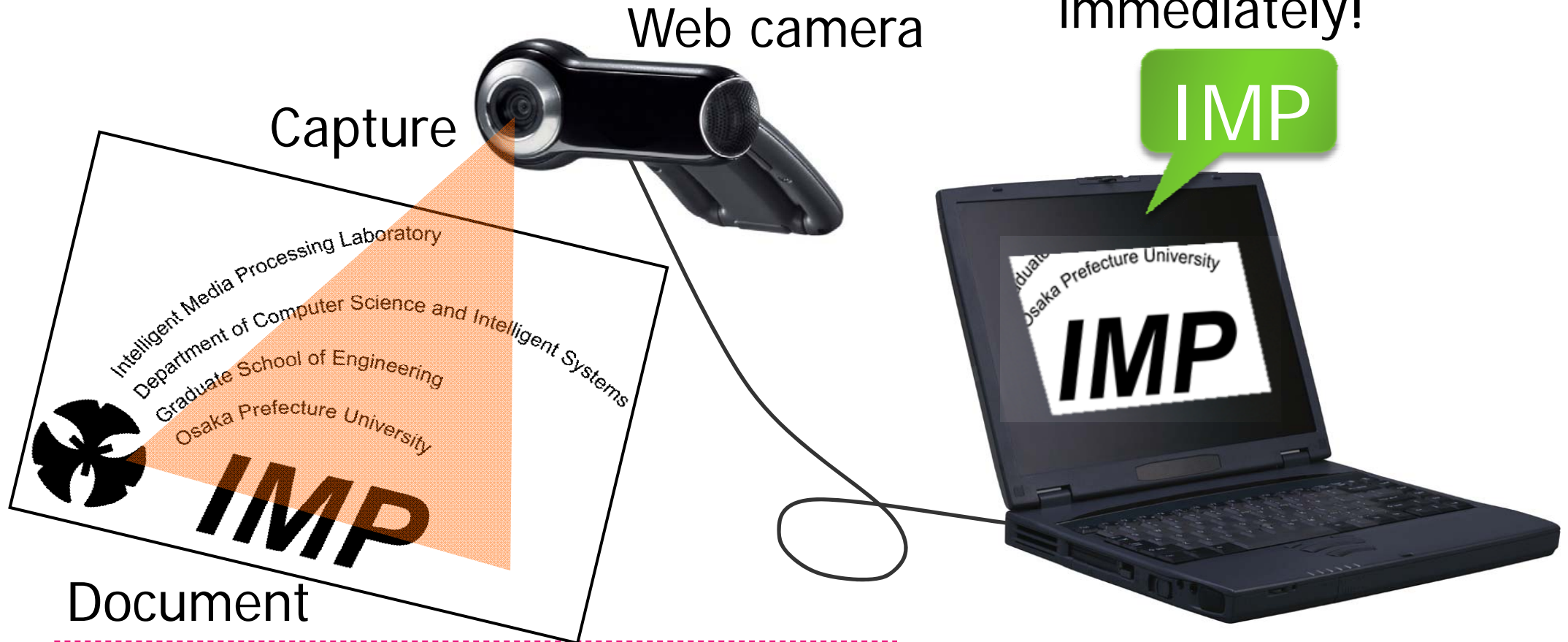# Real-Time Camera-Based Character Recognition Free from Layout Constraints

M. Iwamura, T. Tsuji, A. Horimatsu, and K. Kise

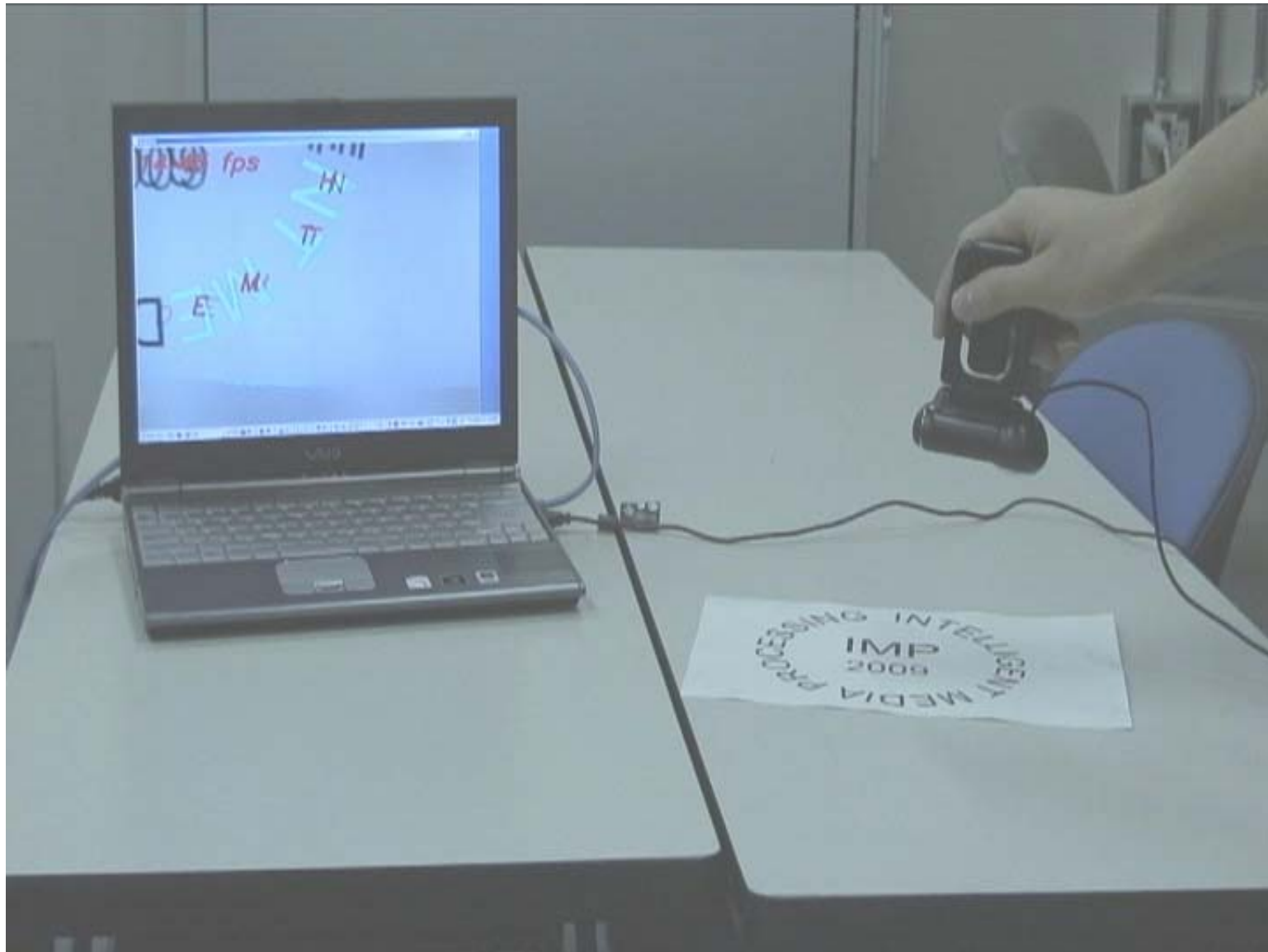# Real-Time Camera-Based Character Recognition System

Recognizes ~200 characters/sec

Recognizes characters immediately!

