

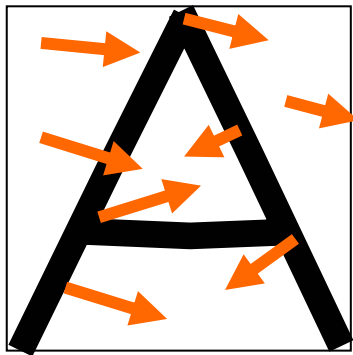
Using Eigen-Deformations in Handwritten Character Recognition

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Fukuoka, Japan

Elastic Matching (EM)

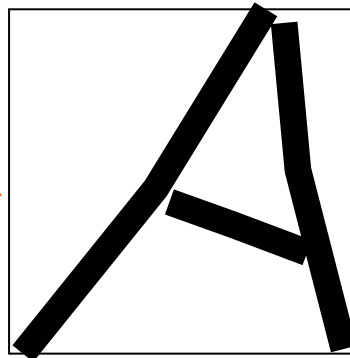
*displacement
field*



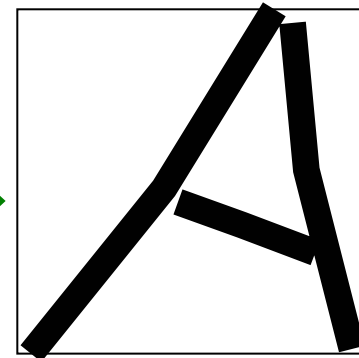
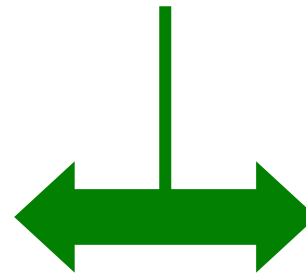
reference



*deformation-invariant
distance*

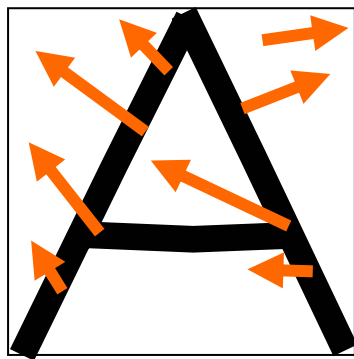


warped
reference

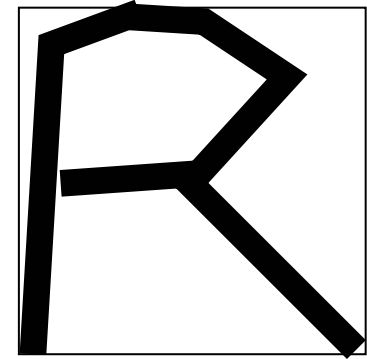
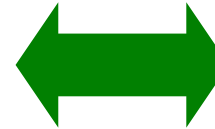
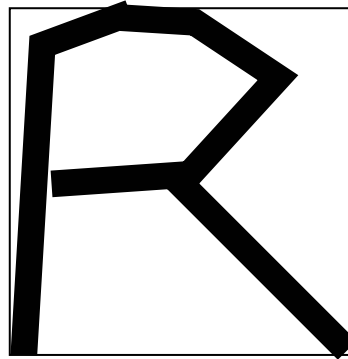


input

Overfitting Problem



reference



input

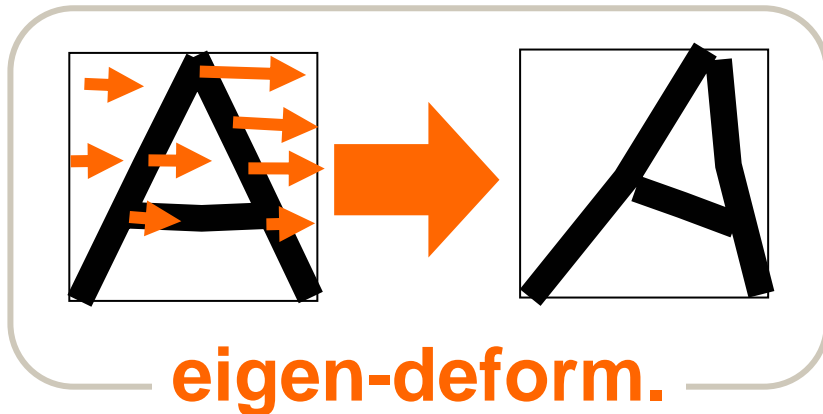


input "R" may be misrecognized as "A"

