Computer Science @ RIT

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Optical Character Recognition using Artificial Neural Networks

> "Much of the world's information is held captive in hard-copy documents. OCR systems liberate this information by converting the text on paper into electronic form."
> - S.V. Rice, G. Nagy, & T. A. Narker [5]

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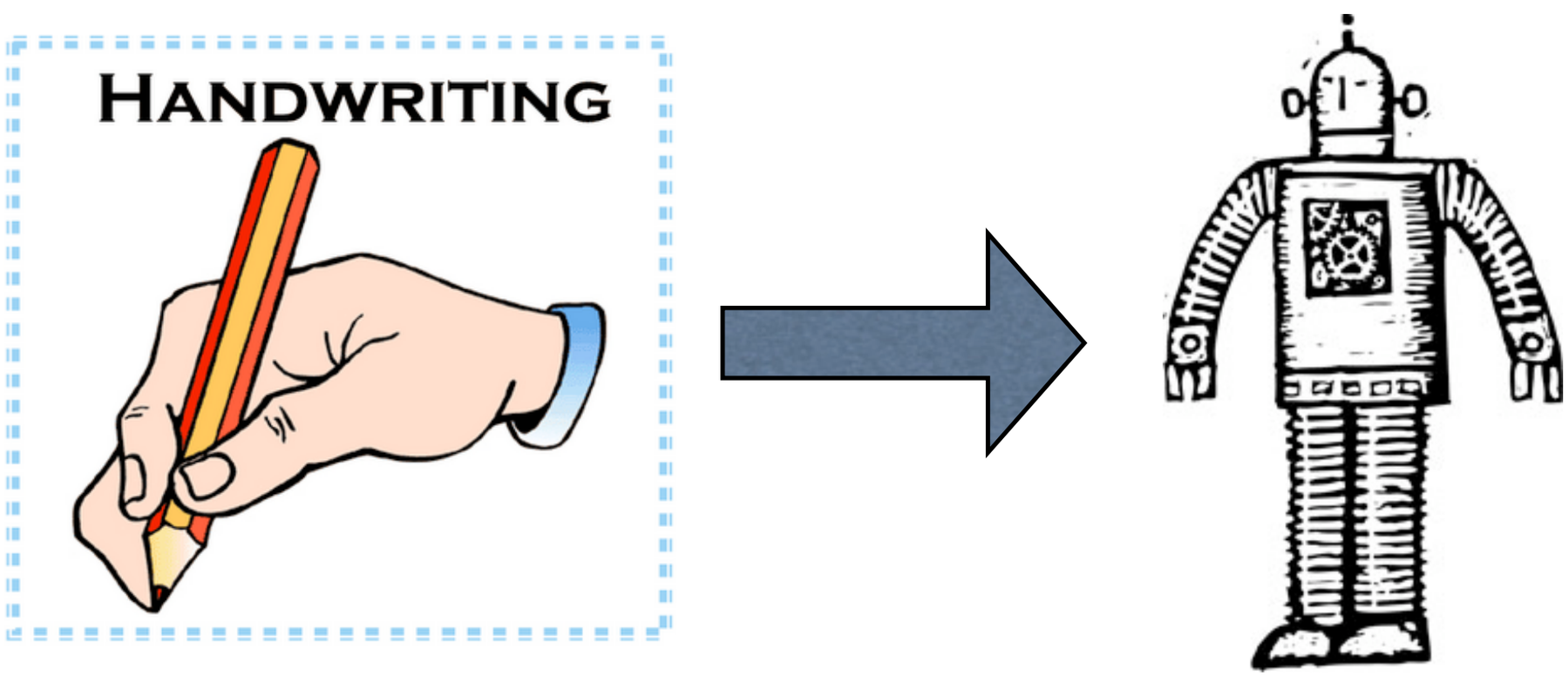
OCR

- Definition: the process of translating images of handwritten, typewritten, or printed text into a format understood by machines
- Why? allows for reduced storage size, editing, indexing, searching, etc.