IMP

Web camera

Capture

Intelligent Media Processing Laboratory
Department of Computer Science and Intelligent Systems
Graduate School of Engineering
Osaka Prefecture University

IMP

Document

Osaka Prefecture University

IMP

DEMO

Applications

Recognizes all characters in a scene and provide useful information only

Voice navigation for visually disabled people

"Push button" is on your right side

PUSH
BUTTON
FOR
WALK
SIGNAL

Translation service for foreign travelers

Car-free mall

歩行者天国

3 Advantages of the Proposed Method
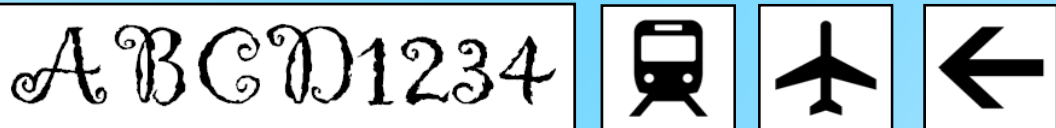
First method that realizes three requirements

1: Real-time

▪ Recognizes ~200 characters/sec

2: Robust to perspective distortion

▪ Recognition accuracy is >80% in 45 deg.

Recognizes designed characters and pictograms

3: Layout free

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Graduate School of Engineering
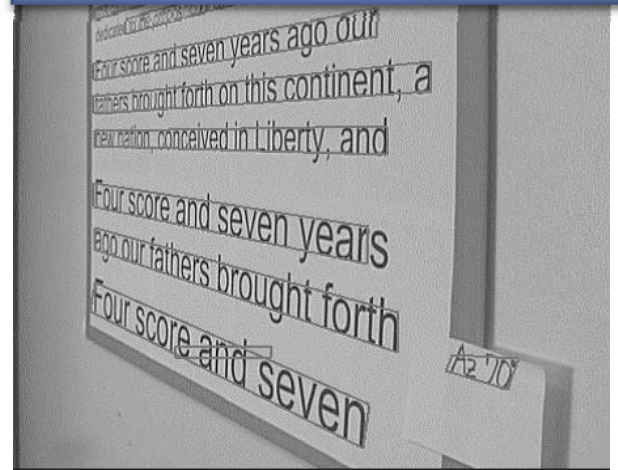Osaka Prefecture University

IMP

Existing Methods and Problems

1. Real-time recognition capable only for characters in a straight text line

Recognizable

Not recognizable

2. Can recognize each character in a complex layout with much computational time

Existing Methods vs Proposed Method

	1: Real-time	2: Perspective distortion	3: Layout free
Myers 2004	O	O	✖
Kusachi 2004	✖	O	O
Li 2008	✖	O	O
Proposed method	O	O	O

Recognition of Individual Characters ➕ **Real-time Processing**

Contents

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Overview of the Proposed Method 1

