Application for Recognition of Handwritten Mathematical Characters

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PUT IT INTO PRACTICE, Nov. 13, 2010.

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Western

This talk is about

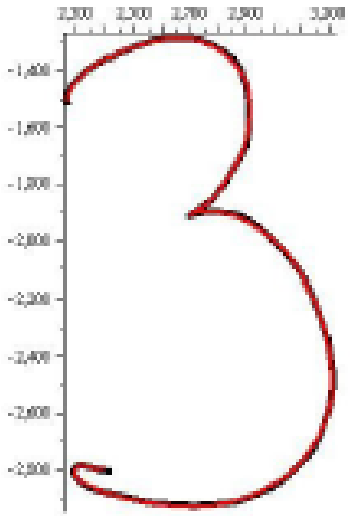
- Representation of digital *handwriting*
- The basic concepts of *recognition*
- Real life application for handwritten input of math characters
- Compact representation of characters

Digital *handwriting*

- Represented as a sequence of points

  $(x_0,y_0), (x_1,y_1), (x_2,y_2)...$

- Each point contains one value of certain channel

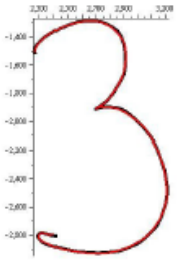


Decomposition of Channels

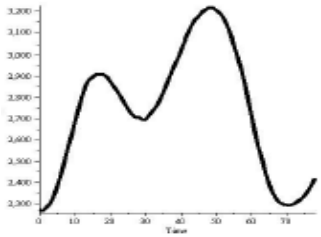
- Consider X and Y coordinates separately, as functions, say, of time:

(x_0,y_0), (x_1,y_1), (x_2,y_2)... → (t_0, x_0), (t_1, x_1), (t_2, x_2)... and (t_0,y_0), (t_1,y_1), (t_2,y_2)...

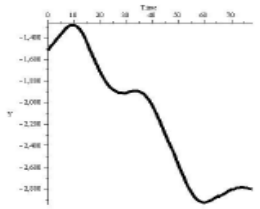
- Then



X(t)



Y(t)



Approximation of a Character

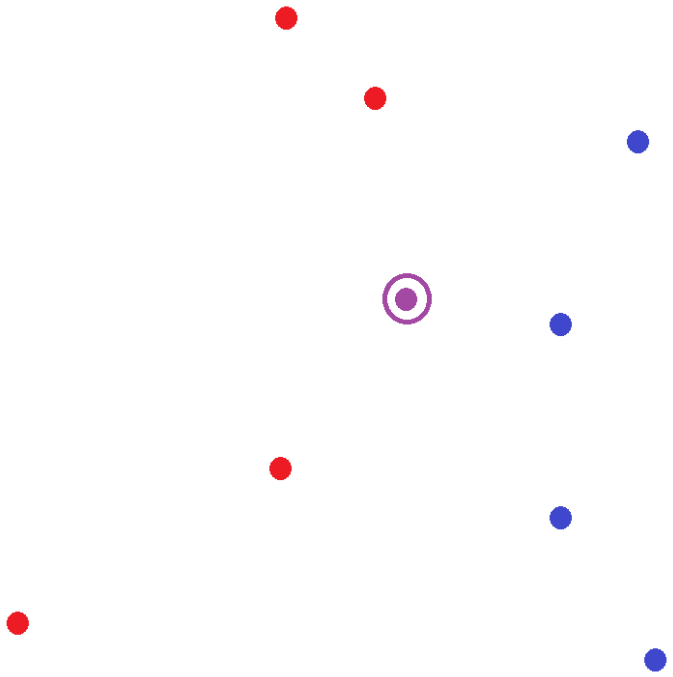
- A function can be approximated with orthogonal polynomials $P_0, P_1, \ldots$:

