

Semantic Segmentation for Line Drawing Vectorization Using Neural Networks

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ETH zürich



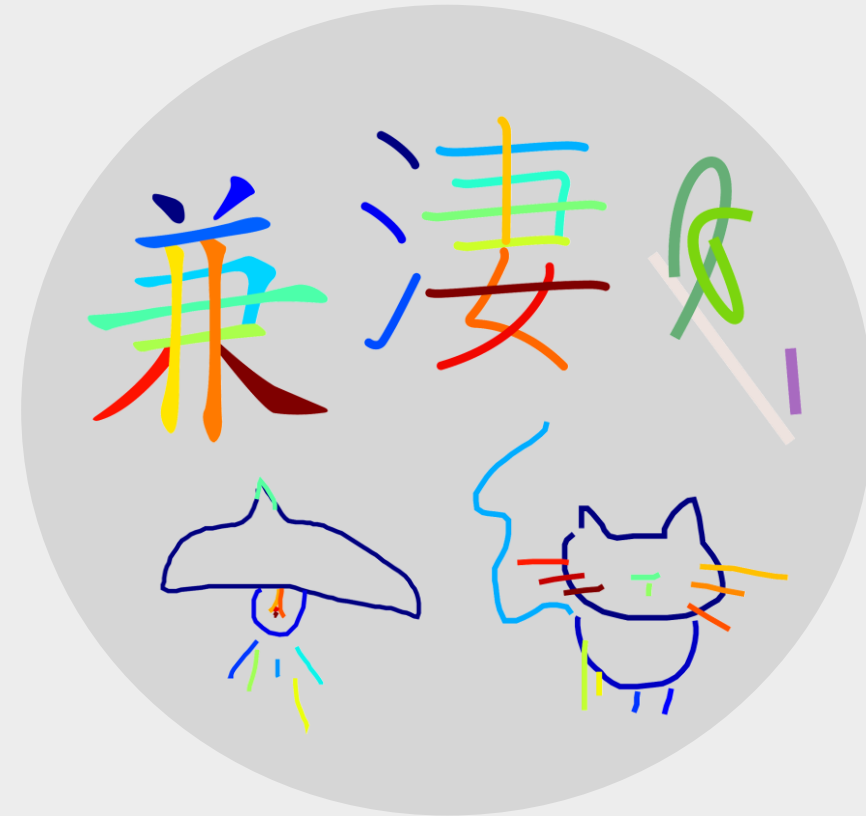
» Raster vs. Vector Drawings



Raster Drawings

Not Scalable

No Semantic Information

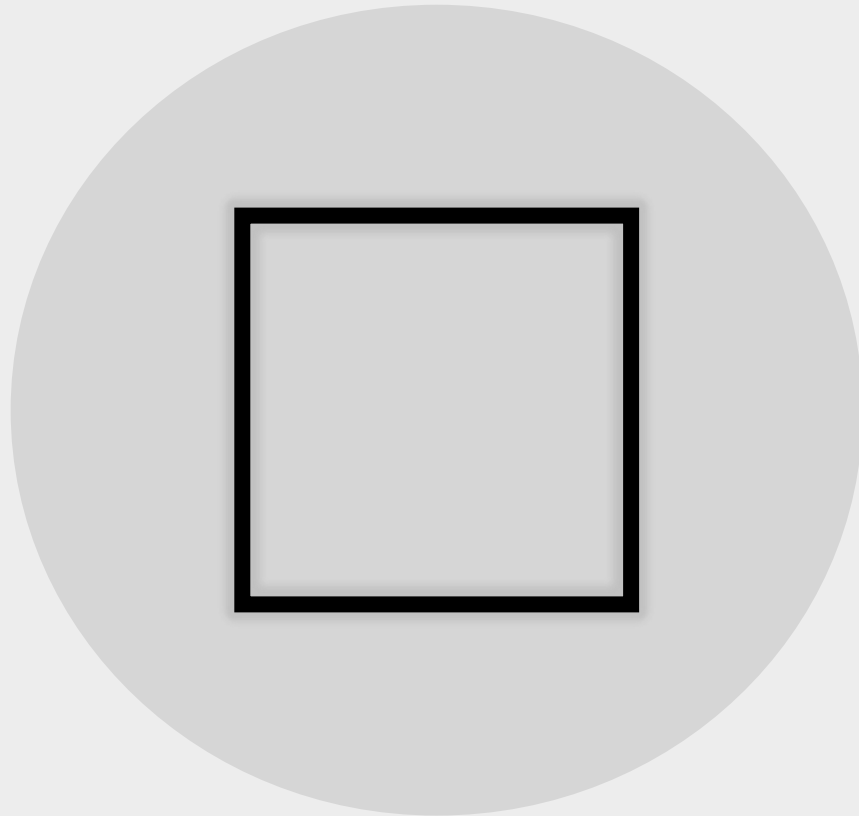


Vector Drawings

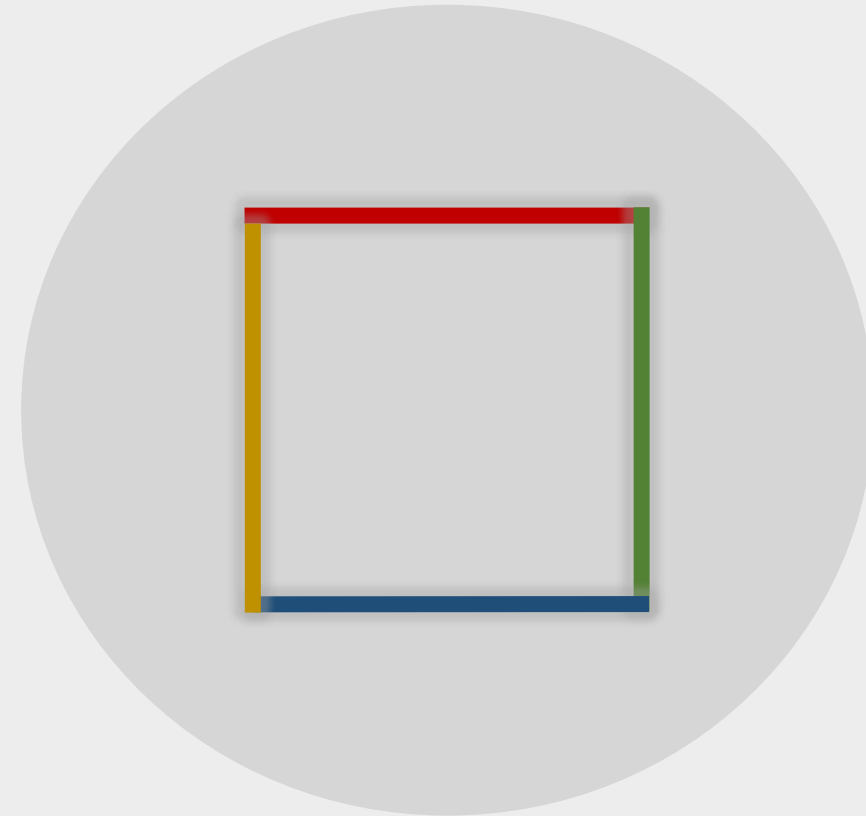
Resolution Independent

Support for Higher-Level Editing

» Vectorization Ambiguities

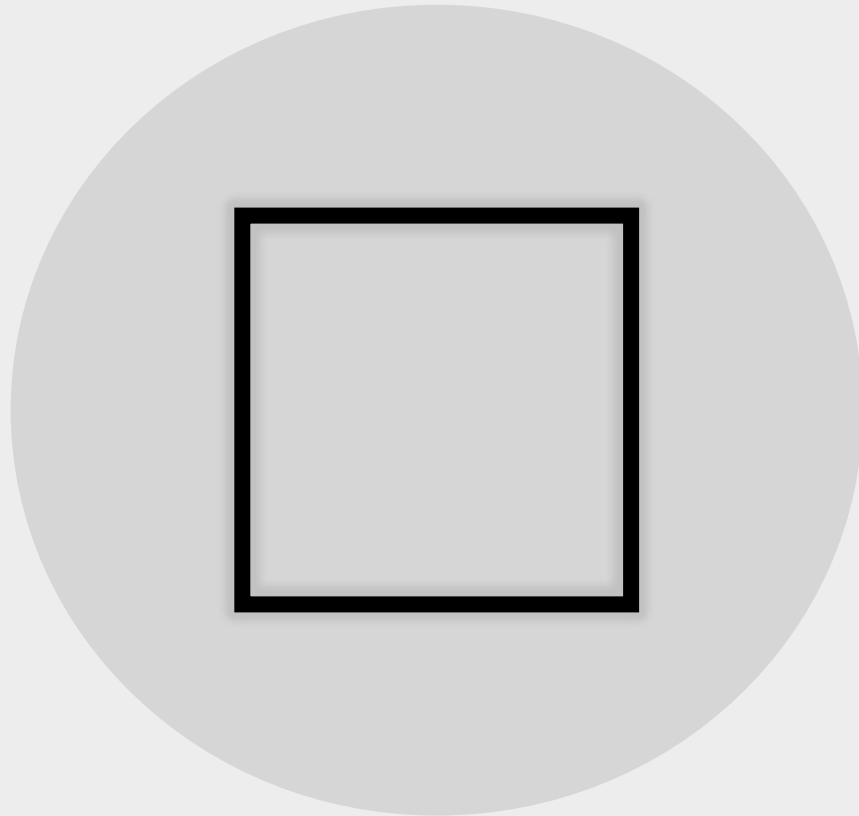


Square

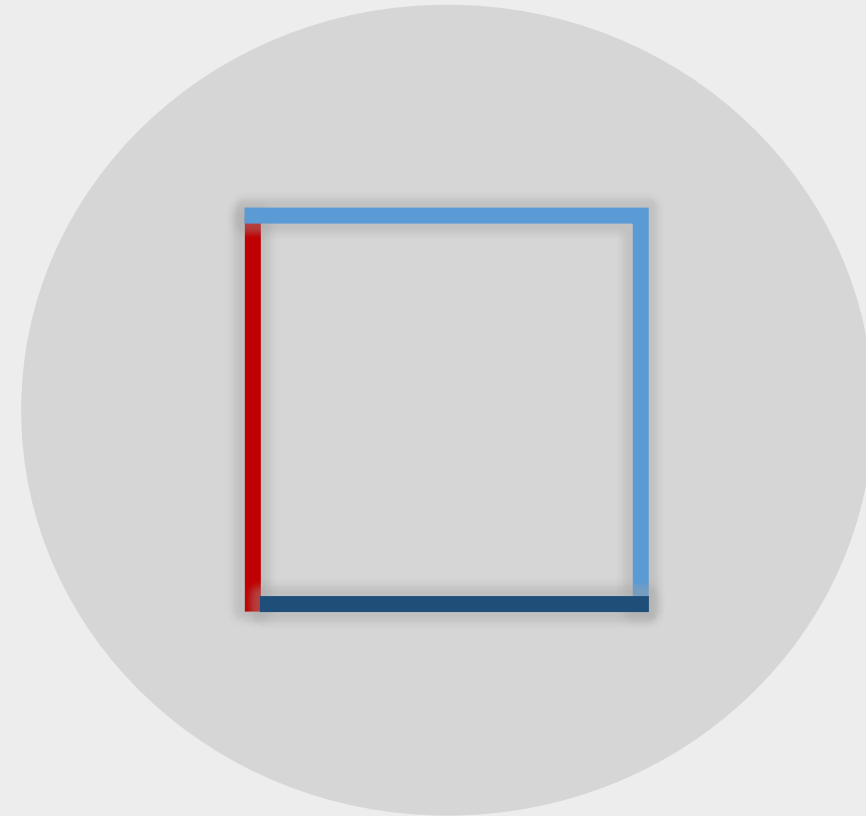


Four Line Strokes

» Vectorization Ambiguities

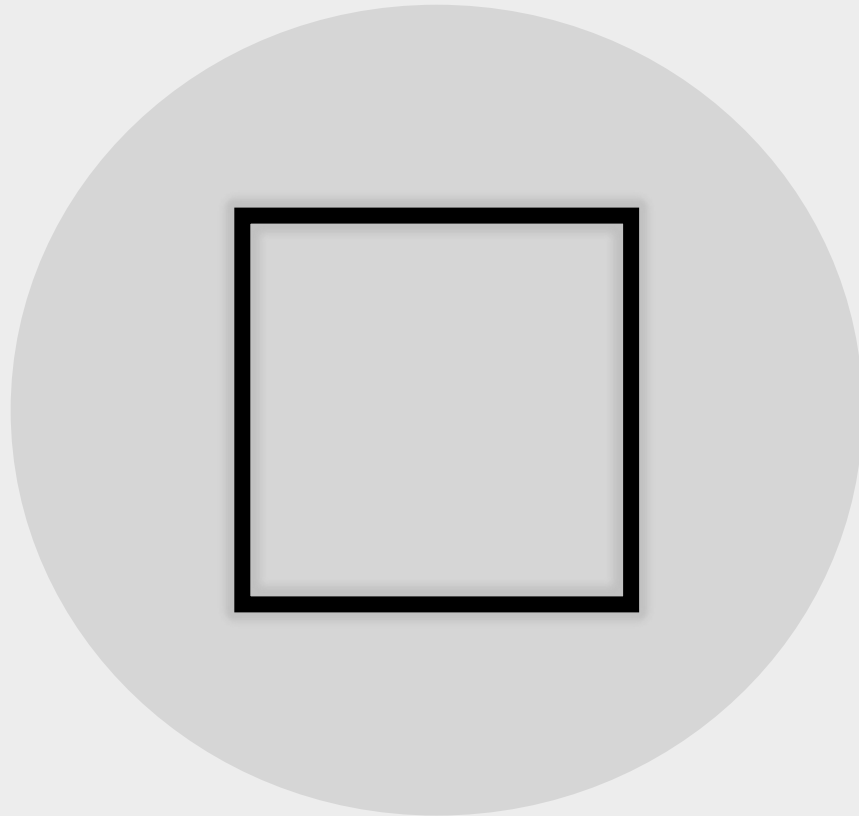


Chinese Character
(Mouth)

