Automatic Recognition of Door Keys

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Overview

- Introduction
- Image Acquisition
- Image Enhancement
- Solutions
  - *Classification based on Moments*
  - *Correlation of the Chain Code*
  - *Image Correlation*
  - Conclusions

Introduction

- The goal of this project is to design an automatic door-key recognition system that recognizes a key model based on its image
- Knowledge base of the system is derived from key images in the manufacturer datasheet

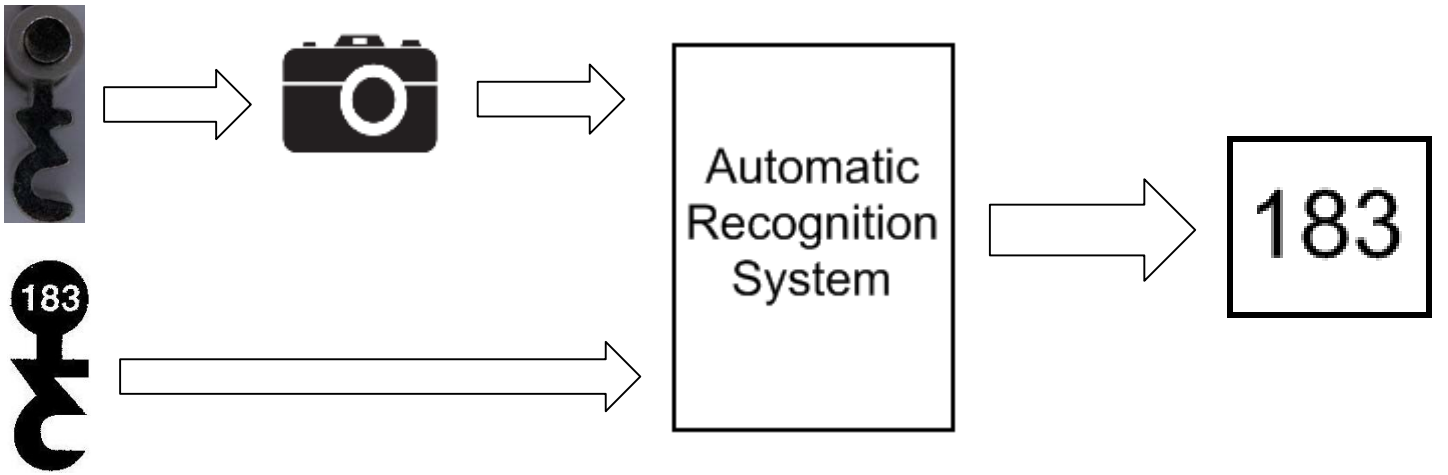
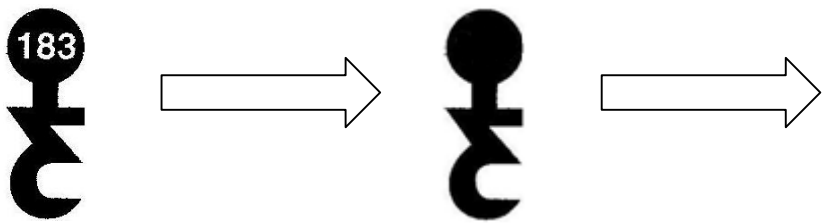


Image Acquisition (1)

- Train image was taken from the key manufacturer datasheet by simple document scanning
- Test images of the keys were taken using digital camera under LED ring light
- Both Train and Test images were preprocessed then classified in QuickCog



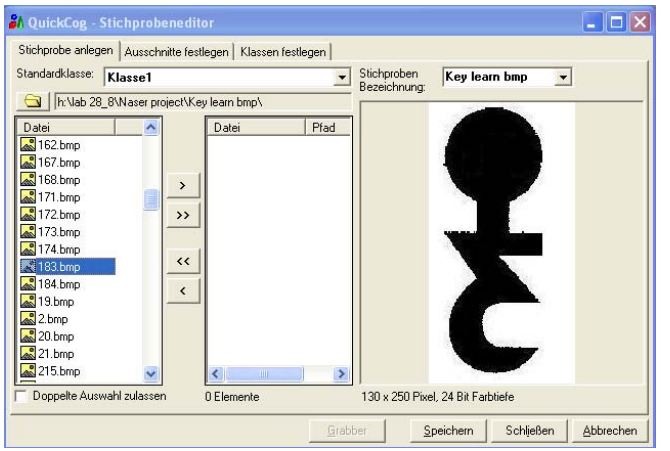
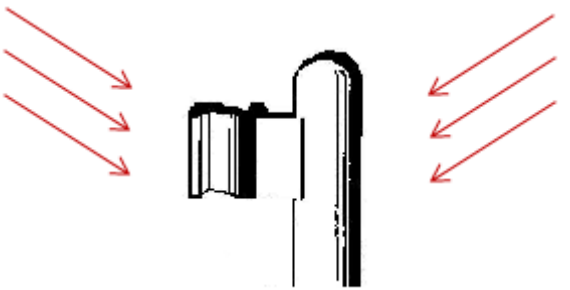