$$f(t) \approx \sum_{i=0}^{d} c_i P_i(t)$$

- We approximate $X(t)$ and $Y(t)$ and obtain

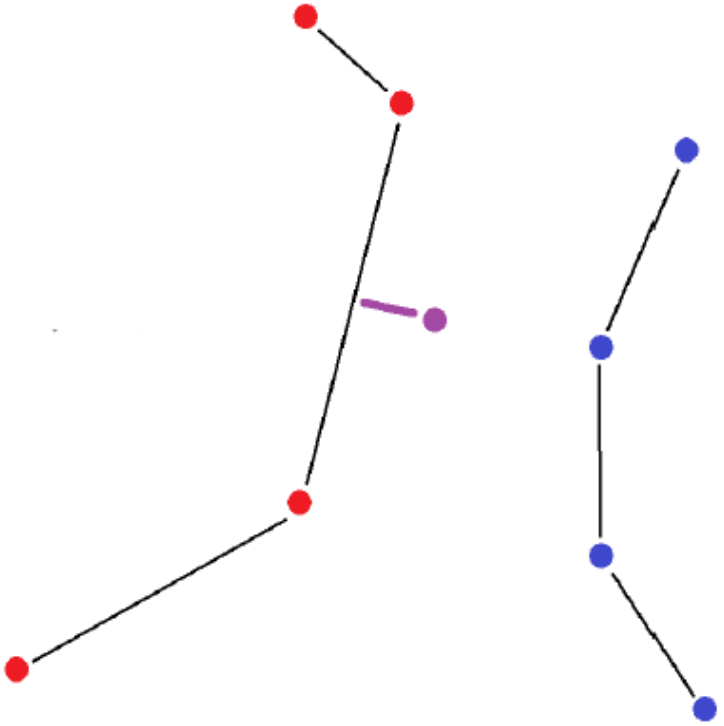
$$c_0^X, c_1^X, \ldots, c_d^X, c_0^Y, c_1^Y, \ldots, c_d^Y$$

Classifying a point



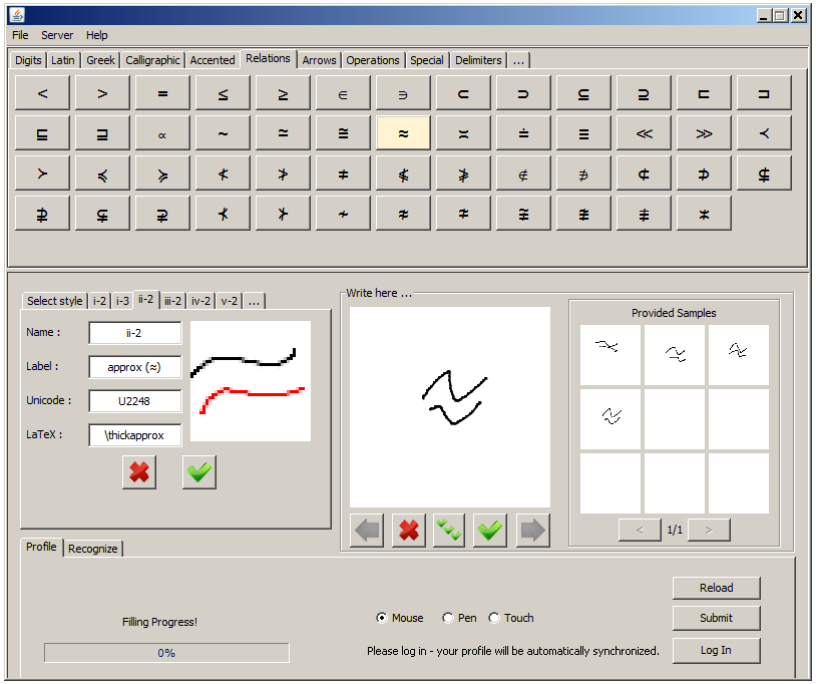
Classification

- Classification is based on the distance to convex hulls of nearest neighbours.