Steps of OCR

- Character segmentation
  - Based on vertical projections (or VP diffs)
  - Connected component analysis
- Feature extraction
  - Side profiles
  - Line adjacency graphs
  - Vertical/Horizontal projections
- Character recognition => ANN

Improving OCR [5]

- Improve the scanning technique
  - Higher dpi
  - Scan in grayscale or color
- Improve pre-processing
  - noise removal
  - skew correction
- Use a single "OCR-friendly" font
- Domain specific knowledge

Artificial Neural Networks

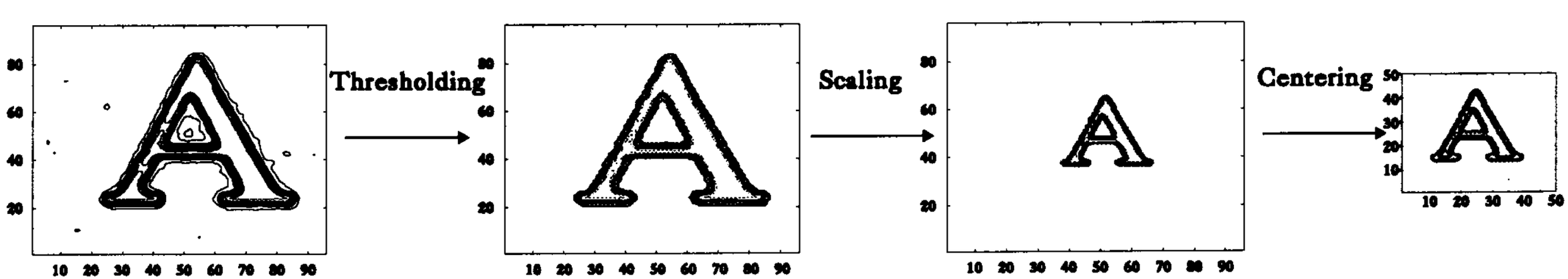
- Why ANNs?
  - can deal with fuzzy data
  - can learn over time
- Steps:
  - Character segmentation
  - Feature extraction
  - Input: feature vectors
  - Output: character class

Avi-Itzhak et al., 1995 [1]

- High Accuracy Optical Character Recognition Using Neural Network with Centroid Dithering
- Idea: Simple is better!
  - Input = every pixel of the scanned character
  - Output = highest indicates character class
- Experiments with multi-font + multi-size
- Near perfect accuracy