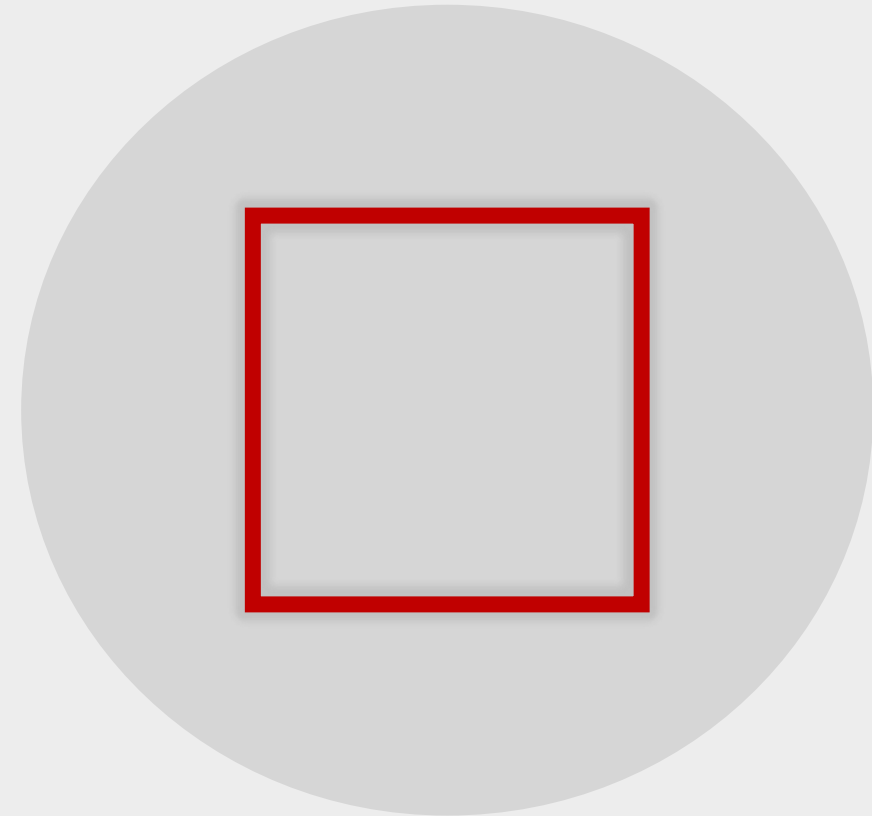


Two Line Strokes
+ One Corner

» Vectorization Ambiguities

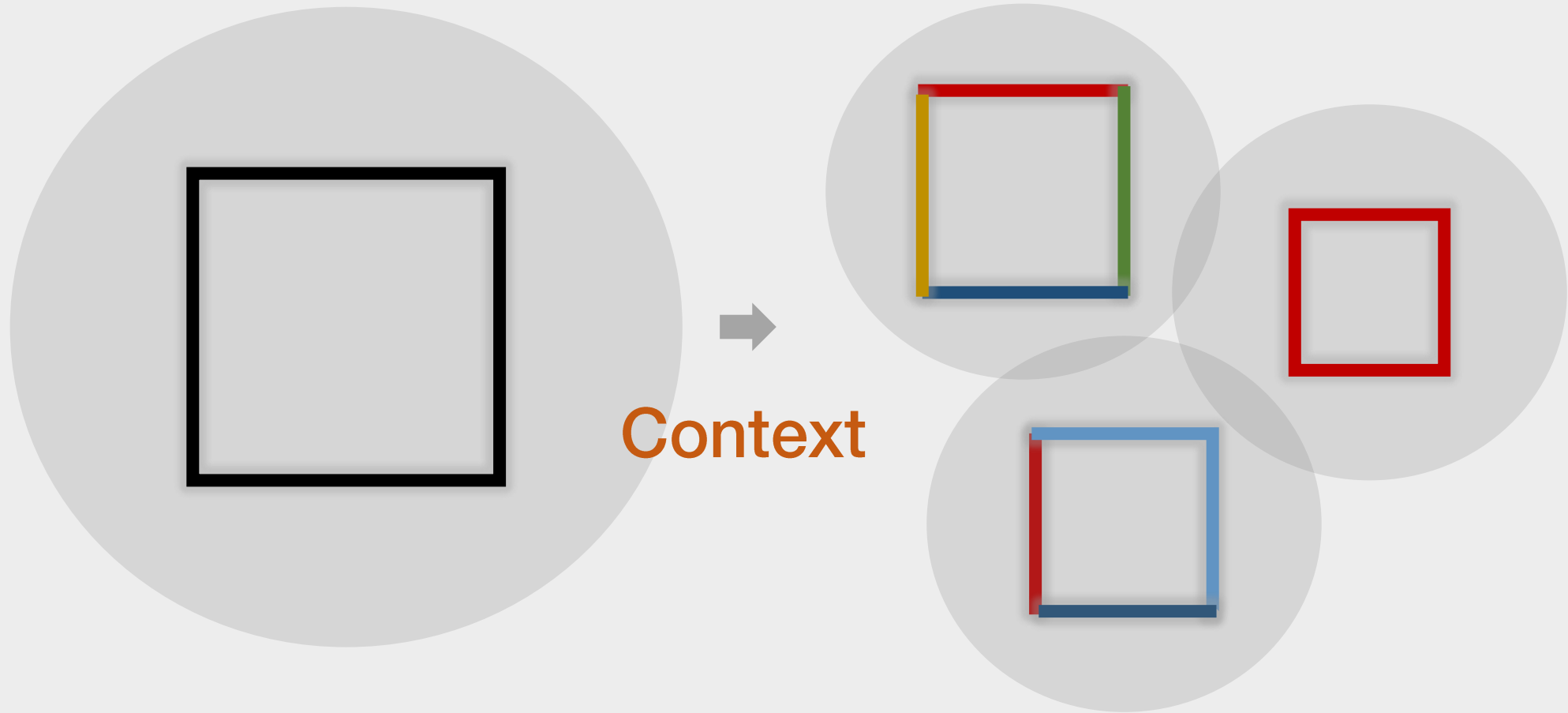


Tetris

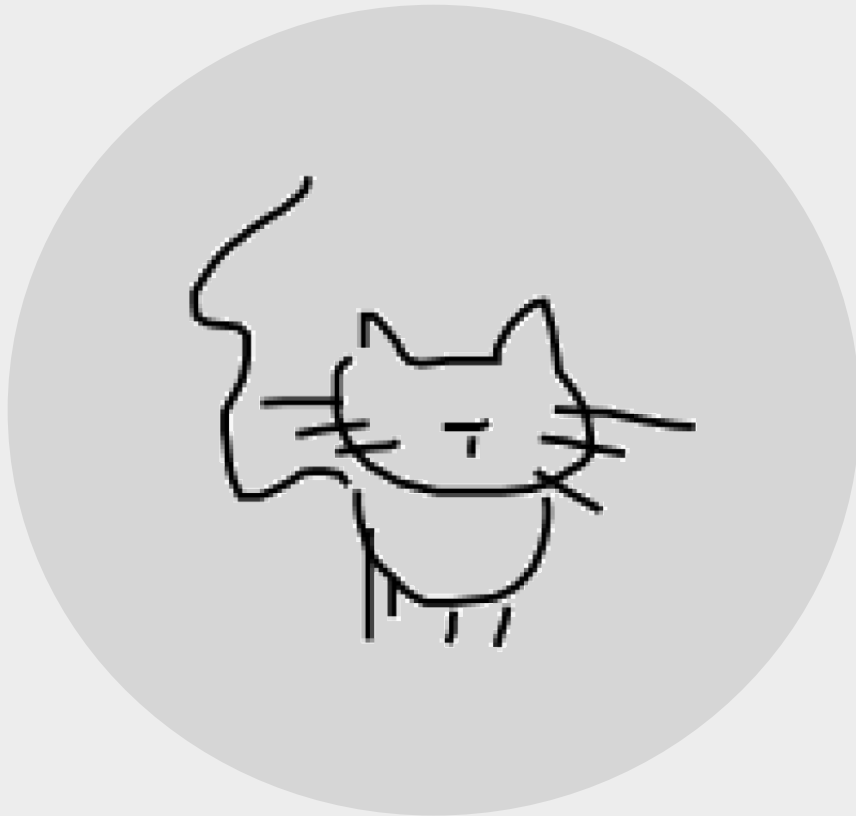


One Connected Stroke

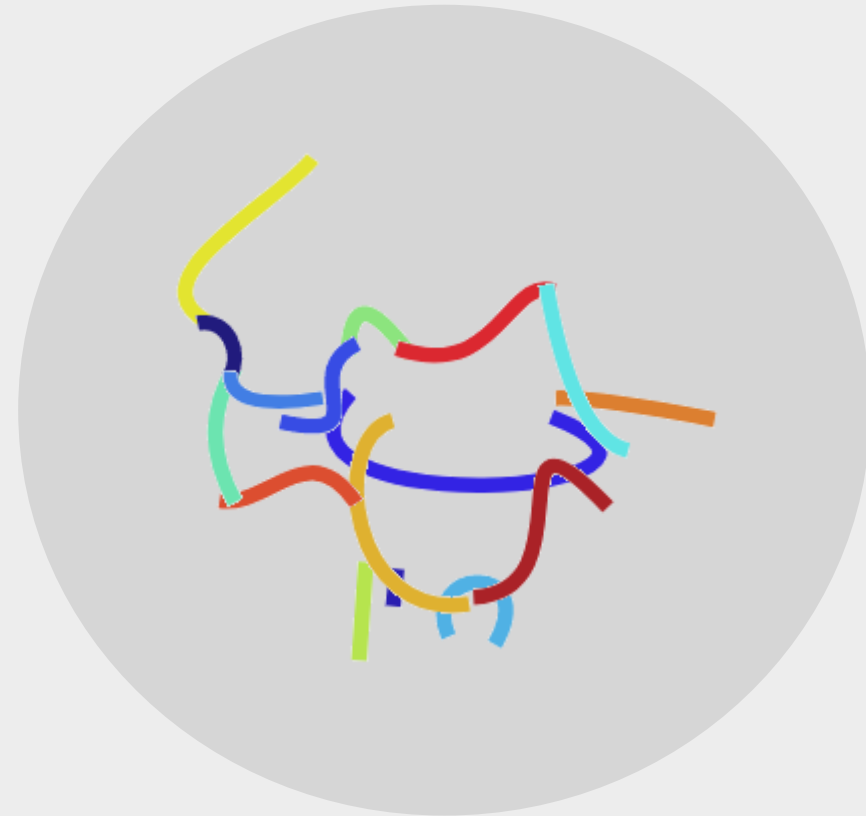
» Vectorization Ambiguities



» Vectorization Ambiguities



Cat



Vector Soup [Favreau et al.16]

Not Easily Editable

» Semantic Vectorization



Cat

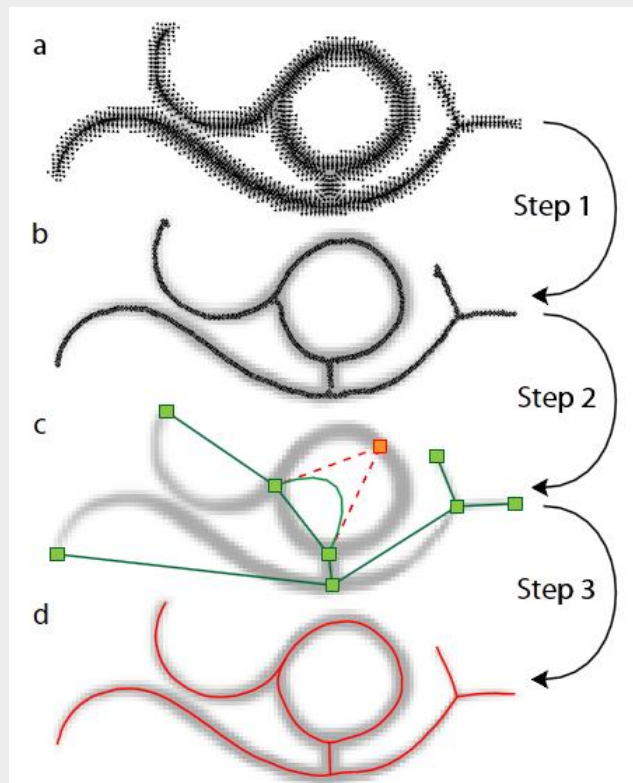


Semantic Vector Set

Related Work

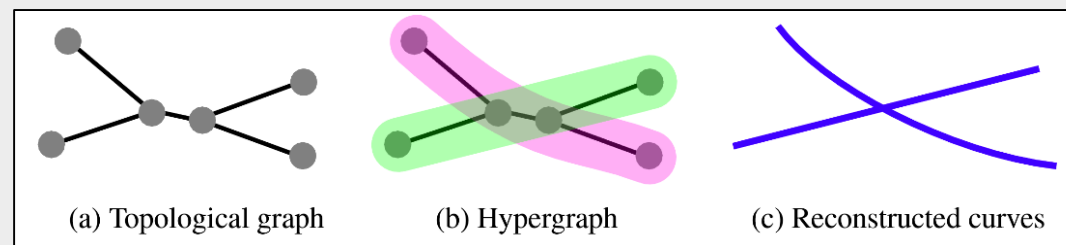
» Line Drawing Vectorization

▪ Three-step **Topology-Driven** Procedure



[Noris et al. 13]

