OCR and HWR Applications

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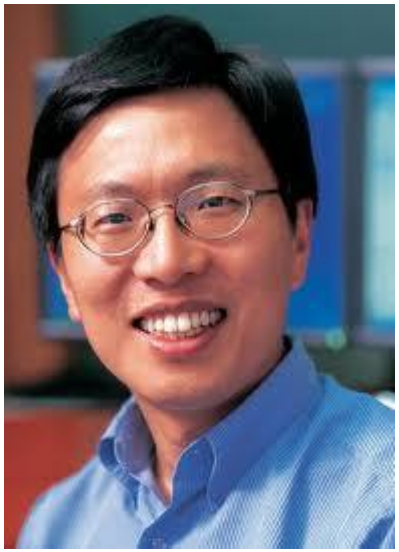
Development Driven Research (DDR)



Project 1:
OCR Translation and Search Using Windows Phone

Jun Du, Qiang Huo, Lei Sun, Jian Sun,
"Snap and Translate Using Windows Phone," ICDAR 2011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Kaifeng Bus Stop Jin mouth
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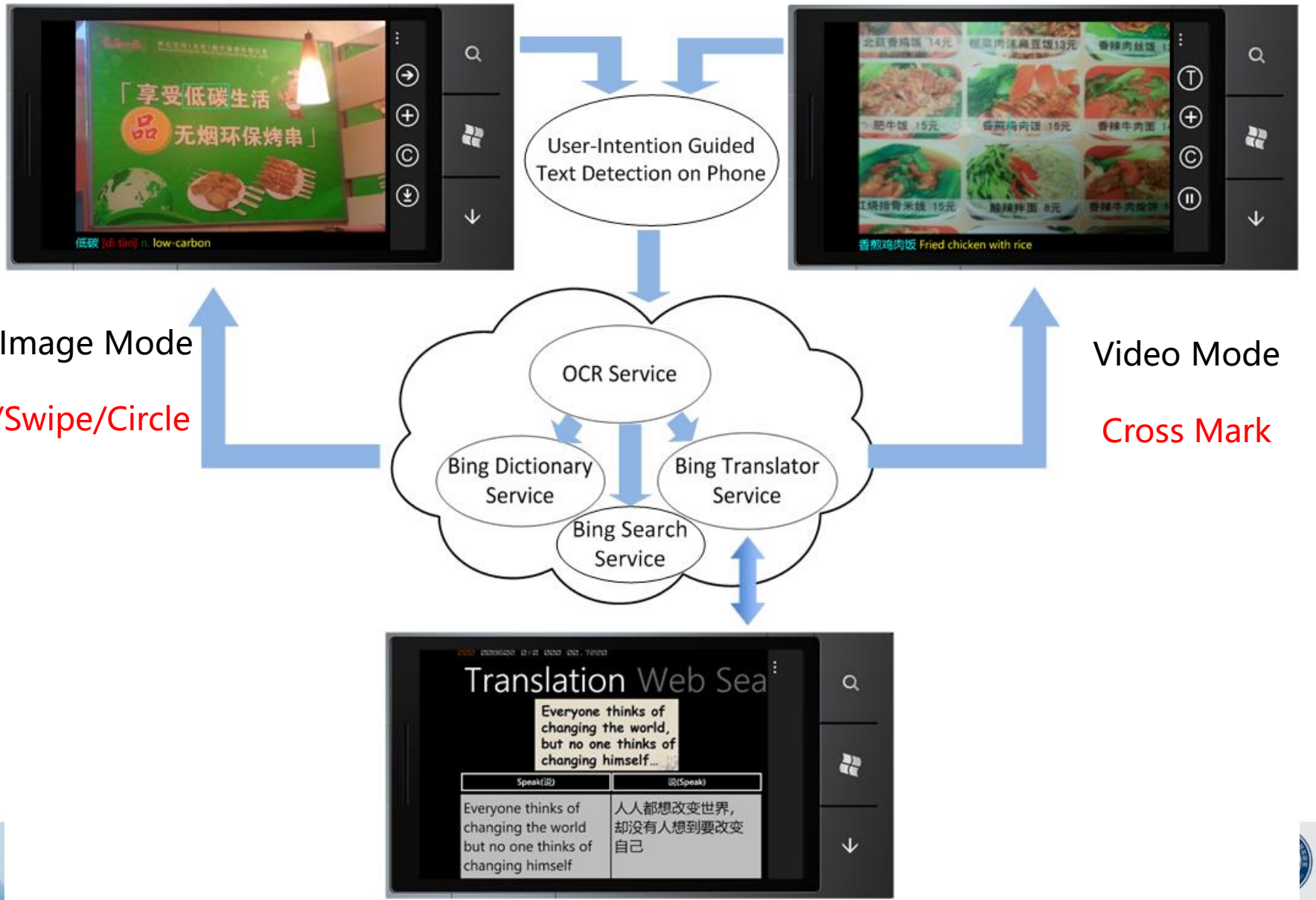
Our Demo