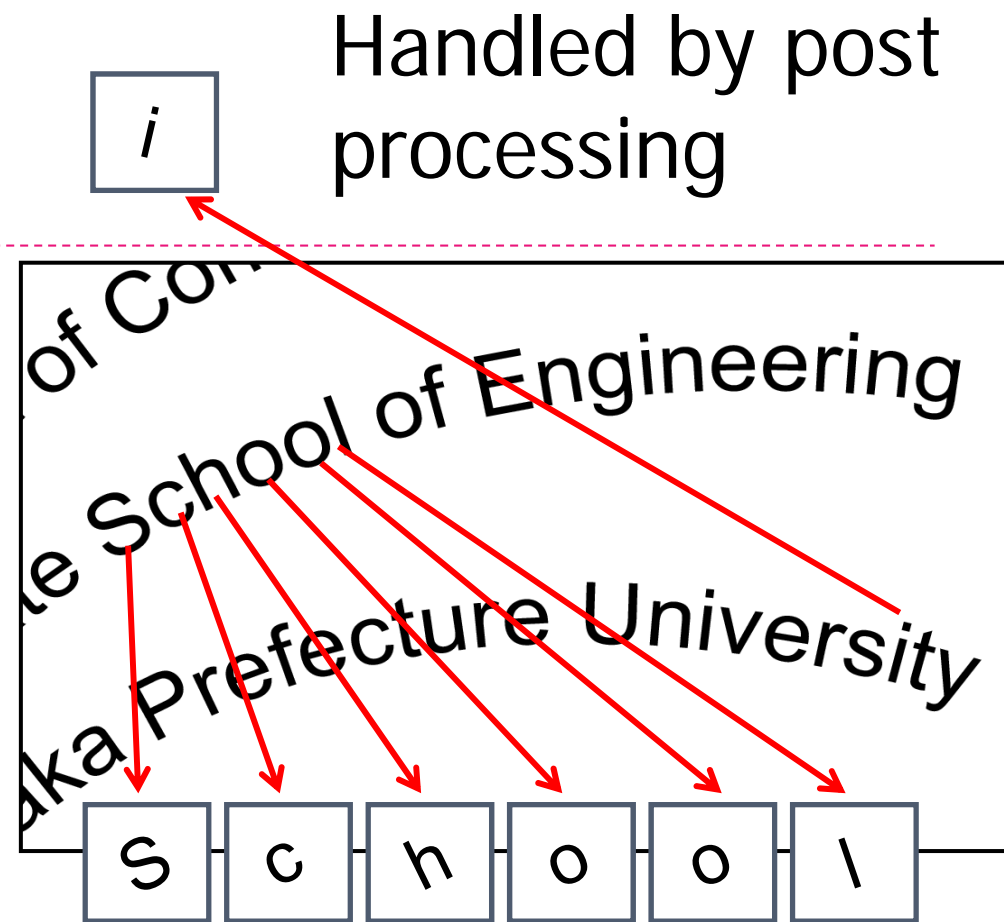Handled by post processing

i

- Recognizes individual connected components

Realizes ■ **3: Layout free**

- Assumptions

  ▸ Black characters are written on a flat white paper

  ▸ All connected components are easily segmented

of Co...
te School of Engineering
...ka Prefecture University

s c h o o l

How to quickly match segmented connected components

Overview of the Proposed Method 2

▶ Affine invariant recognition

  ▶ Three corresponding points help matching

Realizes robust recognition to

2: Perspective distortion

Input Image

Normalization

Match

Normalization

Reference Image
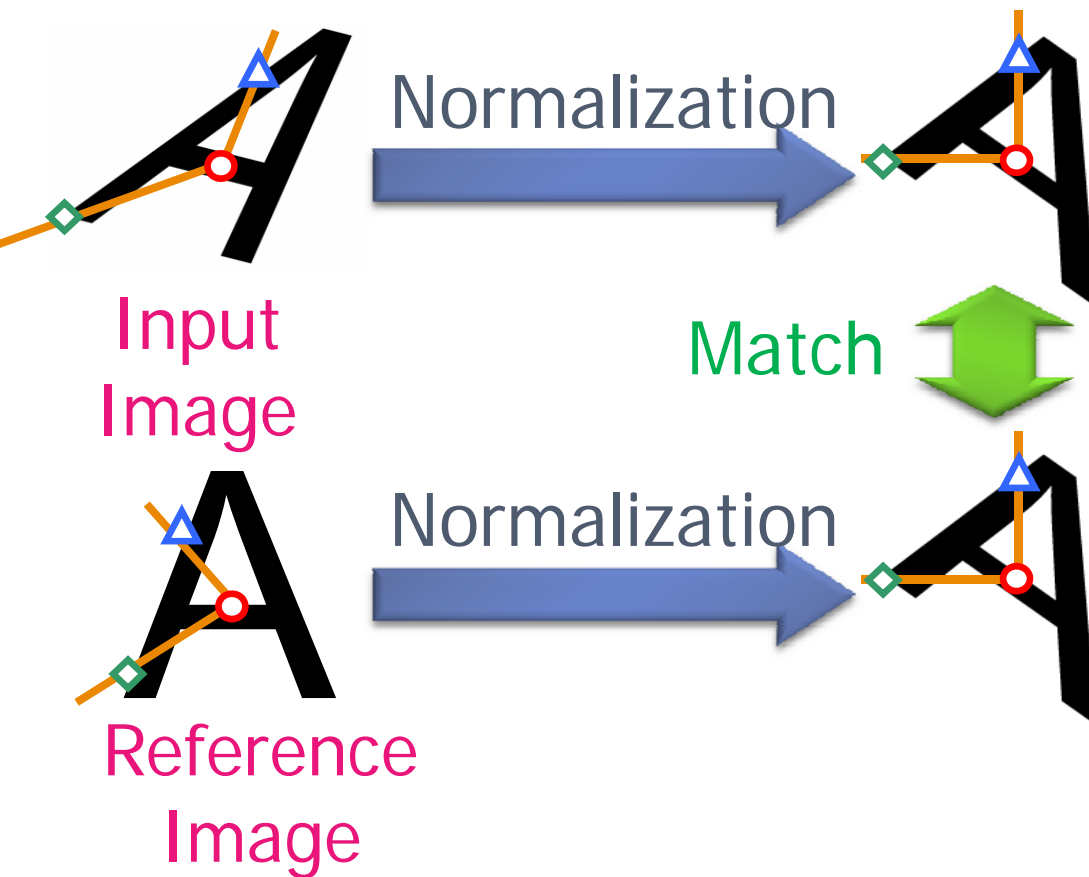
Overview of the Proposed Method 2: Contour Version of Geometric Hashing

Existing method :
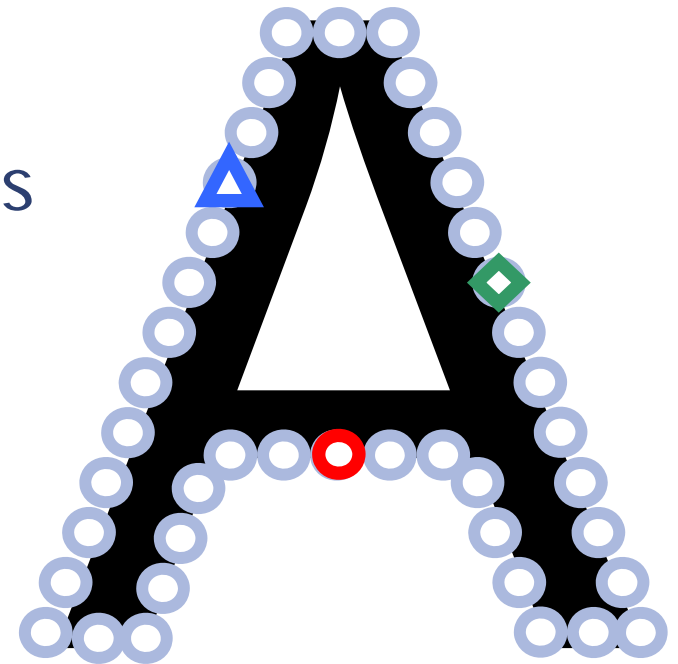   Geometric Hashing (GH)