1. Simplify an input image
2. Identify topological structure
3. Refine it with vector primitives

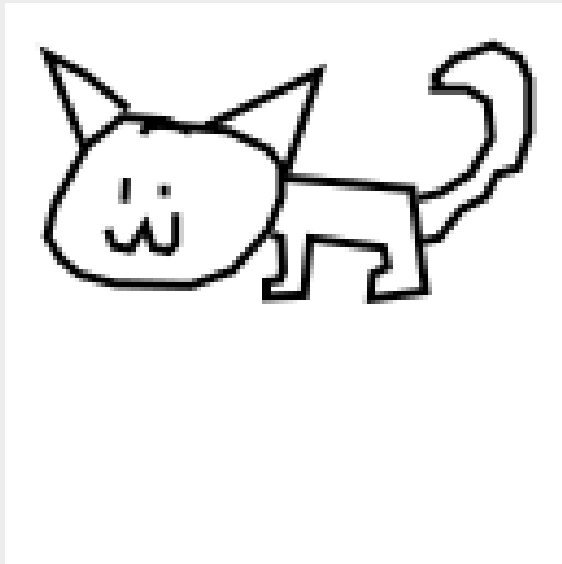


[Favreau et al. 16]

→ Result in **Vector Soup**

» Segmentation

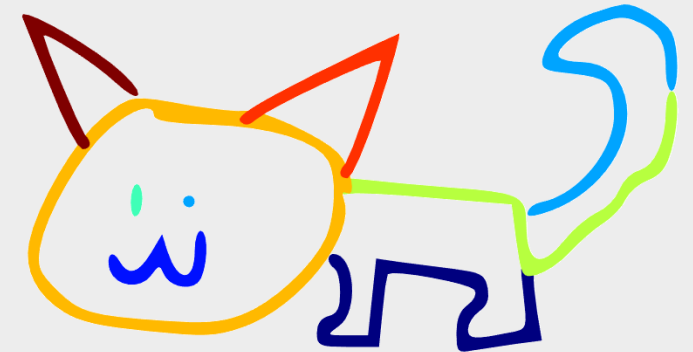
▪ Instance Segmentation



Raster Input



Segmented Paths



Combined Vector Set

» Segmentation

▪ Instance Segmentation

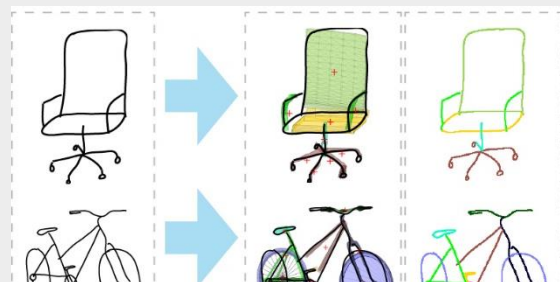


Estimate Objectness on Photos

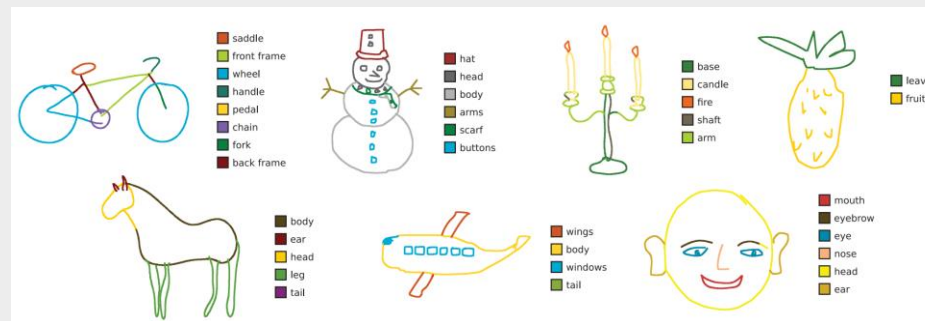


[Li et al. 16]

▪ Non-Photo Based Segmentation



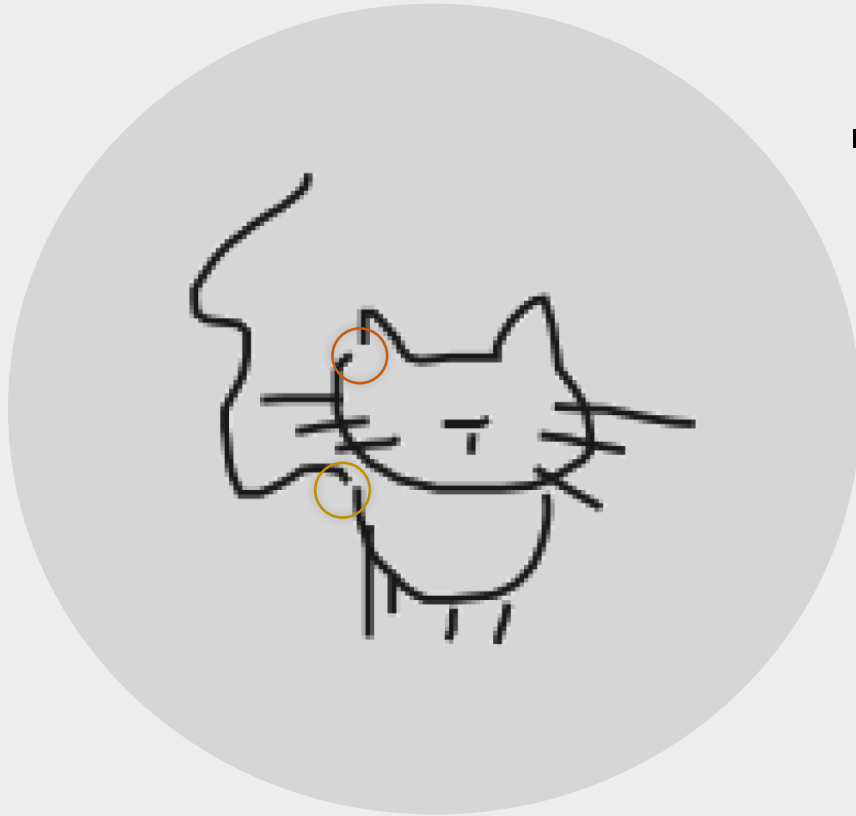
Semantic Classification of Strokes



[Schneider et al. 16]