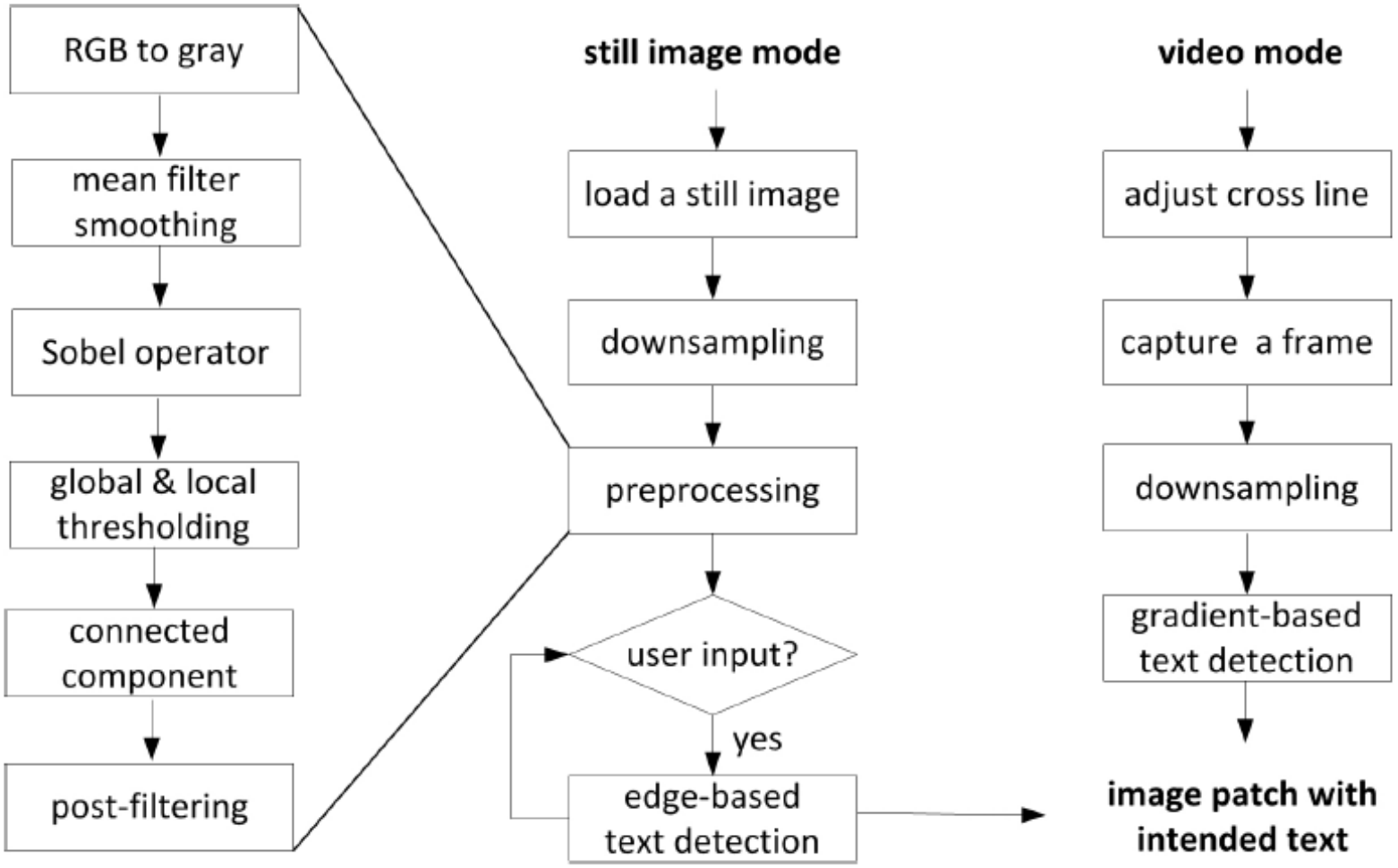
System Architecture



User-Intention Guided Text Detection (I)

- Fast
- Accurate
- Interactive
- Controllable

User-Intention Guided Text Detection (II)



Related Tech-Transfer

- TechFest 2011
  - Most of people want to get this app
- Transfer to OCR Product Team
  - Impact on the UI design of Microsoft Translator app
- Transfer to Bing Dictionary Team (Shipped)
  - OCR-based mouse hovering translation feature
- Transfer to China Incubation Group
  - OCR-based search feature in MyHealth365 Project

My First Ship-it Award

Word Lens

- iPhone App
- Augmented Reality
- Limited Application Scenarios
  - Simple background
  - Word look-up

Microsoft Translator WP App

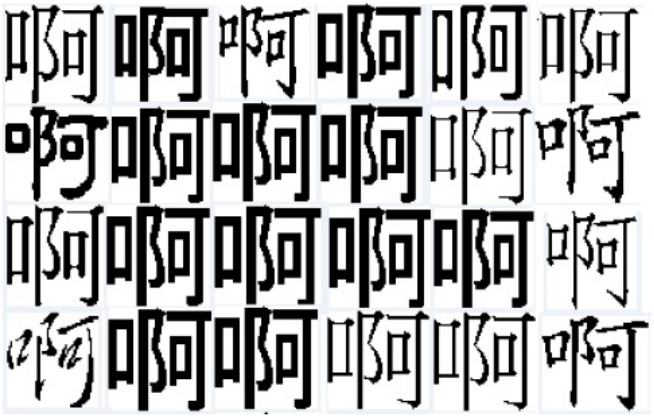
- Three Modes
  - Text
  - Image (OCR: local engine)
  - Speech (ASR: cloud service)

- Translation
  - Local dictionary for most common phases
  - Cloud service

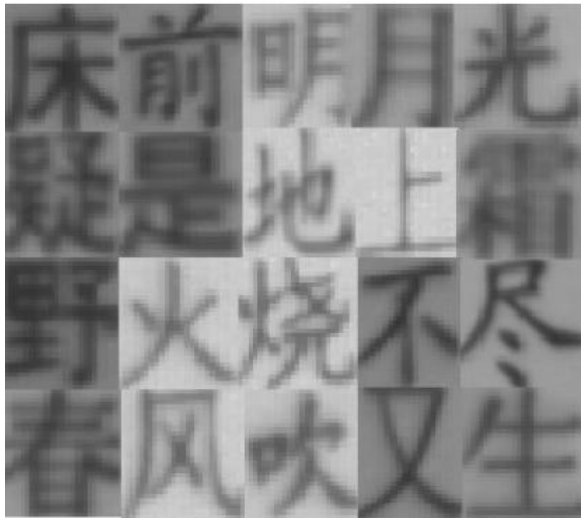
Project 2: Discriminative Linear Regression for OCR Adaptation

Jun Du, Qiang Huo,
"A discriminative linear regression approach to adaptation of multi-prototype based classifiers and its applications for Chinese OCR,"
Pattern Recognition, 2013

