Math Symbol Recognition

By
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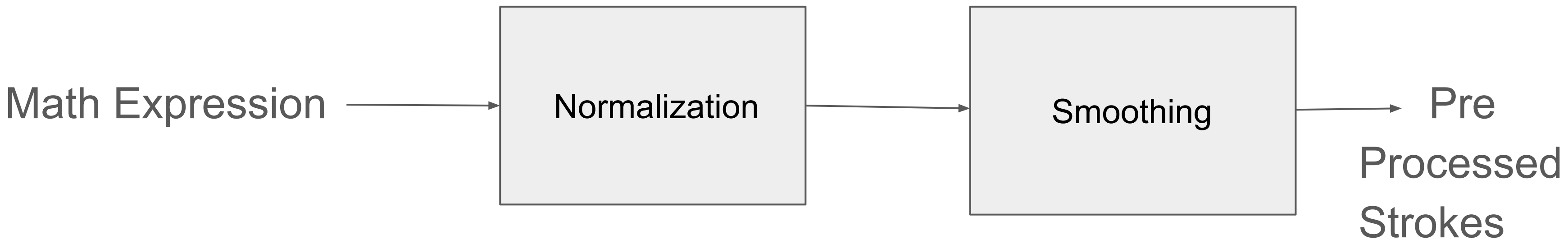
Overview

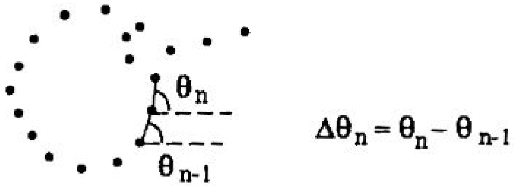
- Preprocessing
- Features
- Random Forest
- Minimum Spanning Tree Segmentation.
- Parsing
- Code

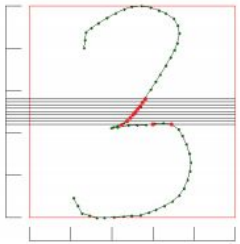
Stroke Preprocessing



Features

- Curvature
- Start direction
- Last direction
- Aspect Ratio
- Delta_x,Delta_y [1]
- Histogram of points
- Writing Angle and Delta Writing Angle
- Crossing features [2]



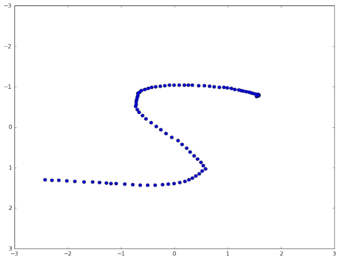


[1] Han Su, “On Line Handwriting Recognition Using Hidden Markov Models”

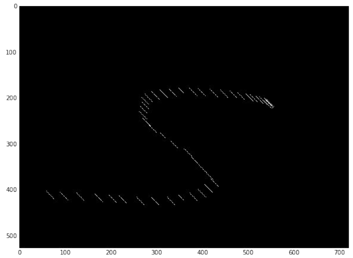
[2] Davila, Kenny, Stephanie Ludi, and Richard Zanibbi. "Using off-line features and synthetic data for on-line handwritten math symbol recognition."*Frontiers in Handwriting Recognition (ICFHR), 2014 14th International Conference on*. IEEE, 2014.

PCA Features

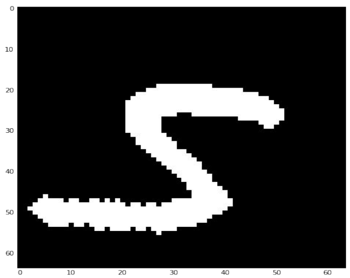
- Stroke points interpolated to image of 64 * 64 pixels



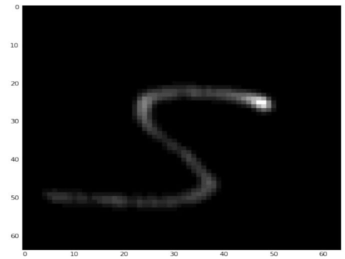
Original image



Interpolated Binary image



Dilation



Gaussian Smoothing

Classification Results

Random Forest Classifier.