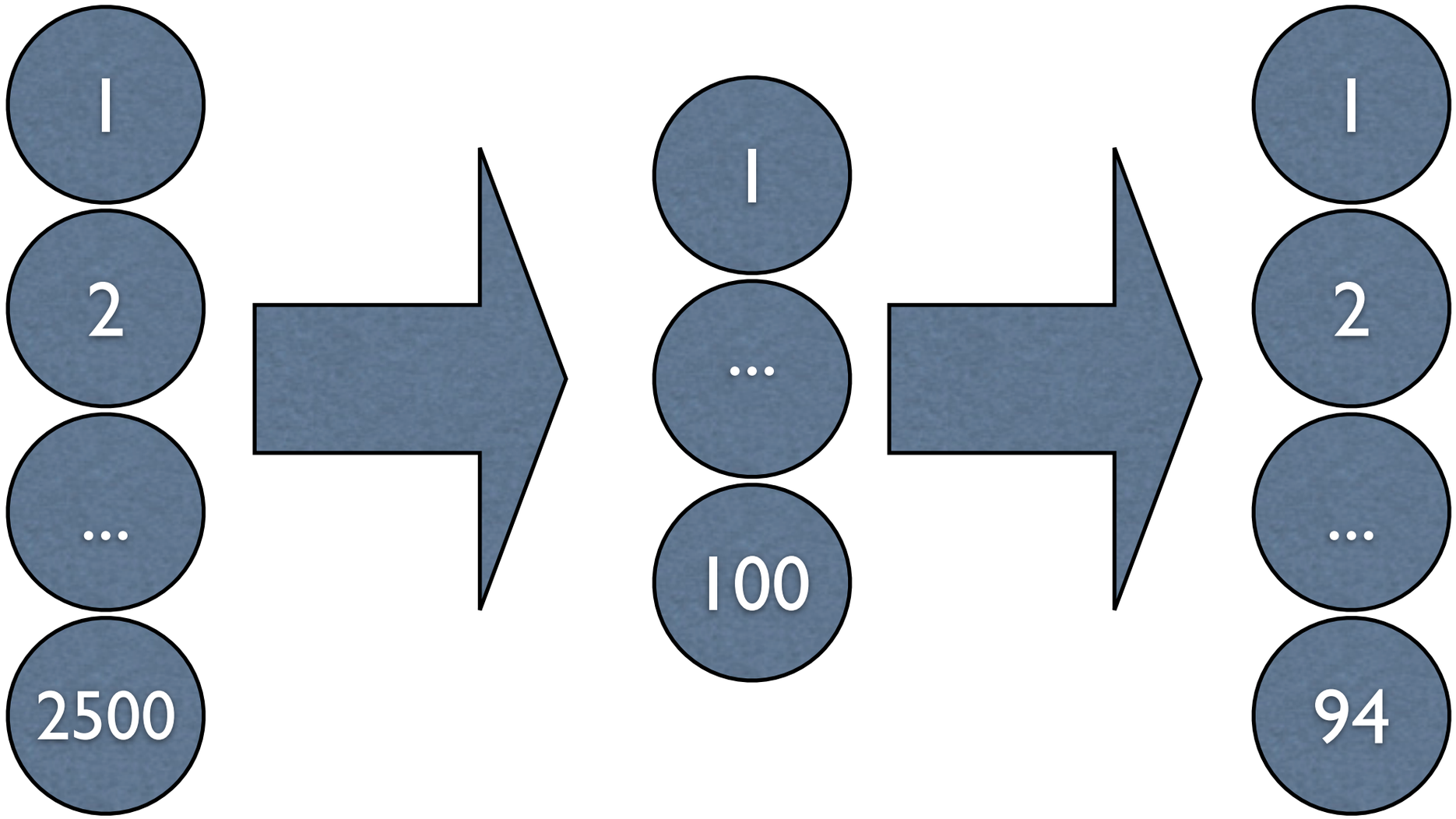
Pre-Processing

- Remove noise via thresholding
- Normalize via scaling to 50x50 pixels
- Center character on centroid



- Convert 2D array to a vector (concatenation)
- Feed into the input nodes of ANN

Network Topology



Input Layer Hidden Layer Output Layer

Training the ANN

- Generate one example character for each of the 12 different fonts
- Centroid dithering: creates many "different" images from this single input character
  - Shift character around in [-2,+2] window
  - Allows for width variations in character strokes
- 8,650,000 iterations => MSE=2x10^-6

Testing the ANN

- Test samples varied in font and size
- Assumes perfect segmentation of cleanly printed characters
- Doesn't account for l vs 1 vs | across fonts
  - Needs surrounding context
  - Ex: "32l0" vs. "SCIENCE" vs. "isRed || isBlue"
- Recognized 100% of the 347,712 test samples