Font-Style Adaptation



Low-Quality Text Adaptation



Prototype-based Classifier

- Prototypes for each character class
- Discriminant functions

$$g_i(\boldsymbol{x};\boldsymbol{\lambda}_i) = -\min_k \| \boldsymbol{x} - \boldsymbol{m}_{ik} \|^2$$

- Decision

$$r(\boldsymbol{x};\boldsymbol{\Lambda}) = \arg\max_i g_i(\boldsymbol{x};\boldsymbol{\lambda}_i) \ .$$

SSM-MCE Classifier Training

- MCE Objective Function

$$l(\boldsymbol{X};\boldsymbol{\Lambda}) = \frac{1}{R_1}\sum_{r=1}^{R_1}\frac{1}{1+\exp[-\alpha d(\boldsymbol{x}_r;\boldsymbol{\Lambda})+\beta]}$$

- Sample Separation Margin

$$d(\boldsymbol{x}_r;\boldsymbol{\Lambda}) = \frac{-g_p(\boldsymbol{x}_r;\boldsymbol{\lambda}_p)+g_q(\boldsymbol{x}_r;\boldsymbol{\lambda}_q)}{2 \parallel \boldsymbol{m}_{p\hat{k}} - \boldsymbol{m}_{q\bar{k}} \parallel}$$

$$\begin{aligned}
\hat{k} &= \arg\min_k \parallel \boldsymbol{x}_r - \boldsymbol{m}_{pk} \parallel^2 \\
q &= \arg\max_{i\in\mathcal{M}_r} g_i(\boldsymbol{x}_r;\boldsymbol{\lambda}_i) \qquad g_i(\boldsymbol{x};\boldsymbol{\lambda}_i) = -\min_k \parallel \boldsymbol{x} - \boldsymbol{m}_{ik} \parallel^2 \\
\bar{k} &= \arg\min_k \parallel \boldsymbol{x}_r - \boldsymbol{m}_{qk} \parallel^2
\end{aligned}$$

Model-Space Adaptation

- Linear Transformation

$$\hat{\boldsymbol{m}}_{ik} = \mathcal{F}(\boldsymbol{m}_{ik};\boldsymbol{\Theta}) = \boldsymbol{A}_{e_i}\boldsymbol{m}_{ik} + \boldsymbol{b}_{e_i}$$

- MCE Objective Function

$$l(\boldsymbol{Y};\boldsymbol{\Lambda},\boldsymbol{\Theta}) = \frac{1}{R_2}\sum_{r=1}^{R_2}\frac{1}{1+\exp[-\alpha d(\boldsymbol{y}_r;\boldsymbol{\Lambda},\boldsymbol{\Theta})+\beta]}$$

- Sample Separation Margin

$$d(\boldsymbol{y}_r;\boldsymbol{\Lambda},\boldsymbol{\Theta}) = \frac{-g_p(\boldsymbol{y}_r;\hat{\boldsymbol{\lambda}}_p)+g_q(\boldsymbol{y}_r;\hat{\boldsymbol{\lambda}}_q)}{2\parallel \hat{\boldsymbol{m}}_{p\hat{k}} - \hat{\boldsymbol{m}}_{q\bar{k}} \parallel}$$

Feature-Space Adaptation

- Linear Transformation

$$\boldsymbol{x}_r = \mathcal{F}(\boldsymbol{y}_r;\boldsymbol{\Theta}) = \boldsymbol{A}\boldsymbol{y}_r + \boldsymbol{b}$$

- MCE Objective Function

$$l(\boldsymbol{Y};\boldsymbol{\Lambda},\boldsymbol{\Theta}) = \frac{1}{R_2}\sum_{r=1}^{R_2}\frac{1}{1+\exp[-\alpha d(\boldsymbol{y}_r;\boldsymbol{\Lambda},\boldsymbol{\Theta})+\beta]}$$

- Sample Separation Margin

$$d(\boldsymbol{y}_r;\boldsymbol{\Lambda},\boldsymbol{\Theta}) = \frac{-g_p(\boldsymbol{x}_r;\boldsymbol{\lambda}_p)+g_q(\boldsymbol{x}_r;\boldsymbol{\lambda}_q)}{2\parallel \boldsymbol{m}_{p\hat{k}}-\boldsymbol{m}_{q\bar{k}}\parallel}$$

Rprop Optimization

- Update the step size adaptively

$$S = \frac{\partial l(\mathcal{X}, \mathcal{L}; \mathbf{\Lambda}^{(t-1)})}{\partial m_{ikd}} \cdot \frac{\partial l(\mathcal{X}, \mathcal{L}; \mathbf{\Lambda}^{(t)})}{\partial m_{ikd}}$$

$$\Delta_{ikd}^{(t)} = \begin{cases} \min\left(\eta^{+}\Delta_{ikd}^{(t-1)}, \Delta_{\max}\right) & \text{if } S > 0 \\ \max\left(\eta^{-}\Delta_{ikd}^{(t-1)}, \Delta_{\min}\right) & \text{if } S < 0 \\ \Delta_{ikd}^{(t-1)} & \text{else} \end{cases}$$

