# 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.

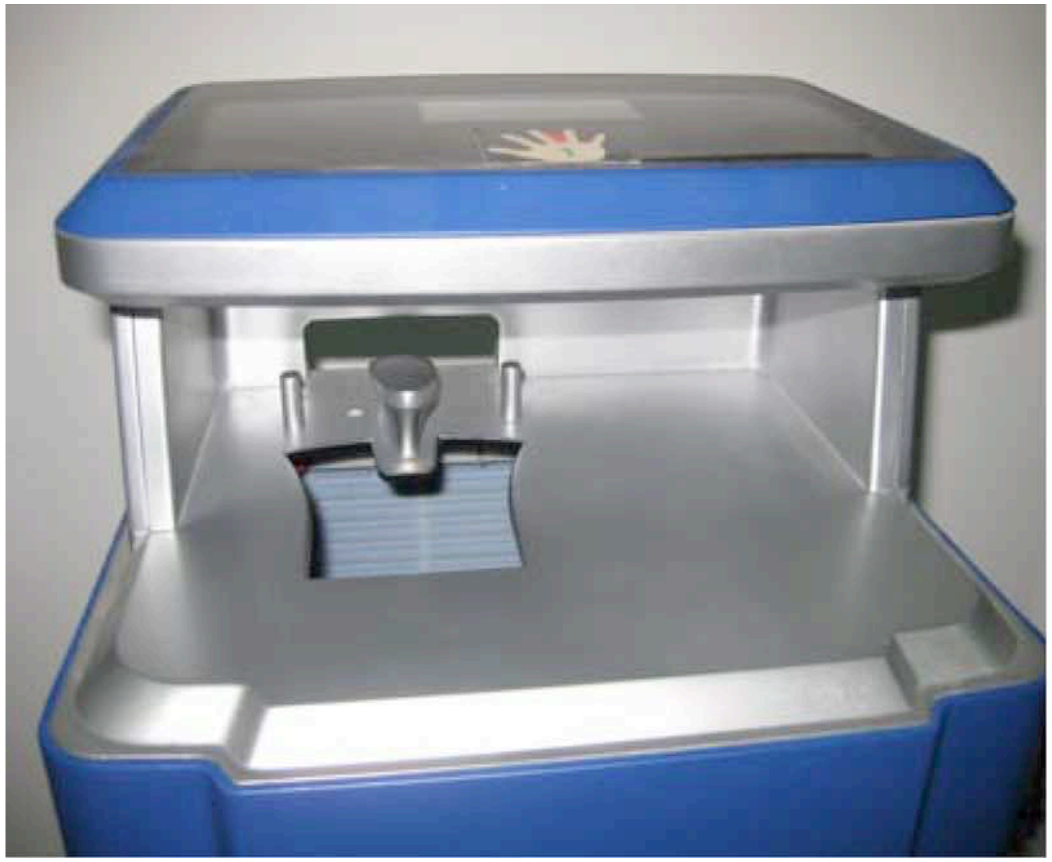
# How?