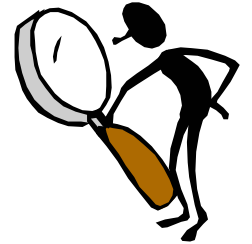
Purpose



Reduce the misrecognition due to overfitting by using eigen-deformations



Two Central Problems

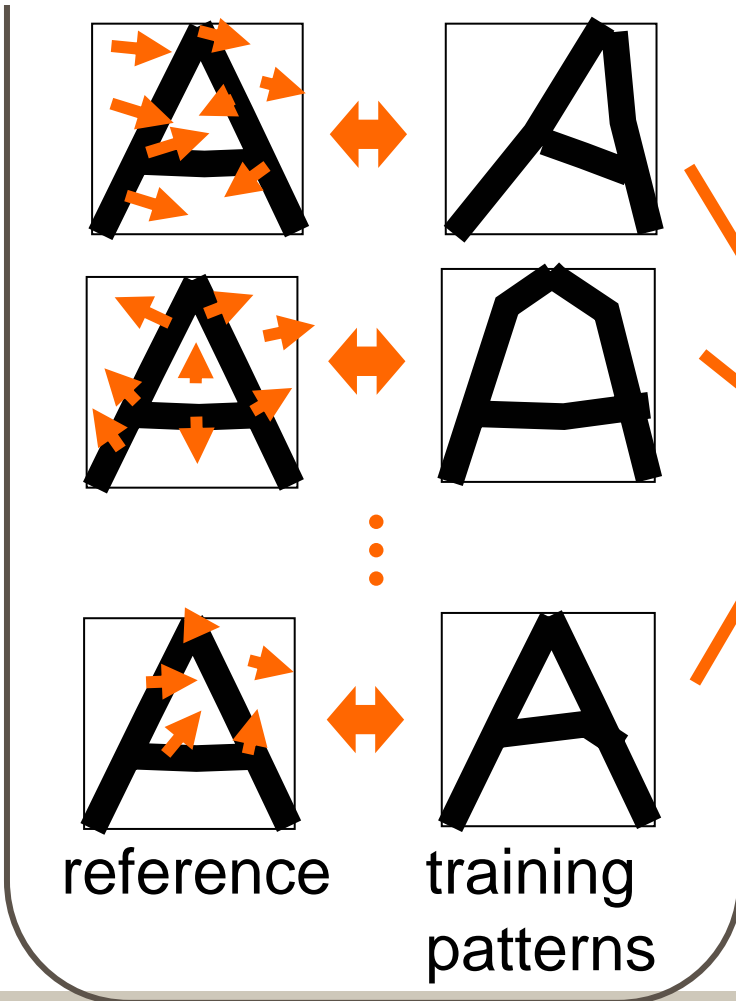


- How to estimate eigen-deformations ?
- How to use the eigen-deformations in EM-based recognizer ?

