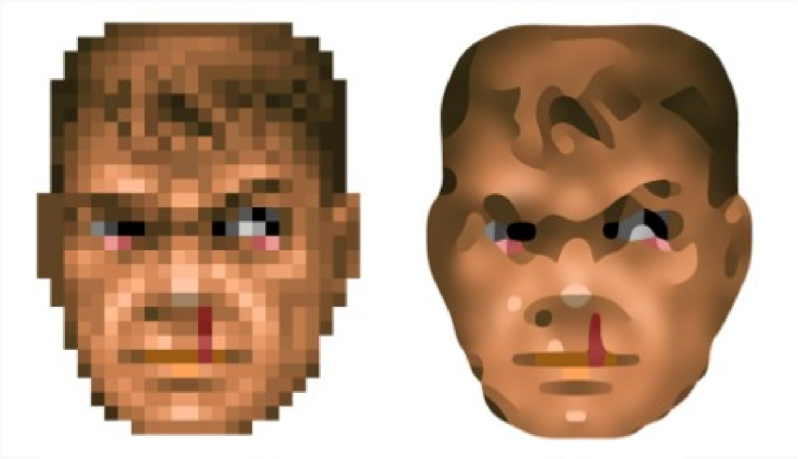
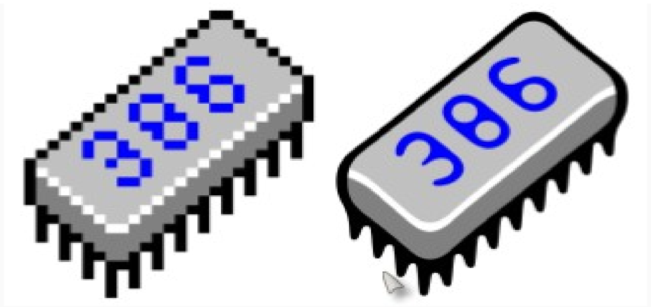
Hq4x



Limitations


http://en.wikipedia.org/wiki/Dither

- Dithering
- Unnecessary sharp edge
- Unnecessary smoothing

Implementation Plan

- Reshaping Pixels and fitting of B-splines
- Renderer
- Optimization

References

•**Depixelizing pixel art**, Kopf, Lischinski, ACM Transactions on Graphics (SIGGRAPH 2011)

•*Diffusion curves: a vector representation for smooth-shaded images*, Orzan, Bousseau, Winnemoller, Barla, Thollot, Salesin, ACM Trans. Graph 2008

•*Vectorization of Pixel Art*, Christian Loos
http://www.multimedia-computing.de/mediawiki/images/3/37/Diploma_Thesis-ChristianLos.pdf

•*A GPU Laplacian Solver for Diffusion Curves and Poisson Image Editing*, Jeschke, Cine, Wonka (SIGGRAPH 2008)