Prototype Setting for Elastic Matching-Based Image Pattern Recognition

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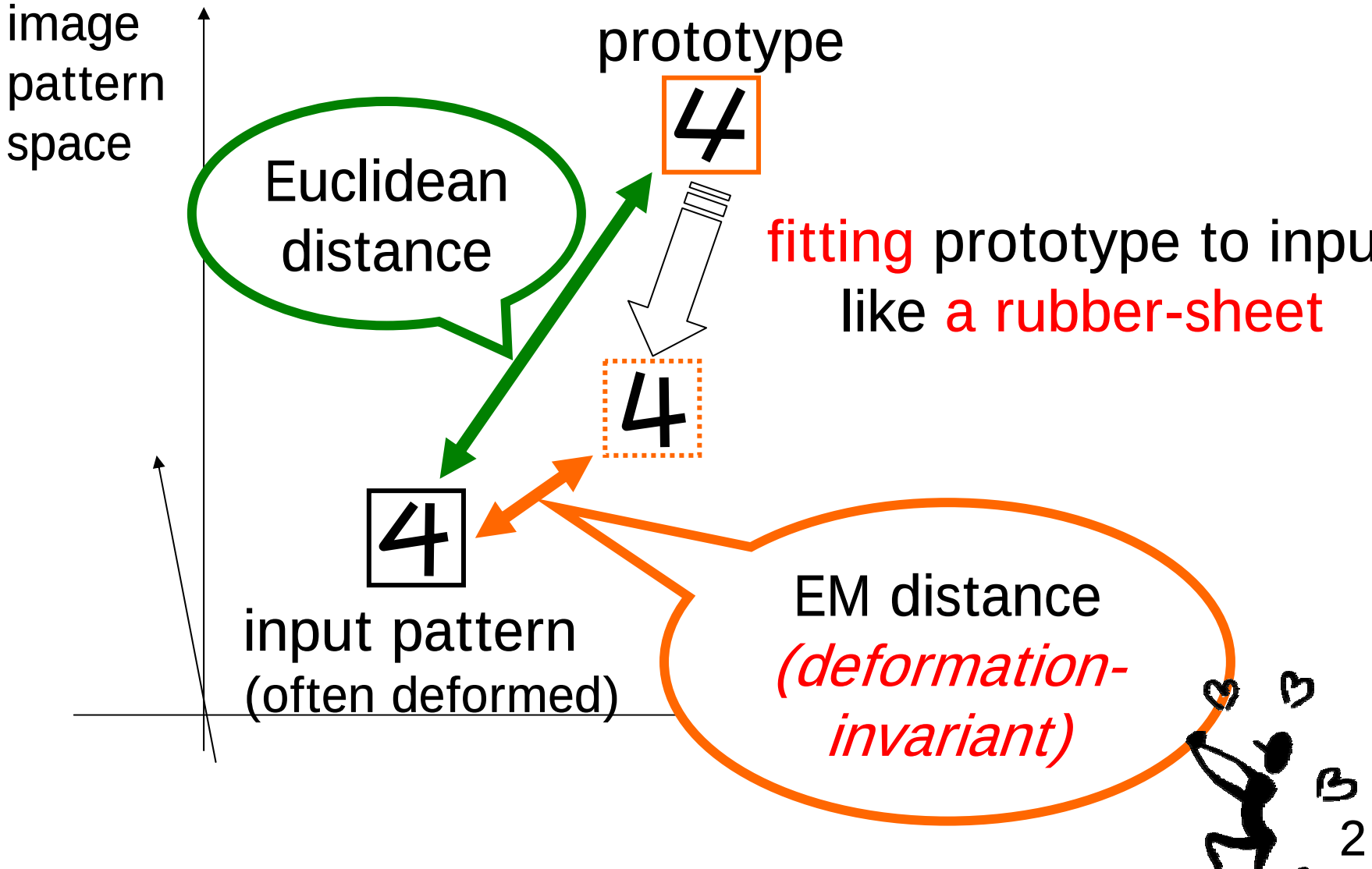
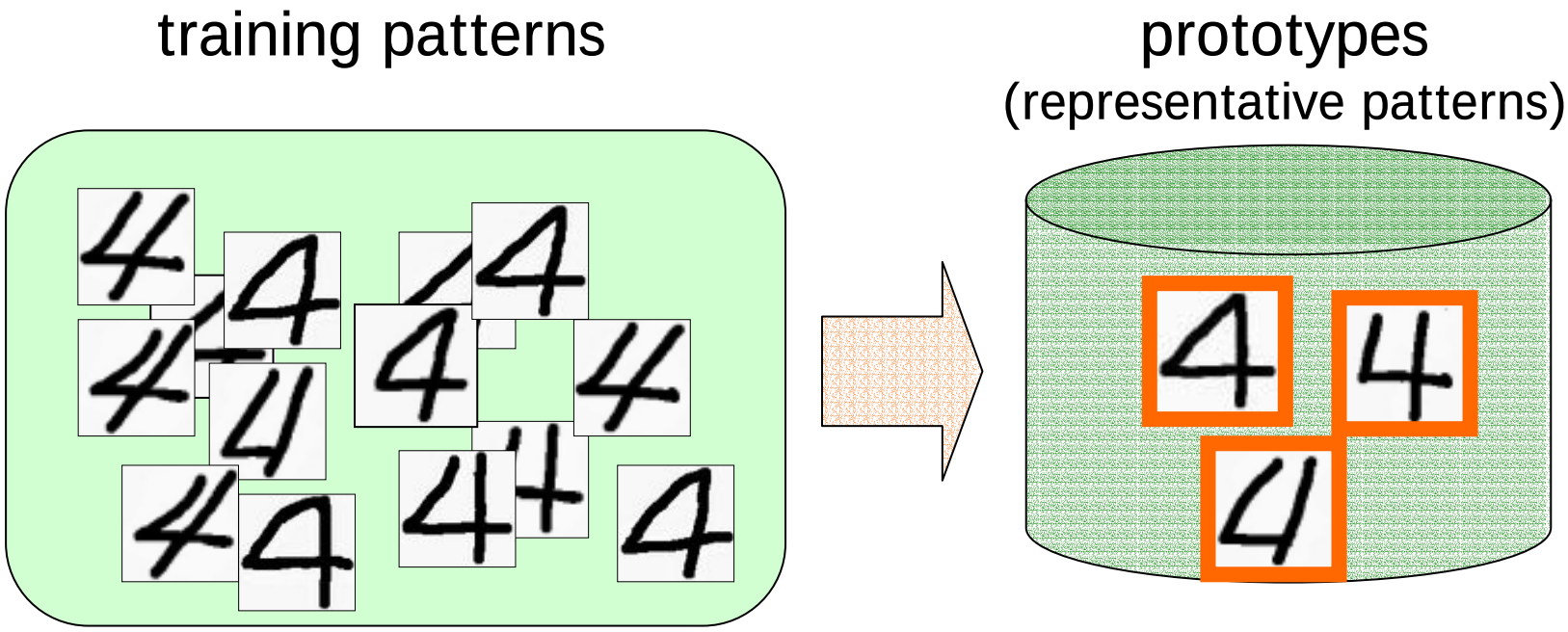
What is Elastic Matching (EM)?