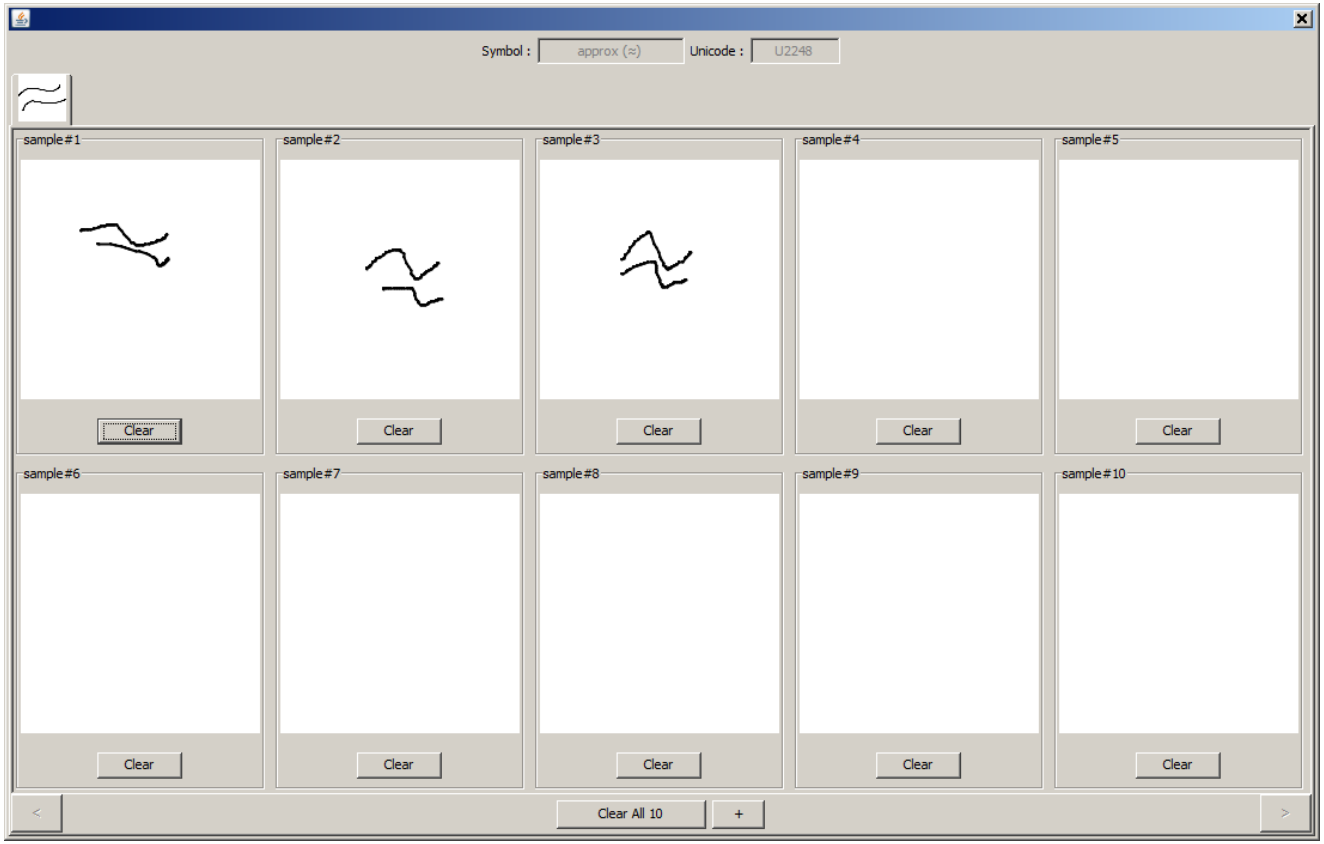


From Theory to Practice

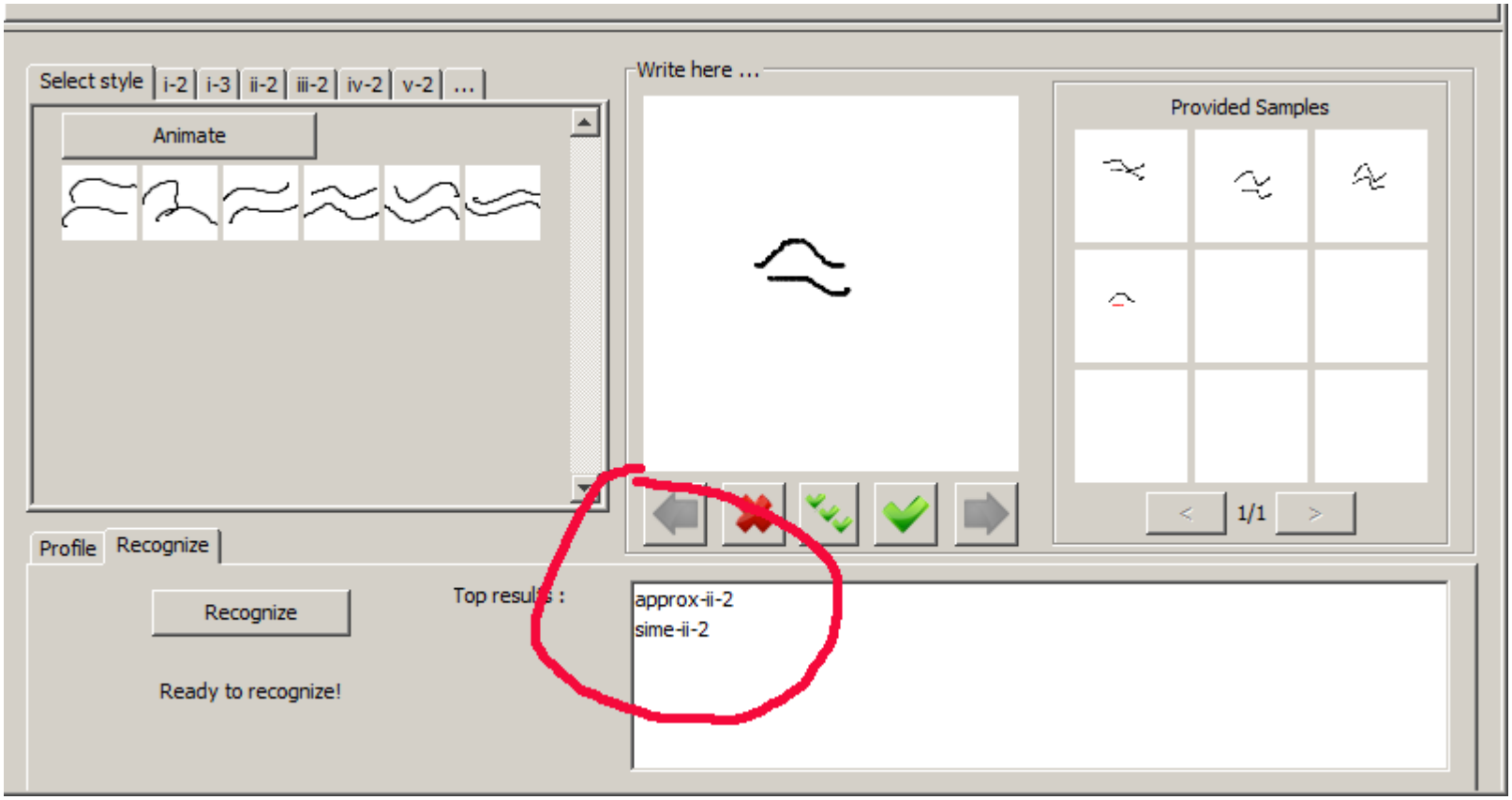
- Students at ORCCA (Ontario Research Center for Computer Algebra, CSD, UWO) have developed this