$$0 < \eta^{-} < 1 < \eta^{+}$$

Font-Style Adaptation

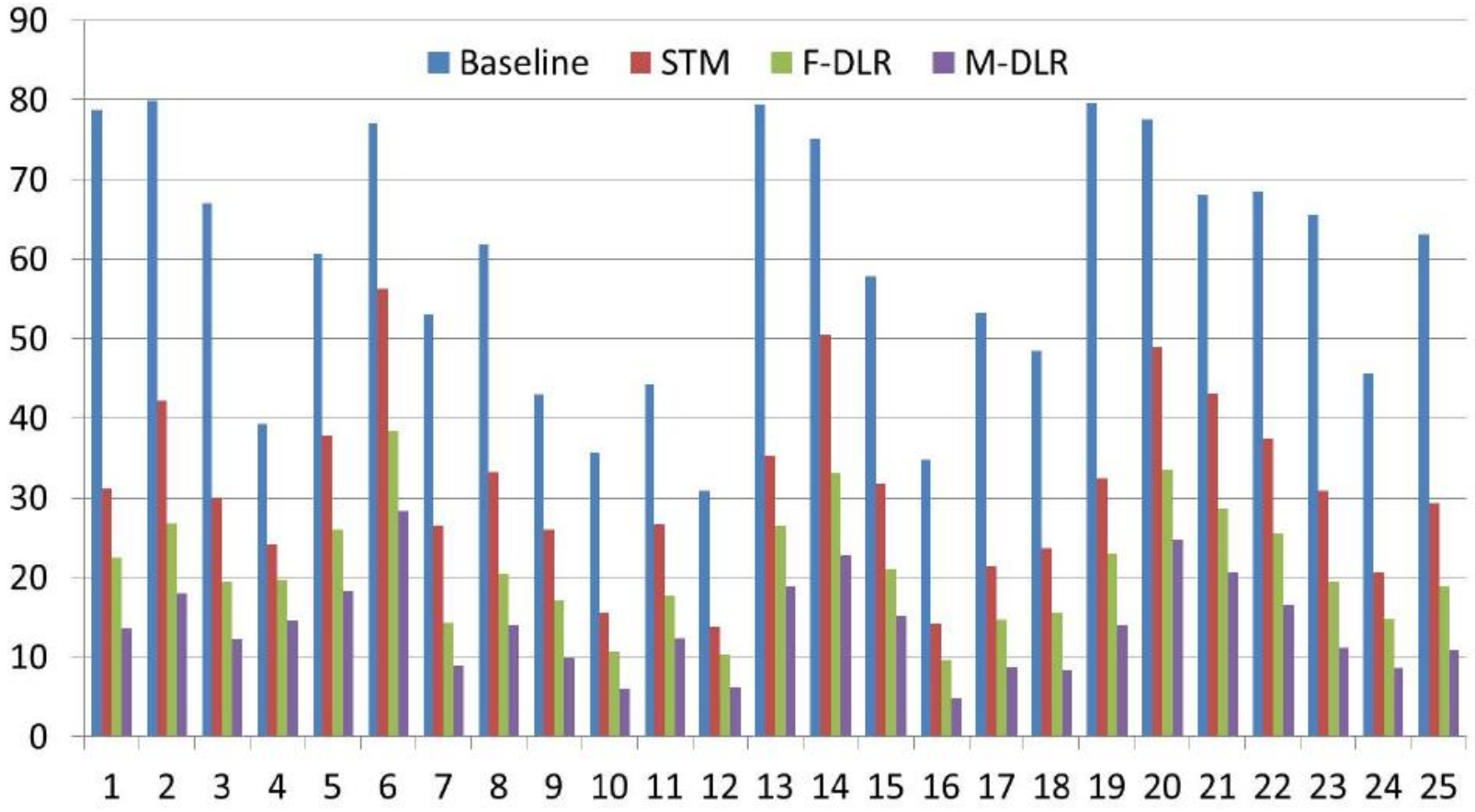


Fig. 6. Performance (character recognition error rate in % on each testing set) comparison of the baseline