Image Acquisition (2)

- Using LED ring lightning applied as side lightning on the key helped to reduce shadows in the image and showed the key print more clearly as a darker area. On the contrary, using top lightning caused shadows around the key and produced a brighter areas in the key print that effect the quality of the binarized image later on

ref. www.gekkotechnology.com



LED side light

Top light

Image Enhancement and Reconstruction (1)

- The train image (containing 140 keys) was divided into separate images, one for each key. the white writing in the key was manually filled and the images were binarized under Matlab, labeled and saved in bitmap format

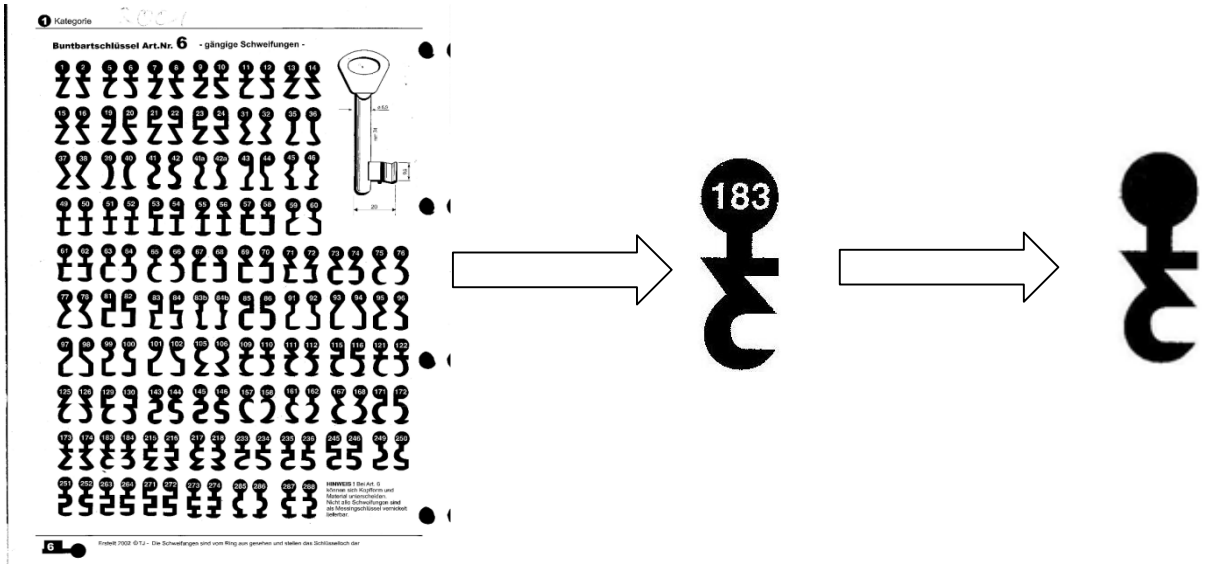
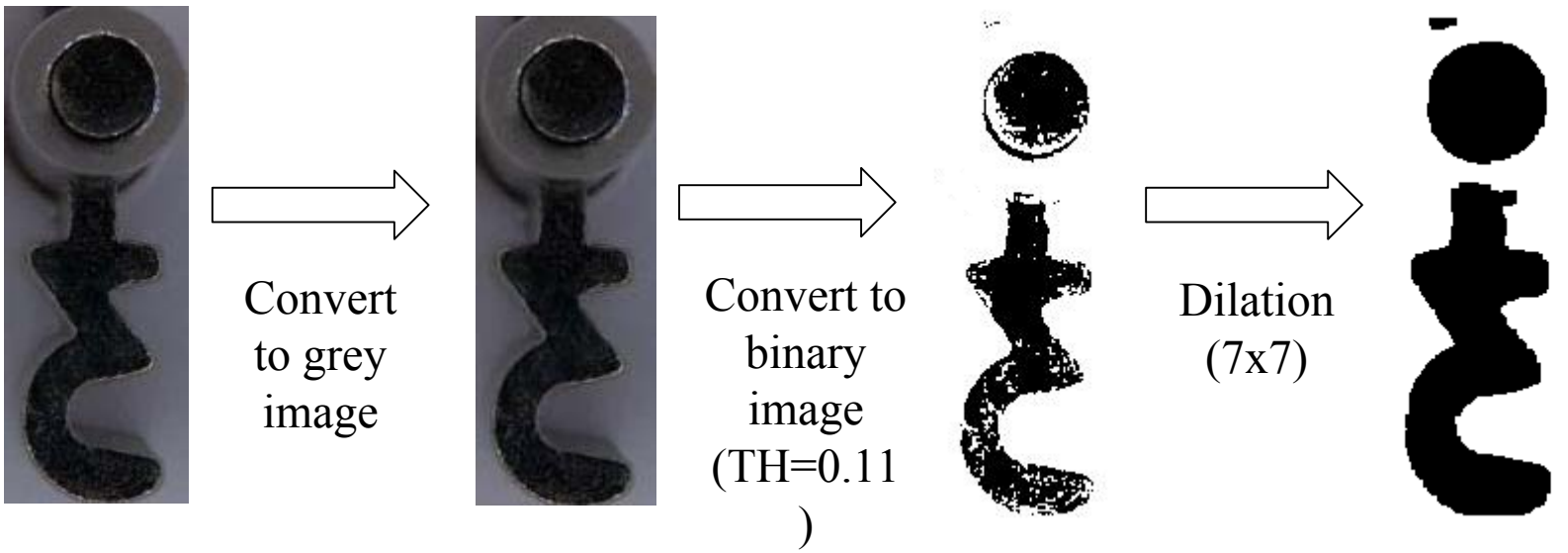