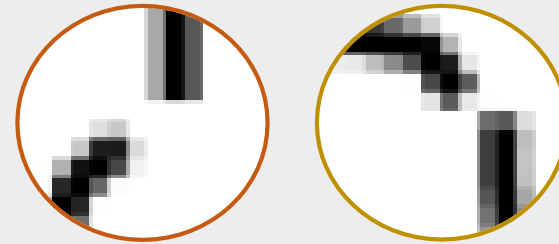
Method

» Challenges



■ Challenges

1. Compute path similarity

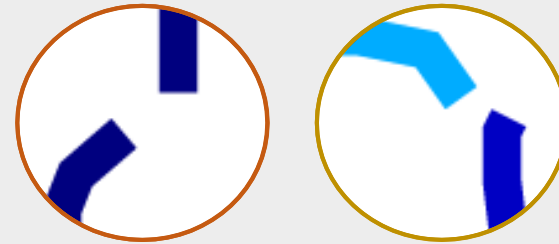


» Challenges



■ Challenges

1. Compute path similarity

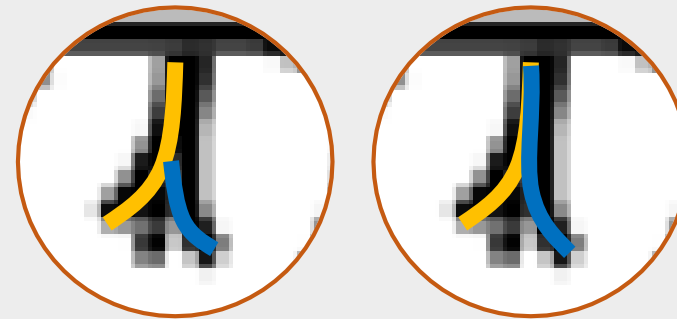


» Challenges

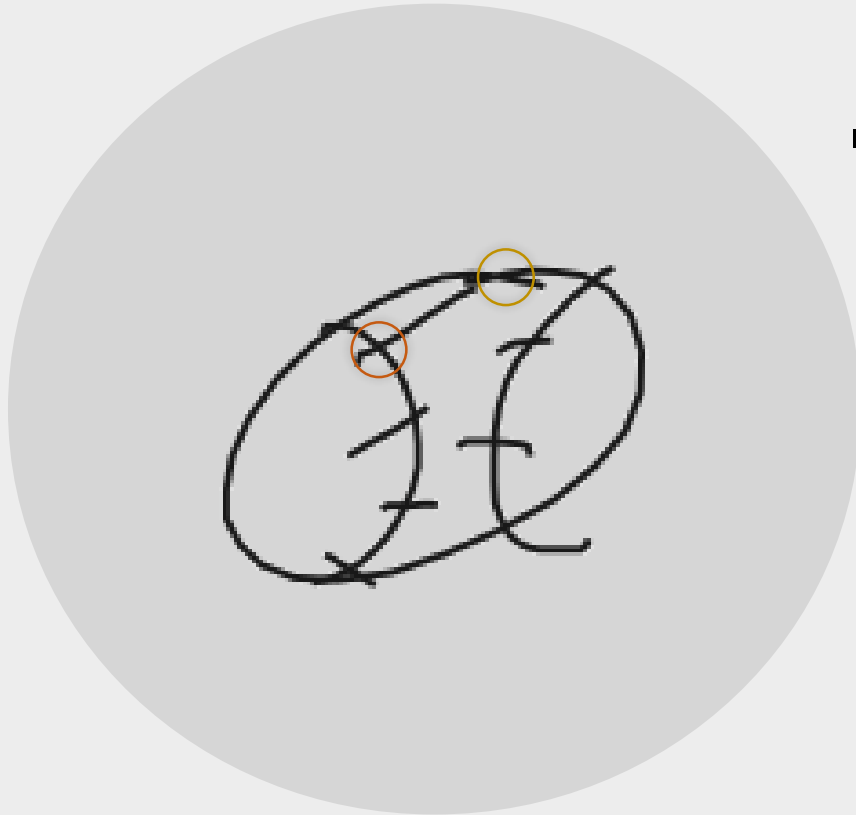


■ Challenges

1. Compute path similarity
2. Handle overlaps between multiple paths

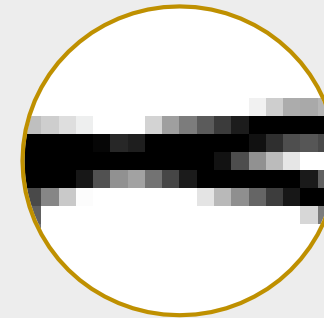
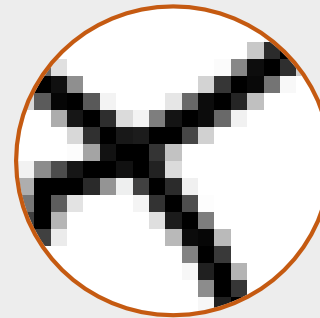


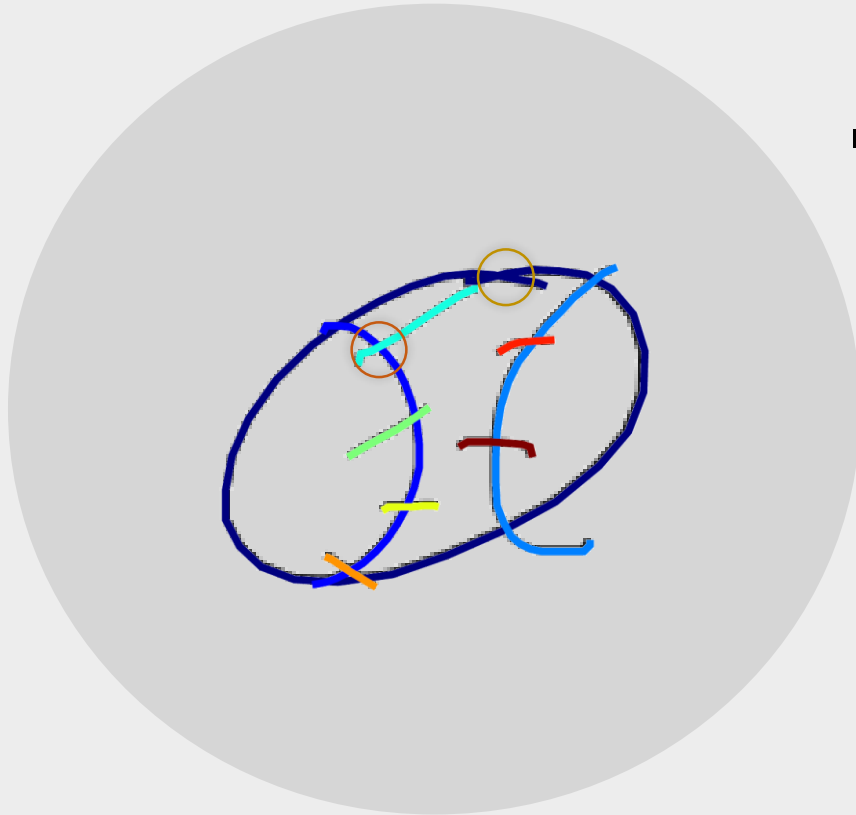
» Challenges



■ Challenges

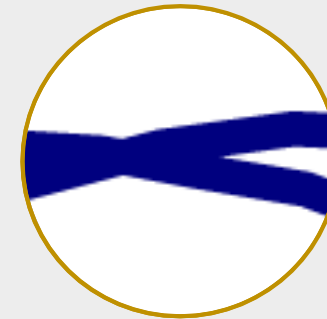
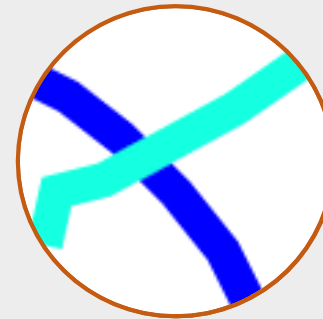
1. Compute path similarity
2. Handle overlaps between multiple paths



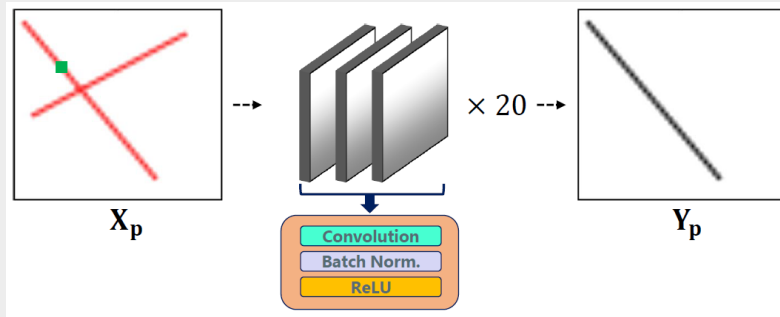


■ **Challenges**

1. Compute path similarity
2. Handle overlaps between multiple paths



» Overview



PathNet

Learning to Predict Path Similarity

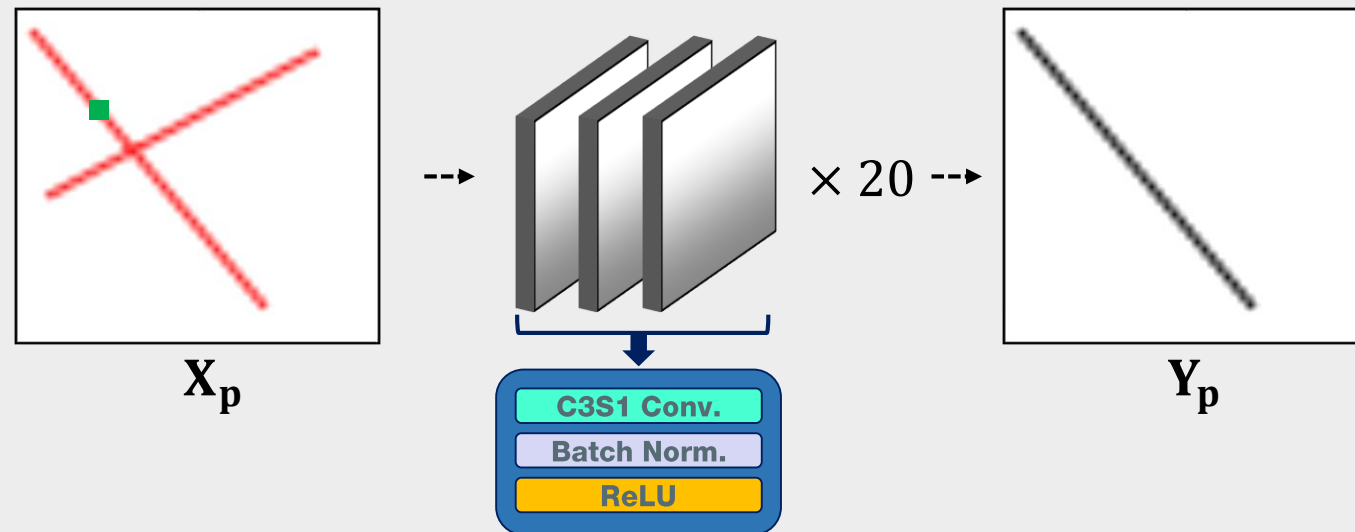
OverlapNet

Handling Overlapping Paths

Global Aggregation

Combine all the local predictions

» PathNet: Learning to Predict Path Similarity



» Path Similarity

■ Labeling Problem

$$E(l) = \sum_{pq \in \mathcal{N}} V_{pq}(l_p, l_q) \quad [\text{DeLong et al. 12}]$$

