Seal Imprint Verification Using SVM and Edge Difference

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Abstract

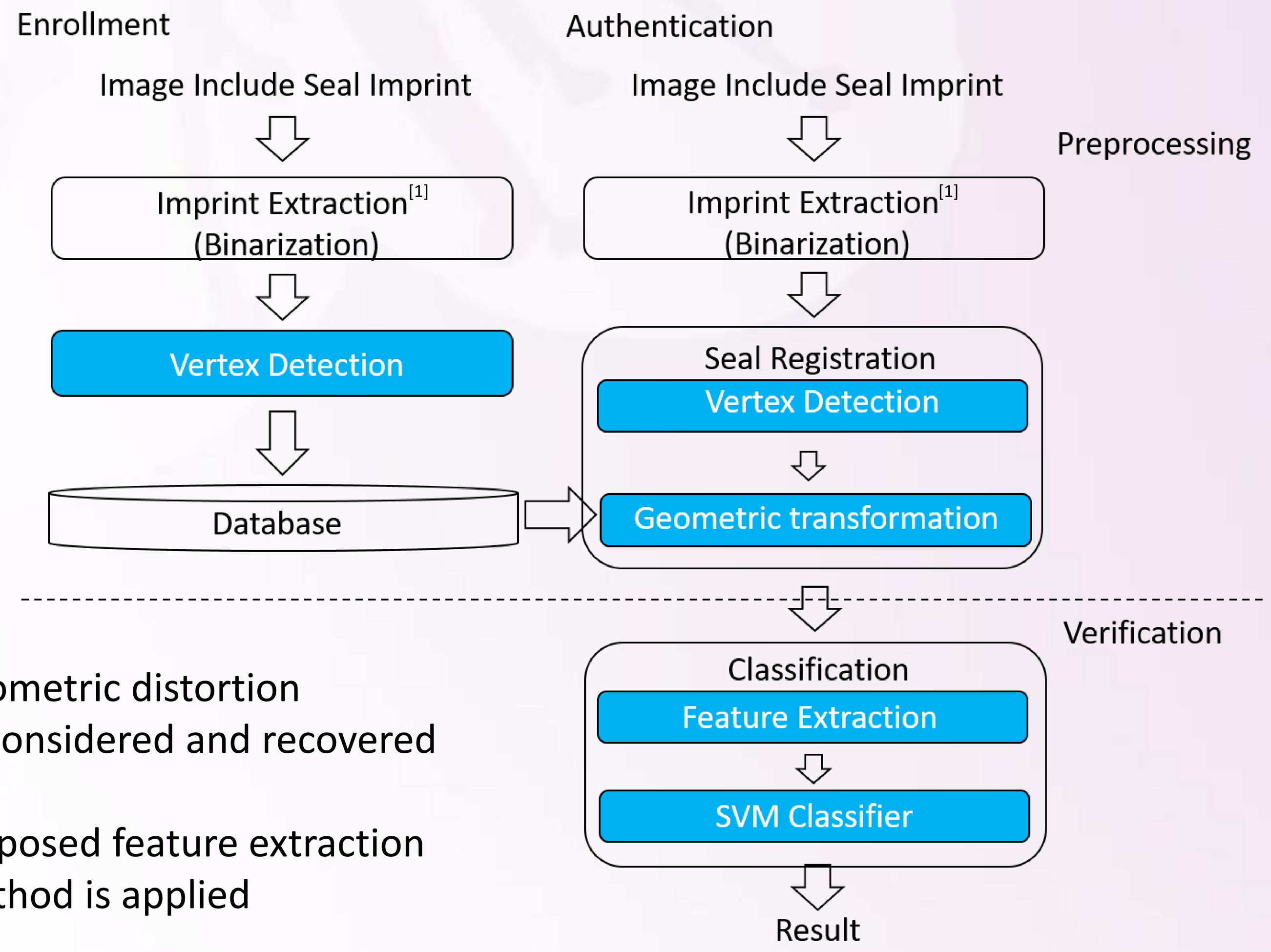
In Asian countries, seals are widely used for authenticating the identity of a person or organization. Therefore, the ability to efficiently verify whether a seal is either genuine or forged is important. We propose an effective method of verification based on Hough transformation to approximate the imprint borders and the four vertexes, and use geometric transformation to align the perspective of the detected imprint image with the genuine imprint. After the edge-difference images between the original image and the detected image are created, distance transformation and connected-component labeling are applied. Finally, the number of edges in the connected component and the distance to the closest point in the edge of original image are used to calculate the input vector for the SVM (support vector machine). The imprint is then determined to be either genuine or forged. The experimental results show the effectiveness of the proposed verification approach.