Estimation of Eigen-Deformations

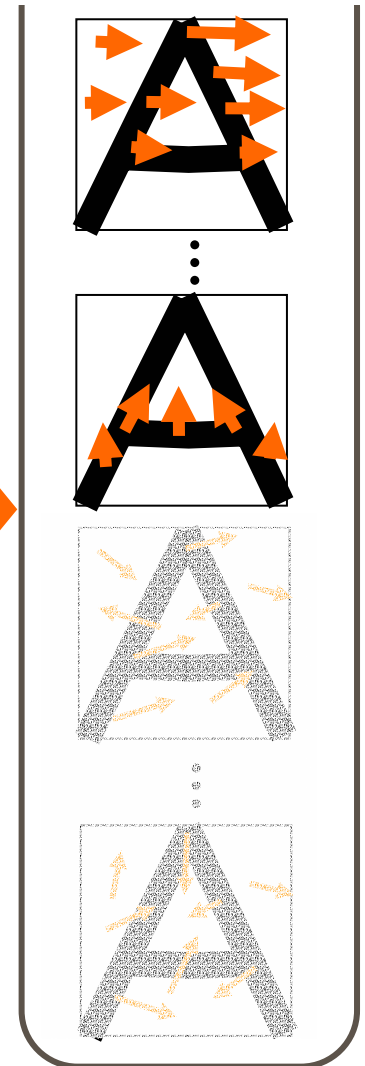
Estimation of Eigen-Deformations

collection of displacement fields using EM

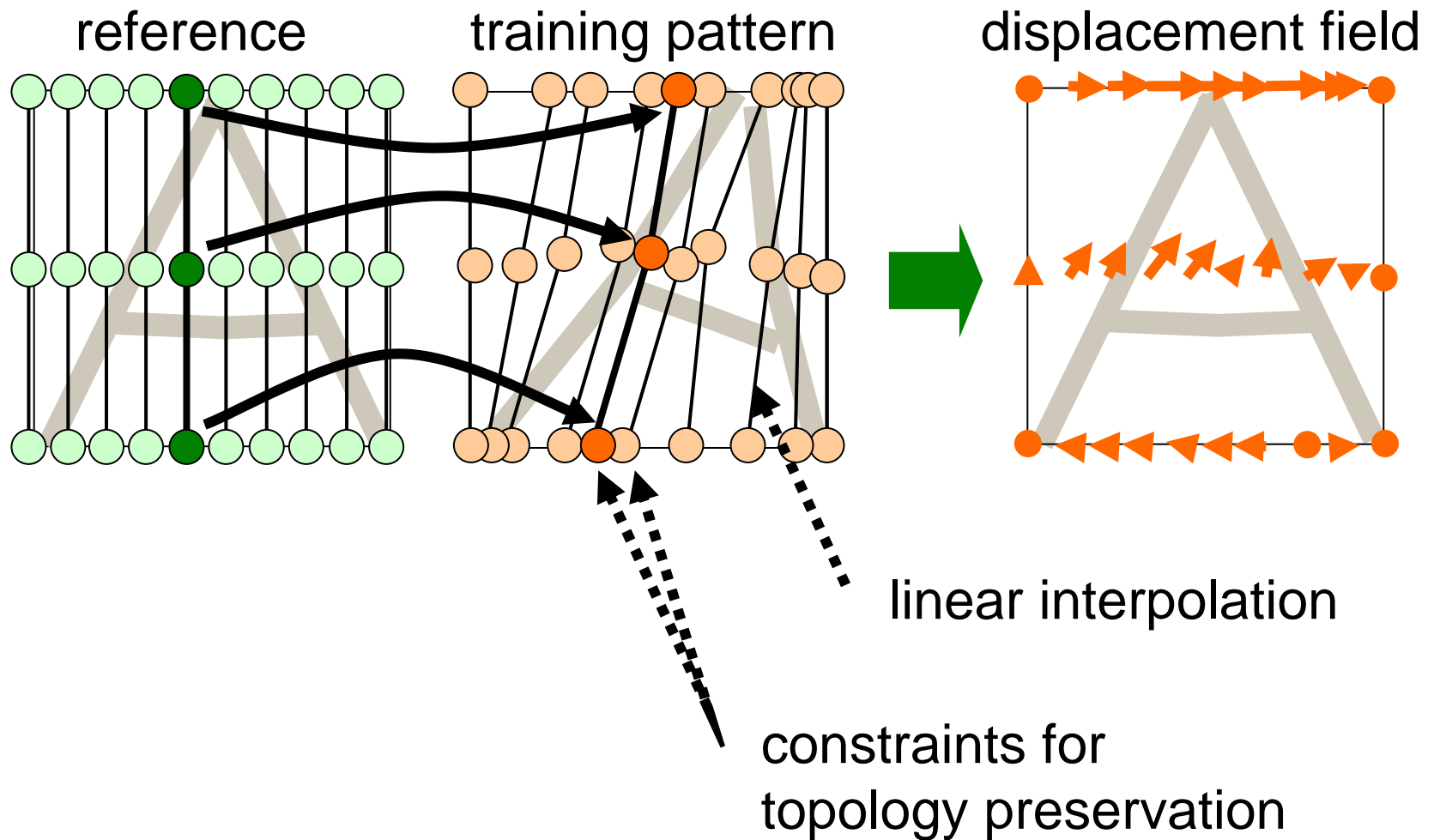