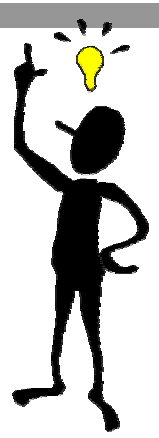


Our Task

- Set reasonable prototypes for EM-based recognizer



How about Clustering ?

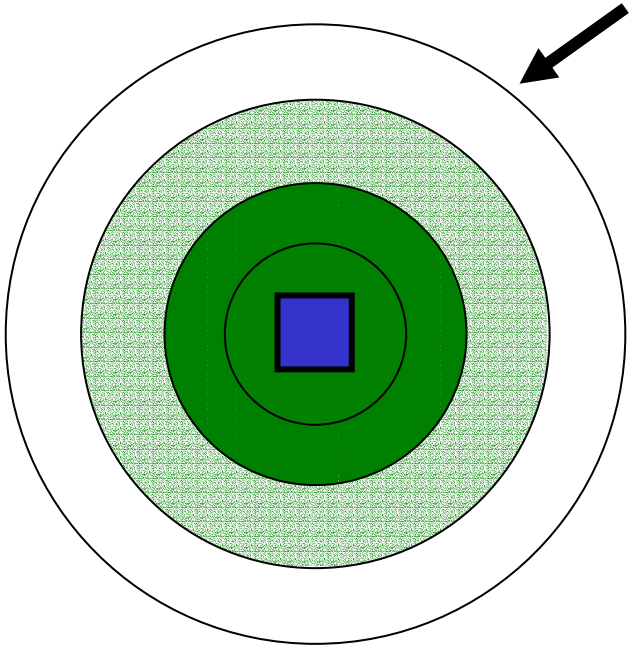


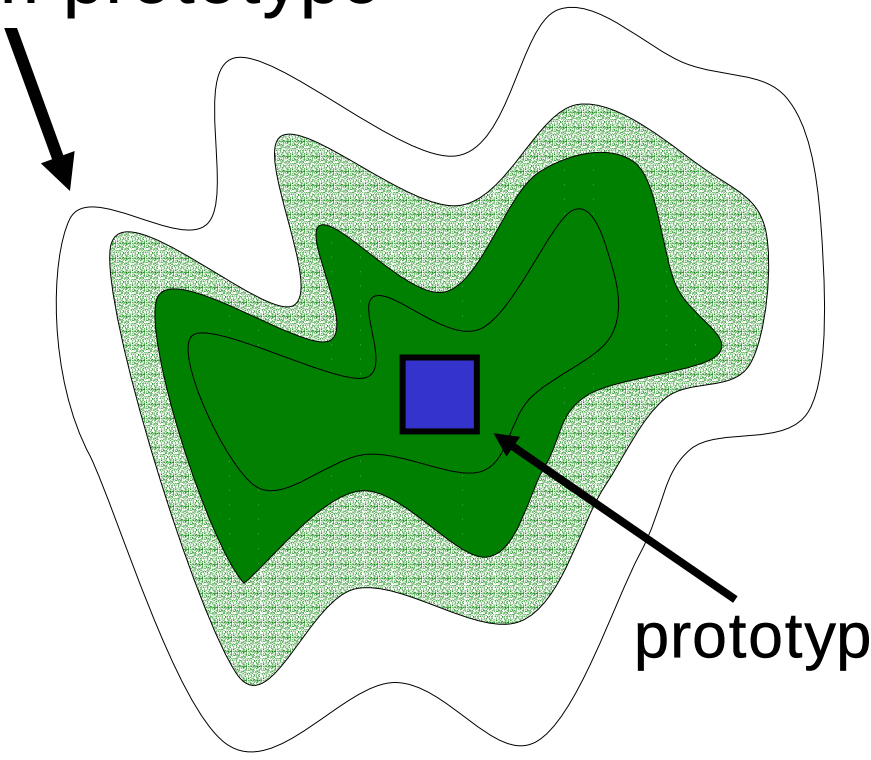
- It seems the most promising way !
  - Because clustering is widely used to set prototypes for various recognizers