Contour Version of GH

Start point of the proposed method
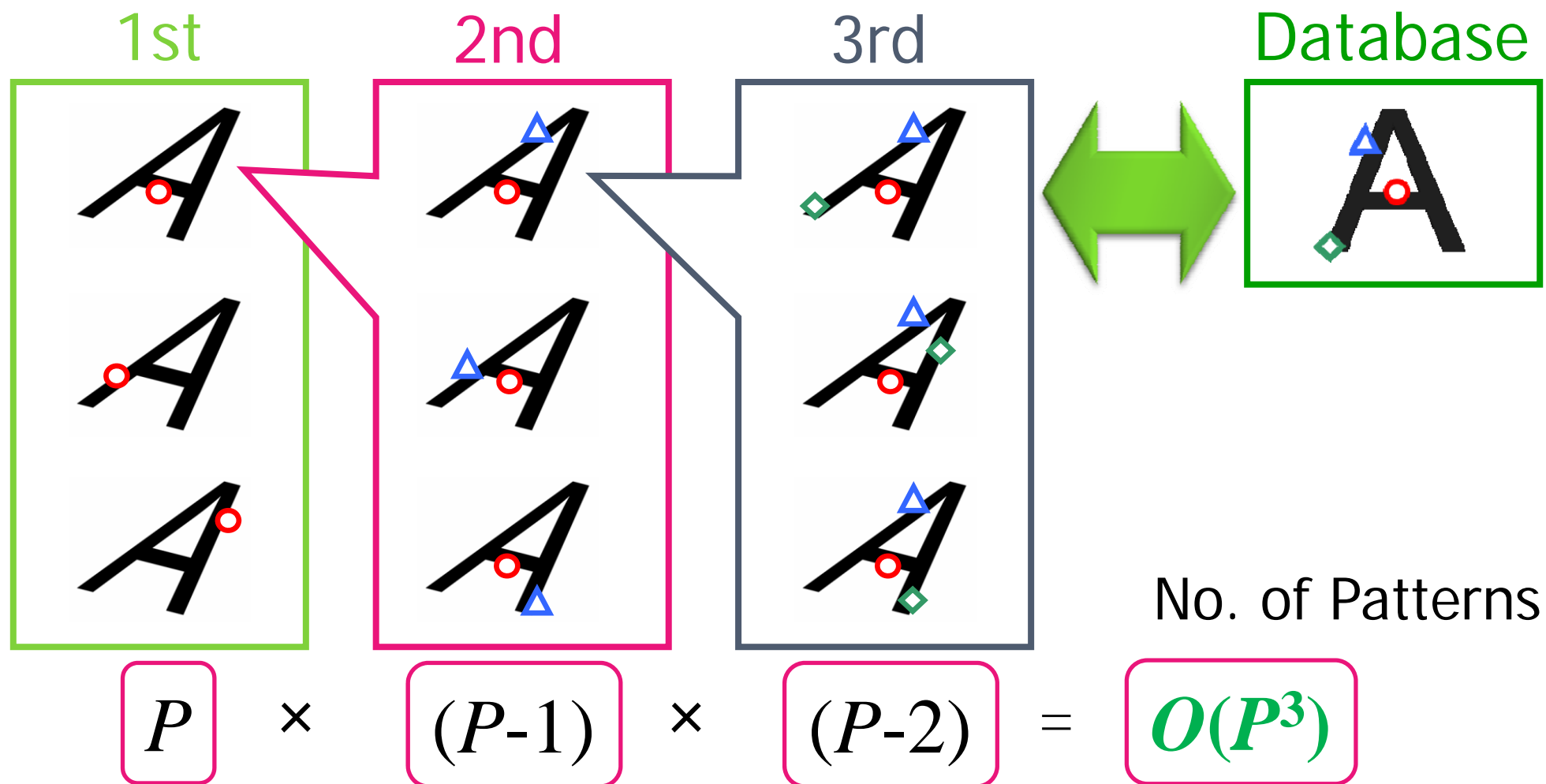
Applied GH to recognition of CCs

No. of Points : P

Matching of point arrangement   Matching of Shape

Overview of the Proposed Method 3: Three-Point Arrangements of CVGH

▸ CVGH examines all three points out of P points

1st   2nd   3rd   Database

No. of Patterns

$$P \times (P\text{-}1) \times (P\text{-}2) = O(P^3)$$

Overview of the Proposed Method 3: Three-Point Arrangements of Prop. Method

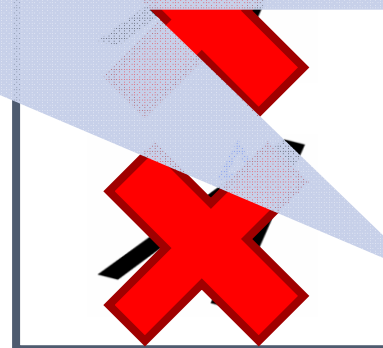▸ Proposed method snips useless three-point arrangements
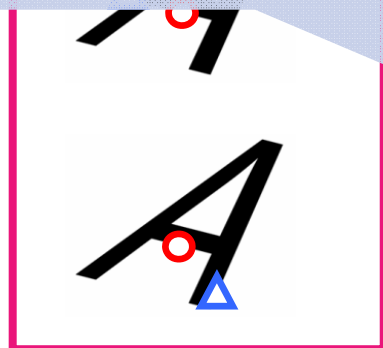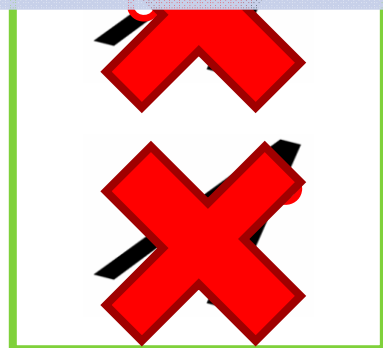
In case of $P = 100$

CVGH 970,200

Proposed Method 100

Realizes 1: Real-time

Database

$O(P^3)$

No. of Patterns

$1 \quad \times \quad P \quad \times \quad 1 \quad = \quad O(P)$
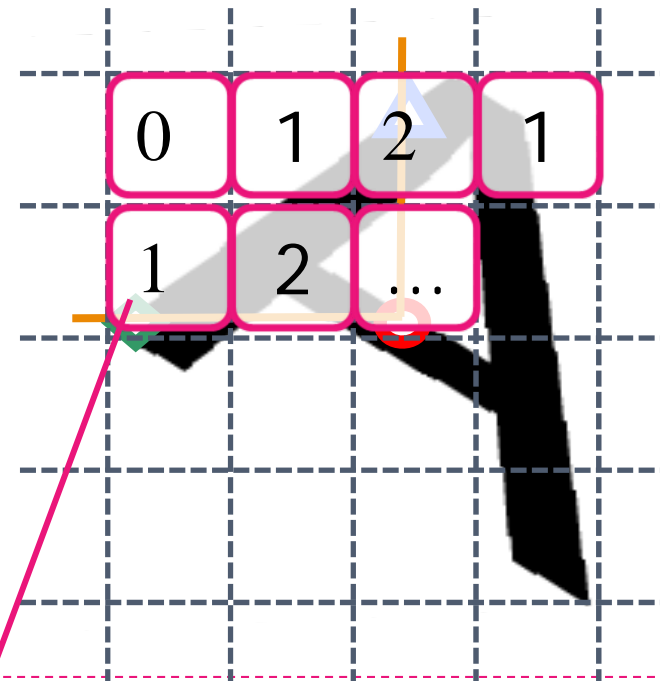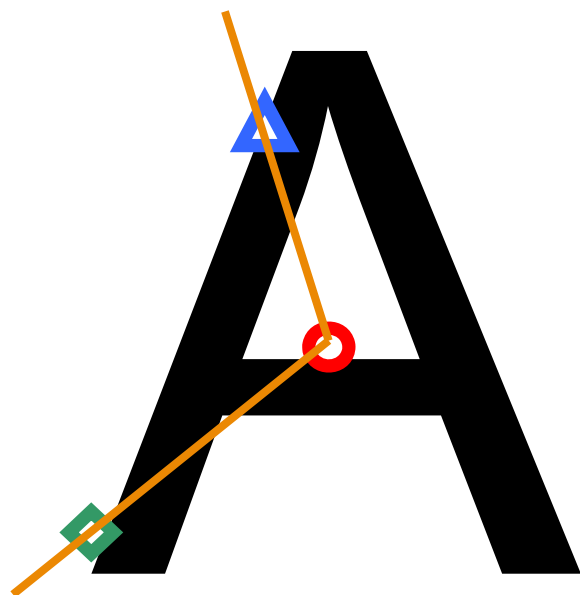
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Contour Version of GH: Matching by Feature Vectors