Introduction

- Important application in financial industry
- Paper-mediated preservation
- Features are proposed as input of SVM
- ROC curve is used to visualize the performance of the methods

Proposed System

- The modules using proposed method are highlighted in blue



- Geometric distortion is considered and recovered
- Proposed feature extraction method is applied

Preprocessing

- Imprint is extracted by thresholding with HSV information [1]
- Vertexes are found for performing geometric transform
- Difference image R_D is calculated

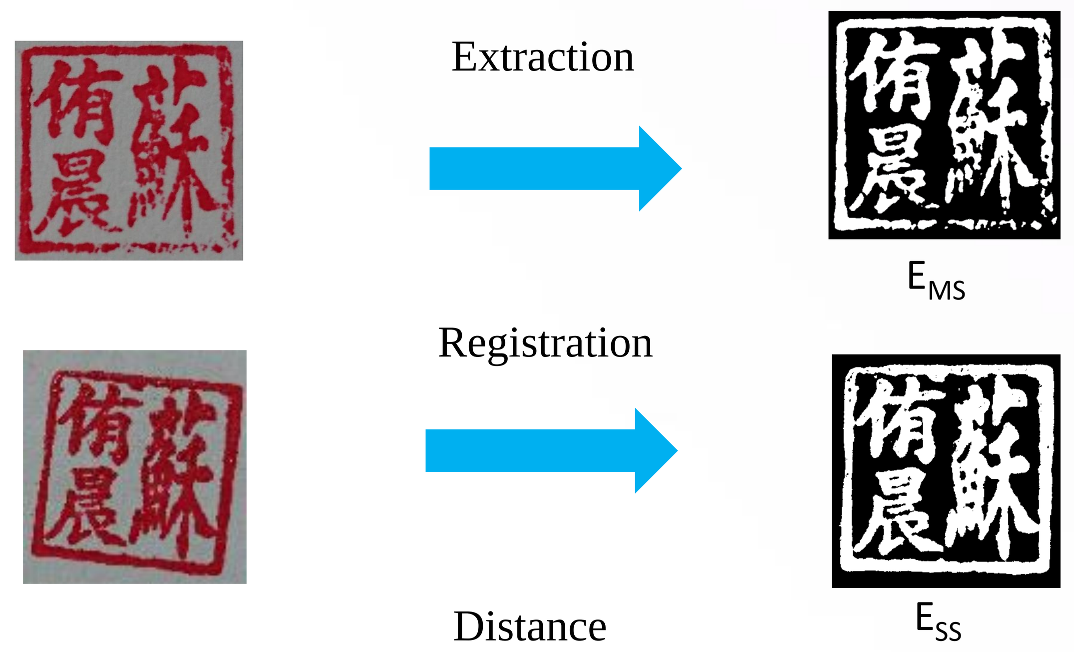
$$R_D(x,y)=\begin{cases}1 & \text{if } \ E_{SS}(x,y)=1, E_{MS}(x,y)=0\\ 0 & \text{otherwise}\end{cases}$$

,where E_{MS} represents the binarized model seal imprint and E_{SS} represents the binarized sample seal imprint after aligning to E_{MS}.

- Distance Transform is performed to obtain the distance from a point to the nearest edge in E_{MS}, which enable us to quantify the difference between E_{MS} and E_{SS}.

$$d(x,y)= \mathrm{DistanceTransform}(E_{MS})$$

- Connected Component Labelling is performed to extract the connectivity of R_D.



Distance Transform

0	0	0	0	0
0	1	1	1	0
0	1	1	1	0
0	0	0	0	0
0	0	0	0	0

1	1	1	1	1
1	0	0	0	1
1	1	1	1	1
1	1	1	1	1
2	2	2	2	2

Connected Component Labelling

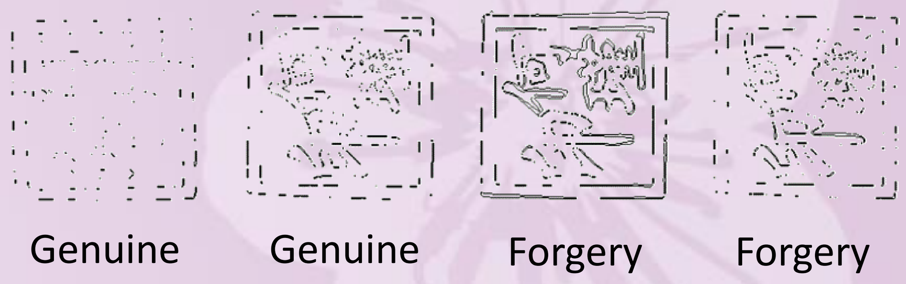
0	0	0	1	0
0	0	0	1	1
1	1	1	0	0
0	0	0	0	1
0	0	0	0	1