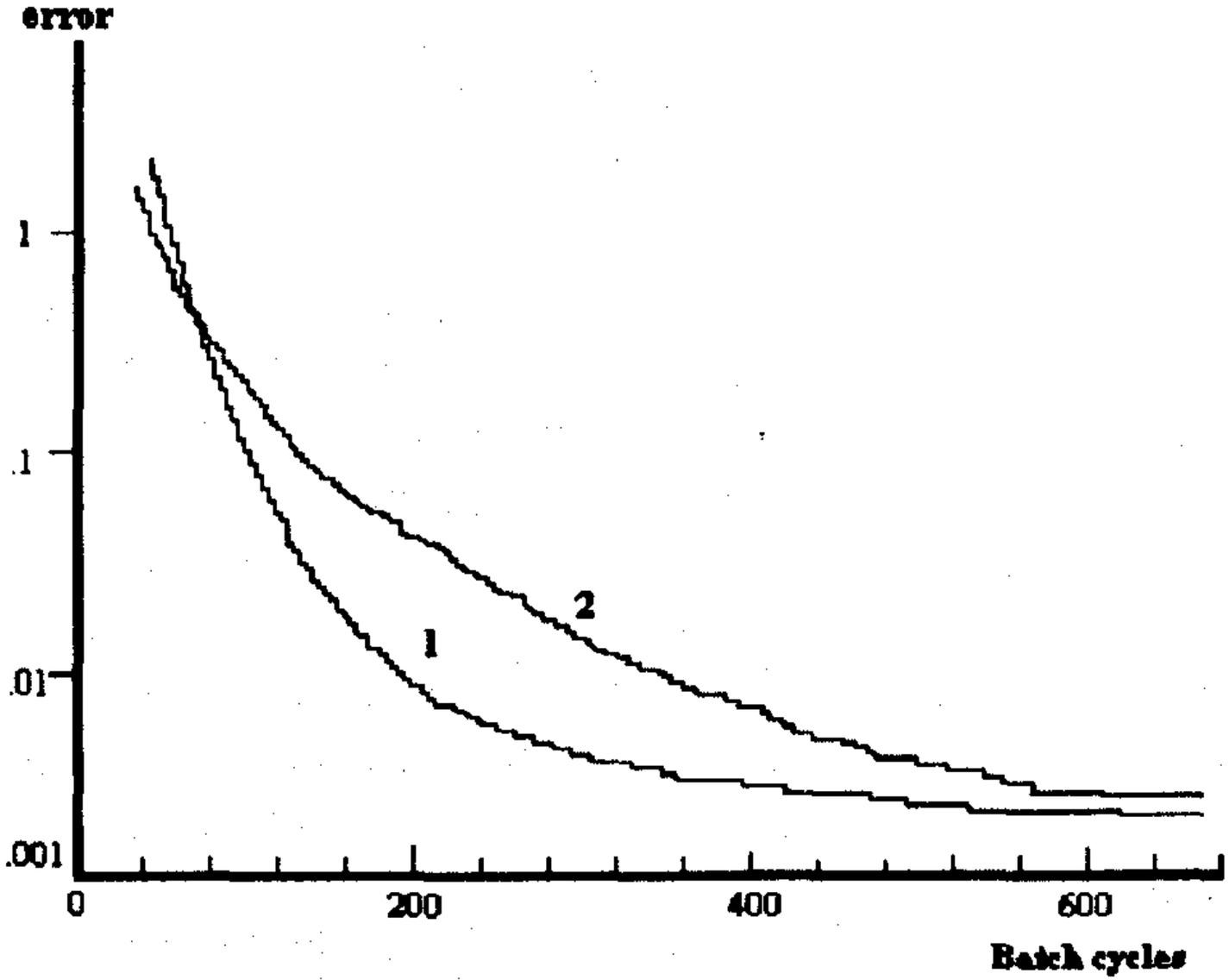
Ramirez et al., 1996 [7]

- On Structural Adaptability of Neural Networks in Character Recognition
- Idea: A fixed structured network is bad
  - Based on idea by T.C. Lee's PhD dissertation [3]
    - Change weights, structure, and learning rate of the network
- Uses vertical + horiz run lengths as features
- Result: Fixed structure network out performs the structure adapting network

Structure Adaptability

- An optimal solution requires a suitable number of neurons in the hidden layer
- If error stabilizes but is still greater than desired, insert another neuron
- If a neuron is a redundant element or a non-functioning element, get rid of it
- Adapt the learning rate to accelerate convergence (high at first, low towards end)