▸ Calculation of feature vector

1. Normalize
2. Divide into subregions
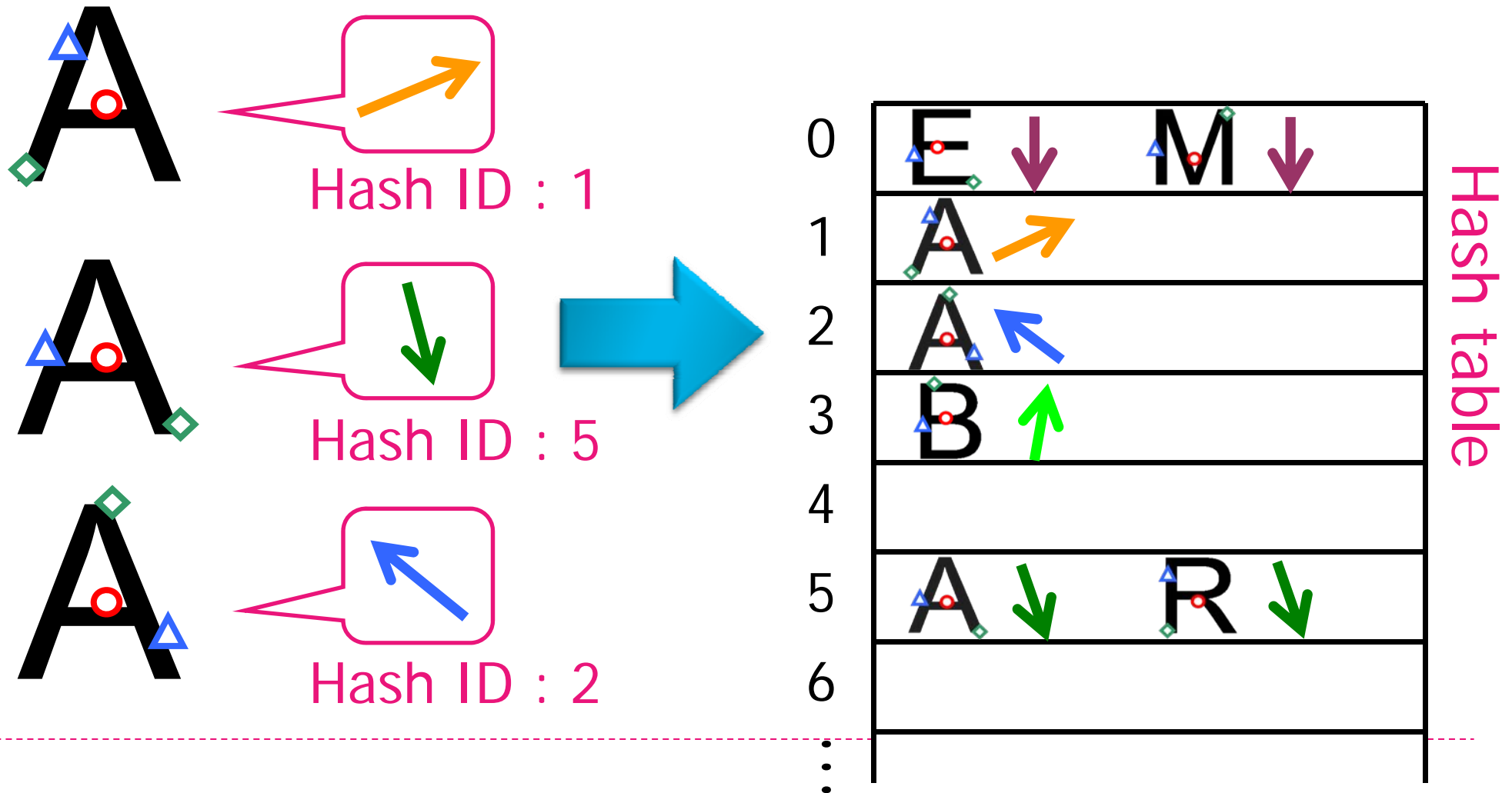3. Create a histogram of black pixel
4. Quantize