Principal
Component
Analysis

eigen-deformations



Piecewise-Linear EM



Estimated 1st Eigen-Deformations

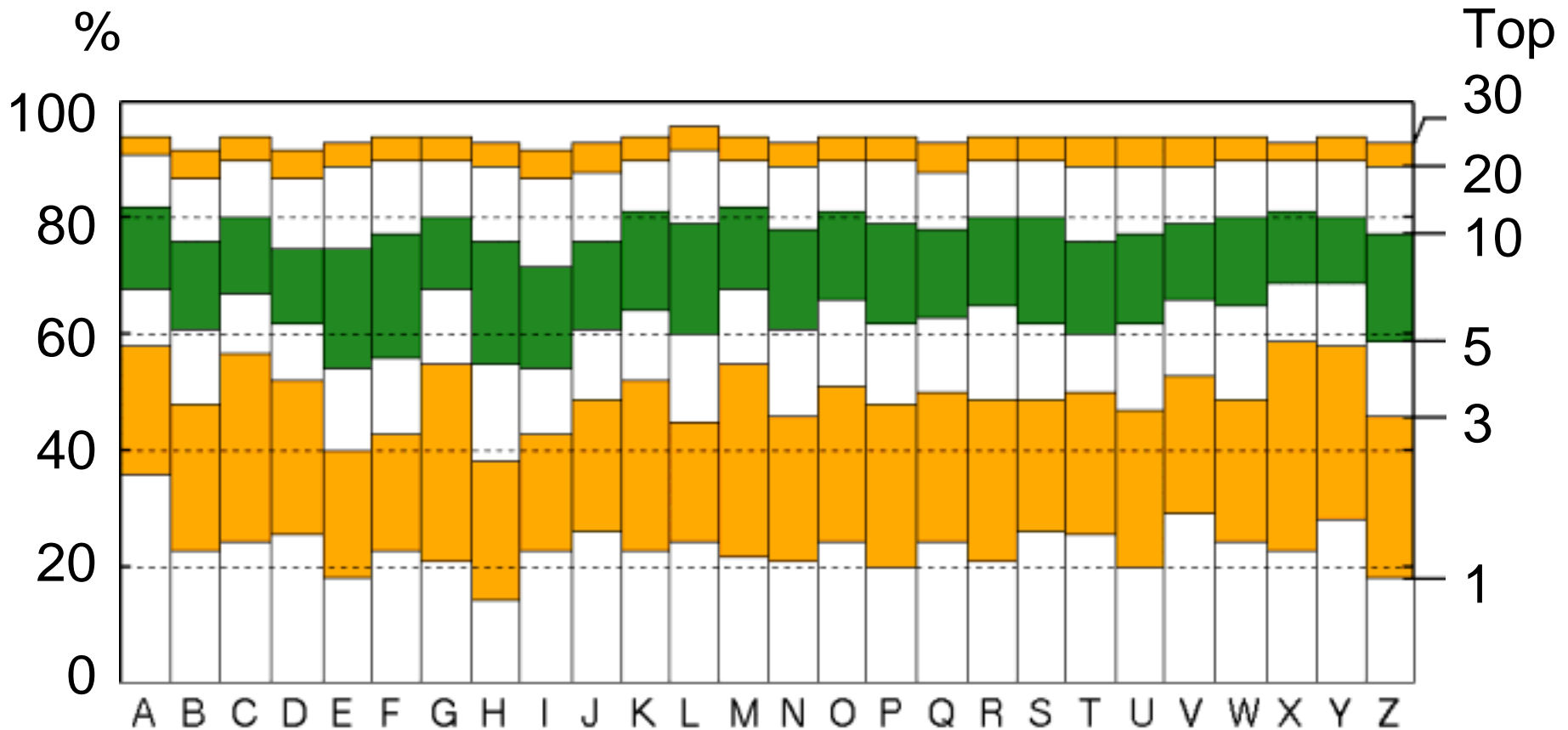


apply
negatively

← 0 →
(reference)