Results

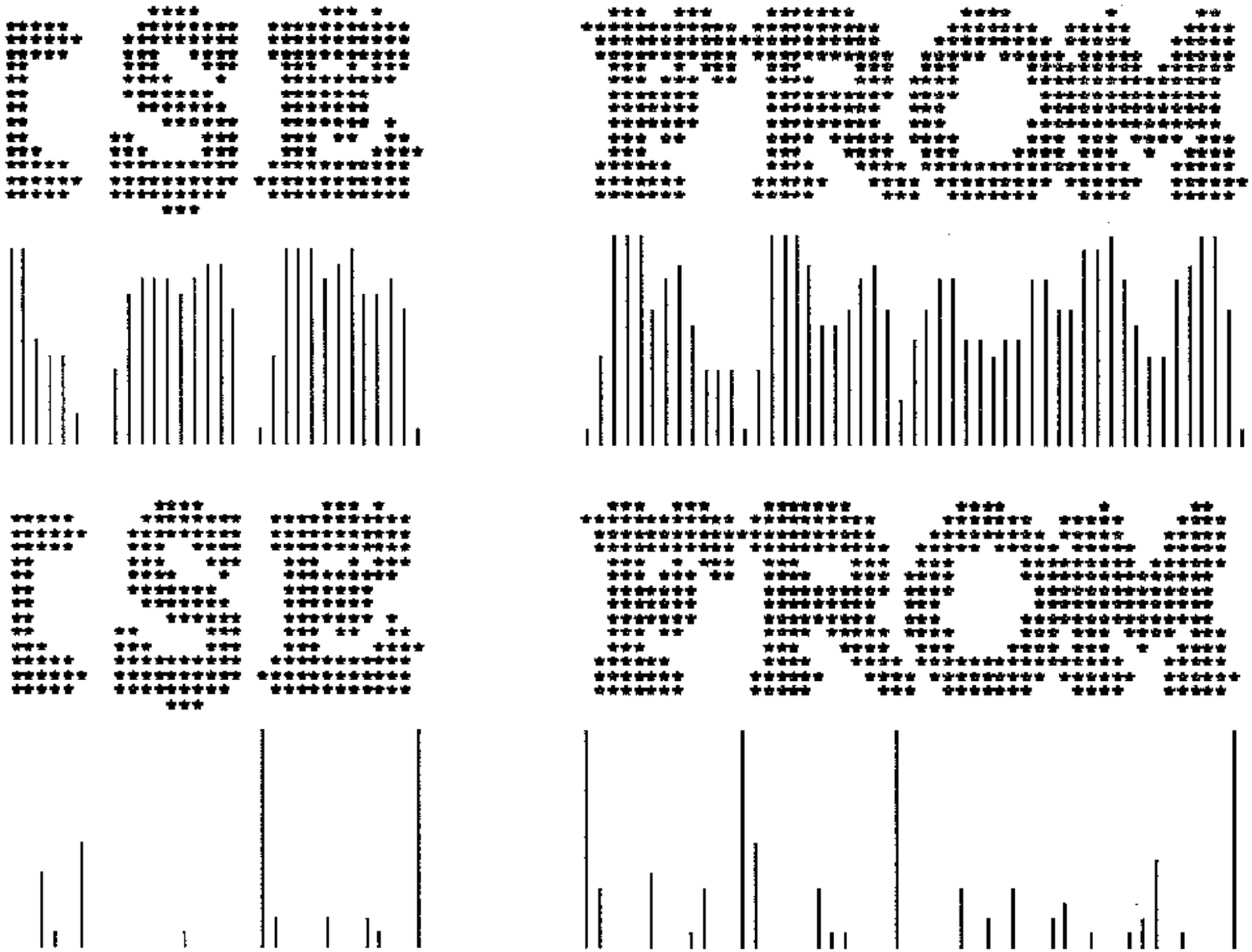


1 = Fixed structure 2 = Adaptable structure

Mani et al., 1997 [4]

- Application of Artificial Neural Network Model for Optical Character Recognition
- Idea: Use histograms as feature vectors
  - Very similar to Avi-Itzhak et al.'s approach
  - Uses image projections as feature vectors
- Result: Not as good as Avi-Itzhak's method
  - Noisy data: 70%
  - Clean data: 99%

Image Projections [2]