4x4 Mesh Feature

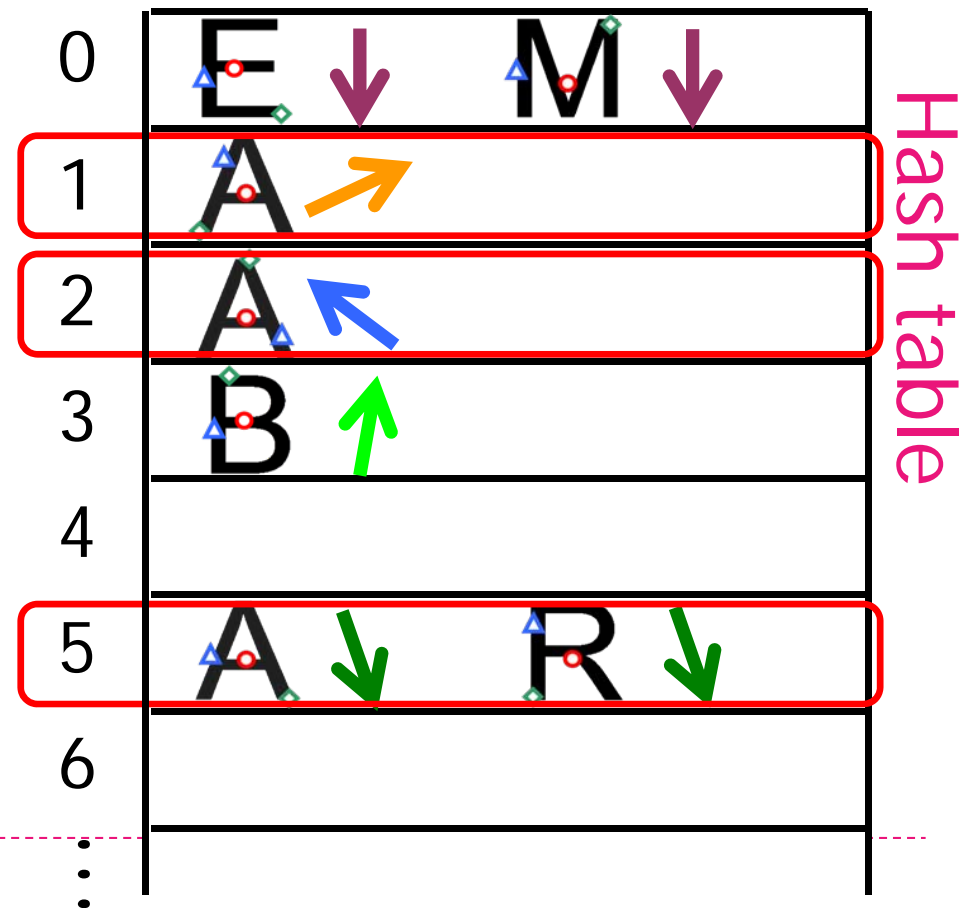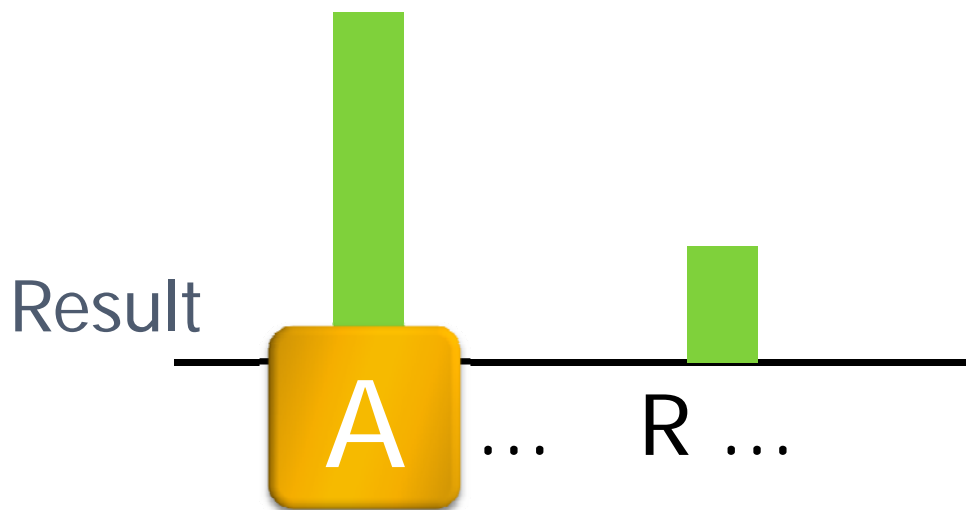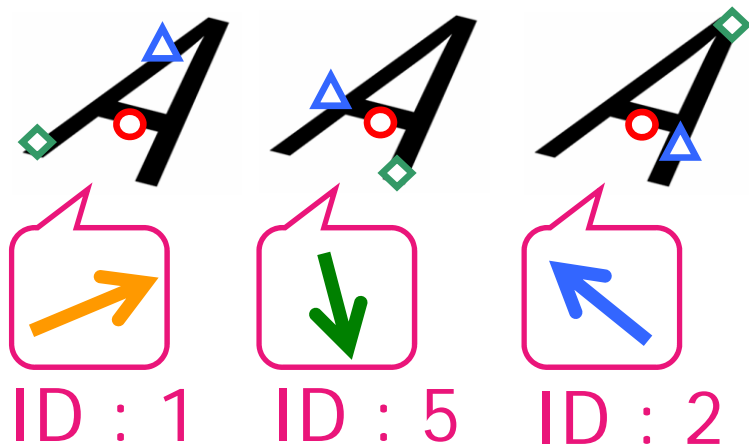| 0	1	2	1
1	2	...	

Feature Vector

Contour Version of GH: Storage

▸ Feature vectors are stored in the hash table

Contour Version of GH: Recognition

1. Calculate feature vectors
2. Cast votes

Contents

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Proposed Method 1:
Real-Time Processing by Affine Invariant