- Conventional clustering techniques are not suitable for EM recognizer
  - Because they use *Euclidean distance* as their criteria

Euclidean Dist. vs. EM Dist.

equidistant from prototype



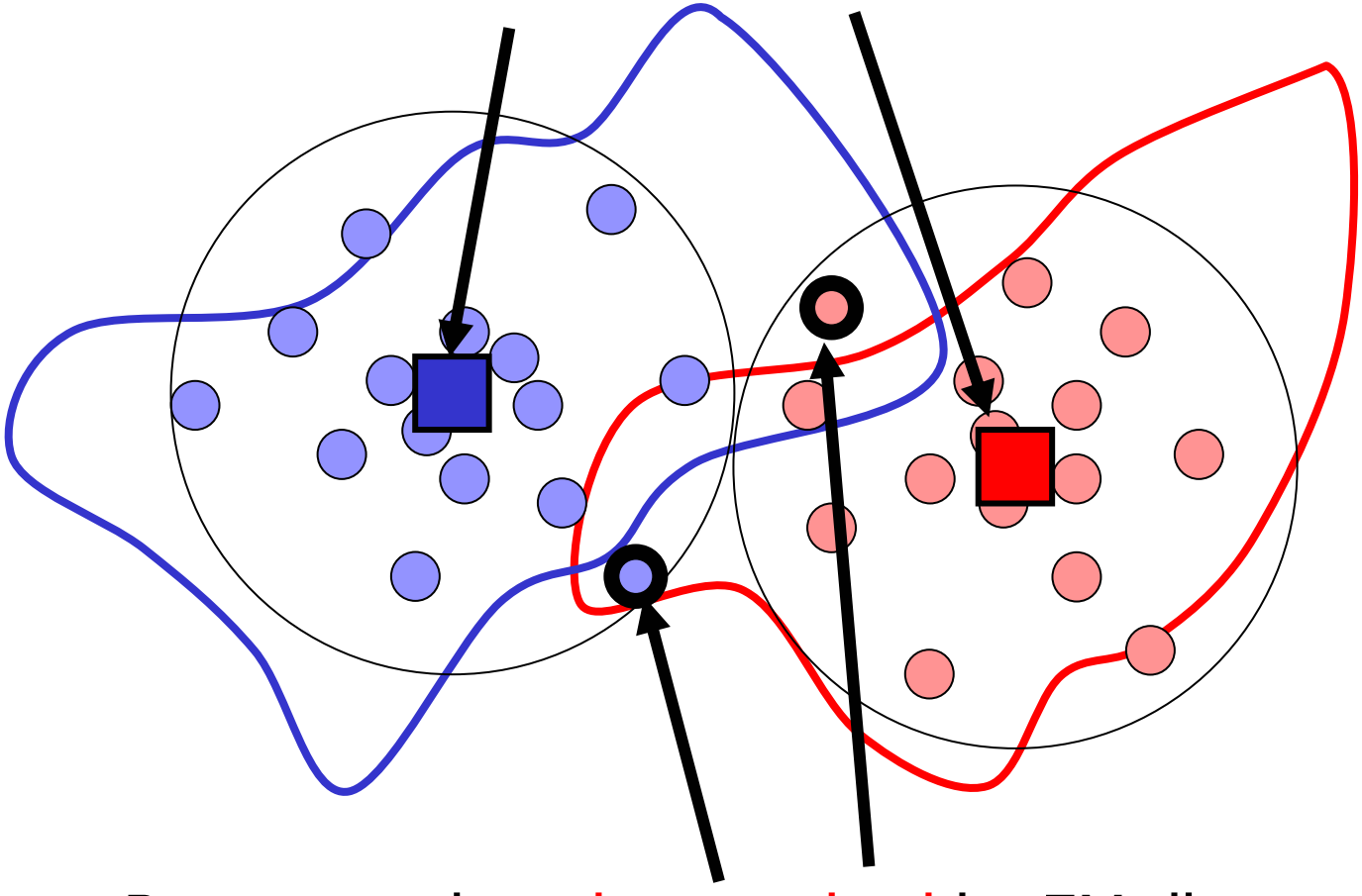


Euclidean dist. = isotropic

EM dist. = not isotropic

Problem of Conventional Clustering

Prototypes set by conventional clustering
(center of gravity in Euclidean sense)

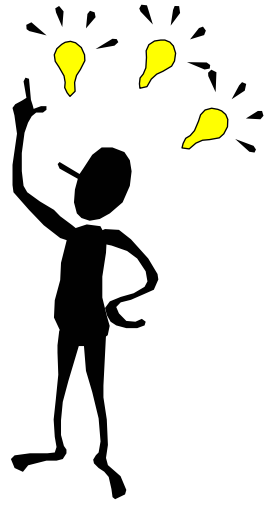


Patterns to be misrecognized by EM distance

Our Purpose

- Modify conventional clustering techniques to use *EM distance* as their criteria