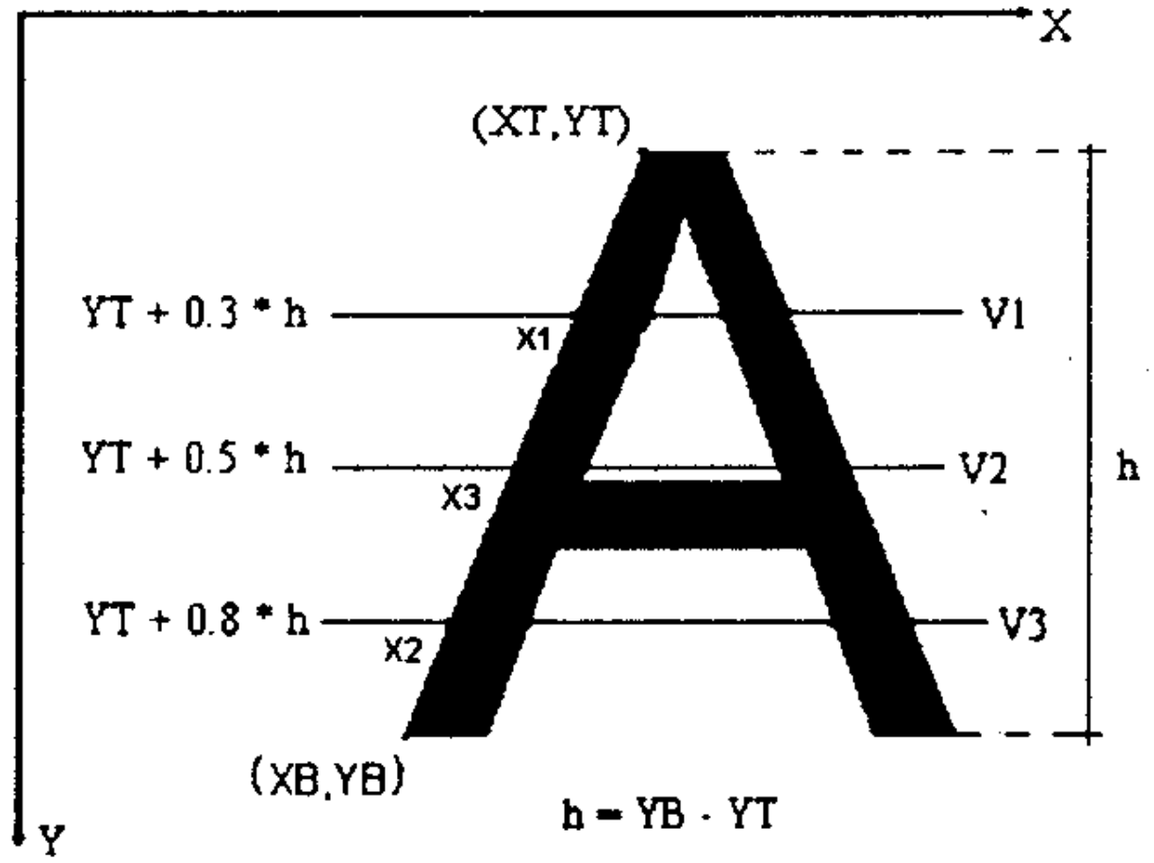


Neves et al., 1997 [6]

