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Image-Based Sketch Recognition

All source code included. Consult `createFeatureImage.m`, `recognizeSymbol.m`, and `test.m`. The last of these was the training code I used to determine optimal parameters.

Accuracy

The accuracy of the system is clearly affected by the parameters, but not to a tremendous degree (within a reasonable parameter range). The improvement with my best parameters over the defaults was 8% on circuits, 4% on digits, and actually slightly negative for shapes.

Method	Digits	Circuits	Shapes
Default	93.75%	80%	99.5%
Best	97.75%	88%	98.5%
Pixel-only	95.25%	83.25%	98.5%
No smoothing	80.5%	77%	98.75%

Baseline Analysis

The pixel-only method actually produced very good results, better than the default system at everything but shapes. My theory for this is that, in our implementation, the details of angle became noise. This could be because my default tangent window was too wide, and was thus obscuring details of the drawing which actually contained valuable information.

The method without smoothing, on the other had, performed quite poorly on digits and circuits. It makes perfect sense that this would be the case, as the distance metric that we used would penalize minor misalignment very harshly, and without some fuzzing misalignment was guaranteed.

Best Parameters

Using my best parameters, this system achieved an accuracy of 97.75% on `digits`, 88% on `circuits`, and 98.5% on `shapes`.

There were two parameters mentioned in the assignment, `sigma` and `h`, but there was one more: the window used for tangent approximations. I ran a test on the `digits` set using three possible values around the defaults for each of these three parameters, for a total of nine combinations. These possible values were:

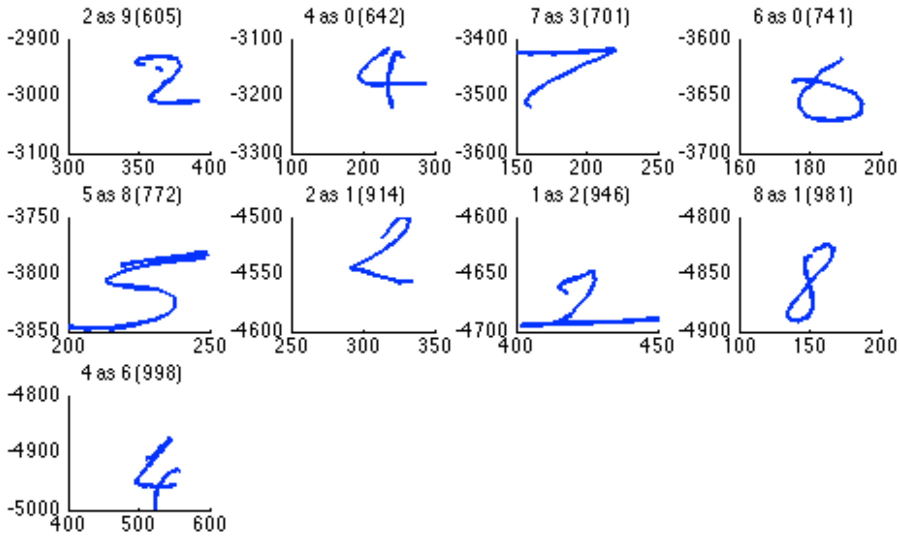
```
h = {16, 24, 32} (before downsampling)
tangentWindowSize = {5, 10, 15}
sigma = {0.5, 1.0, 1.5}
```

From these, the optimal selection on the `digits` set was `h=16, tangentWindowSize=5, sigma=1.5`

Errors

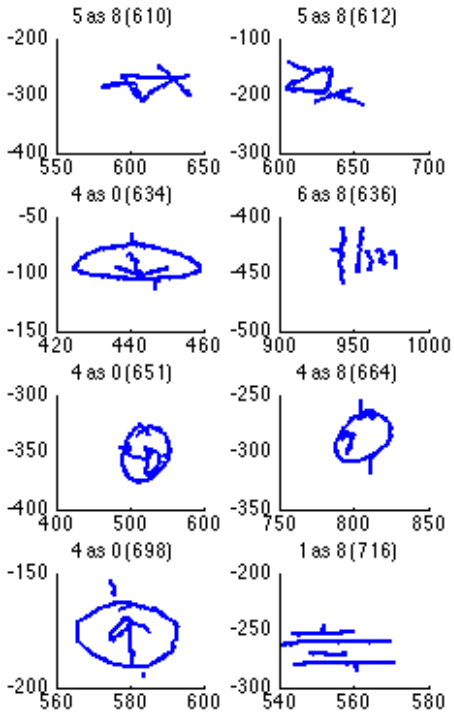
Digits

```
errors =

   605   642   701   741   772   914   946   981   998
```


2 as 9 (605)
4 as 0 (642)
7 as 3 (701)
6 as 0 (741)
5 as 8 (772)
2 as 1 (914)
1 as 2 (946)
8 as 1 (981)
4 as 6 (998)

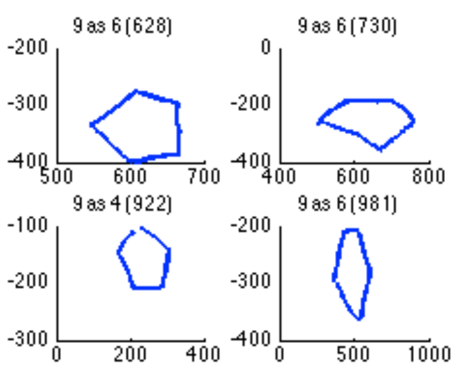
Circuits

```
errors =

  Columns 1 through 11

   610   612   620   623   634   636   639   644   651   664   6

  Columns 12 through 22

   681   698   716   729   733   735   738   740   746   748   7

  Columns 23 through 33

   781   794   799   813   836   849   857   861   867   871   8

  Columns 34 through 44

   889   892   893   907   913   938   948   957   959   962   9

  Columns 45 through 48

   971   975   981   997
```



Shapes

```
errors =

   628    730    812    890    922    981
```



Analysis

Some of the errors here were made for good reason. The 'five' in the second row of digits, for example, I wouldn't have been able to identify myself, and similarly I would say that the 'six' in the first row would be *better* labeled a zero. Some errors, like the first two in the second row, were probably made because of orientation problems. Others may simply have been not quite similar enough to the training set, which IDM might help.

Several of the shape and circuit cases are likewise at slightly off angles, or have been nonuniformly deformed.

Default Parameters

Using the default parameters of `h=24, tangentWindowSize=10, sigma=1.0`, this system had an accuracy of 93.75% on `digits`, 80% on `circuits`, and 99.5% on `shapes`.

This `shapes` performance was very good indeed, and the difference in performance based on these parameter changes may indicate that shape drawing or 'more freehand' drawing in general requires a different set of parameters. Of course, it could just be that having a broader tangent window allowed slightly more rotation-invariance.

Additional Steps

Of the steps described in the paper, accounting for rotations has to be the biggest (and simplest) improvement to make to this system. While in the case of digits, the system could reasonably be expected to get digits in only one orientation (or, equivalently, with a known orientation), and thus rotation-insensitivity wouldn't help much, in the cases of circuits and shapes many orientations will likely be encountered. As it stands, this system only matches different orientations when a sample of that orientation exists in the training set, which would drastically reduce effectiveness in real-world situations.