Palmprint Recognition with Three Dimensional Features

Thesis Defense
M.Sc. in Software Technology

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Acknowledgement

- David Zhang
- Lei Zhang
- Wei Li

Why?

What?

How?

Why?

Motivation

personal authentication

Motivation

personal authentication

- password
  - most used
  - but most easily subverted

Motivation

personal authentication

- smartcard
  - more secure
  - but will you carry dozens of smartcards with you everyday?

Motivation

personal authentication

- biometrics
  - fingerprint, palmprint, iris, face, voice
  - code complex enough
  - high availability

Motivation

personal authentication

- palmprint
  - texture
  - geometry

Motivation

personal authentication

- palmprint
  - texture - almost fully explored
  - geometry - **not yet**

What?

Verification & Recognition

based on palmprint captures

Research Questions

- How much information lies the palmprint geometry?
- How to take advantage of the additional information?

Literature Review

- 2D techniques achieved high accuracy

Adams Kong, David Zhang, and Mohamed Kamel. A survey of palmprint recognition. Pattern Recognition, 42(7):1408–1418, July 2009.

Literature Review

- 3D devices are available

D Zhang, Guangming Lu, Wei Li, Lei Zhang, and Nan Luo. Three Dimensional Palmprint Recognition using Structured Light Imaging. In Biometrics: Theory, Applications and Systems, 2008. BTAS 2008. 2nd IEEE International Conference on, pages 1–6, 2008.

Literature Review

- Texture-based methods on 3D data
  - Mean Curvature Image
  - Gaussian Curvature Image

D Zhang, Guangming Lu, Wei Li, Lei Zhang, and Nan Luo. Palmprint Recognition Using 3-D Information. Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, 39(5):505–519, 2009.

Literature Review

- Geometry-based methods on 3D data
  - Surface Type

D Zhang, Guangming Lu, Wei Li, Lei Zhang, and Nan Luo. Palmprint Recognition Using 3-D Information. Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, 39(5):505–519, 2009.

Literature Review

- Fusion of texture and geometry features

W. Li, D Zhang, L. Zhang, G. Lu, and J. Yan. 3-D palmprint recognition with joint line and orientation features. Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, (99):1–6, 2011.

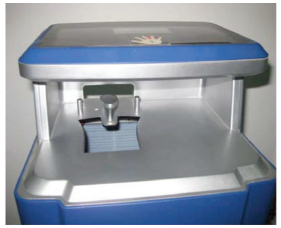
How?

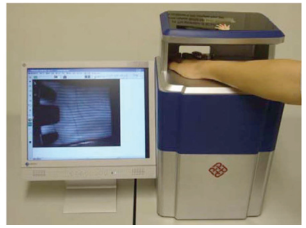
Method

- Data collection (regards to Wei Li)
- Data processing
- Recognition system

Data Collection

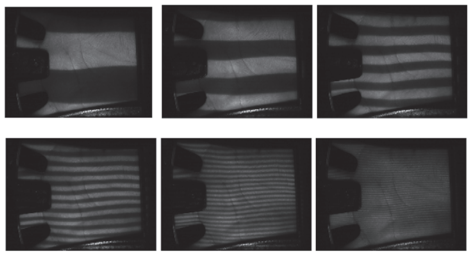
- Structural Light Imaging





Data Collection

- Structural Light Imaging



A Sample

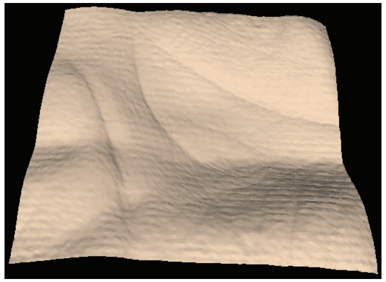
- 768x576
  single precision float depth matrix

Data Processing

- ROI extraction
- Feature extraction
- Dimension reduction
- Feature matching

Region of Interest

- 400x400, down-sample to 200x200



Noise Cancellation

- Gradient Threshold

$$|\nabla D| = \sqrt{\left(\frac{\partial D}{\partial x}\right)^2 + \left(\frac{\partial D}{\partial y}\right)^2}$$

Feature Extraction

- Maximum Depth
- Horizontal Cross-section Area
- Radial Line Length

Maximum Depth

- Depth from a <u>reference plane</u> to the <u>deepest point</u>

Maximum Depth

- Reference plane

$$d_r = \frac{1}{\sum_{i=R_s}^{R_e} \sum_{j=C_s}^{C_e} m_{ij}} \sum_{i=R_s}^{R_e} \sum_{j=C_s}^{C_e} (d_{ij})$$

Maximum Depth

- Deepest point

$$d_{max} = \max_{i=R_s}^{R_e}(\max_{j=C_s}^{C_e}(d_{ij}))$$

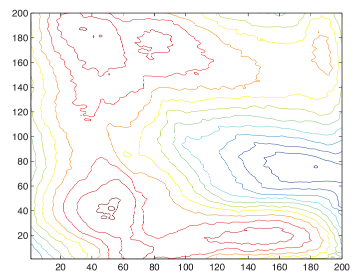
Maximum Depth

- Maximum Depth (MD)

$$MD = d_{max} - d_r$$

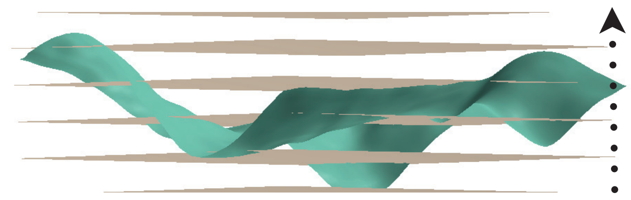
Horizontal Cross-section Area

- Contour view



Horizontal Cross-section Area

- Cut the ROI



Horizontal Cross-section Area

- Group pixels to N levels

$$G_{ij}^k = \begin{cases} 1 & \text{if } d_{ij} > h \cdot (N-k+1)/N, \\ 0 & \text{otherwise} \end{cases}$$