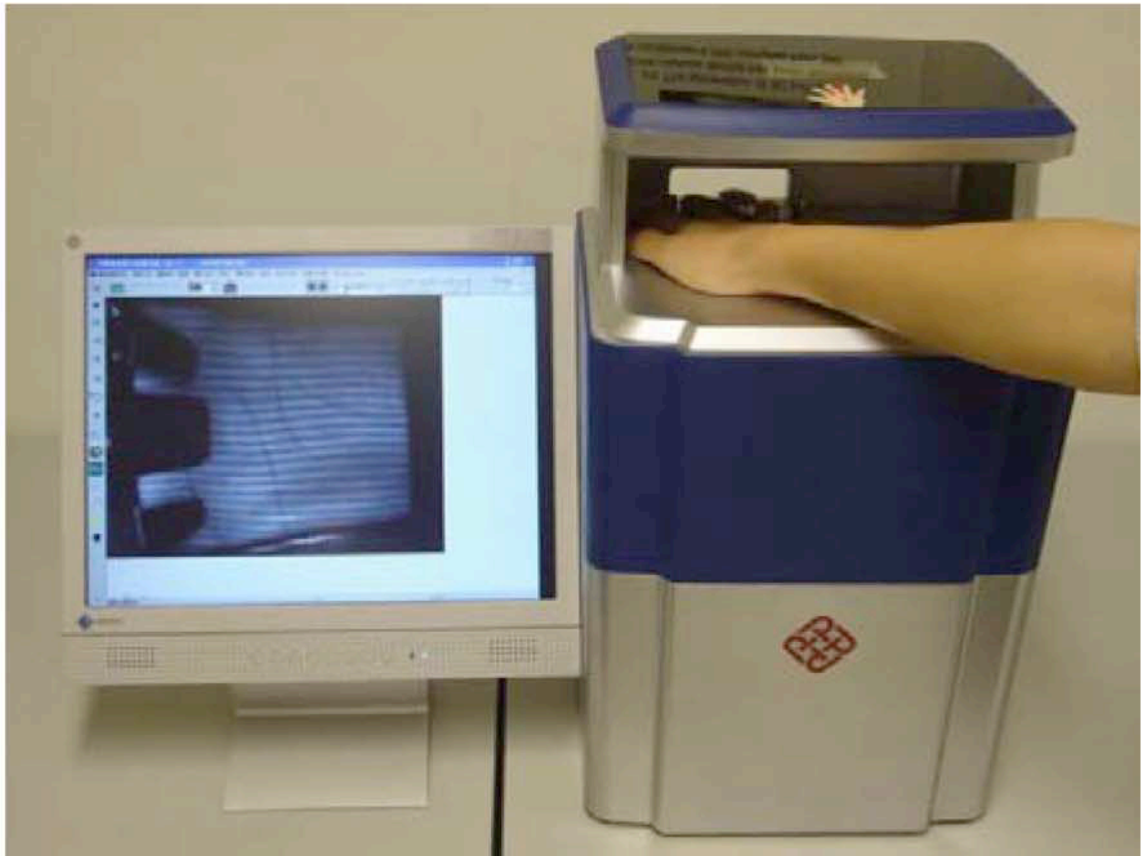
# Method

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

# Data Collection

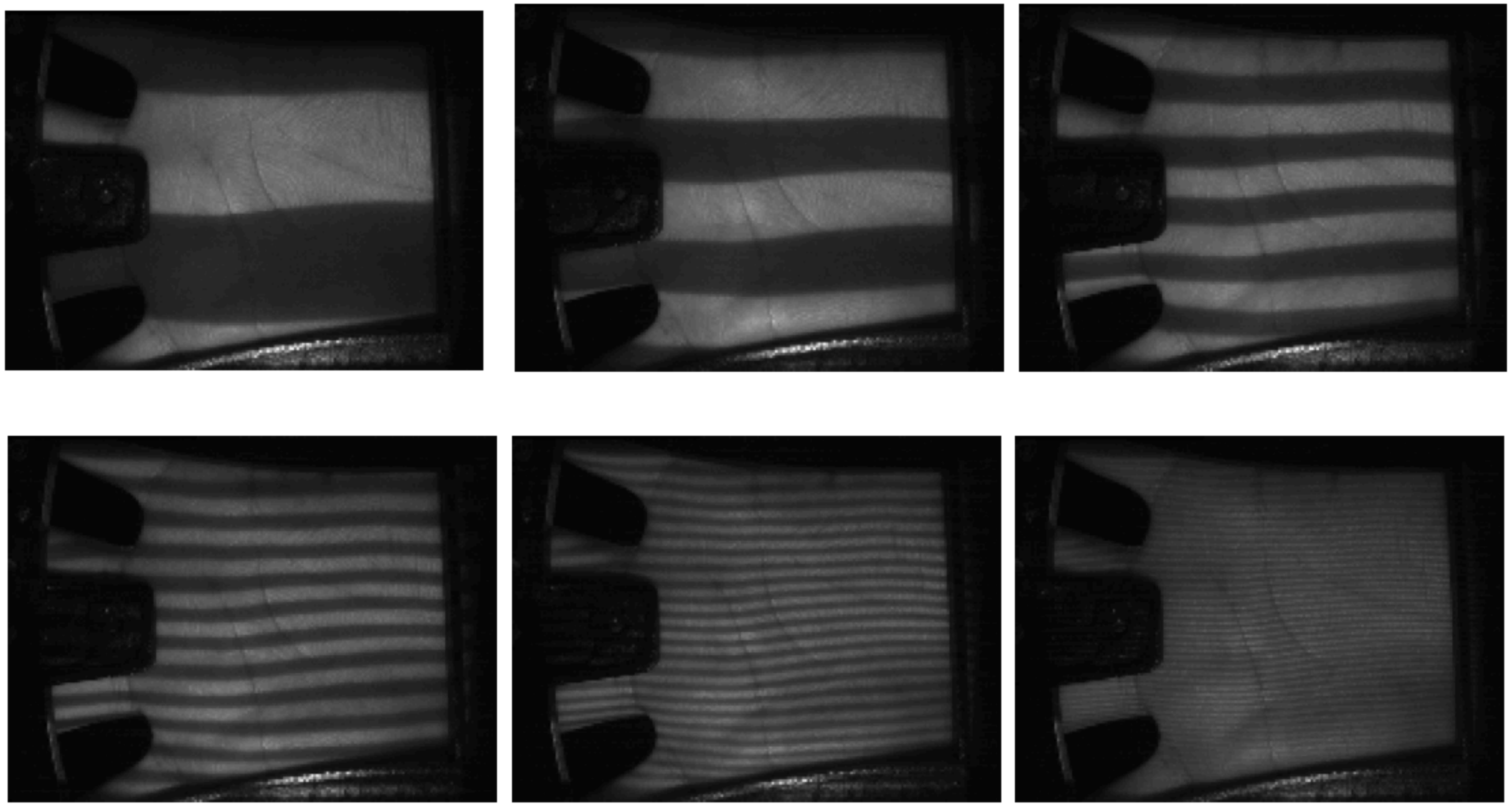