Image Enhancement and Reconstruction (2)

- The test images taken under LED ring light where manually resized then converted to grey image, binarized and reconstructed under Matlab



Solutions

1. Classification based on the Moments of the key image under QuickCog

2. Correlation of the Chain Code extracted from the key image edge under Matlab

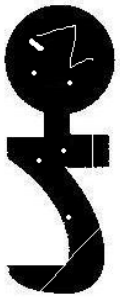
3. Image Correlation between the test key images and datasheet image under Matlab

Classification Based on Moments (1)

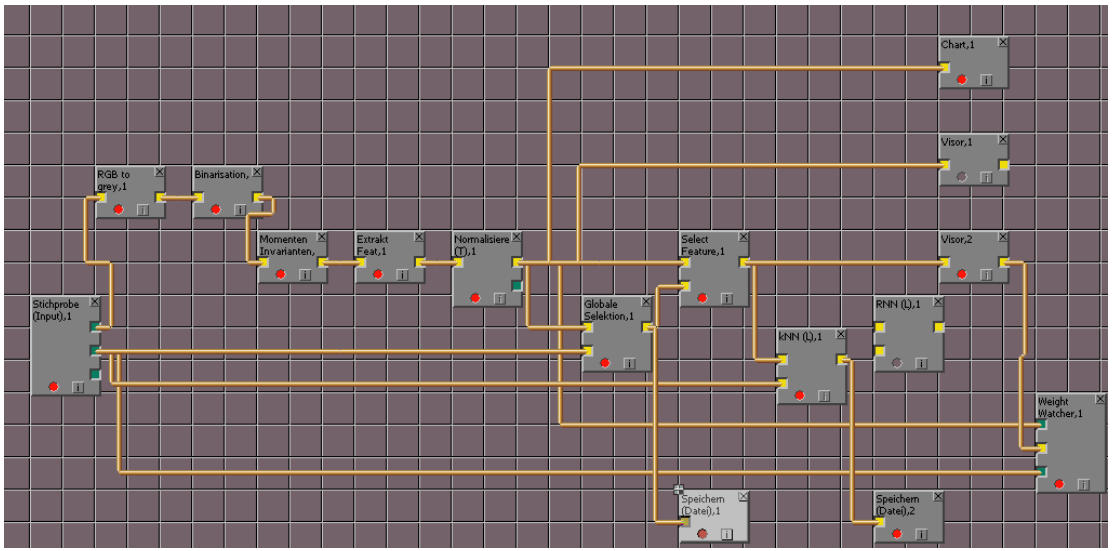
- Moments are a description of the image structure and intensity and can be modified to be translation, scale and rotation invariant

$$M_{ij} = \sum_x \sum_y x^i y^j I(x,y)$$

Classification Based on Moments (2)