0	0	0	1	0
0	0	0	1	1
1	1	1	0	0
0	0	0	0	2
0	0	0	0	2

Related Knowledge

- In ideal condition, $P(R_D(x,y)=1 | Genuine=0)$[2]

- P(Burst error | Forgery)>P(Burst error | Genuine)[3]



Feature Extraction

- Difference image R_D is focused on for identifying
- Average distance of i_{th} component D_i and length of i_{th} component L_i are calculated

$$\begin{cases} L_i = \text{\# of pixel in } i_{th} \text{ component} \\ D_i = \dfrac{1}{L_i}\sum_{k=1}^{M_i} d_k \end{cases}$$

0	0	0	1	2
0	0	0	1	2
1	1	1	1	2
2	2	2	2	2
3	3	3	3	3

DistanceTransform of E_{MS}

0	0	0	1	0
0	0	0	1	1
1	1	1	0	0
0	0	0	0	2
0	0	0	0	2

Labelled R_D

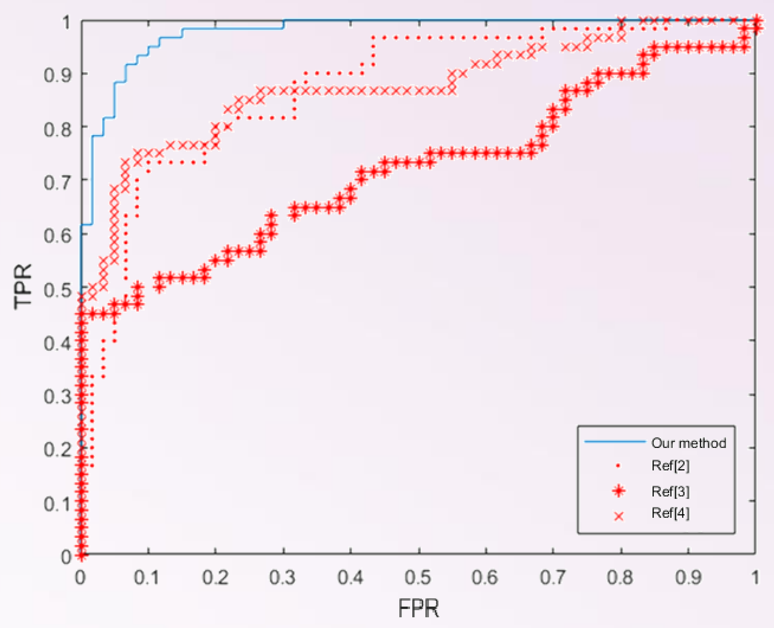
$L_1=6$
$D_1=7/6$
$L_2=2$
$D_2=2.5$

- Rate of R_D at certain distance d are estimated for genuine and forgery seal imprint which are denoted as $R_{p,G}$ and $R_{p,F}$,respectively.
  The rates are utilized to calculate the weighting parameter for R_D .
  Modified weighted-correlations[4] are obtained as feature.

$$S_1=\frac{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)D_i(x,y)}{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)} \qquad S_2=\sum_{i=1}^{K}D_i(x,y)*\log(L_i) \qquad S_3=\max(L_i)$$

$$S_4=\frac{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)*(1+d(x,y))^2}{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)} \qquad S_5=\frac{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)*R_{p,G}(x,y)}{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)} \qquad S_6=\frac{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)*\log(\frac{R_{p,F}(x,y)}{R_{p,G}(x,y)})}{\sum_{x=1}^{N}\sum_{y=1}^{M}R_D(x,y)}$$

Result



ROC curve for both the proposed method and existing methods

Reference

[1]X. Qi H. Lang, C. Xie and H. Ling, "Seal forgery detection by geometric consistency," Information: An International Interdisciplinary of Journal, 2012.
[2] T. Horiuchi, "Automatic seal verification by evaluating positive cost," in Document Analysis and Recognition, 2001. Proceedings. Sixth International Conference on. IEEE, 2001, pp. 572–576.
[3]Z. Hao and J. He, "Automatic seal imprint verification by quantifying edge difference," in Optoelectronic Imaging and Multimedia Technology. International Society for Optics and Photonics, 2010, vol. 7850, p. 78500D
[4]FAN, Ting-Jun; TSAI, Wen-Hsiang. Automatic Chinese seal identification. *Computer vision, graphics, and image processing*, 1984, 25.3: 311-330.