Penalty of assigning l_p and l_q

■ Intuition

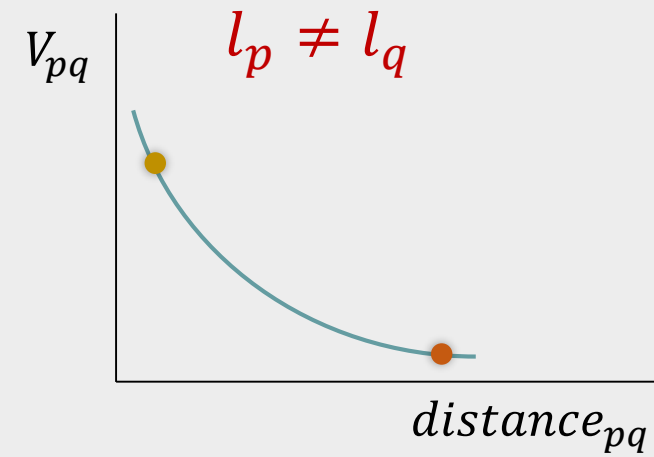
- Path Similarity K_{pq} : How likely two pixels are to occur on the same path

$$V_{pq} \propto K_{pq}, \text{ where } l_p \neq l_q$$

» Path Similarity

■ Penalty V_{pq}

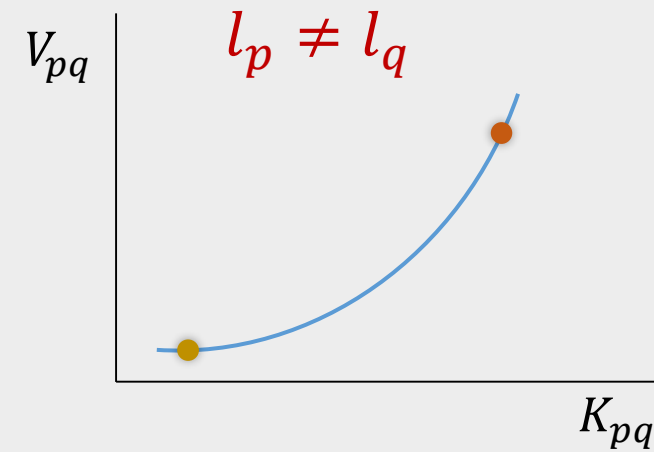
With a **spatial smoothness** assumption:



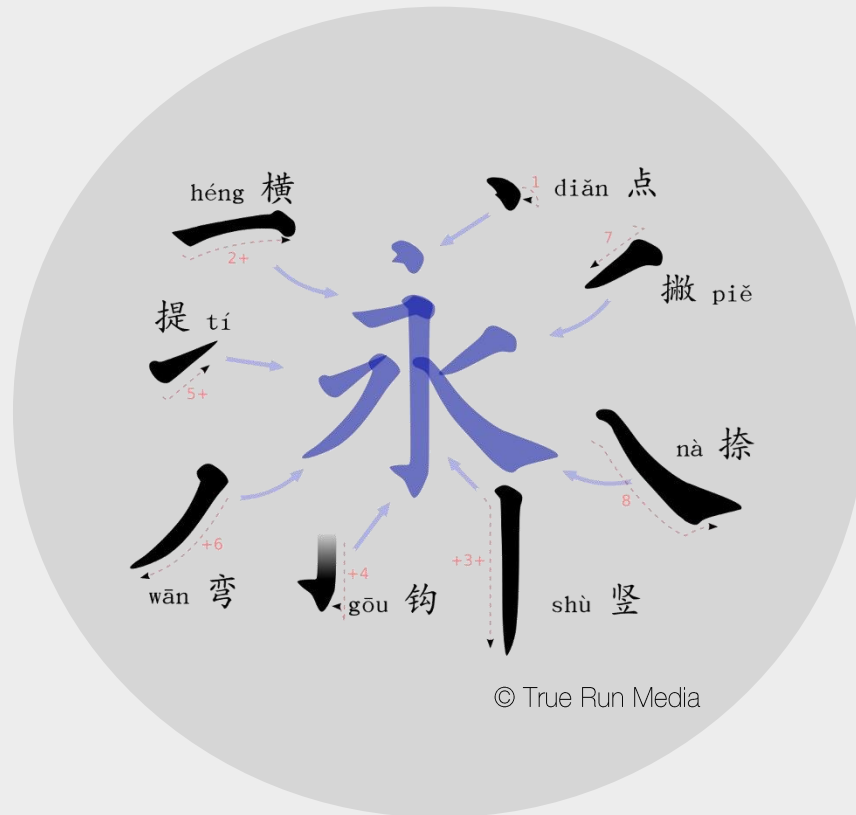
» Path Similarity

■ Penalty V_{pq}

With a path similarity K_{pq} :



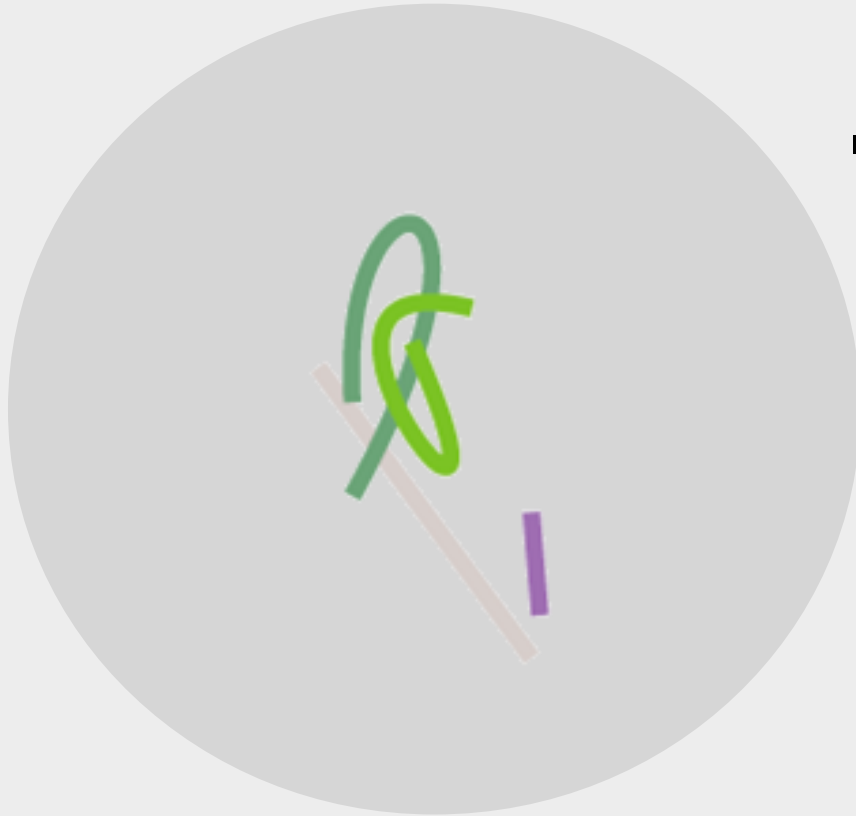
» Path Similarity



■ Path Similarity K_{pq}

1. Chinese Character: Stroke composition

» Path Similarity



■ Path Similarity K_{pq}

1. Chinese Character: Stroke composition
2. Synthetic Lines: Straight lines & Bezier curves

» Path Similarity



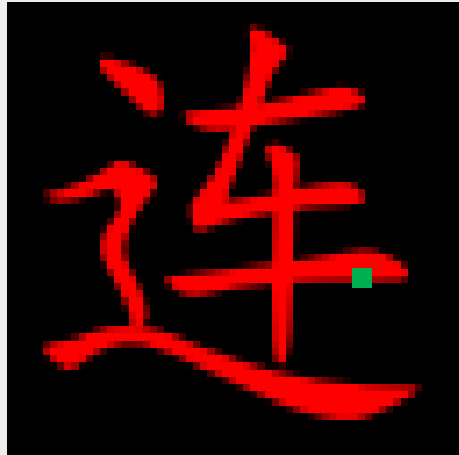
■ Path Similarity K_{pq}

1. Chinese Character: Stroke composition
2. Synthetic Lines: Straight lines & Bezier curves
3. Sketches: How people tend to draw

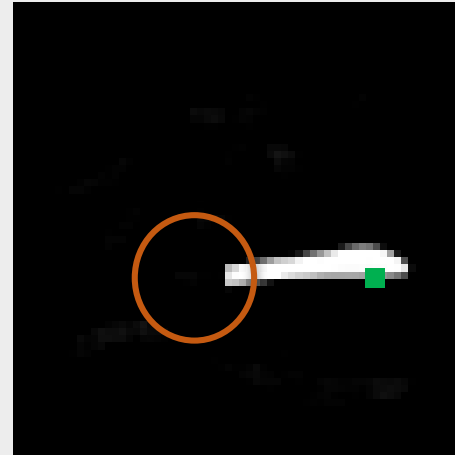
→ How to predict?