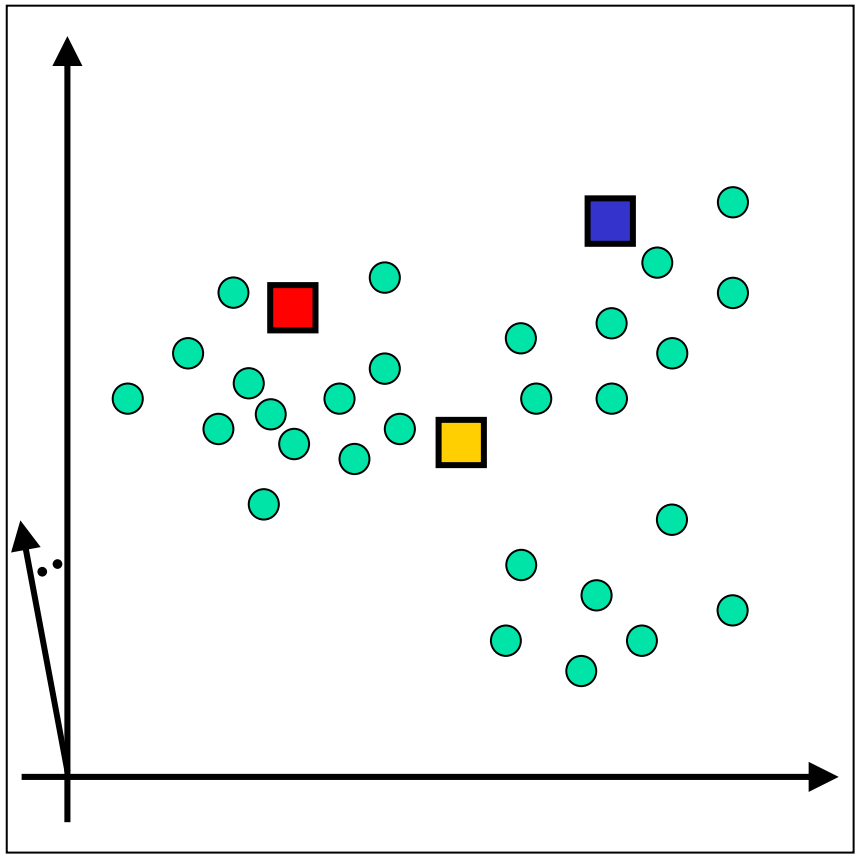
  (instead of Euclidean distance)



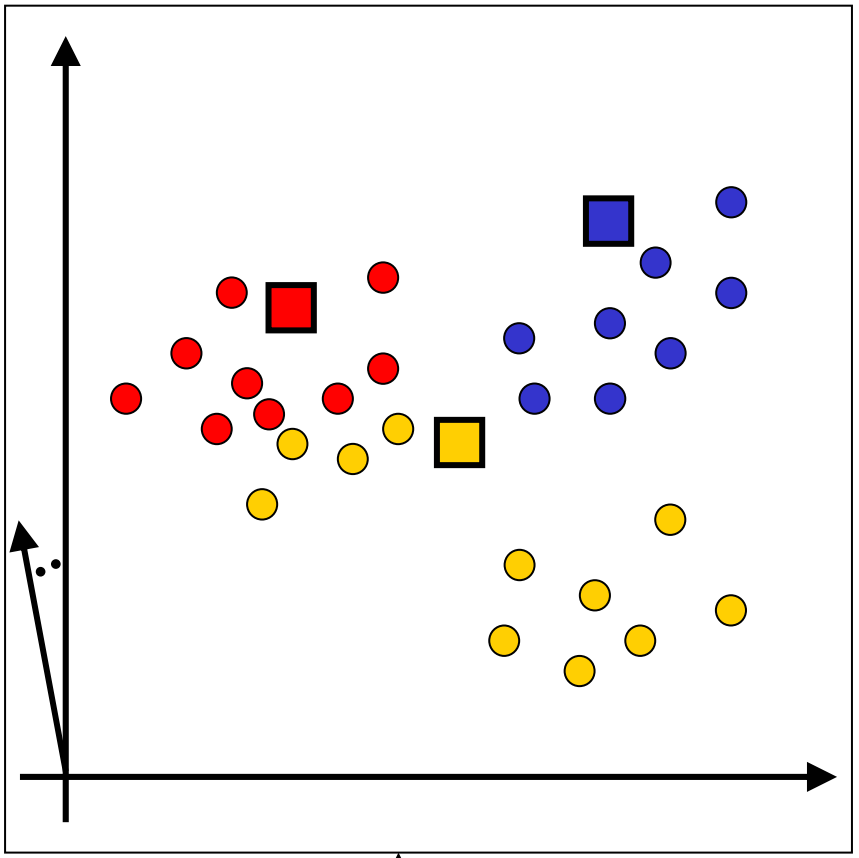
- For example, modify
  - K-means algorithm, and
  - Generalized learning vector quantization (GLVQ)

K-means Modified for EM (1)