No of Trees	60	100
Accuracy (Test)	77.52 %	78.30%

Minimum Spanning Tree Segmentation

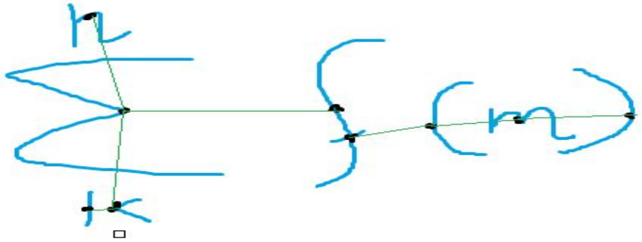
- Calculate Centroid of every stroke [1]
- Calculate Euclidean distance between strokes
- Construct Graph between all the strokes, where weight of edges is the euclidean distance
- Construct a minimum spanning tree using Kruskal’s algorithm.
- Use Dynamic Programming to find different possible ways to combine strokes to symbol in an efficient way.
- Use classifier to get probability estimate, i.e the set of strokes belong to a class with highest probability.
- Sum the probability of different symbols in the partition set, and choose the partition with highest cost value.

[1] Nicholas.E Matsakis, “Recognition of Handwritten Mathematical Expressions”

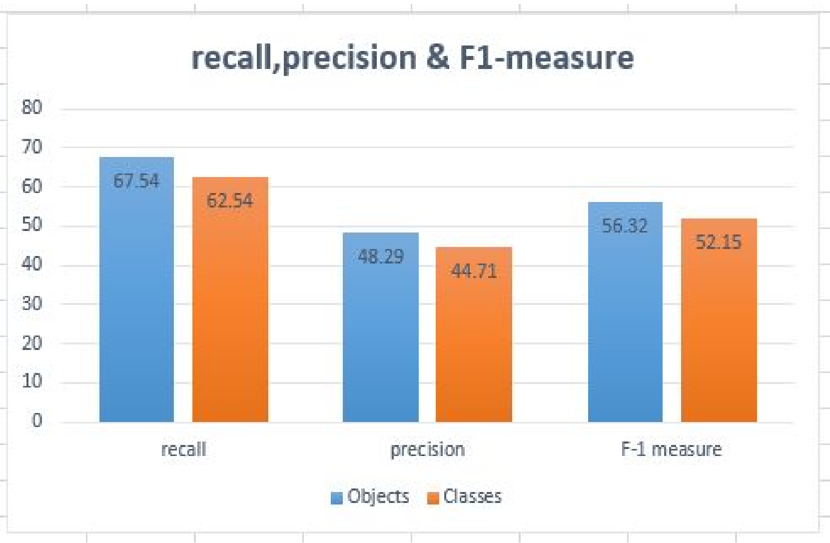
Minimum Spanning Tree Segmentation

Advantages of using MST.

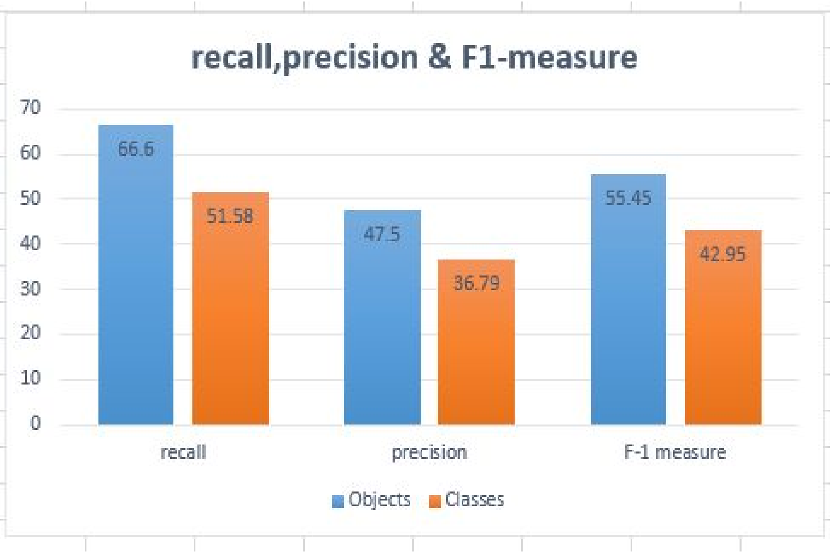
- No need to consider combination of strokes, which do not have an edge between them. Thus, reduces the search space and is more computationally efficient.
- Following figure is the MST for an expression, green lines are connection between stokes



Segmentation Results



Training



Testing

Parsing

- Line of Sight Graph for parsing [1], which is a method from computational geometry.
- Idea is that the object (i.e central object or an eye) can only be connected to other object, if it can see other object.
- If an object's view is blocked, then the central object or eye , cannot have an edge to that object.
- Compared to fully connected graphs, we only see potential candidates,thereby reducing search space.

[1] Lei Hu Phd Dissertation "Features and Algorithms for Visual Parsing of Handwritten Mathematical Expression"

Code

- Code available on github

https://github.com/suhaspillai/Handwritten-Recognition-of-Math-Symbols.git

Thank You

Questions?