apply
positively

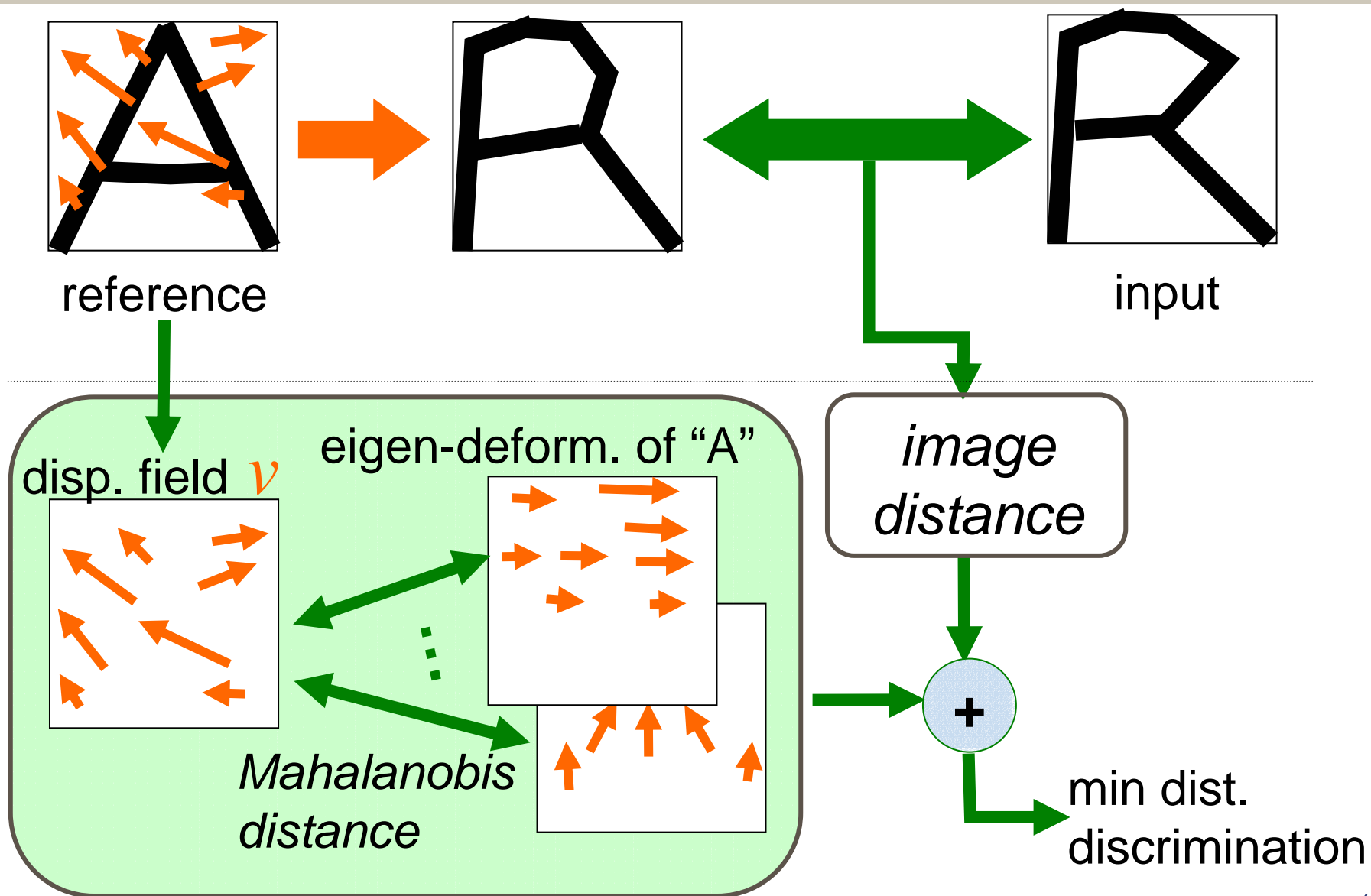
Cumulative Proportion



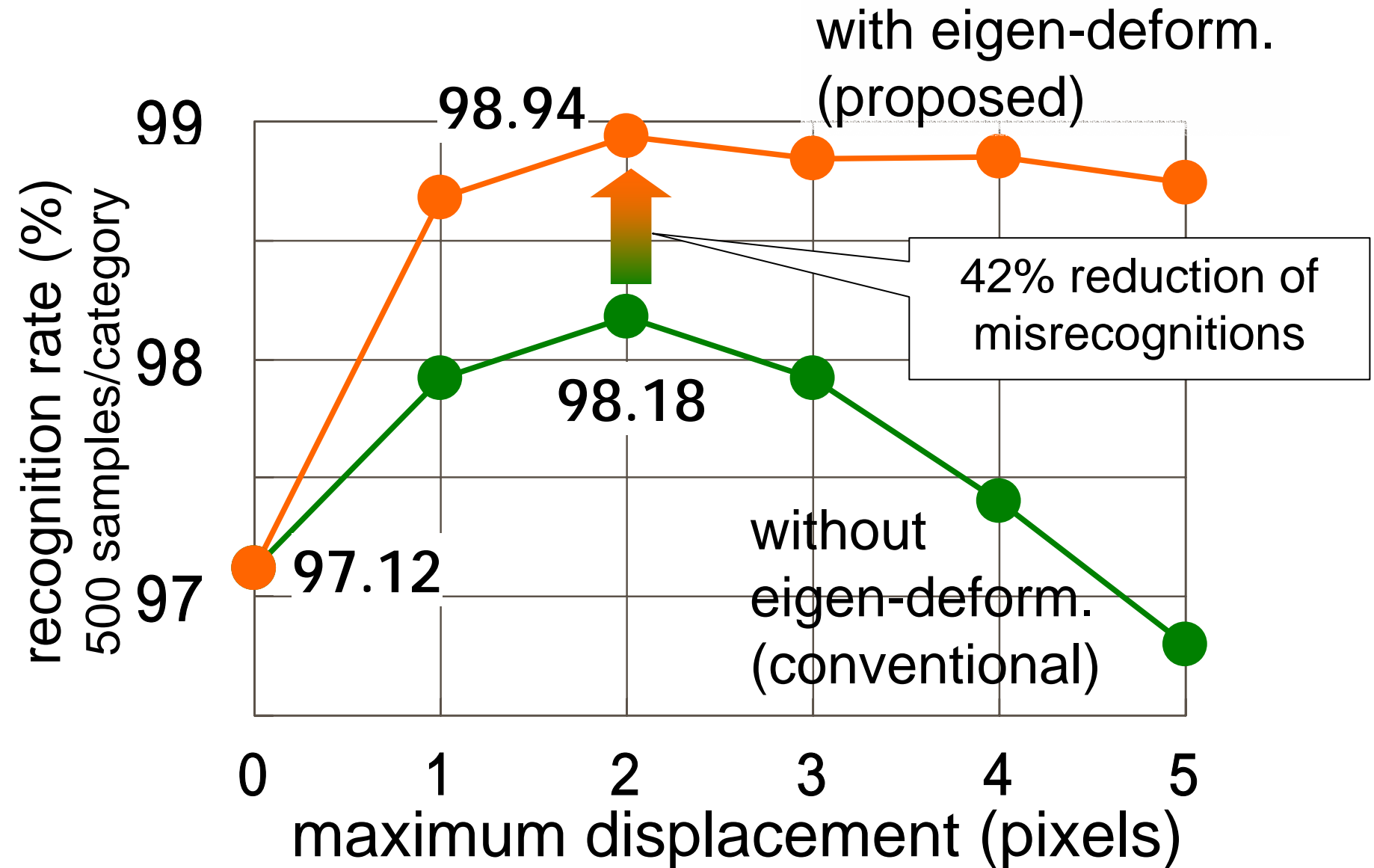
⇒ over 50% with 3-5 (of 74) eigen-deformations