Step1: Initialize

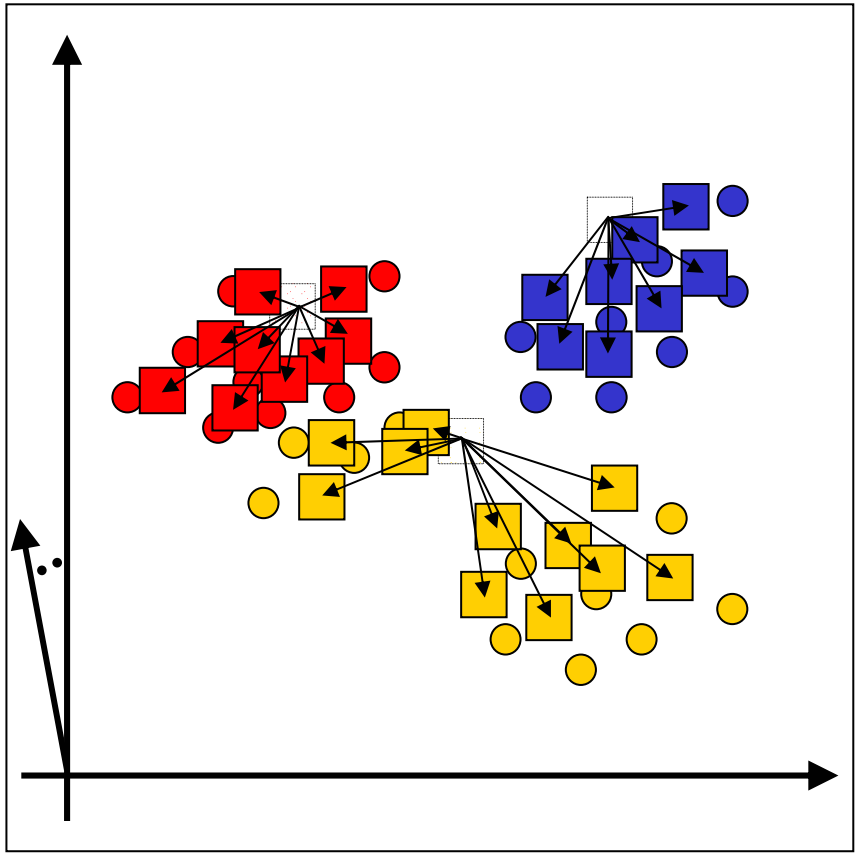


Step2: Partition by EM distance

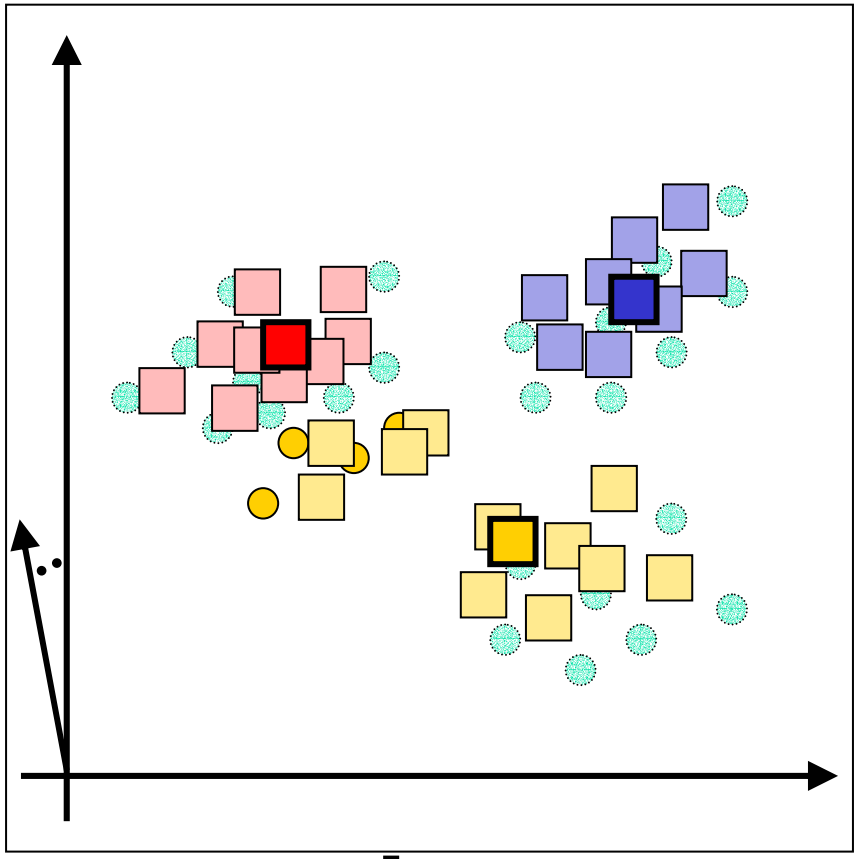


K-means Modified for EM (2)

Step3: Fit to each training patterns by EM



Step4: Update prototypes by taking average



Back to Step 2

Derivation of the Algorithm

Minimize $J_{EM} = \sum_{k} \sum_{T_l \in C_k} D_{EM}(T_l, R_k)$

NOTE: D_{EM} includes the optimization problem of EM

w.r.t. partitioning $\{C_k\}$ and prototypes $\{R_k\}$,

where

- $\{T_l\}$ are training patterns, and
- $D_{EM}(T_l, R_k)$ is EM distance between T_l and R_k.