- Structural Light Imaging





# Data Collection

- Structural Light Imaging



# A Sample

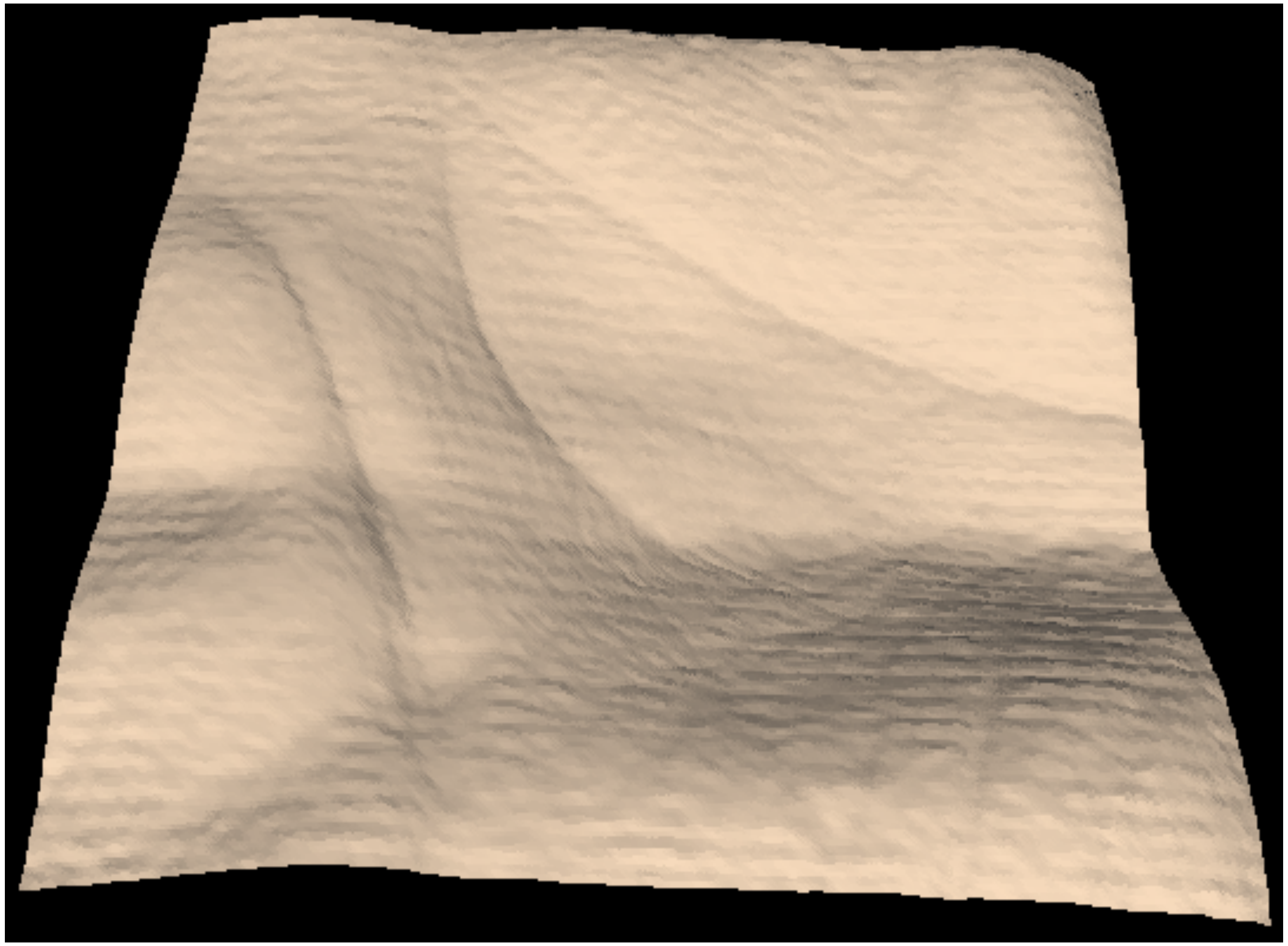
- 768x576
  single precision float depth matrix