Recognition Using Eigen- Deformations

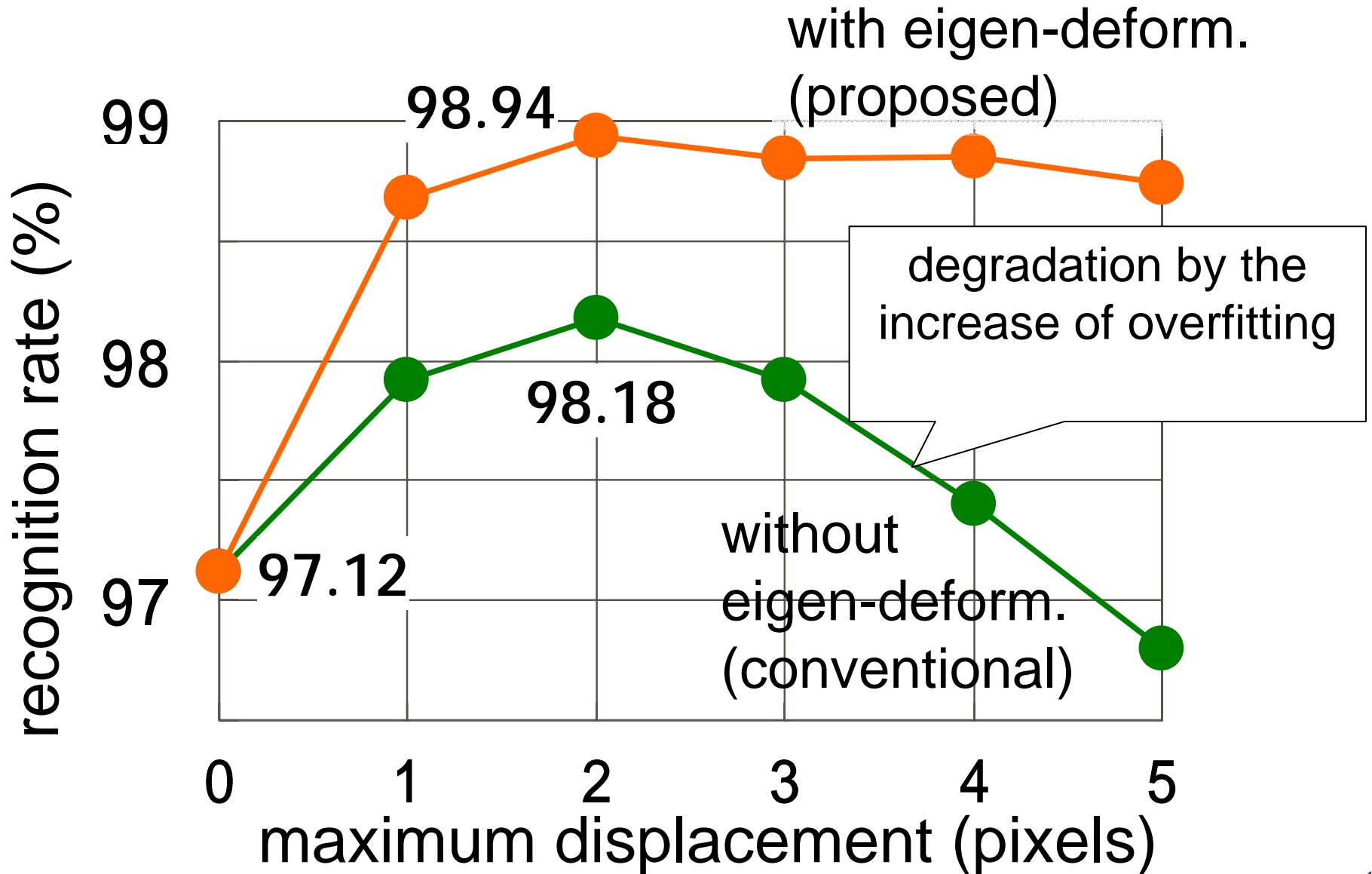
Recognition Using Eigen-Deformations



Recognition Result (1)