Training the Application



Recognition

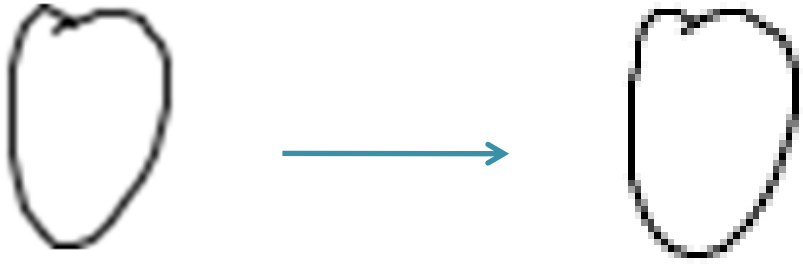


Compact Representation of Symbols

- We use Legendre-Sobolev inner product to generate orthogonal polynomials.
- Training samples are approximated with these polynomials.
- Coefficients of approximation describe samples compactly and precisely.

Compact Representation of Symbols

- Approximation



- Representation of the approx. sample is

<st>0.024;18.41;-17.67;11;2;-12;63;-71;-18;1;-76;14;14;8;5;-2;3;1;-7;5;8;-10;6;</st>

Interpretation of Representation

<st>0.024;18.41;-17.67;11;2;-12;63;-71;-18;1;-76;14;14;8;5;-2;3;1;-7;5;8;-10;6;</st>

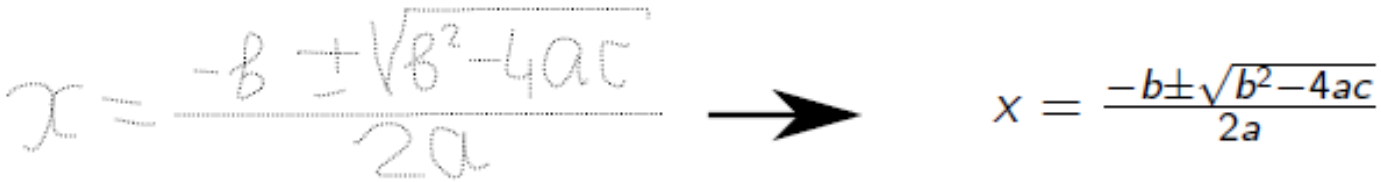
- From left to right:
  - Size normalization weight
  - Coordinates of the first point
  - Normalized LS coefficients of approximation (multiplied by 256)

- Such representation is suitable for direct usage in recognition applications

Conclusion

- Recognition and compression of digital ink can go hand in hand and give high performance.

- The algorithms and software that we are working on is a stepping stone towards



References

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Thank you!