# 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 **reference plane** to the **deepest point**

# 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

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

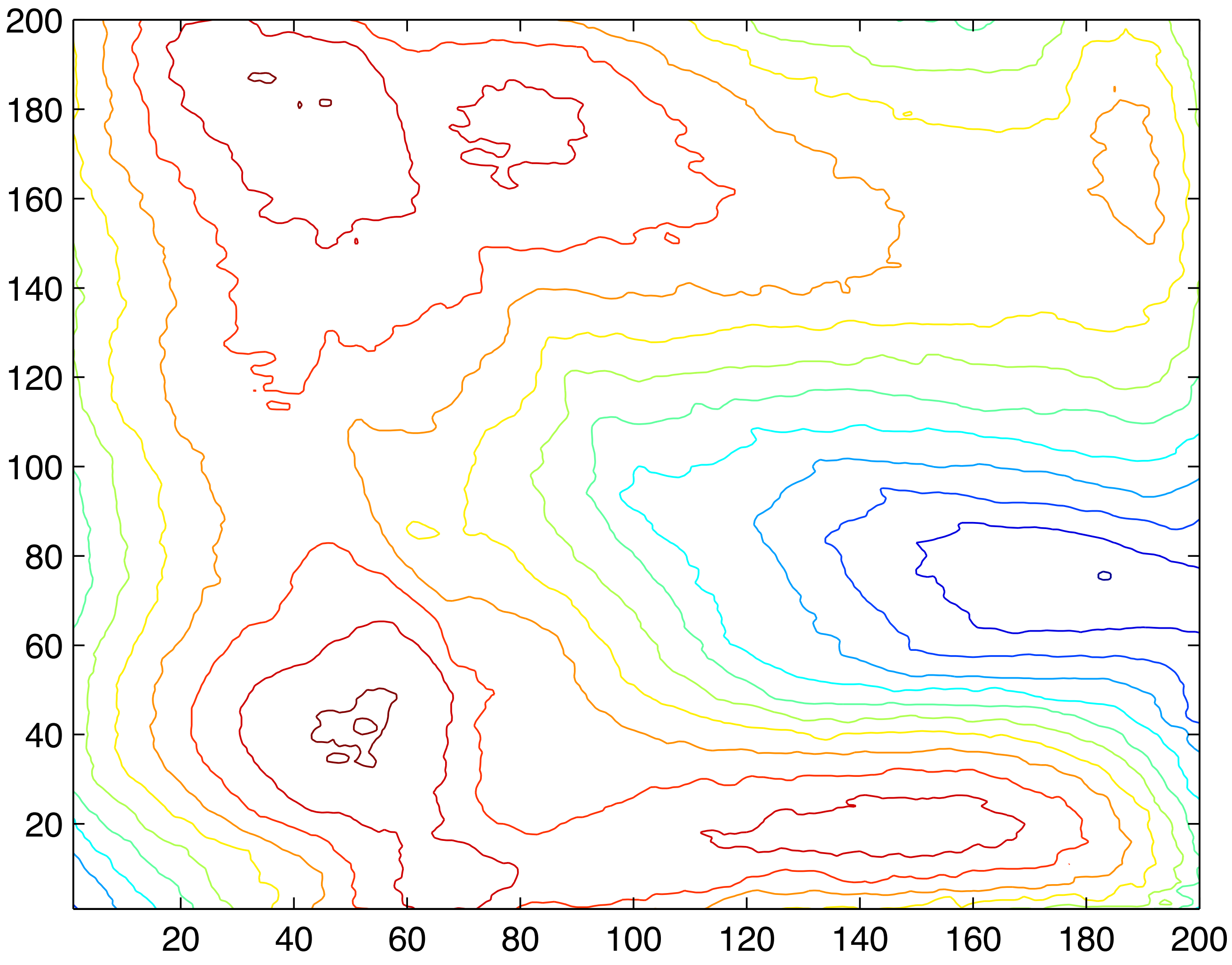
# Maximum Depth

- Maximum Depth (MD)