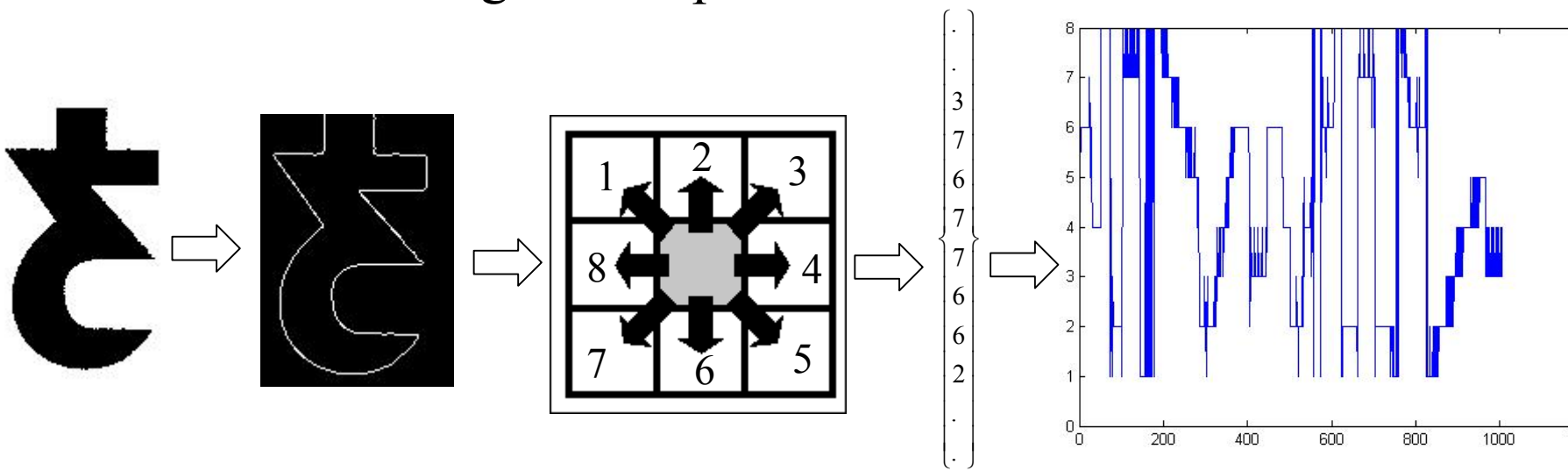


- Using the moments as a feature for classification gave poor results when tested with virtual test images and no correct results when tested with the real test images
- Problem in auto selection of features (global selection) with one image per class



Correlation of the Chain Code (1)

- Chain Code is a description of objects that assigns a position indicator to each edge pixel with respect to the previous edge pixel
- The edge of binary key images from train and test was extracted using Sobel operator under Matlab



Correlation of the Chain Code (2)

- Correlation was used to measure the degree of similarity between the Chain Codes of test and train

{ . . 4 5 5 5 3 3 5 6 7 7 6 6 . . . }

{ . . . 2 5 6 5 7 7 6 6 . . . } ⟹ Sum(dot product)

Max(Sum((C1-mean(C1)).(C2-mean(C2)))/sqrt(sum(C2-mean(C2))^2)

Chain Code Correlation

22.2167

23.5575

Indistinctive results

Image Correlation (1)

- Image Correlation was used to find the most similar part of the datasheet image to the test image

$$Correlation\,Coefficient = \frac{\sum_i \sum_j [F(x_i, x_j) - \overline{F}][G(x_i^*, x_j^*) - \overline{G})]}{\sqrt{\sum_i \sum_j [G(x_i^*, x_j^*) - \overline{G})]^2 [F(x_i^*, x_j^*) - \overline{F})]^2}} \qquad \in [0,1]$$