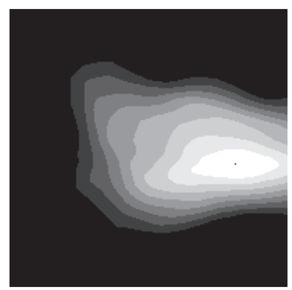
$$k = 1, 2, \ldots, N; i = 1, 2, \ldots, 200; j = 1, 2, \ldots, 200;$$

Horizontal Cross-section Area

- Stabilization: grow while connected

$$L^k = \begin{cases} G^1 & k = 1 \\ G^k \cap (L^{k-1} \oplus \Theta^{k-1}) & k = 2, 3, \ldots, N \end{cases}$$

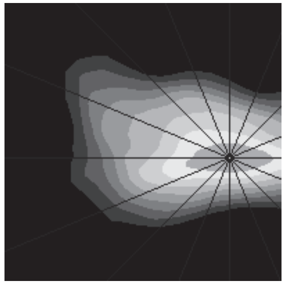
Horizontal Cross-section Area



Radial Line Length

- Finer description of the shape of HCA at each level
- Using the length of M line segments

Radial Line Length



Combined Feature Vector

- F consists of MD+HCA+RLL
  - F has 1+N+NxM dimensions

Dimension Reduction

- Project F to a lower dimensional space
- Preserve as much information as possible

$$\tilde{F} = W^T F$$

Dimension Reduction

- Orthogonal Linear Discriminant Analysis

JP Ye. Characterization of a family of algorithms for generalized discriminant analysis on undersampled problems. Journal of Machine Learning Research, 6:483–502, 2005.

Feature Matching

- Coarse-level matching

$$Similarity = \|\tilde{F}_1 - \tilde{F}_2\| = \sum_{i=1}^{\Gamma} (f_i^1 - f_i^2)^2$$

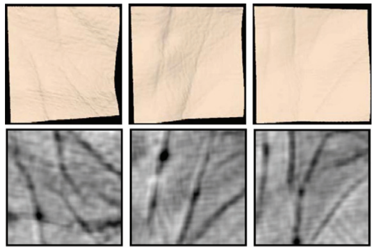
Improved Matching

- Ranking Support Vector Machine

Thorsten Joachims. Optimizing search engines using clickthrough data. In KDD '02: Proceedings of the eighth ACM SIGKDD international conference on Knowledge discovery and data mining. ACM Request Permissions, July 2002.

Fine-matching Feature

- Mean Curvature Image



Experiment

- 8000 samples
  - 4000 for training
  - 4000 for testing
- Matlab

Optimizing Parameters

- Recall that we have a feature vector of 1+N+NxM dimensions
- And we want to reduce the dimension to Γ

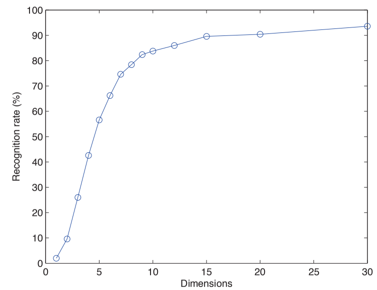
Optimizing Parameters

- Choosing N and M (by EER)

	M=8	M=16	M=32	M=64
N=4	14.3	19.15	14.35	14.07
N=8	14.2	16.3	**12.32**	12.54
N=16	18.11	18.35	15.21	14.11

Optimizing Parameters

- Choosing Γ



Performance Metrics

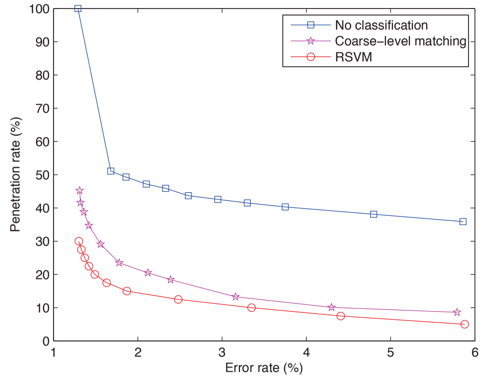
- Error rate

$$\text{error rate} = \frac{\text{number of false match}}{\text{total number of probe}} \times 100\%$$

- Penetration rate

$$\text{penetration rate} = \frac{\text{number of accessed template}}{\text{total number of template in the database}} \times 100\%$$

Performance Results



Speed

MCI only

Process	Time (ms)
Feature extraction	112
Dimension reduction	0
Preprocess	0
MCI matching	0.86
Total (for one probe)	456

Speed

with Coarse-level matching

Process	Time (ms)
Feature extraction	136
Dimension reduction	0.1
Preprocess	0.5
MCI matching	0.86
Total (for one probe)	**292.09**

1.56X

Speed

with RSVM

Process	Time (ms)
Feature extraction	136
Dimension reduction	0.1
Preprocess	1.56
MCI matching	0.86
Total (for one probe)	**240.86**

1.9X

Discussion

Conclusions

- Geometric features extracted
- Matching process improved

Limitations

- 3D devices are *lower* in resolution (compared to 2D ones)
  - possible, but not as cost effective

Limitations

- 3D depth values are more susceptible to movement than 2D textures
  - less stable
  - or less user-friendly

Limitations

- General biometrics authentication limitations

Future work

- Try different ROI
- Find geometric features with lower error rate
- Anti-counterfeiting considerations

Thank you.