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

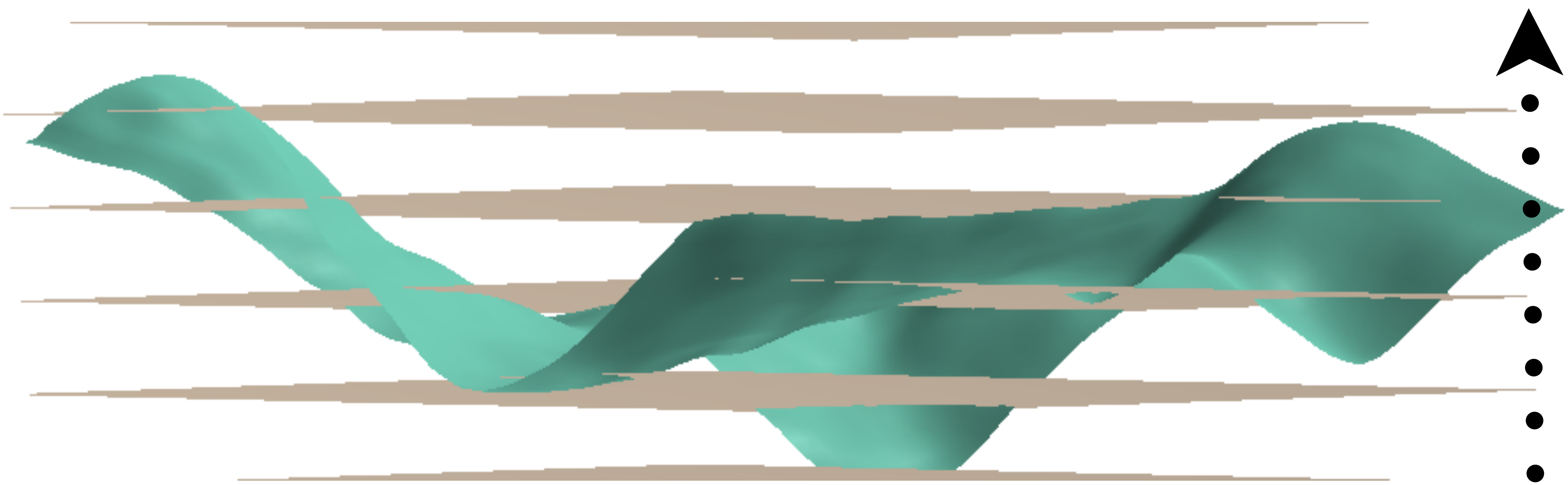
# Horizontal Cross-section Area

- Contour view



# Horizontal Cross-section Area

- Cut the ROI



# Horizontal Cross-section Area

- Group pixels to N levels

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

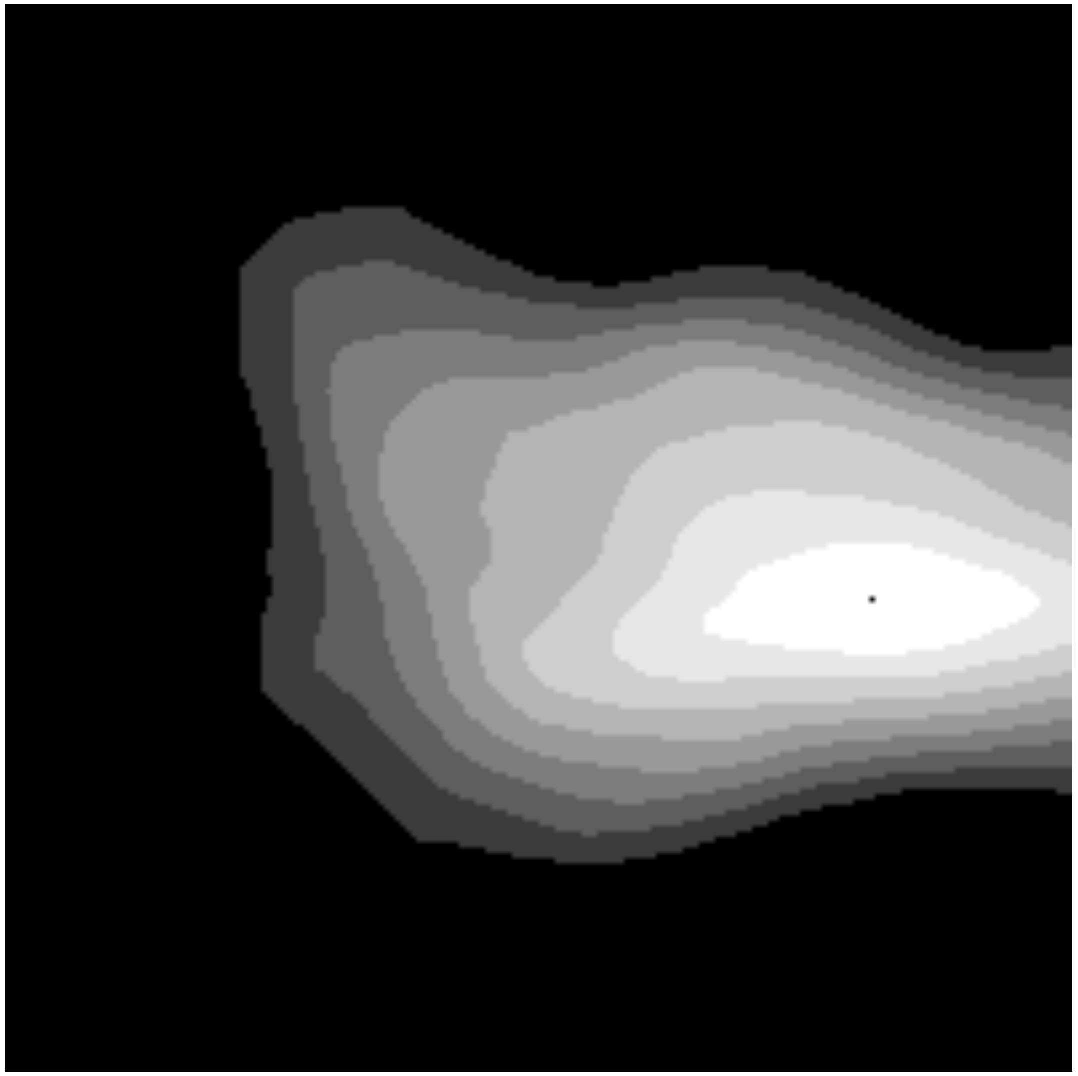
$$k = 1, 2, \ldots, N; i = 1, 2, \ldots, 200; j = 1, 2, \ldots, 200;$$