- Area ratio
  - Three-point arrangement ➡ Area ratio

Usual usage

Affine Invariant

Area Ratio

S_1

S_0

S'_1
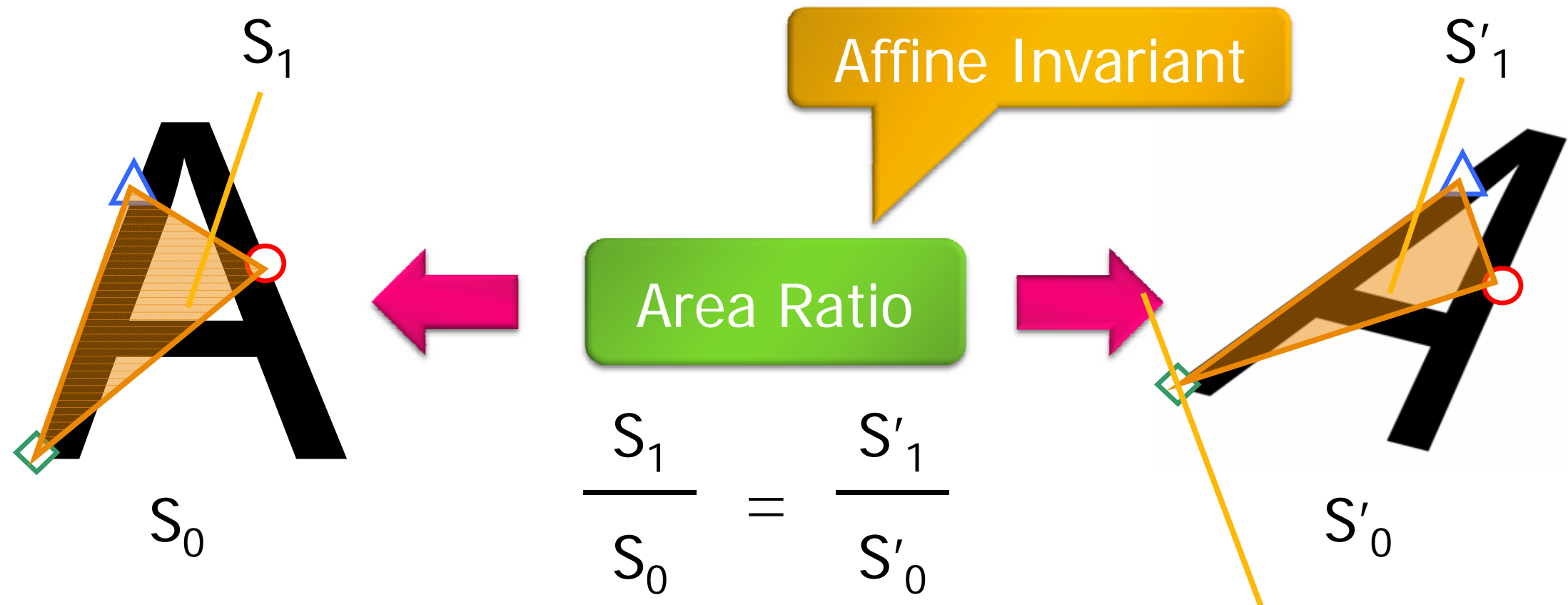
S'_0

$$\frac{S_1}{S_0} = \frac{S'_1}{S'_0}$$
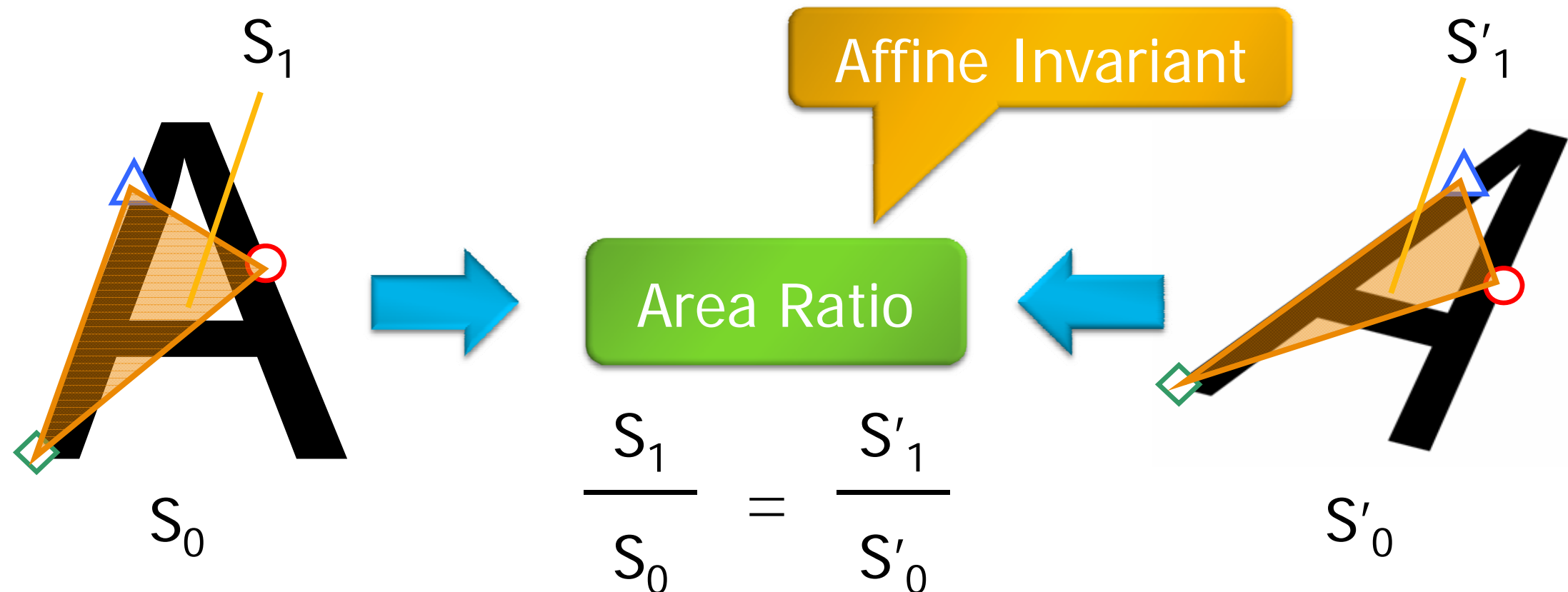
Proposed Method 1:
Real-Time Processing by Affine Invariant

▸ Area ratio   **Unusual usage**

   ▸ Two-point arrangement + Area ratio ➜ Third point

Affine Invariant

Area Ratio

$$\frac{S_1}{S_0} = \frac{S'_1}{S'_0}$$

S_1

S_0

S'_1

S'_0

▸

Proposed Method 1:
How to Select Three Points

- ★1st point: Centroid (Affine Invariant)
- 2nd point: Arbitrary point out of P points
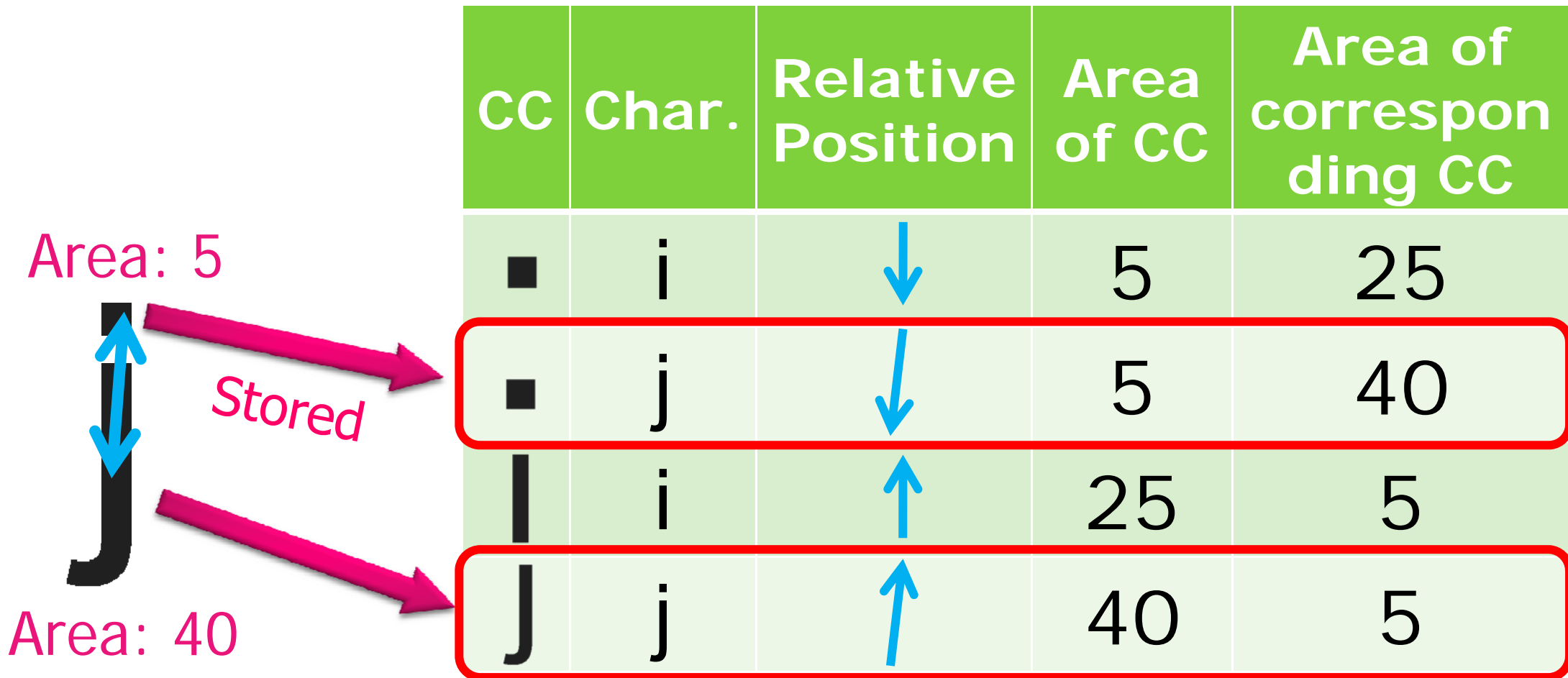- ★3rd point: Determined by the area ratio