Effect on Overfitting Reduction



Conclusion and Future Work

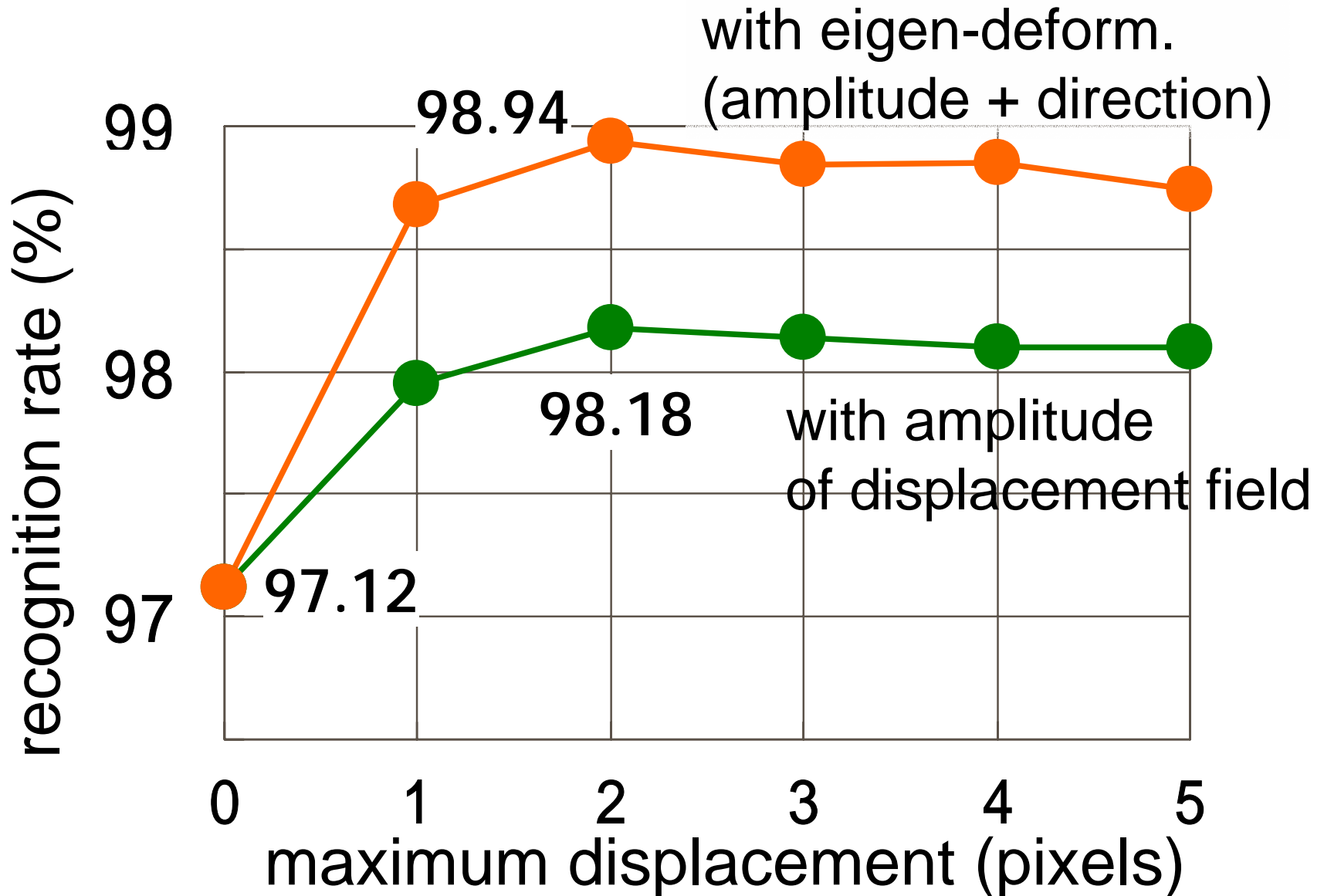
■ Conclusion

- Proposition of the use of eigen-deformations in EM-based recognizer
- Verification of its usefulness through experiments

■ Future work

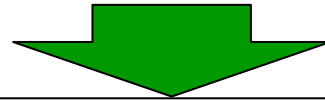
- Use of other EM techniques
- Direct incorporation of eigen-deformations into EM

Comparison with Another Evaluation Method

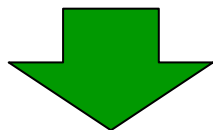


Data

English capital letters from ETL6
(1100 samples / category)

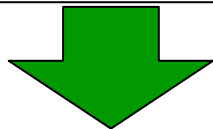


preprocessing
(size normalization, blurring, histogram equalization...)

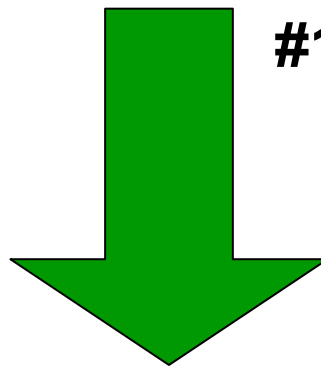


#1-100

average

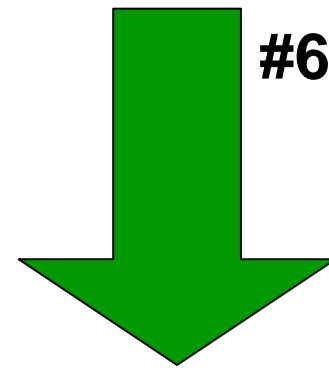


reference



#101-600

training patterns



#601-1100

test patterns

Mahalanobis Distance

$$\sum_{m=1}^M \frac{1}{c,m} \left(\mathbf{v} - \overline{\mathbf{v}}_c, \mathbf{u}_{c,m} \right)$$