# Horizontal Cross-section Area

- Stabilization: grow while connected

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

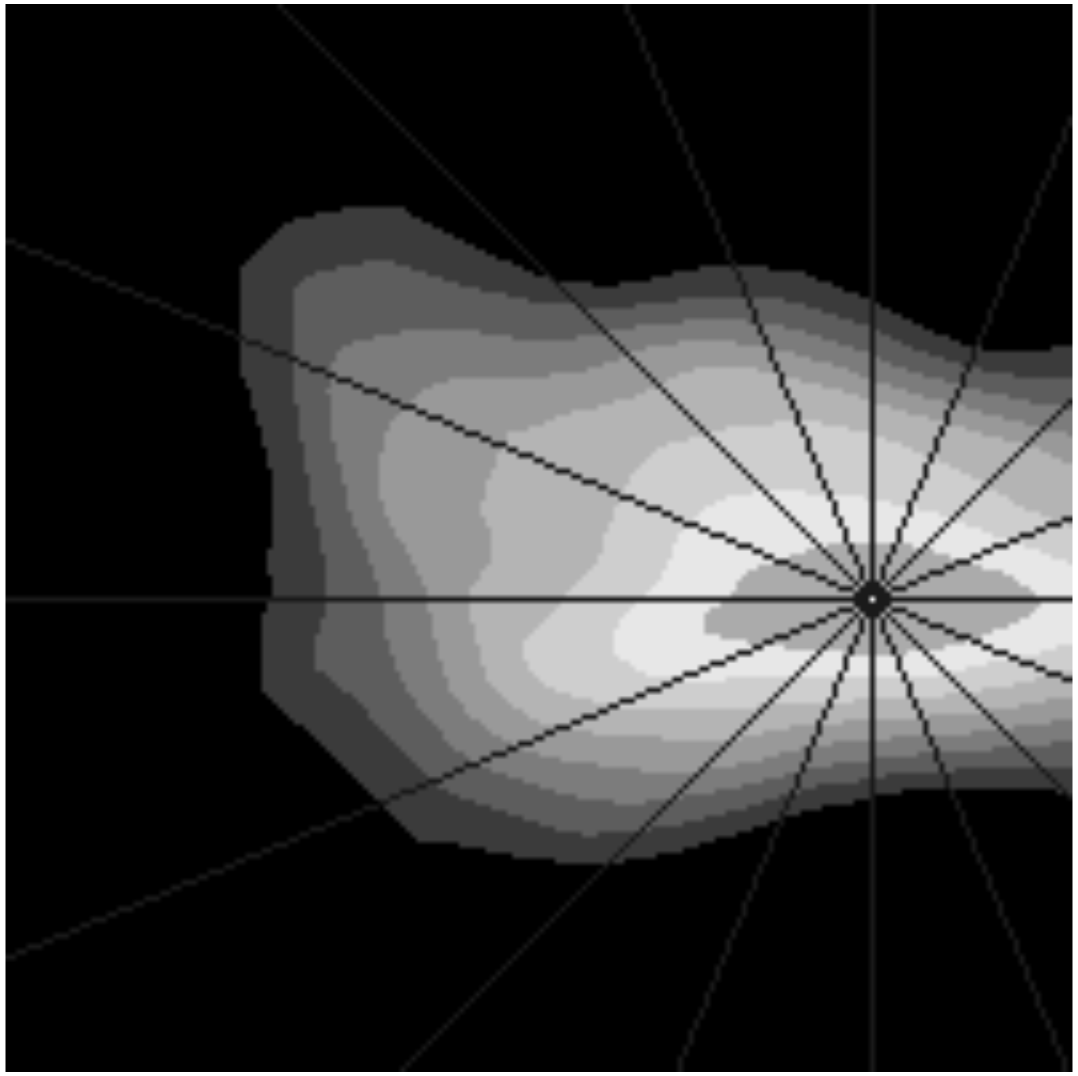
# Horizontal Cross-section Area



# 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