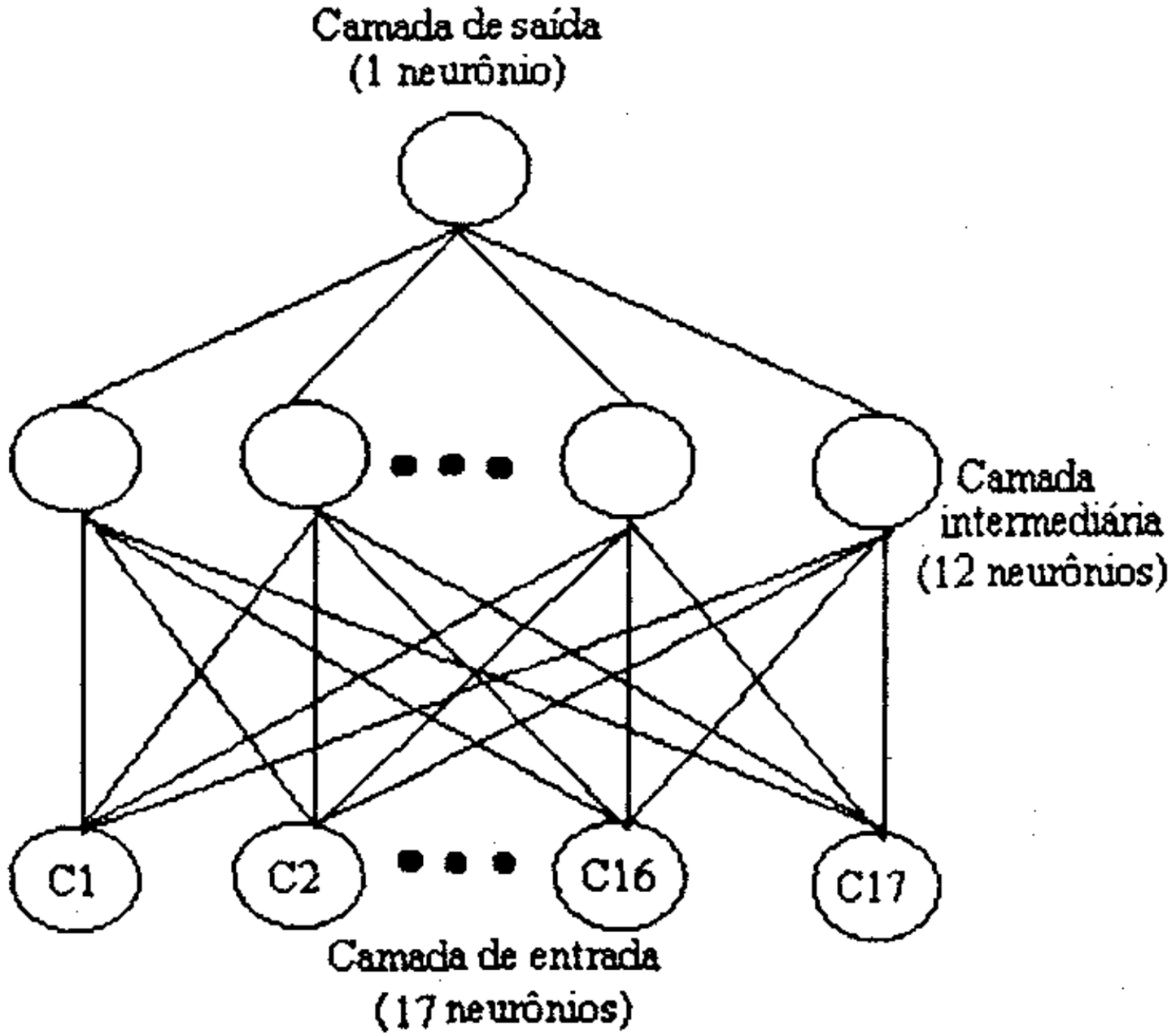
- A Multi-Font Character Recognition Based on its Fundamental Features by Artificial Neural Networks
- Idea: Use a complex feature vector to recognize multi-font capital letters
  - Use curvature, line slope, space, line interconnection, relative distance between two lines, and other topological and geometrical features
  - 17 features in total

Feature Example

- Number of line intersections at three horizontal crossing lines (V1, V2, V3) drawn at 30%, 50%, and 80% of overall character height



Network Topology



Results

- 99.3% accuracy on the fonts it was trained on
- Can also recognize unknown fonts semi-reliably (3 fonts 100%, 2 fonts ~70%)
- Developing features for feature vectors is difficult and requires human interaction

References

[1] H.I. Avi-Itzhak, T.A. Diep, and H. Garland. High accuracy optical character recognition using neural networks with centroid dithering. *Transactions on Pattern Analysis and Machine Intelligence*, 17(2):218–224, Feb 1995.

[2] Richard G. Casey and Eric Lecolinet. A survey of methods and strategies in character segmentation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 18(7):690–706, July 1996.

[3] Tsu-Chang Lee. *Structure level adaptation for artificial neural networks: theory, applications, and implementations.* PhD thesis, Stanford University, Stanford, CA, USA, 1990. Adviser-Allen M. Peterson.

[4] N. Mani and B. Srinivasan. Application of artificial neural network model for optical character recognition. *Systems, Man, and Cybernetics, 1997. 'Computational Cybernetics and Simulation'., 1997 IEEE International Conference on*, 3:2517–2520, October 1997.

[5] George L. Nagy, Stephen V. Rice, and Thomas A. Nartker. *Optical Character Recognition: An Illustrated Guide to the Frontier.* Kluwer Academic Publishers, Norwell, Massachusetts, USA, 1999.

[6] E.M. de A. Neves, A. Gonzaga, and A.F.F. Slaets. A multi-font character recognition based on its fundamental features by artificial neural networks. *Cybernetic Vision, 1996. Proceedings., Second Workshop on*, pages 196–201, December 1996.

[7] J.M. Ramirez, P. Gomez-Gil, and D. Baez-Lopez. On structural adaptability of neural networks in character recognition. *Signal Processing, 1996., 3rd International Conference on*, 2:1481–1483, October 1996.