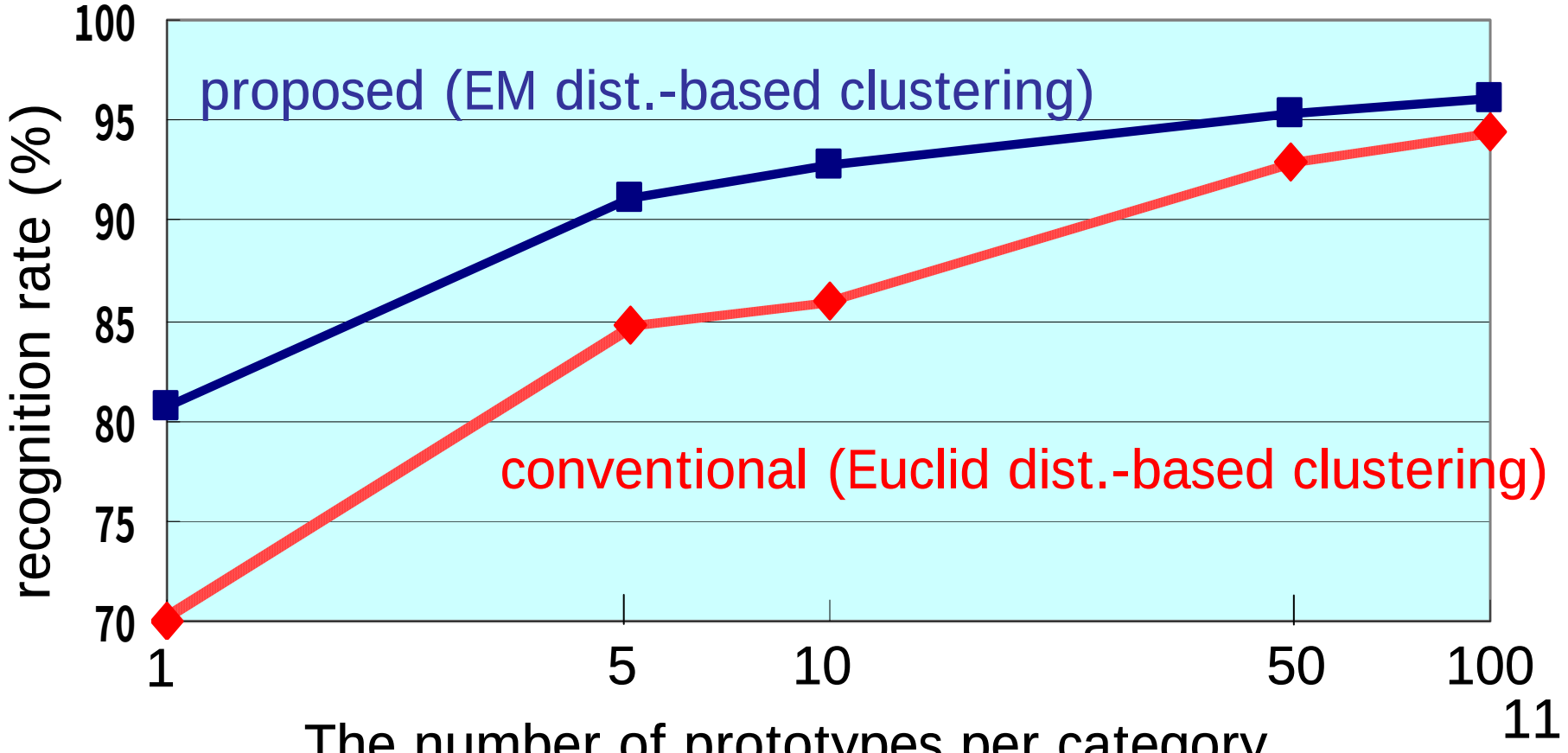
Iterative solution

Optimize $\{C_k\}$ and EM with fixed $\{R_k\}$ $\rightarrow$ Step 2

Optimize $\{R_k\}$ with fixed $\{C_k\}$ and EM $\rightarrow$ Step 3 & 4

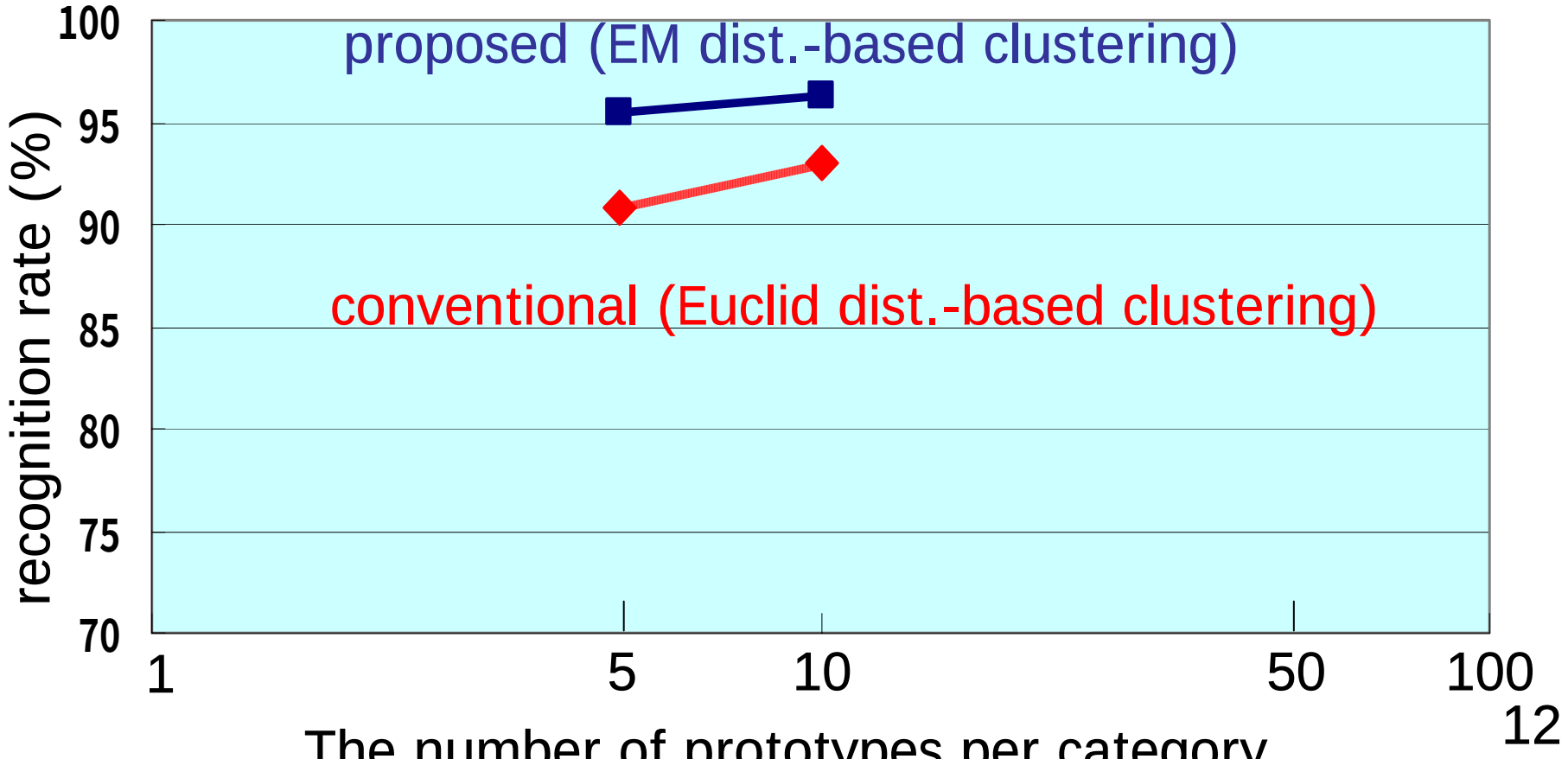
Recog. Rate by Modified K-means

- 10 categories of handwritten numerals from MNIST database
- 60,000 training patterns and 10,000 test patterns