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

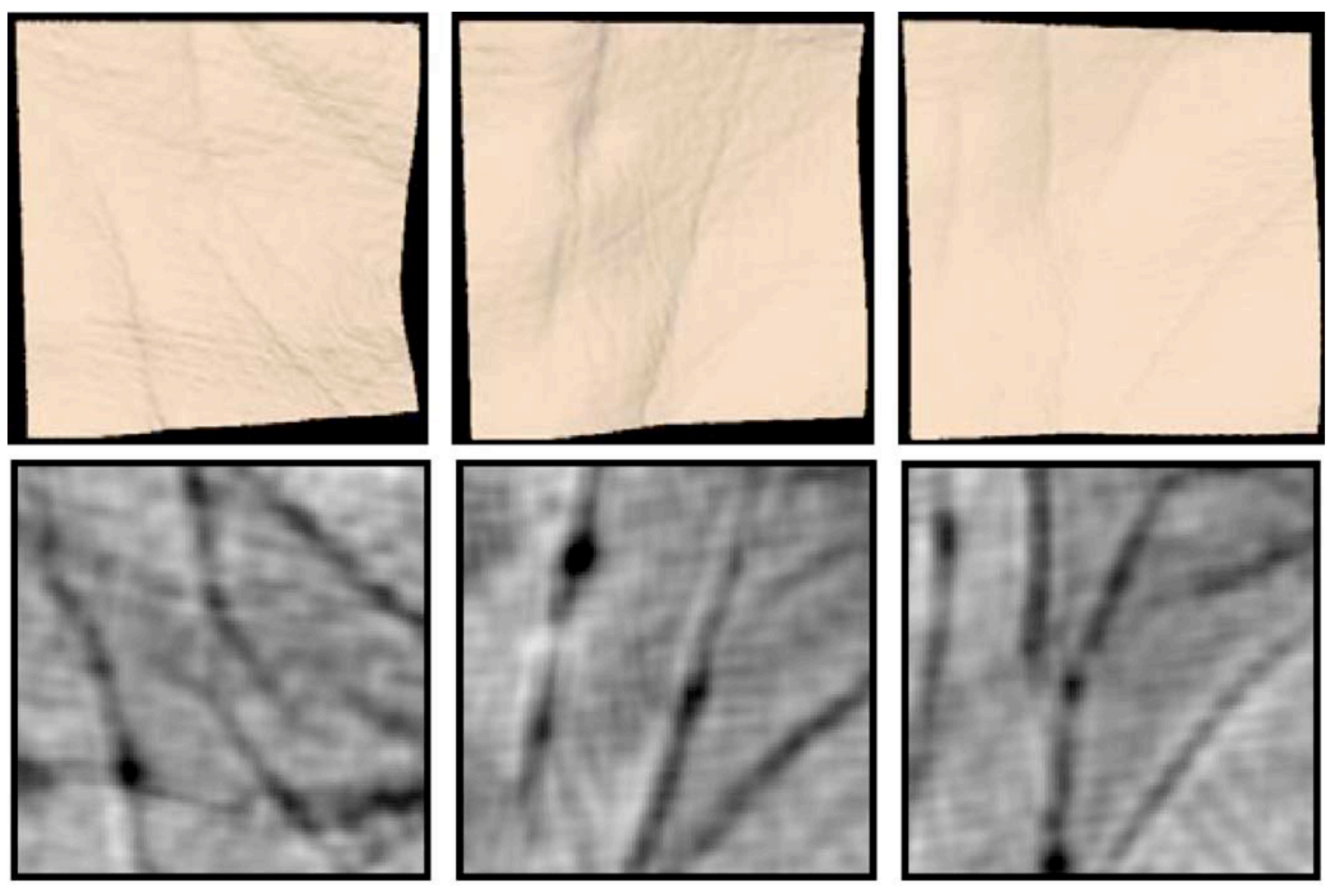
# Improved Matching

- 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 $\mathbf{\Gamma}$

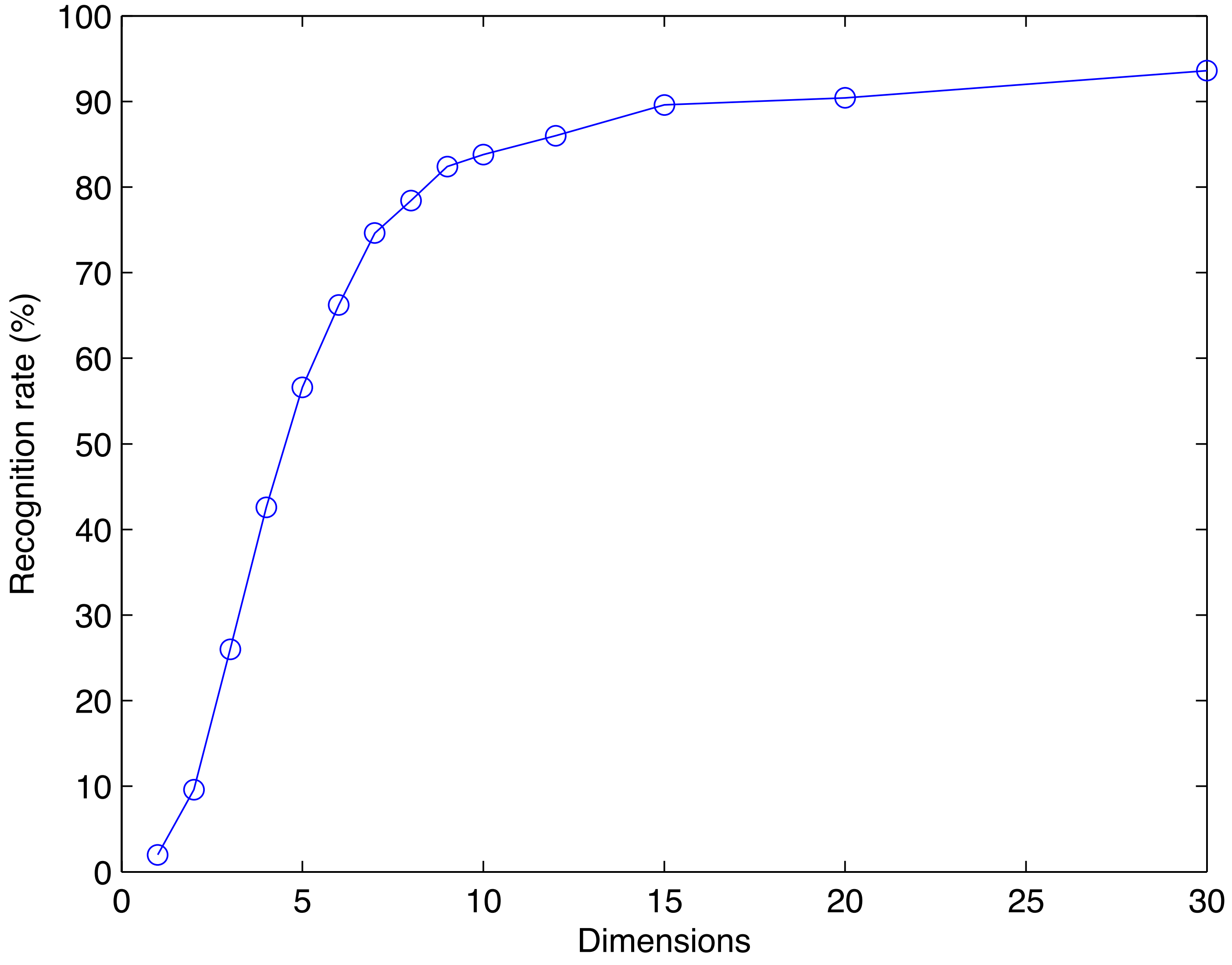