PathNet

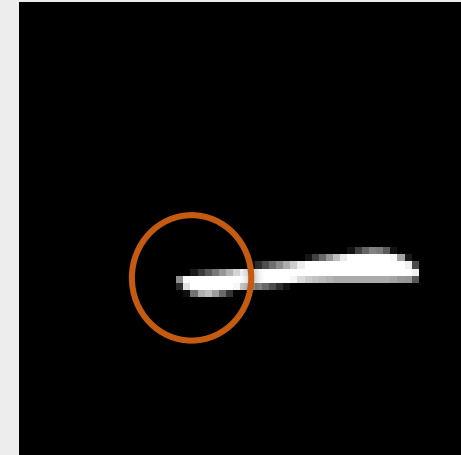
» PathNet: Learning to Predict Path Similarity



Input

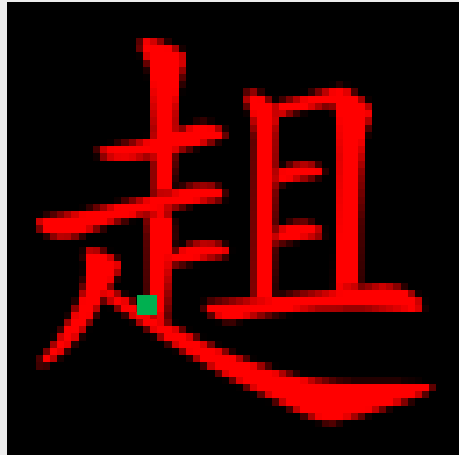


Output



Ground Truth

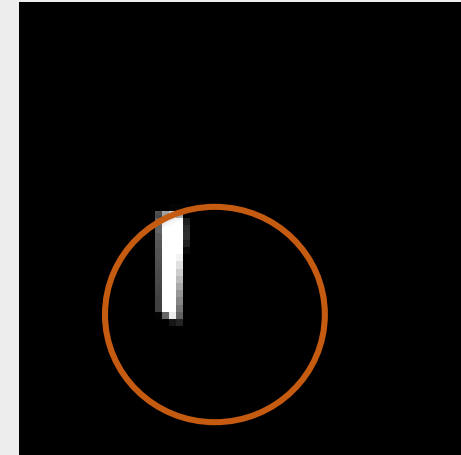
» PathNet: Learning to Predict Path Similarity



Input

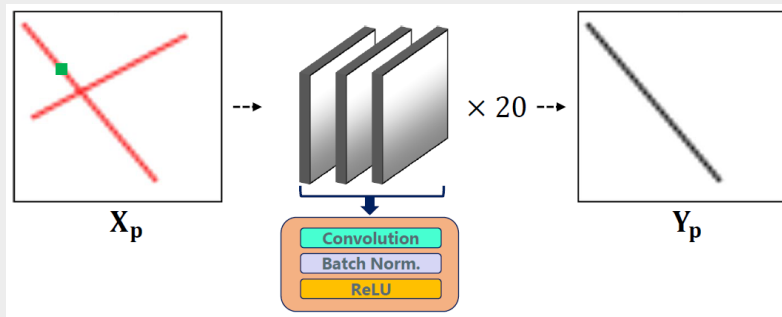


Output



Ground Truth

» Overview



PathNet
Learning to Predict Path Similarity



OverlapNet
Handling Overlapping Paths

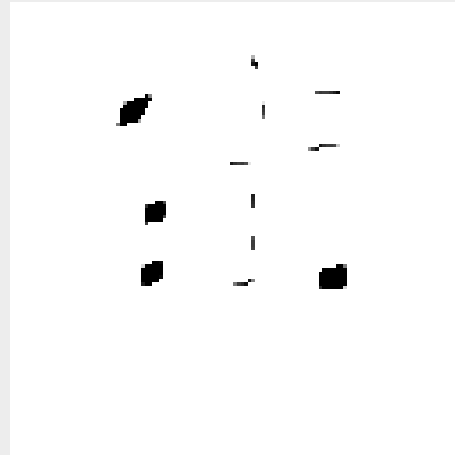


Global Aggregation
Combine all the local predictions

» OverlapNet: Handling Overlapping Paths



Input

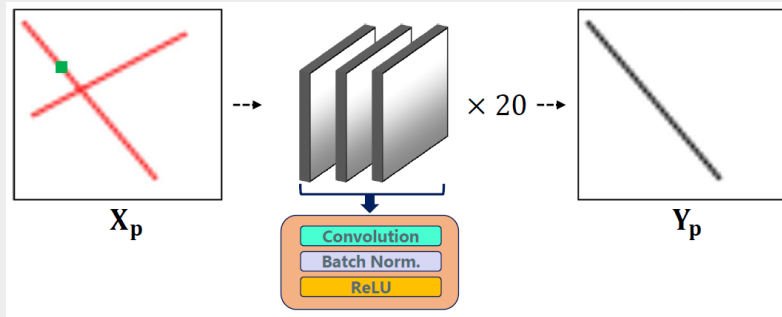


Overlaps



Blended Image

» Overview



PathNet

Learning to Predict Path Similarity

OverlapNet

Handling Overlapping Paths

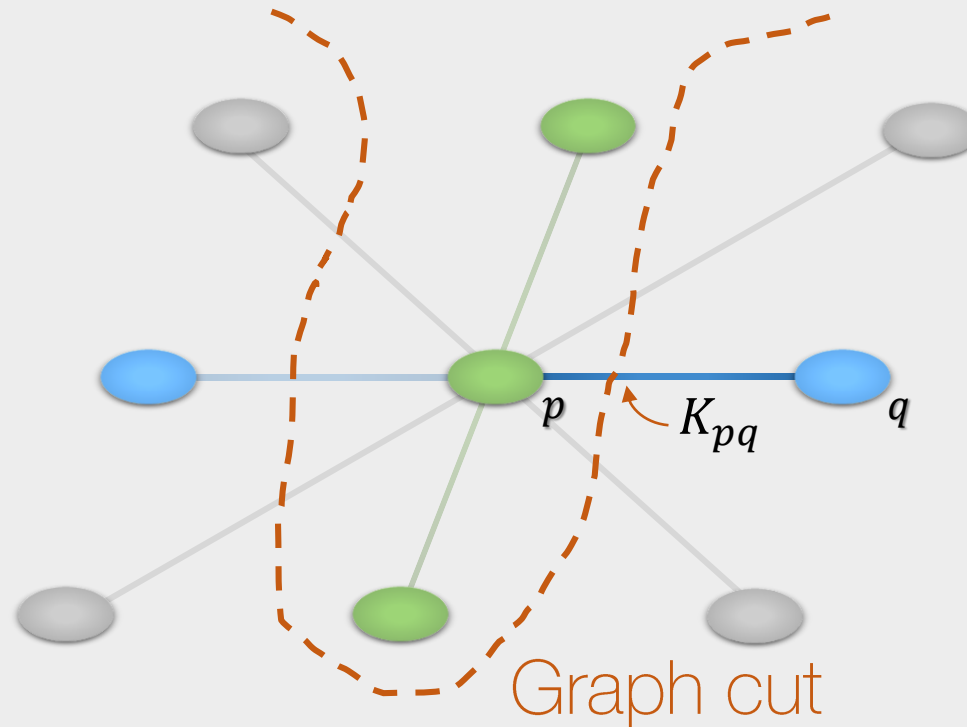
Global Aggregation

Combine all the local predictions

» Global Aggregation

■ Labeling Problem

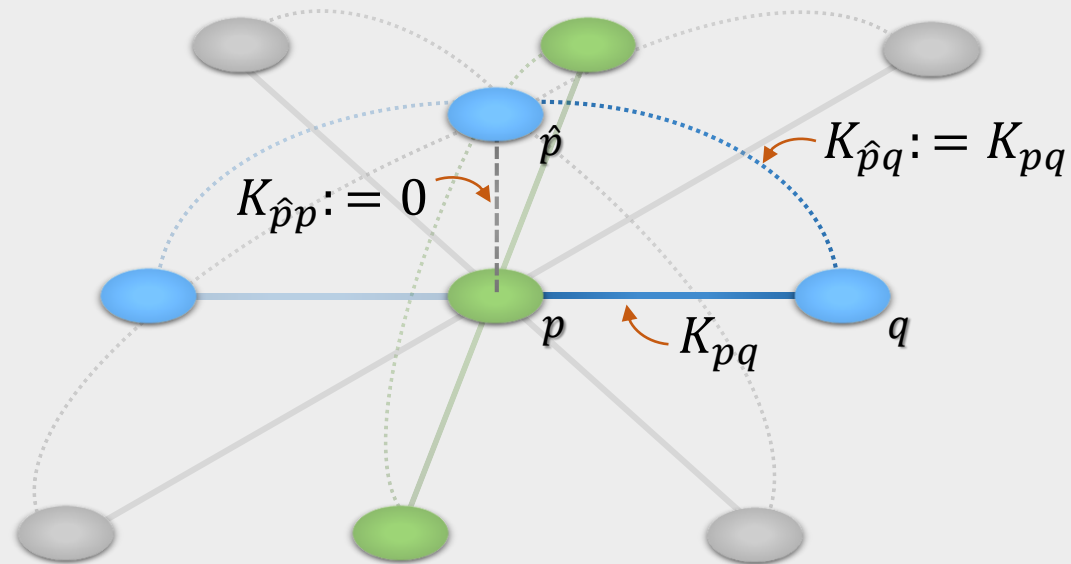
$$E(l) = \sum_{pq \in \mathcal{N}} V_{pq}(l_p, l_q) \quad [\text{DeLong et al. 12}] \quad (V_{pq} \propto K_{pq}, \text{ where } l_p \neq l_q)$$



» Global Aggregation

■ Labeling Problem

$$E(l) = \sum_{pq \in \mathcal{N}} V_{pq}(l_p, l_q) \quad [\text{DeLong et al. 12}] \quad (V_{pq} \propto K_{pq}, \text{ where } l_p \neq l_q)$$