★Uniquely Determined

No. of Points : P

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Proposed Method 2: Recognition of Separated Characters

▸ Create a separated character table for post processing

Area: 5

Stored

Area: 40

CC	Char.	Relative Position	Area of CC	Area of corresponding CC
▪	i	↓	5	25
▪	j	↓	5	40
▮	i	↑	25	5
J	j	↑	40	5

▸

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Proposed Method 3:
Pose Estimation

▸ Esti... ...eters
corr... ...ee po...

Pose of Paper

Pose of Characters

...fine
...rmat...
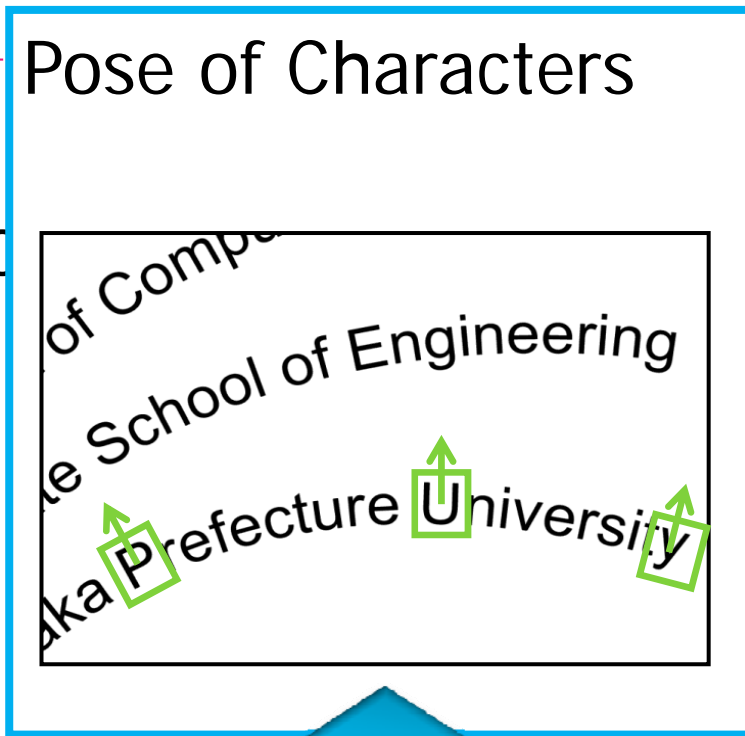
Parameters

Independent Scaling

Shear
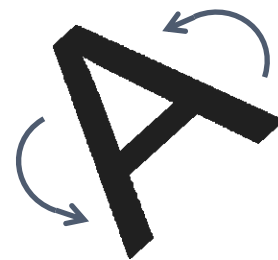
Rotation

Scaling

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Experiment: Recognition Target

Experiment:
Recognition Target

- Captured from three different angles
- A server was used
  - CPU: AMD Opteron 2.6GHz

Angle: 0 deg.   Angle: 30 deg.   Angle: 45 deg.

Experiment: Conditions

▸ Some characters are difficult to distinguish under affine distortions

➔ Characters in a cell were treated as the same class

0 O o	W w
6 9	X x
C c	N Z z
I l	p d
S s	q b
u n	7 L V v

▸

Experiment: Recognition Result

▸ Achieved high recognition rates and high speed by changing a control parameter

180-210 characters/sec

Settings	High recognition rates			High speed		
Angle (deg.)	0	30	45	0	30	45
Time (ms)	7990	7990	7020	1300	1260	1140
Recog. Rate (%)	94.9	90.7	86.4	86.9	81.8	76.3
Reject. Rate (%)	0.4	3.0	6.4	6.4	9.3	16.5
Error Rate (%)	4.7	6.4	7.2	6.8	8.9	7.2

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Document

Future Work

- Recognition of Chinese characters
- Improvement of segmentation for
  - Broken connected components
  - Colored characters
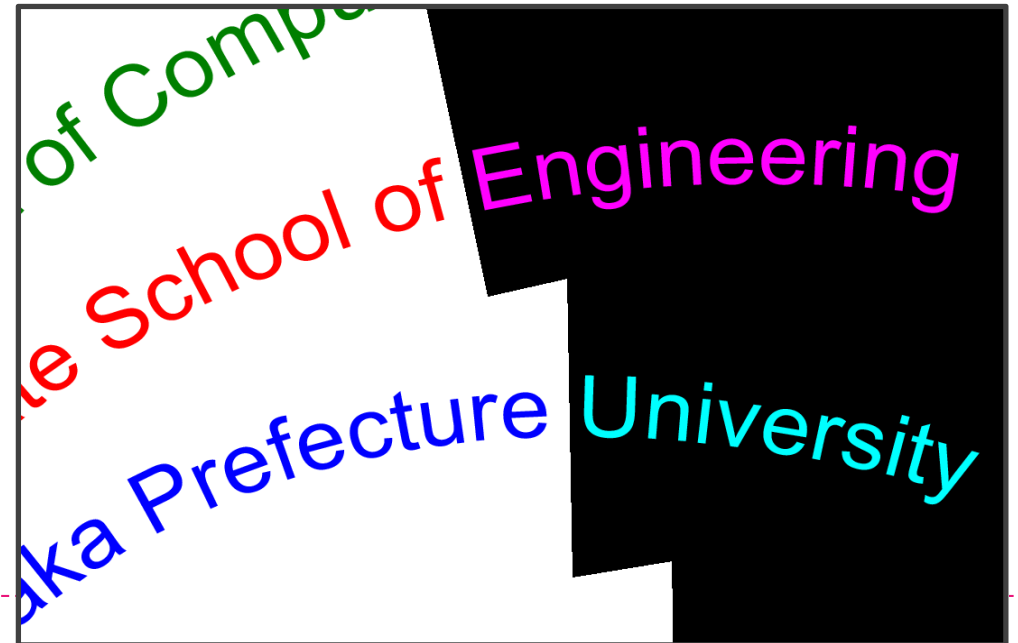
Real-Time Camera-Based Recognition of Characters and Pictograms

M. Iwamura, T. Tsuji, A. Horimatsu, and K. Kise