classifier and different approaches for supervised adaptation to *each of 25 new font styles*.

Low-Quality Text Adaptation

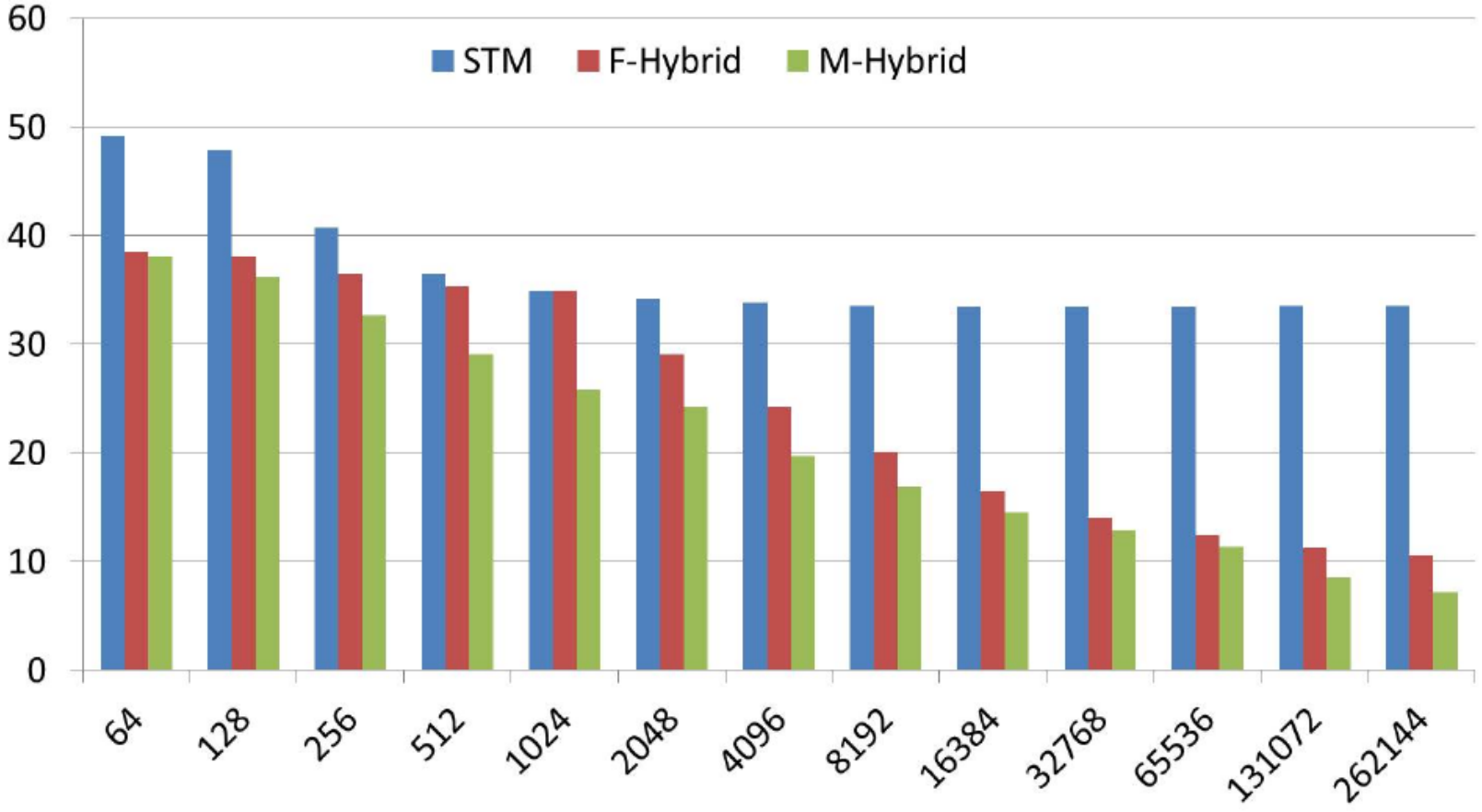
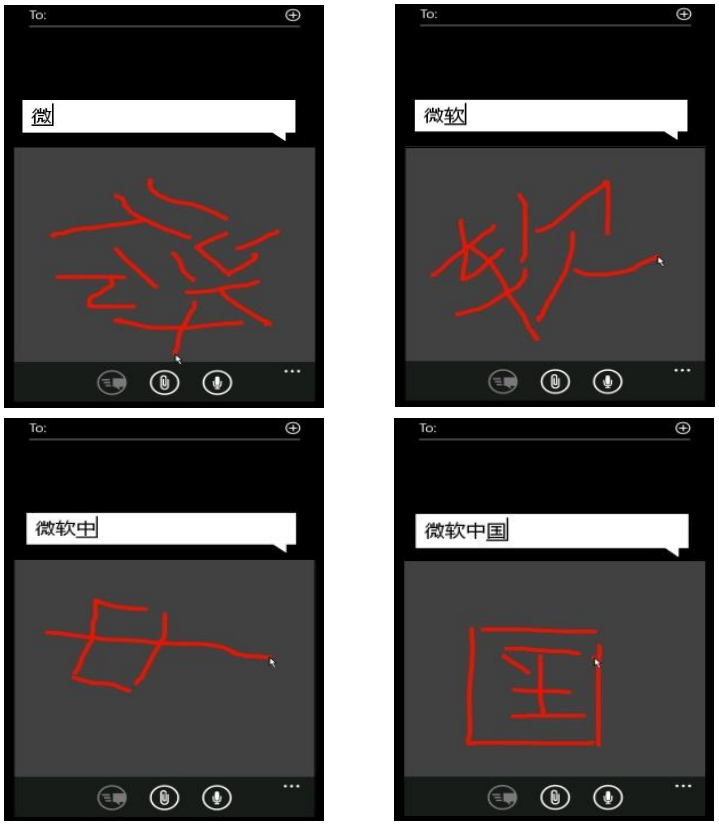