# Optimizing Parameters

- 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 $\boldsymbol{\Gamma}$



# Performance Metrics

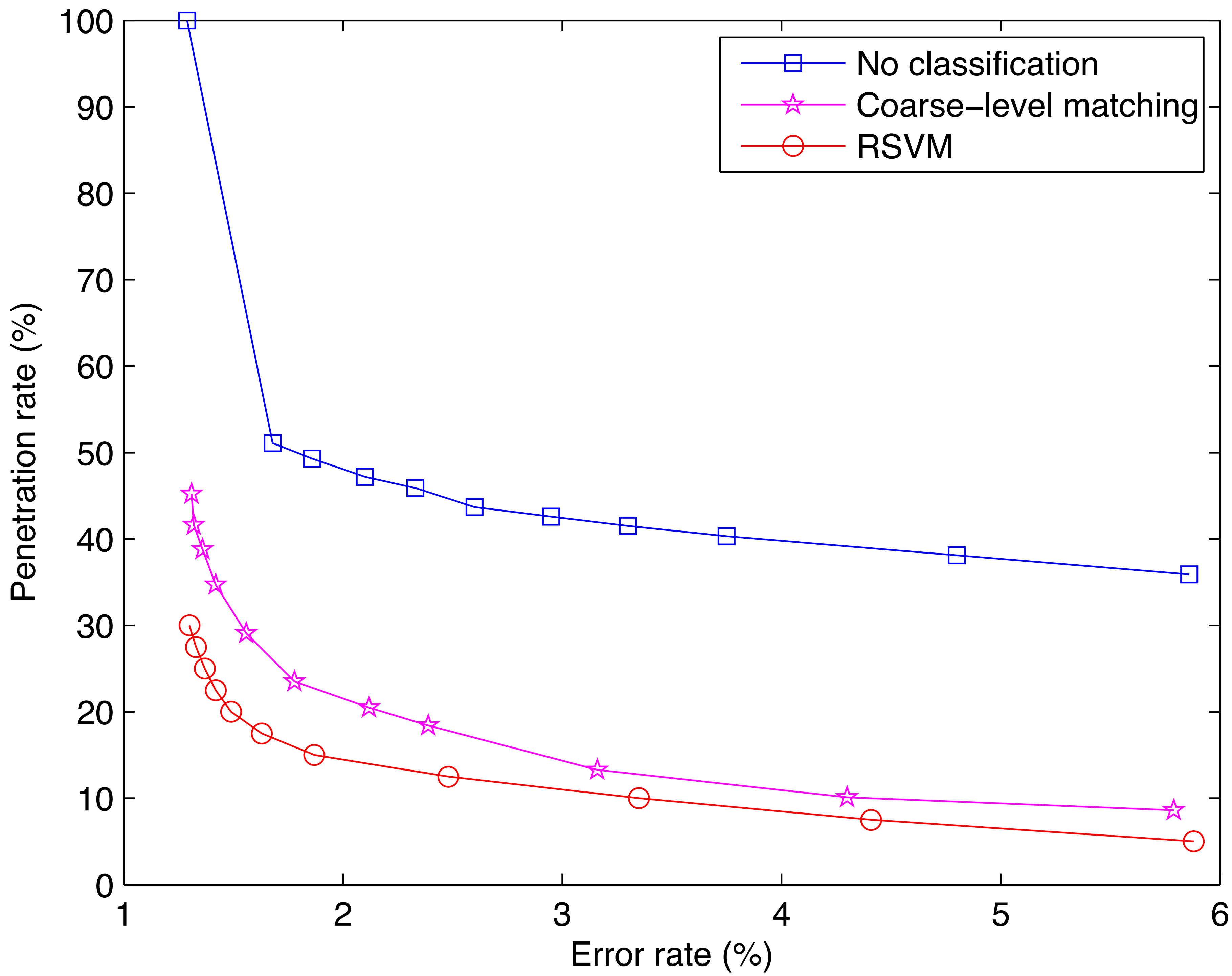
- Error rate

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

- 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.**

# Q&A