Overlap Augmented Graph

» Global Aggregation

■ Labeling Problem

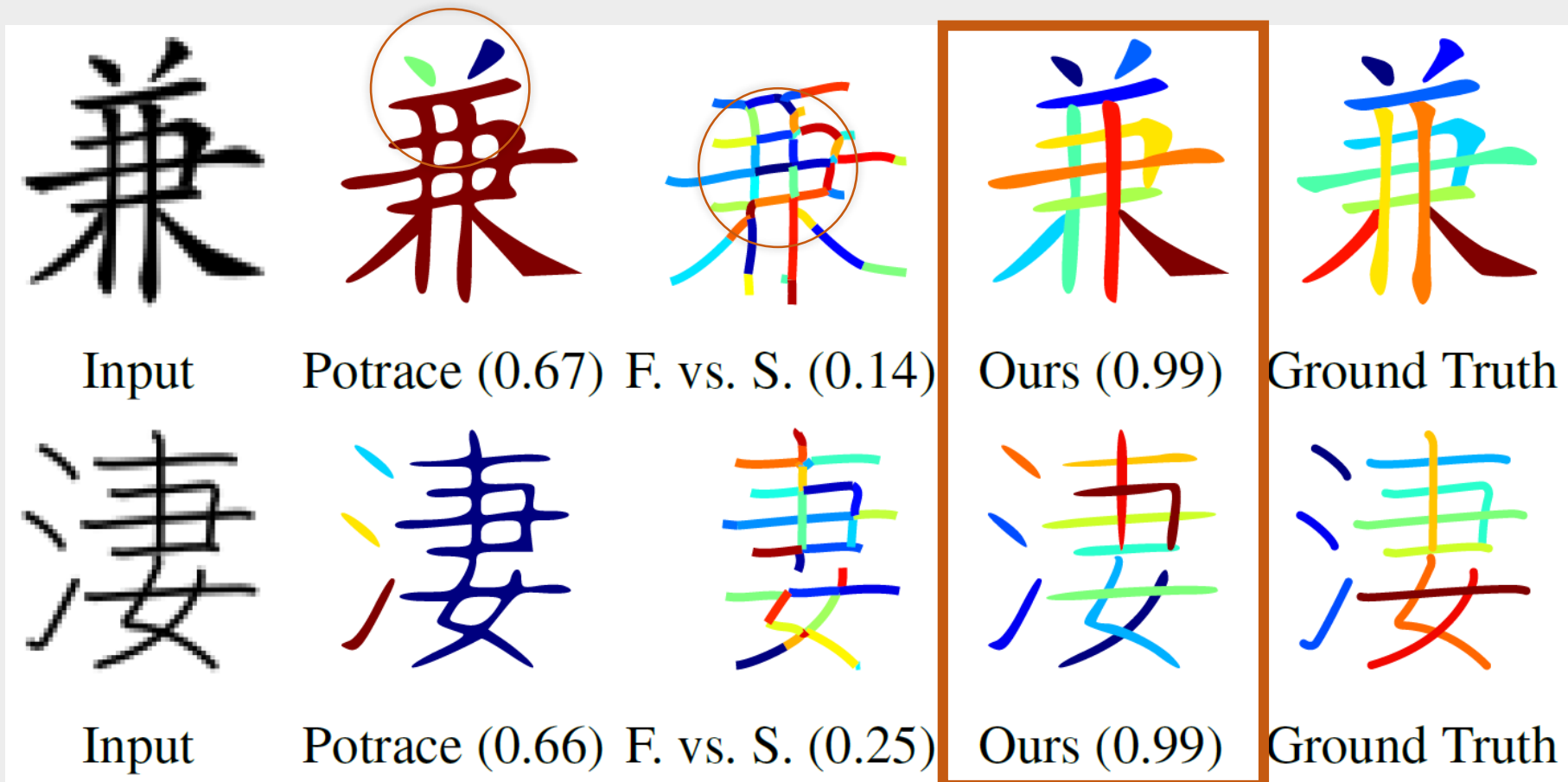
$$E(l) = \sum_{pq \in \mathcal{N}} V_{pq}(l_p, l_q) \quad [\text{DeLong et al. 12}] \quad (V_{pq} \propto K_{pq}, \text{ where } l_p \neq l_q)$$