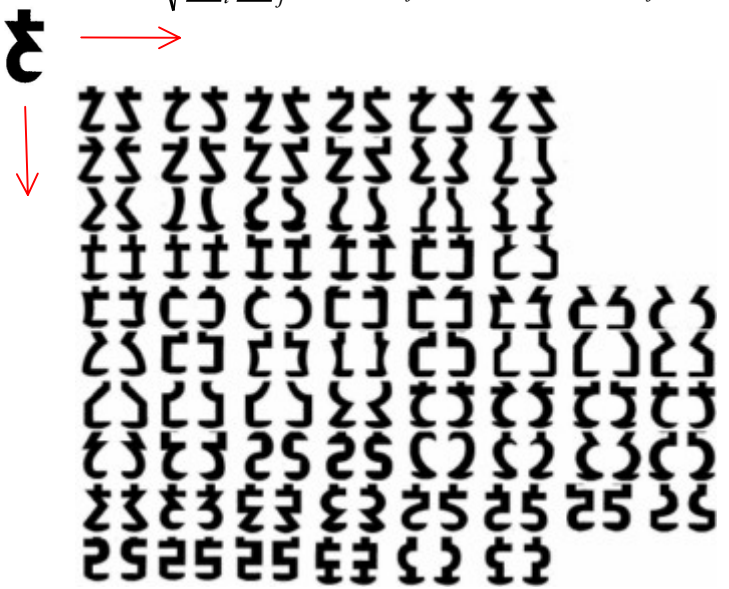


Image Correlation (2)

- The upper common round part of the keys was discarded to enhance discrimination between keys and both train and test images are downsized to optimize execution time (execution time down to 2 sec)
- A black rectangle representing the highest match area is drawn in the train key set image and around the corresponding model number in a similar set of model numbers

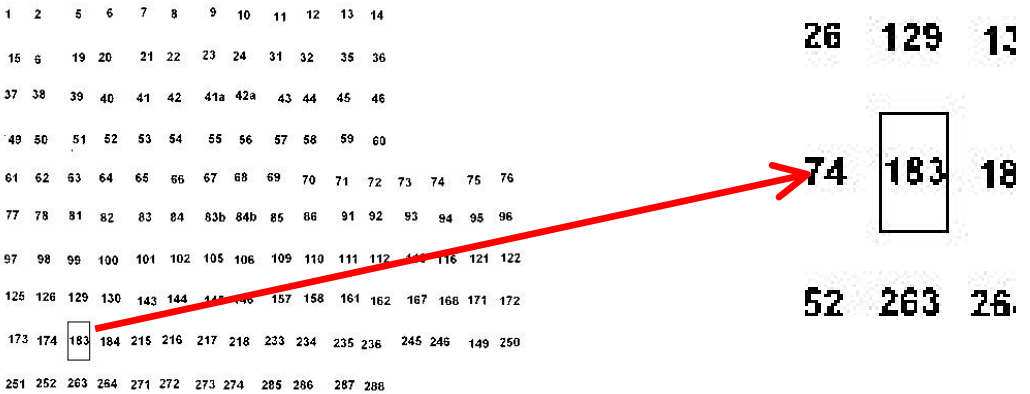
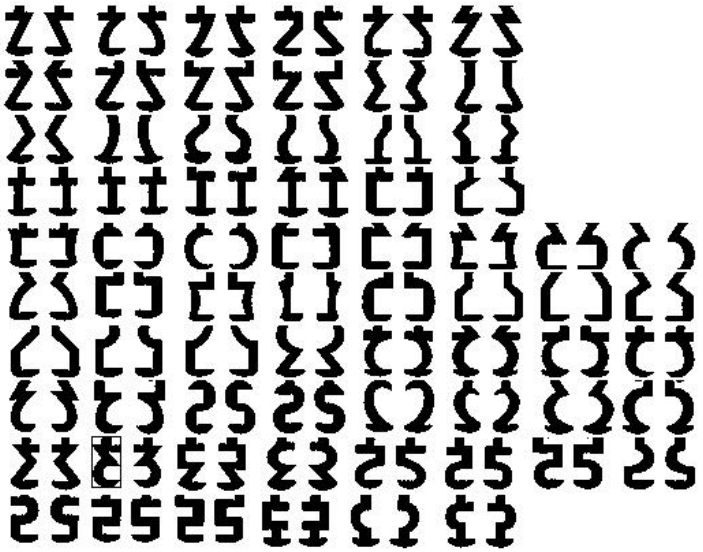
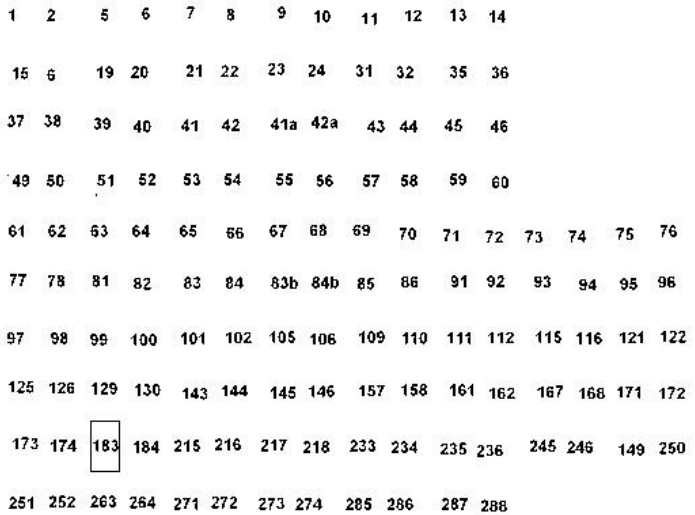
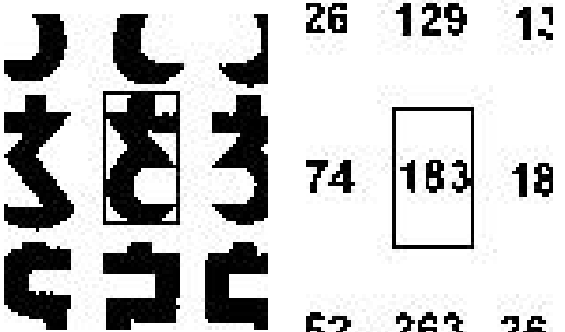