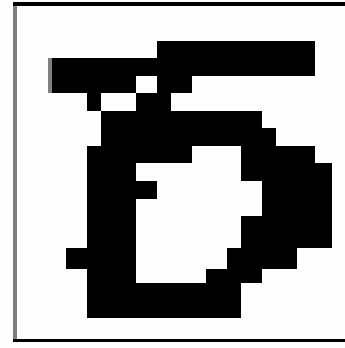
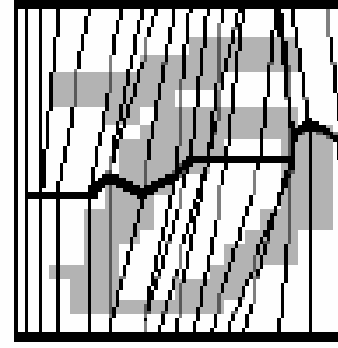
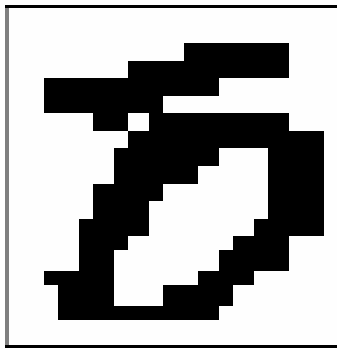
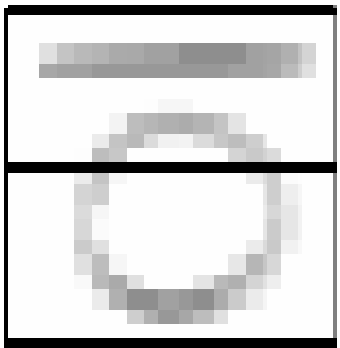
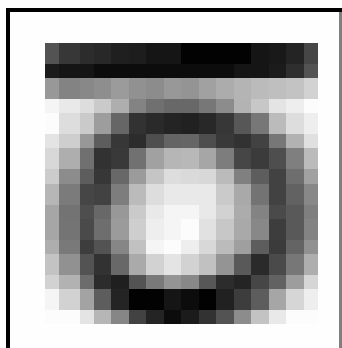
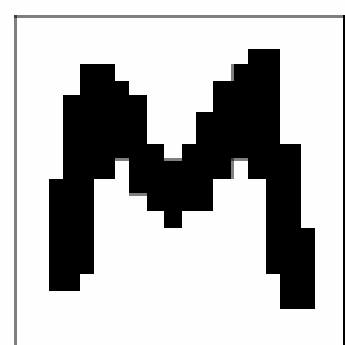
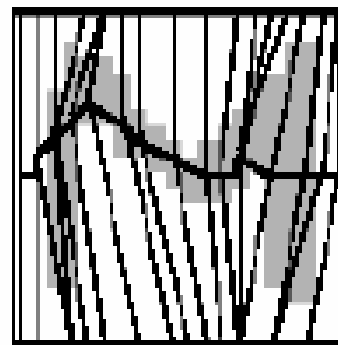
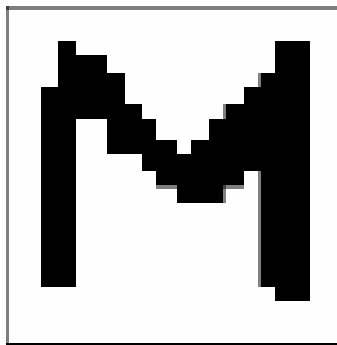
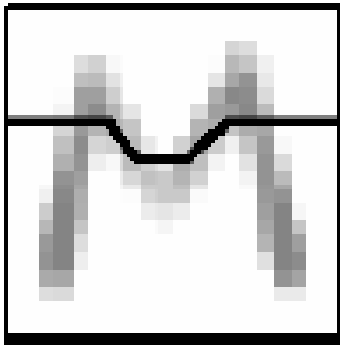
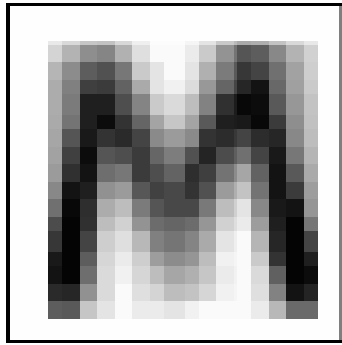
\mathbf{v} : displacement field to be evaluated

c : class ("A", "B", ..) of reference

$\mathbf{u}_{c,m}$: m -th eigen-deformation of class c

c,m : contribution (eigenvalue) of $\mathbf{u}_{c,m}$

Piecewise linear elastic matching



reference

A

pivots on

A

input

B

warp on

B

warped

B

given

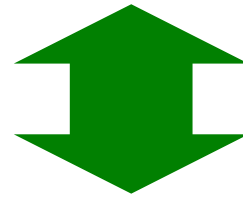
results

Effect on Overfitting Reduction (2)

the most remarkable improvement:

M→H

(30 misrecognitions → 13)



in [Ronee et al., ICDAR2001]

“M→H is the most typical misrecognition due to overfitting.”