- 97.9% when all training patterns are used as prototypes



Recog. Rate by Modified GLVQ

- GLVQ= A clustering technique where a Euclidean distance-based minimum classification error (MCE) criterion is used



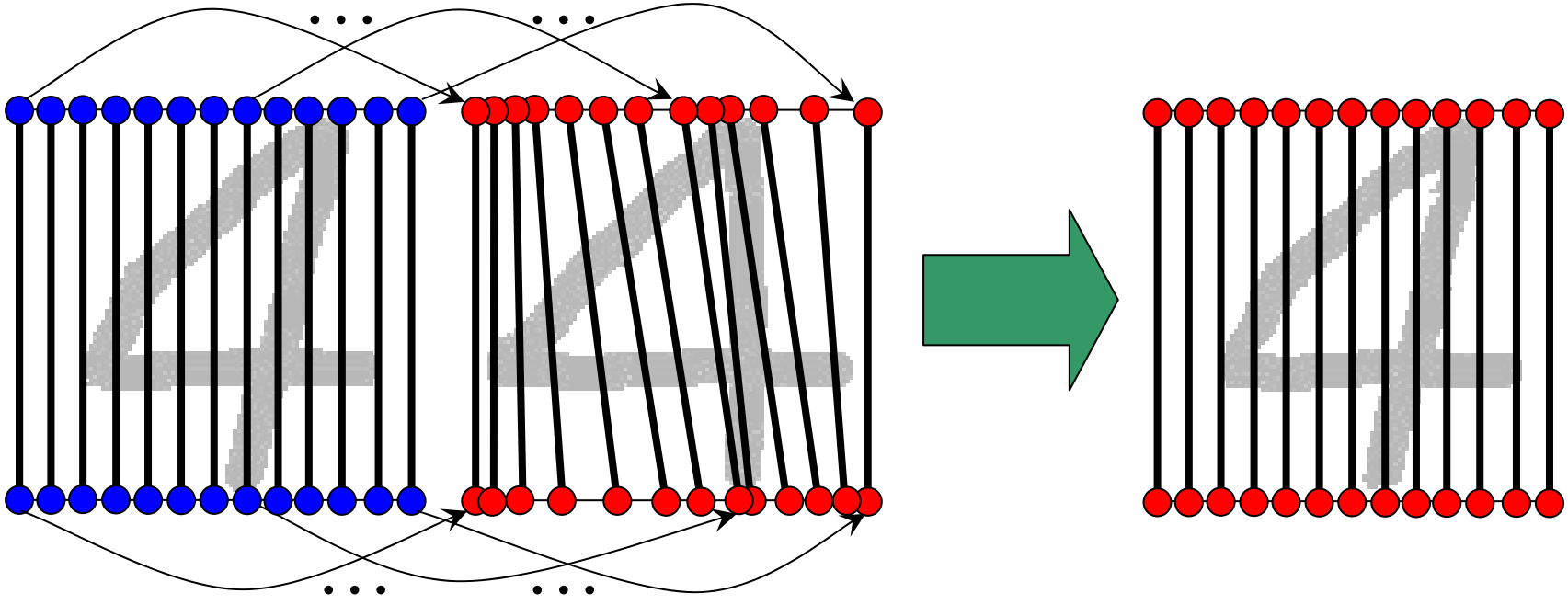
Conclusion

- For setting prototypes of EM-based recognizer conventional clustering techniques were modified to use EM distance as their criteria