Image Correlation Results (1)

Key number 183





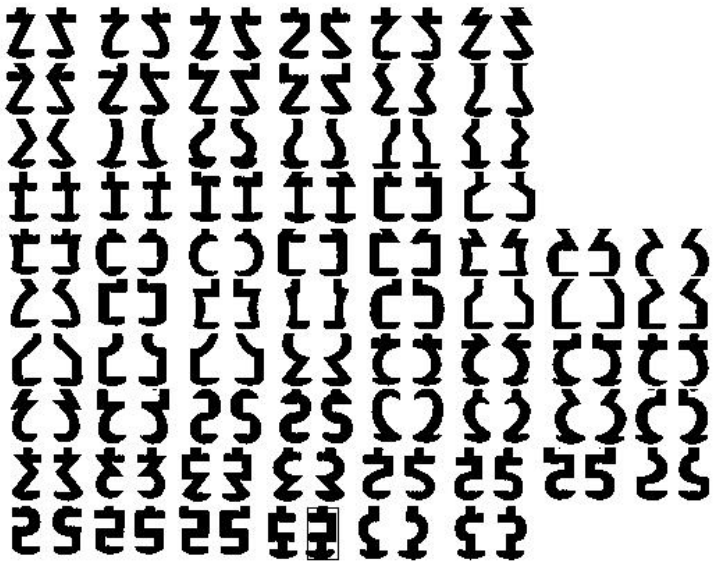


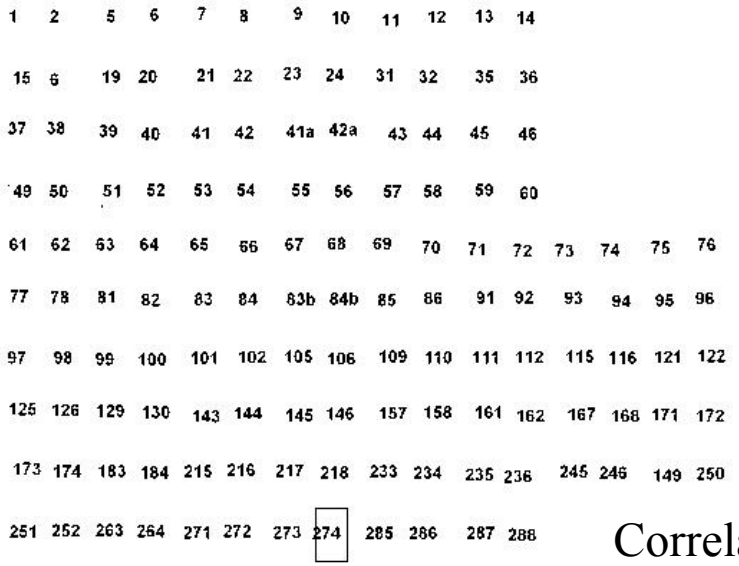
Correlation Coefficient: 0.7688

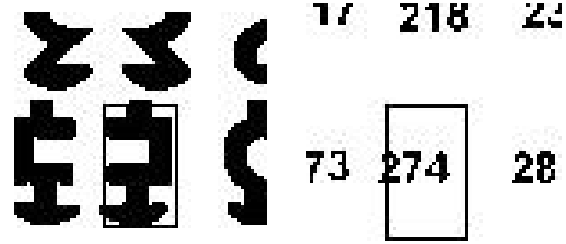
Second highest Corr. Coeff.: 0.7188

Image Correlation Results (2)

Key number 274







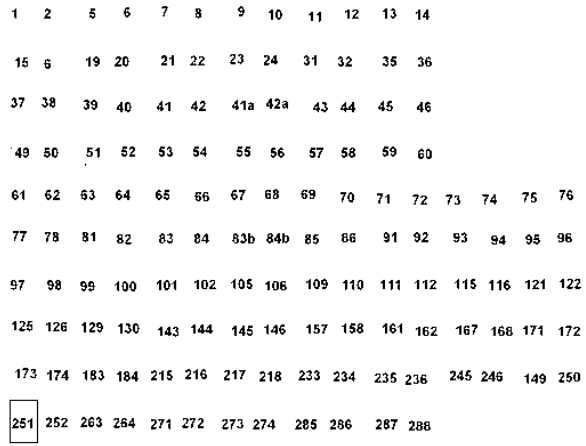
Correlation Coefficient: 0.7570

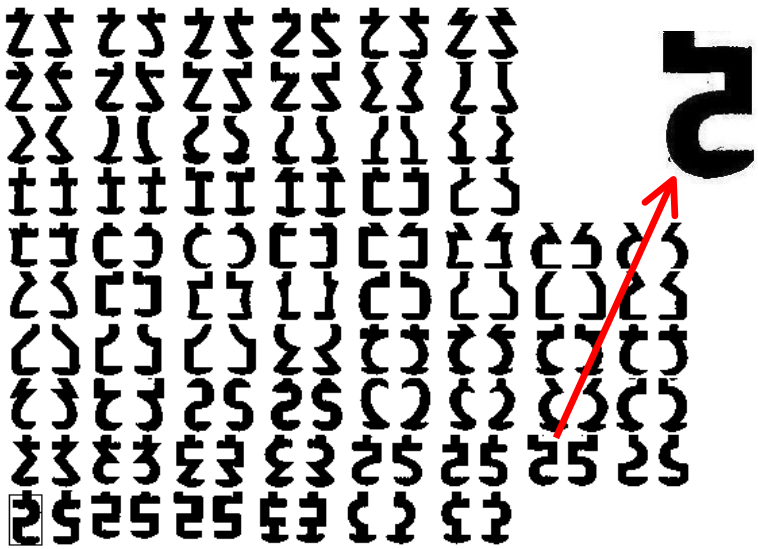
Second highest Corr. Coeff.: 0.7400

Image Correlation Results (3)

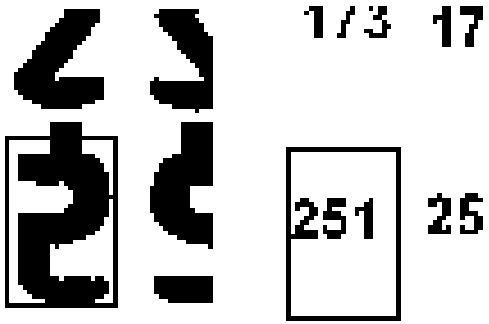
Strange Key(not included)

System Message:
"Correlation Coefficient is low, this solution is rejected"





Visually most similar key print achieved a Corr. Coeff. of 0.6140



Correlation Coefficient: 0.7253

Second highest Corr. Coeff.: 0.6850

Conclusion

- The solution using image correlation gave correct results for 2 of the 3 test keys (only 3 keys where available for testing). It should be noted however that the wrongly classified key is not included in the search data and the rejection of the result was pointed out in a system warning message
- In the case of having test data which is different in nature from train data, one must try to enhance both toward a common similar nature
- Image Acquisition conditions may have a major effect later in the classification procedure

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Thank You