Fig. 9. Performance (character recognition error rate in % on testing set) comparison of different approaches for supervised adaptation with different number of adaptation samples of low-quality text (Baseline recognition error rate is 46.98%).

Project 3:
Snake: a WP8 HWR engine

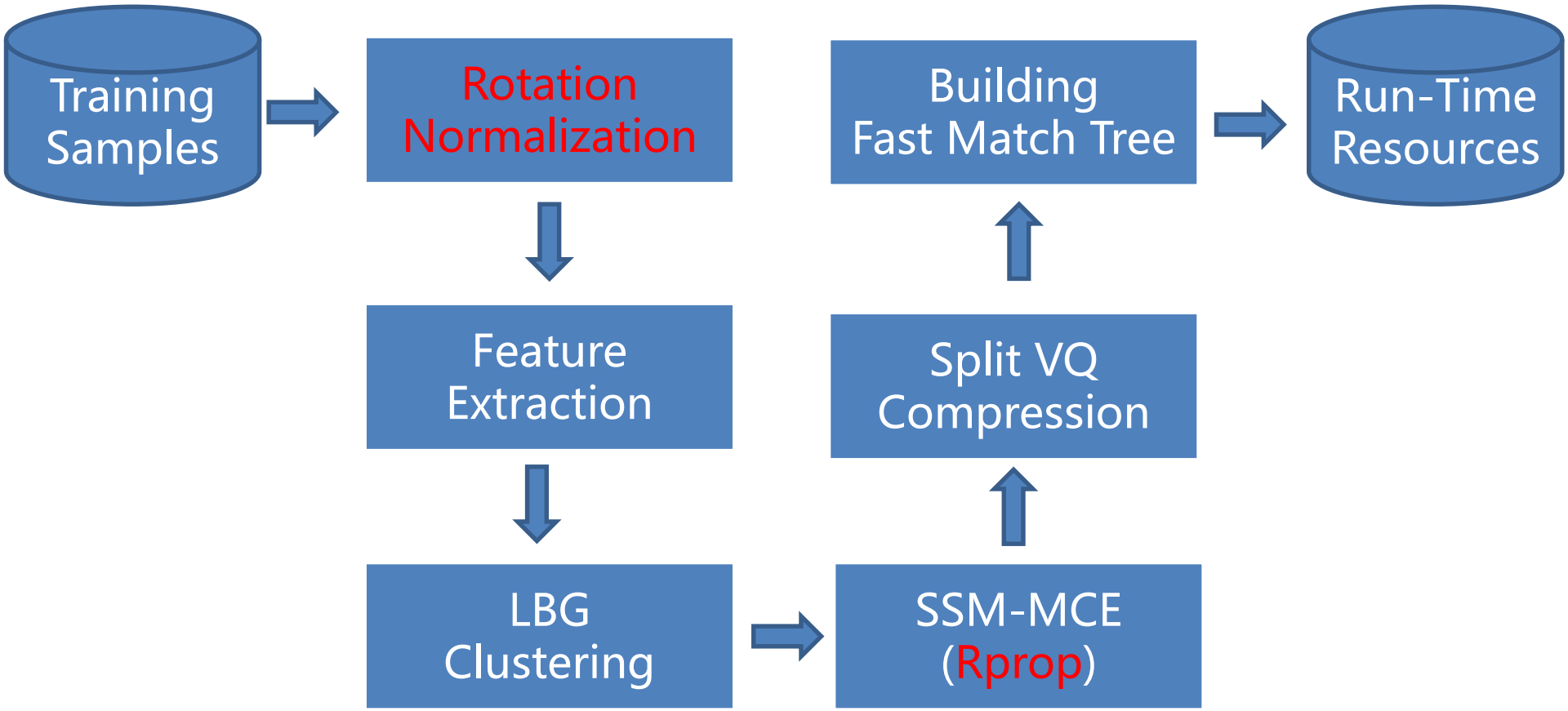


Jun Du, Qiang Huo, Kai Chen
"Designing compact classifiers for rotation-free recognition of large vocabulary online handwritten Chinese characters," ICASSP, 2012

Motivation

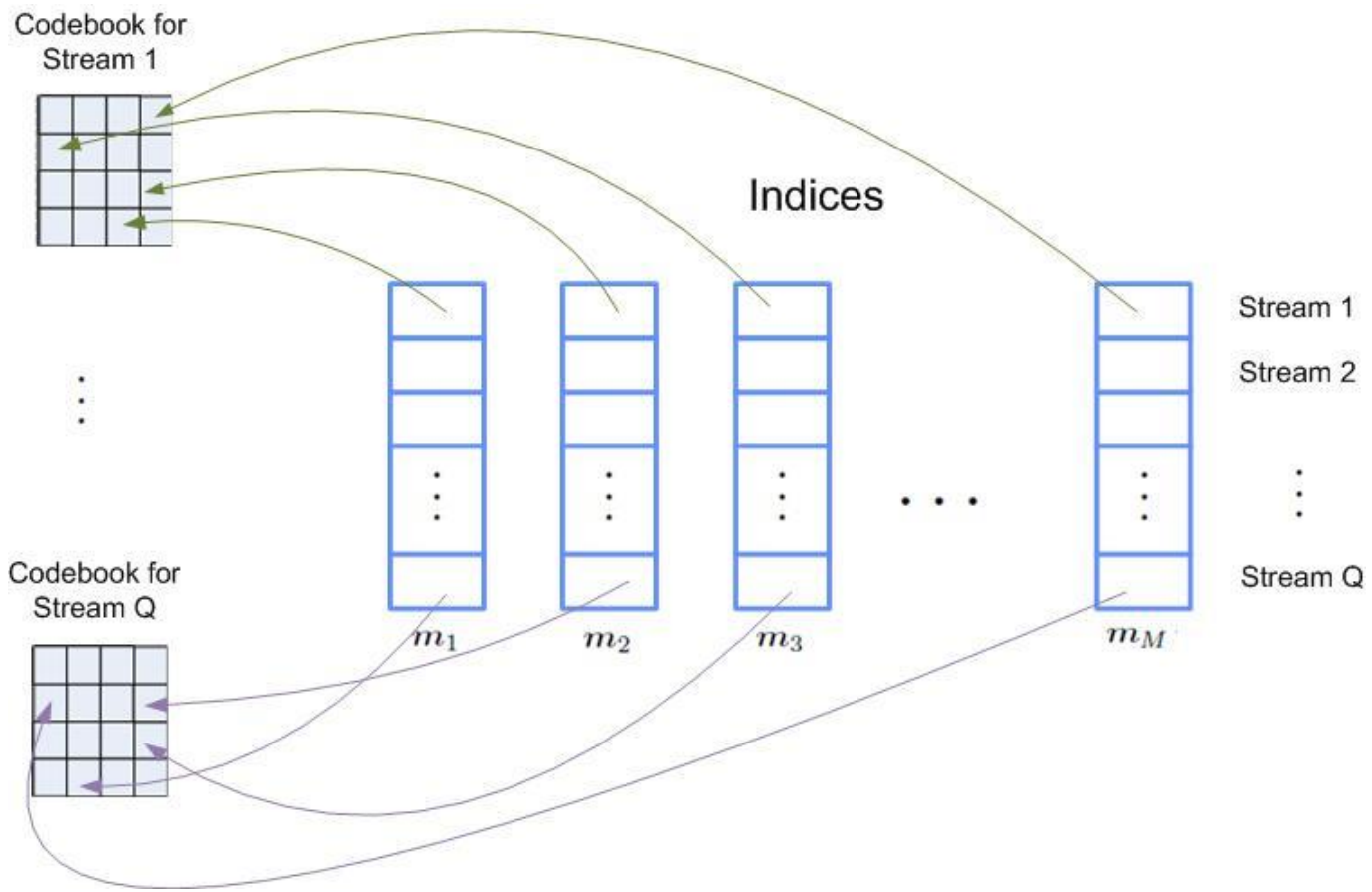
- Requirement of WP8 HWR in China Markets
  - Support GB18030 (27533 China Characters)
  - Robust to rotational distortion
- The Status of HWR Product Team
  - The original team is reorganized to STC
  - The new team have no capability to build the engine