- Experimental results showed that the same EM distance must be used at prototype setting and recognition

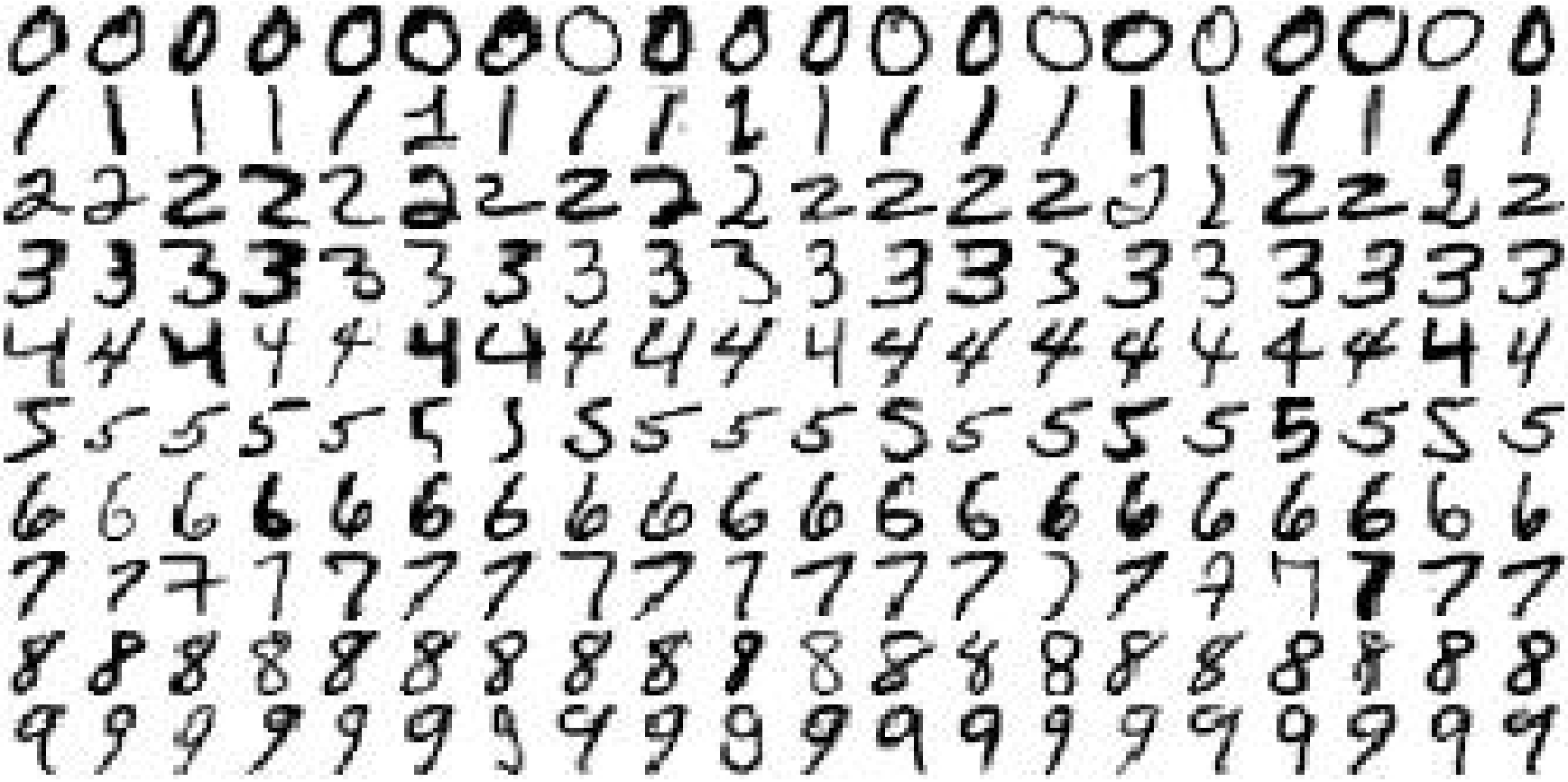
The EM Used in Our Experiment

piecewise linear fitting (warping) function



input $\boldsymbol{X}$ prototype $\boldsymbol{R}$ prototype fitted to the input

Samples in MNIST



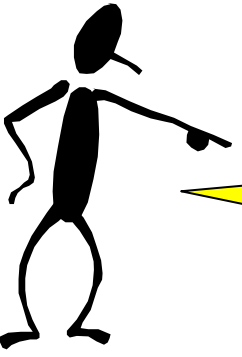
Recognition rates reported in literatures: 88 – 99.3%

Our Main Conclusion

Distance metric at prototype setting

=

Distance metric at recognition (discrimination)



should be the same!