■ Pipeline

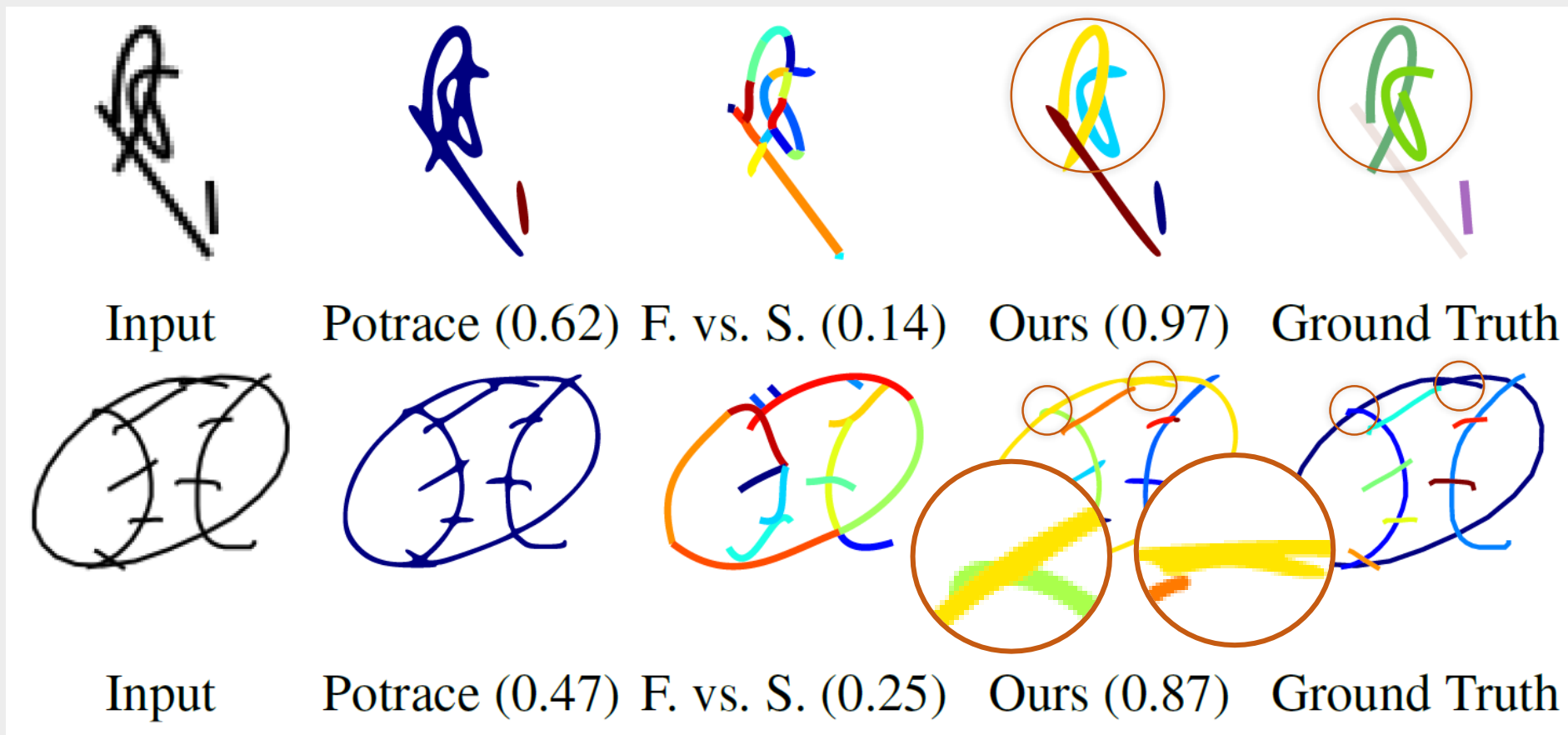


Result

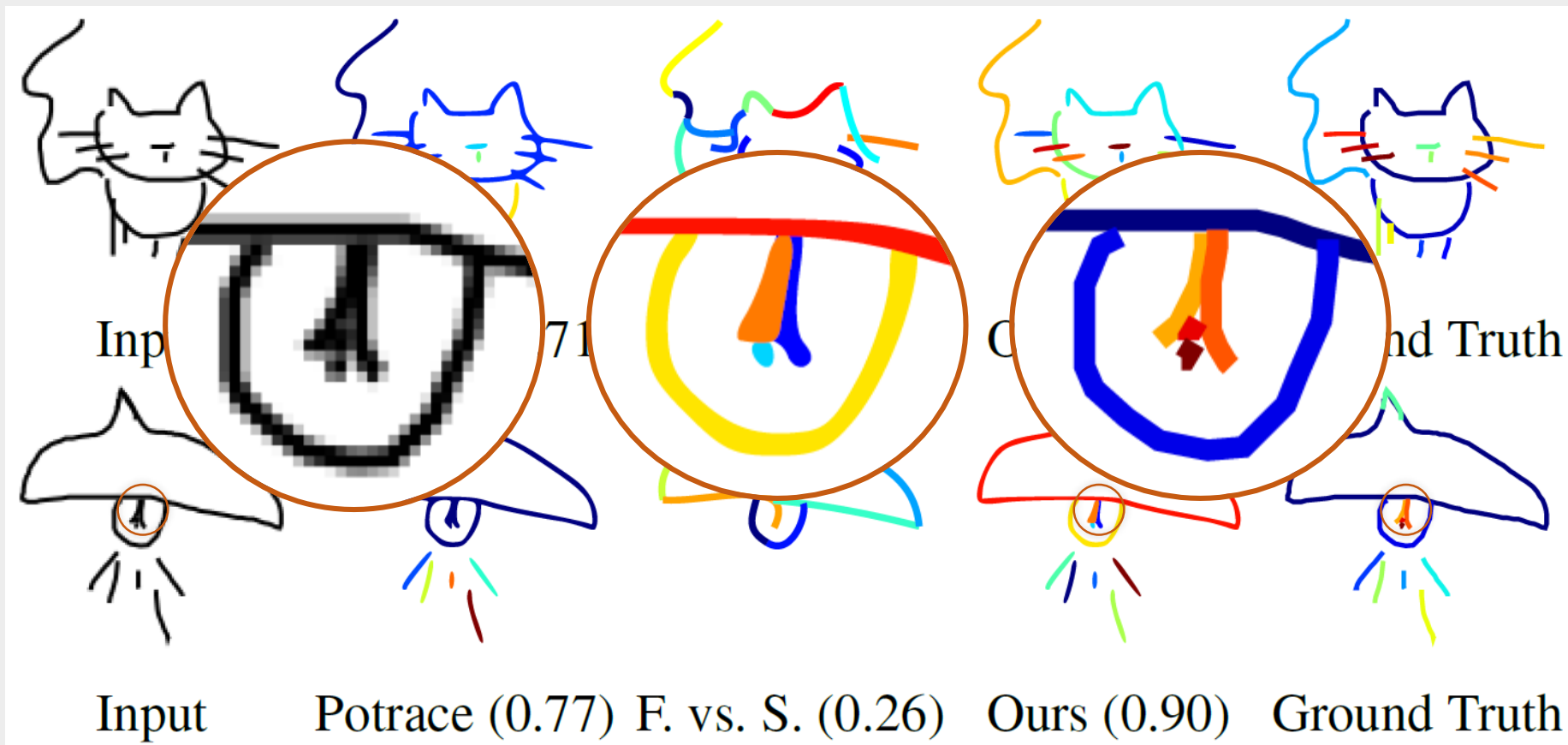
» Chinese Characters



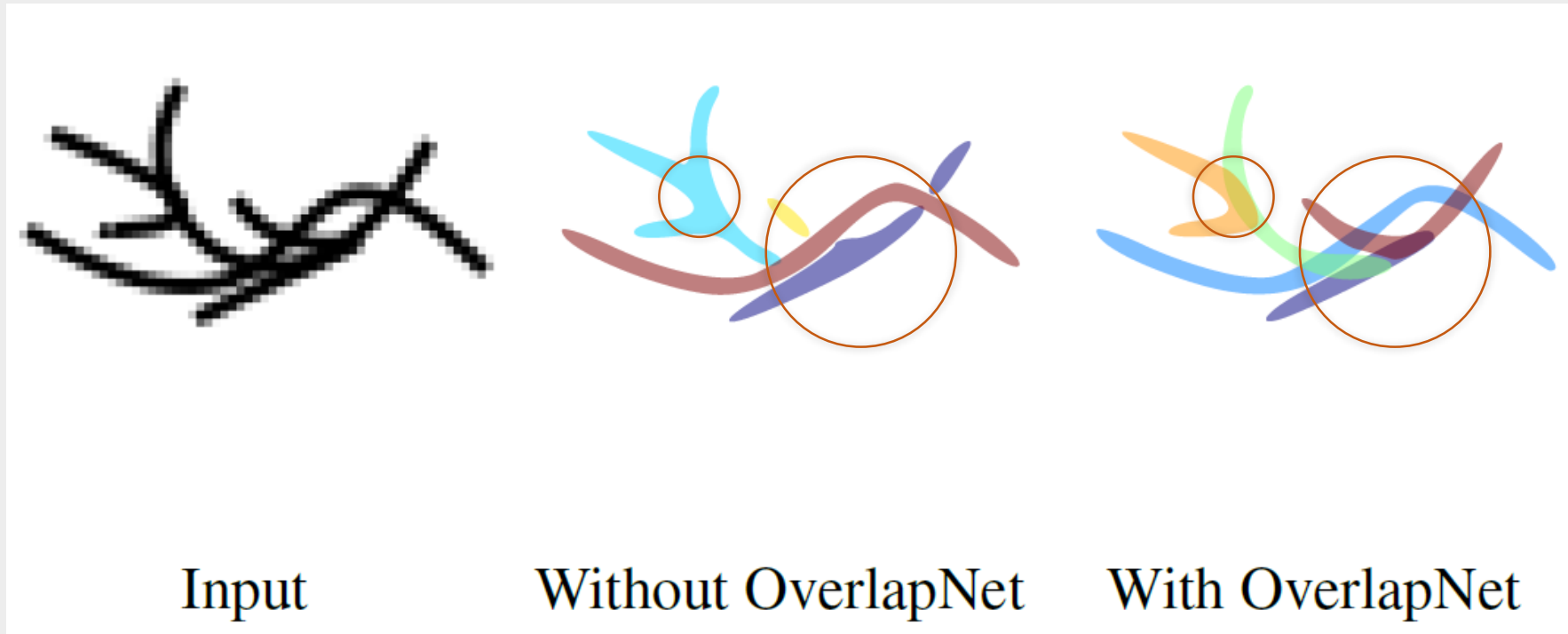
» Synthetic Lines & Sketches



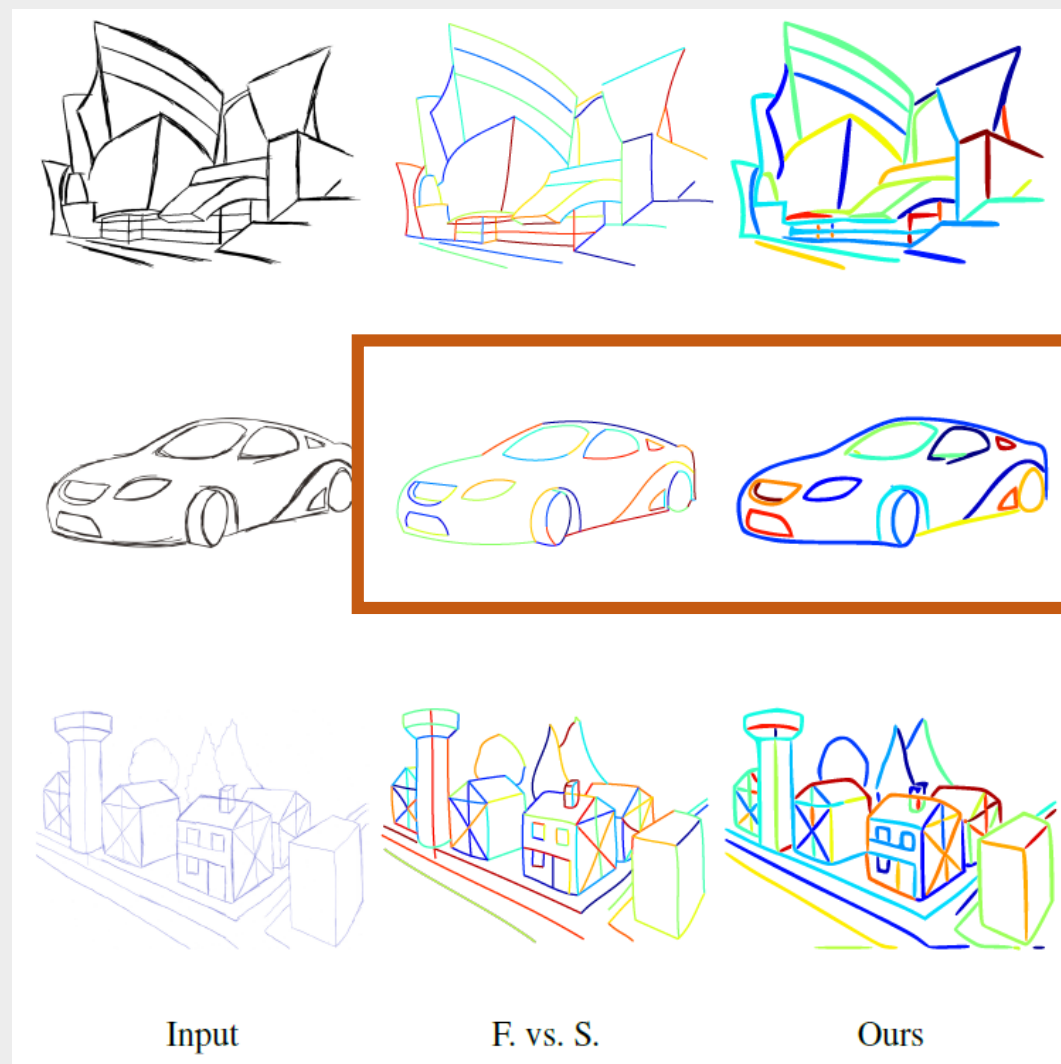
» Sketches

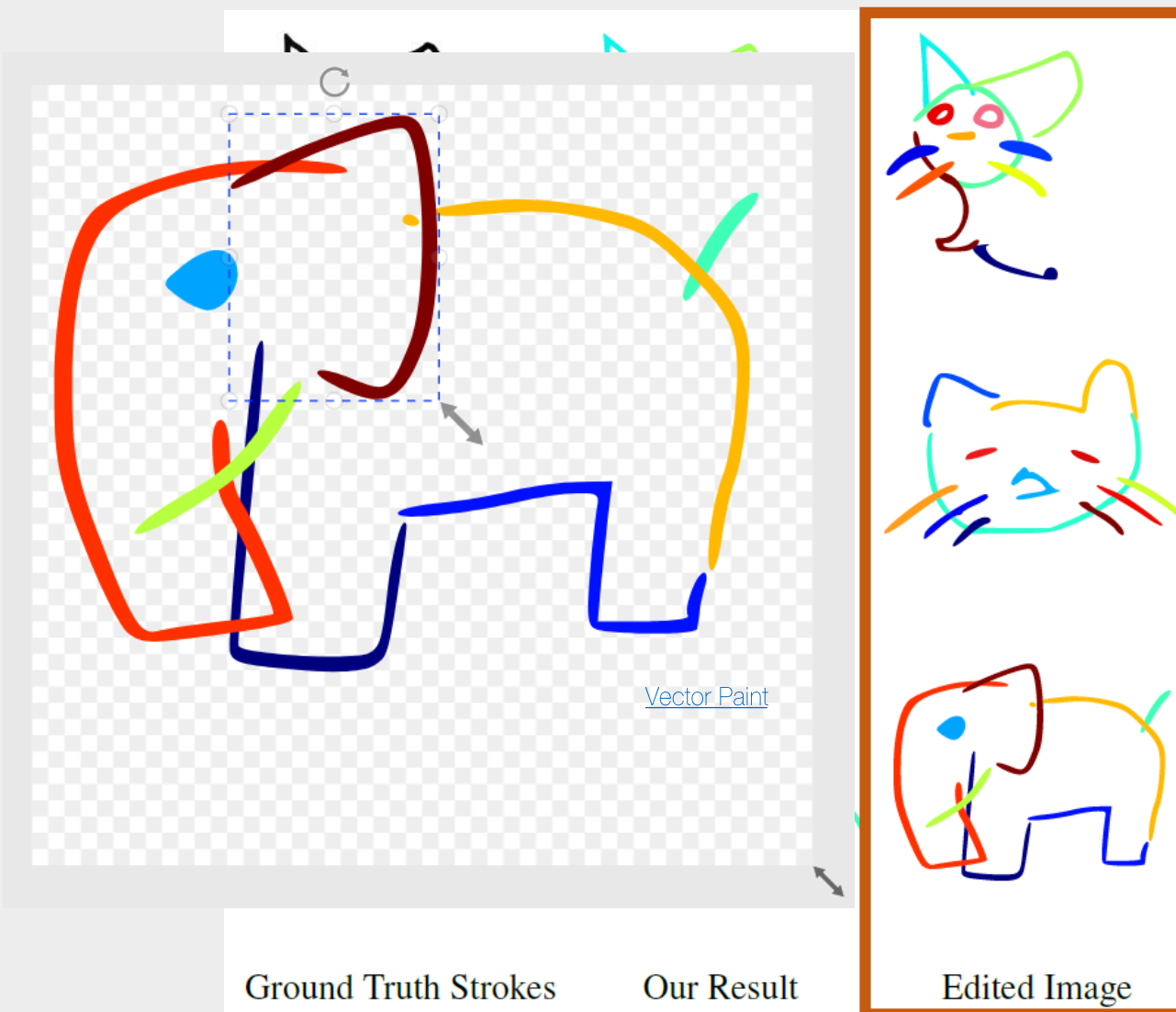


» Effect of the OverlapNet



» Preprocessed Rough Sketches





Ground Truth Strokes

Our Result

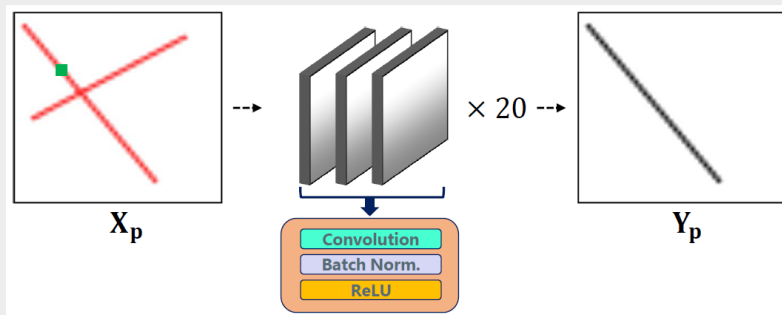
Edited Image



Multiple Overlapping Paths



Support for Colored Patches



PathNet

Learning to Predict Path Similarity

OverlapNet

Handling Overlapping Paths

Global Aggregation

Combine all the local predictions

Copyright

Chinese characters: [Make Me a Hanzi](#), [KanjiVG](#)

Sketches: [Google Quick, Draw](#)

Thank you for your attention!