Training Stage

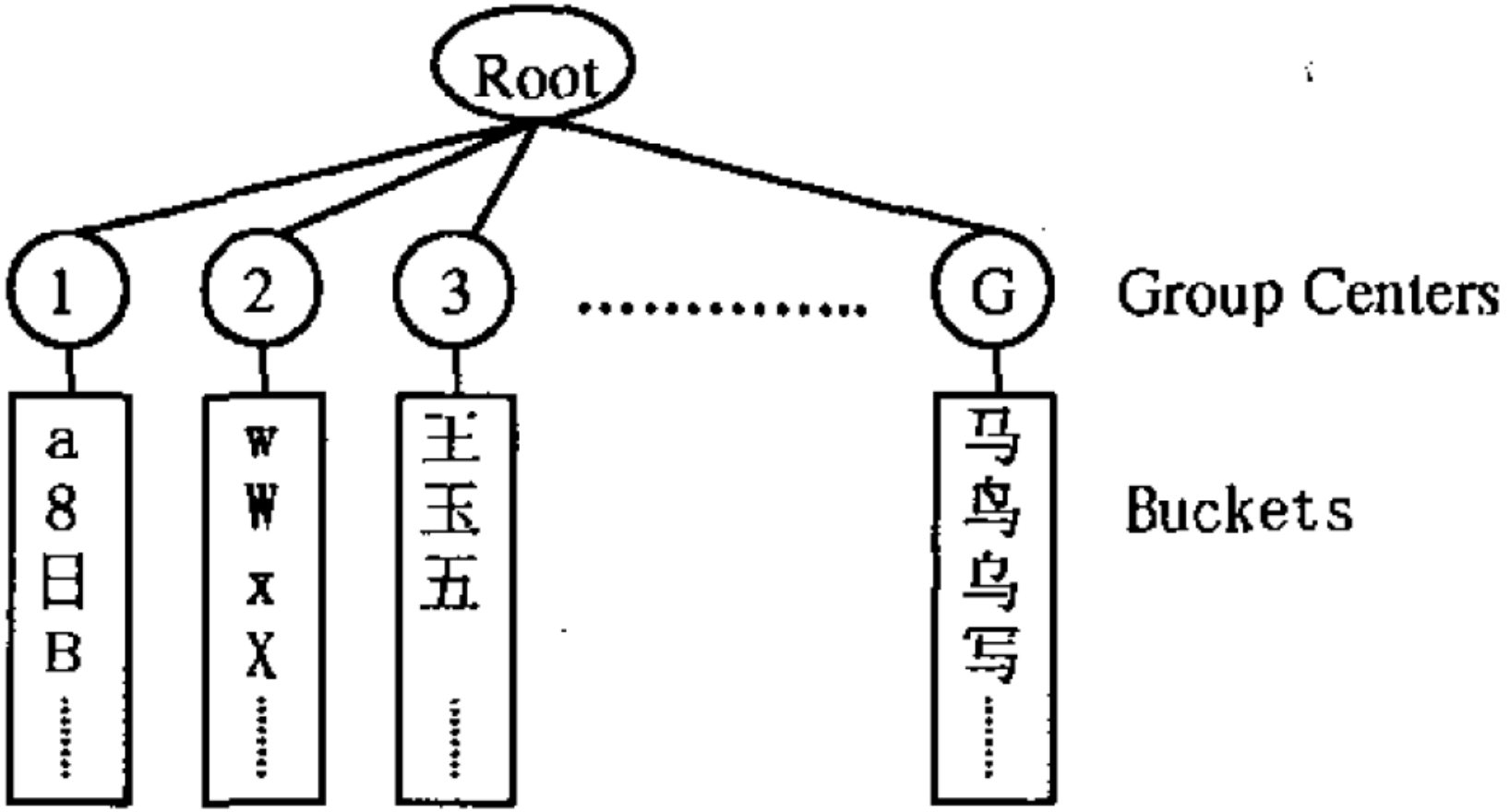


Split VQ Compression

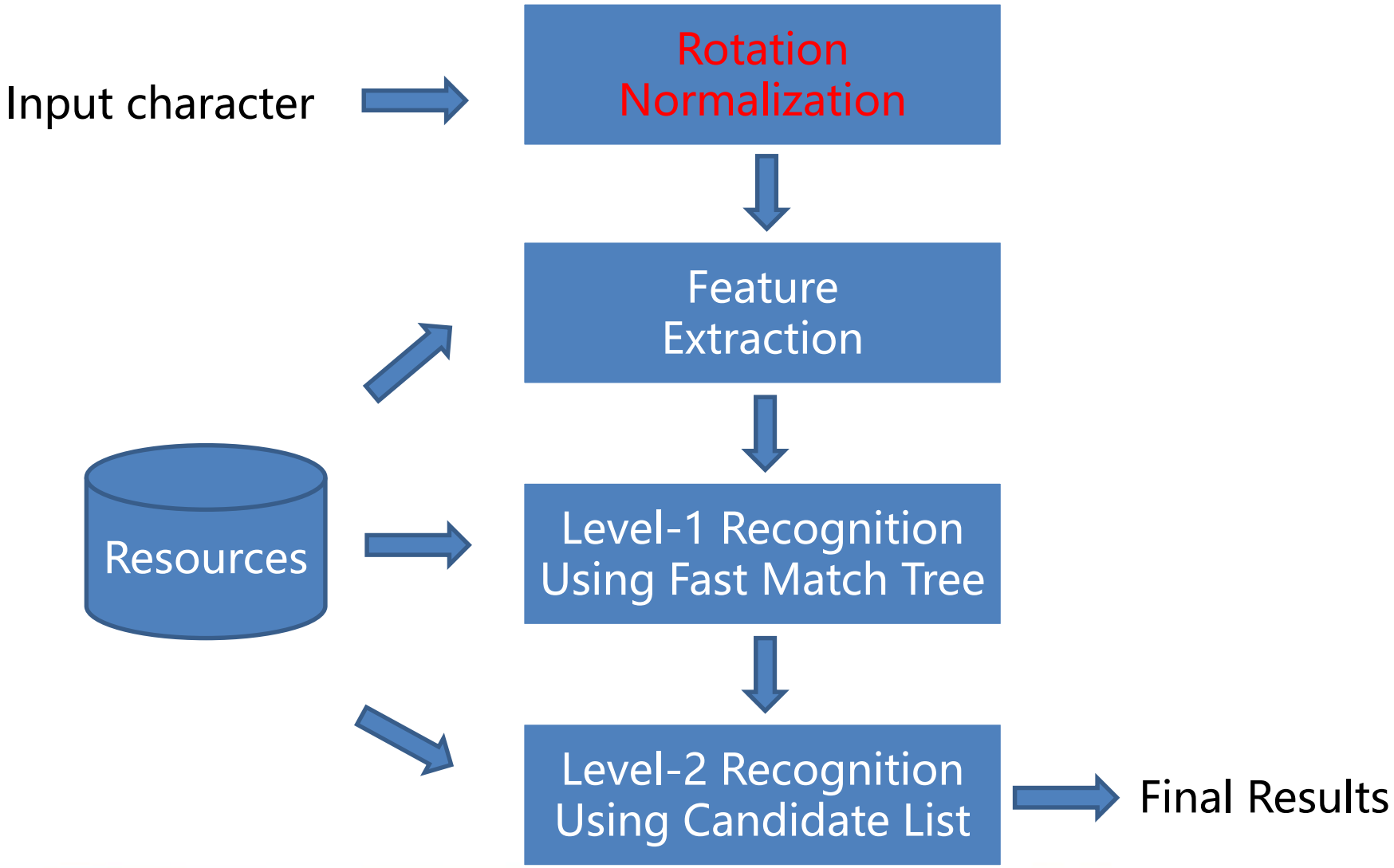
- Split D-dimensional prototype vectors into Q streams
- Sub-vectors in different streams are quantized by VQ with different codebooks



Fast-Match Tree



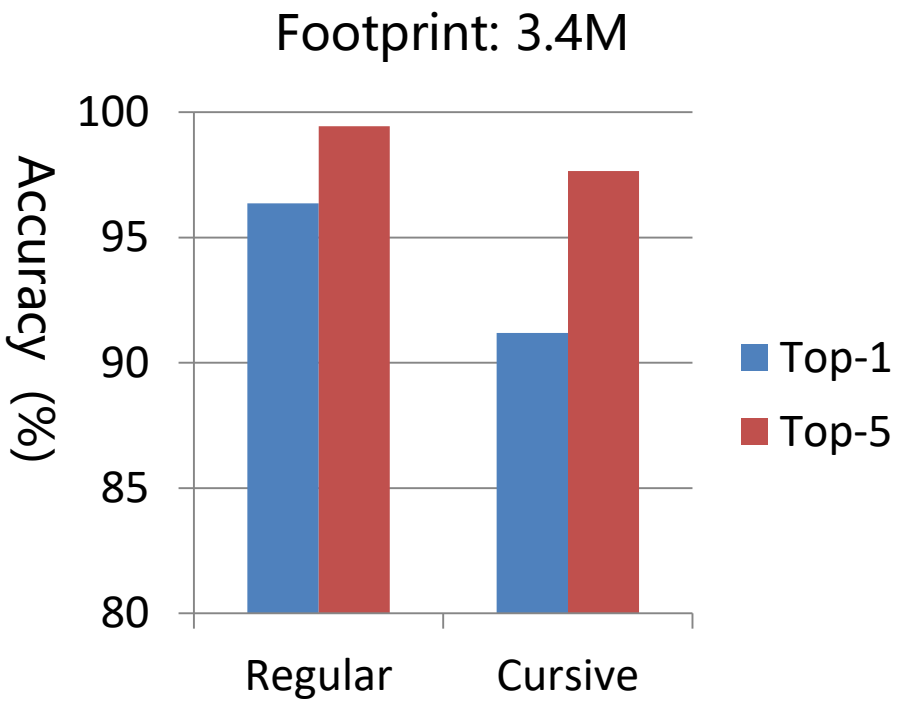
Recognition Stage



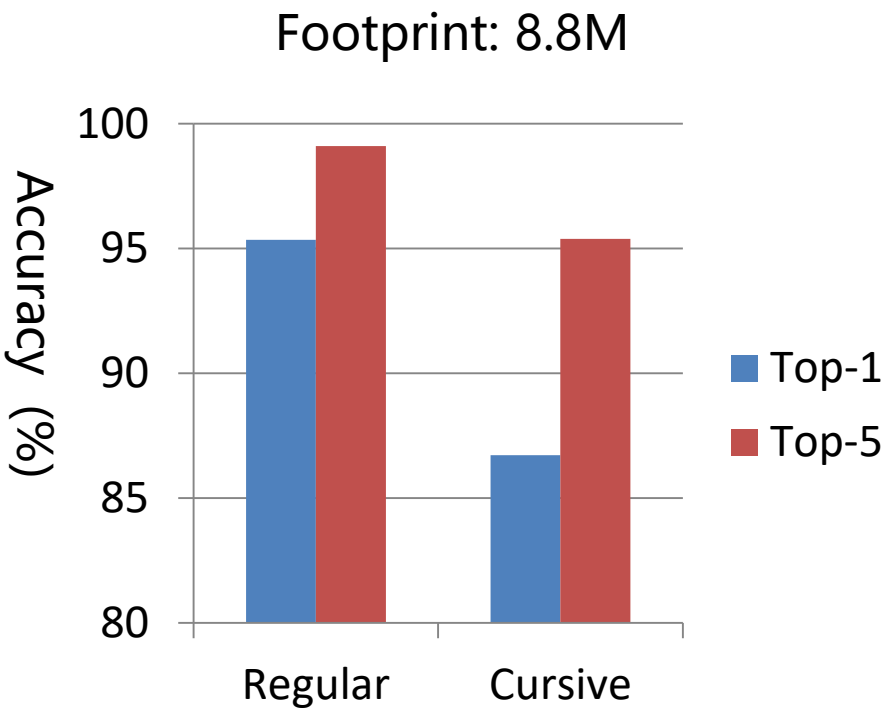
A Magic for Rotation Normalization

- Starting point of each stroke
- Ending point of each stroke
- Averaged starting point over all strokes
- Averaged ending point over all strokes

Rotation-Sensitive vs. Rotation-Free



Recognizer #1: rotation-sensitive



Recognizer #2: rotation-free

Comparison with Mango (WP7.5) System

	Current System	Mango System
Vocabulary	27533 Characters	6763 Characters
Footprint	6MB+	2MB
Accuracy	94.5%	94.2%
Recognition Time Per Character	7ms	11ms

Summary

- A Chinese HWR solution for WP8 Apollo release
  - Rotation-free
  - Fast
  - Compact
  - Accurate
  - Large vocabulary