# Clustering Algorithms for Face Recognition Based on Client-Server Architecture



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# Abstract

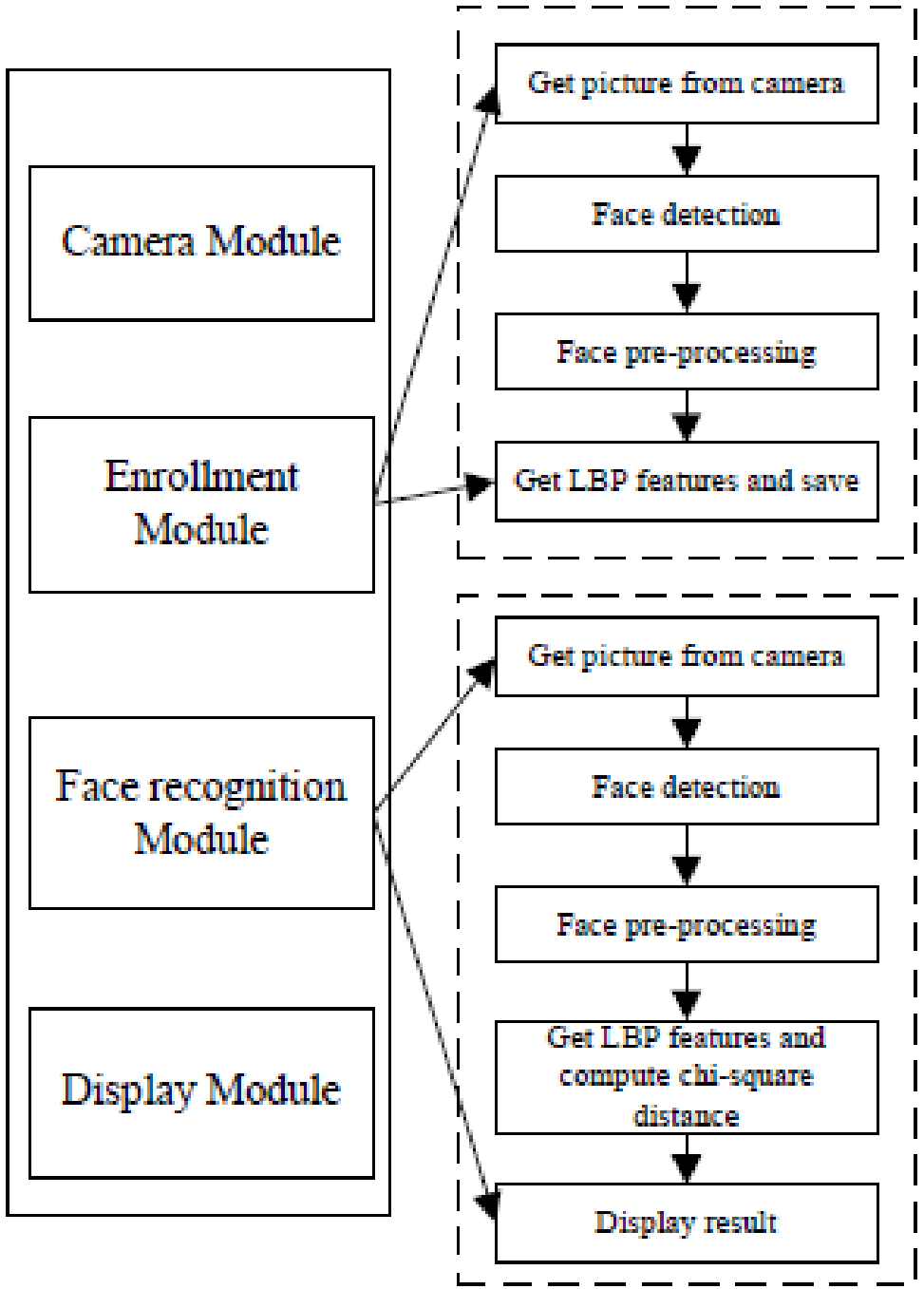
- Mobile devices
- Biometric methods
- Computer performance
- Client server application
- Clustering algorithms

# Introduction

- Client-server application
  - Advantages:
    - Performance
    - Storage
  - Disadvantages:
    - Amount of transmitted data
    - Transfer speed
  - Solution:
    - Preprocessing
    - Feature extraction
    - Clustering algorithms

# State-of-the-art

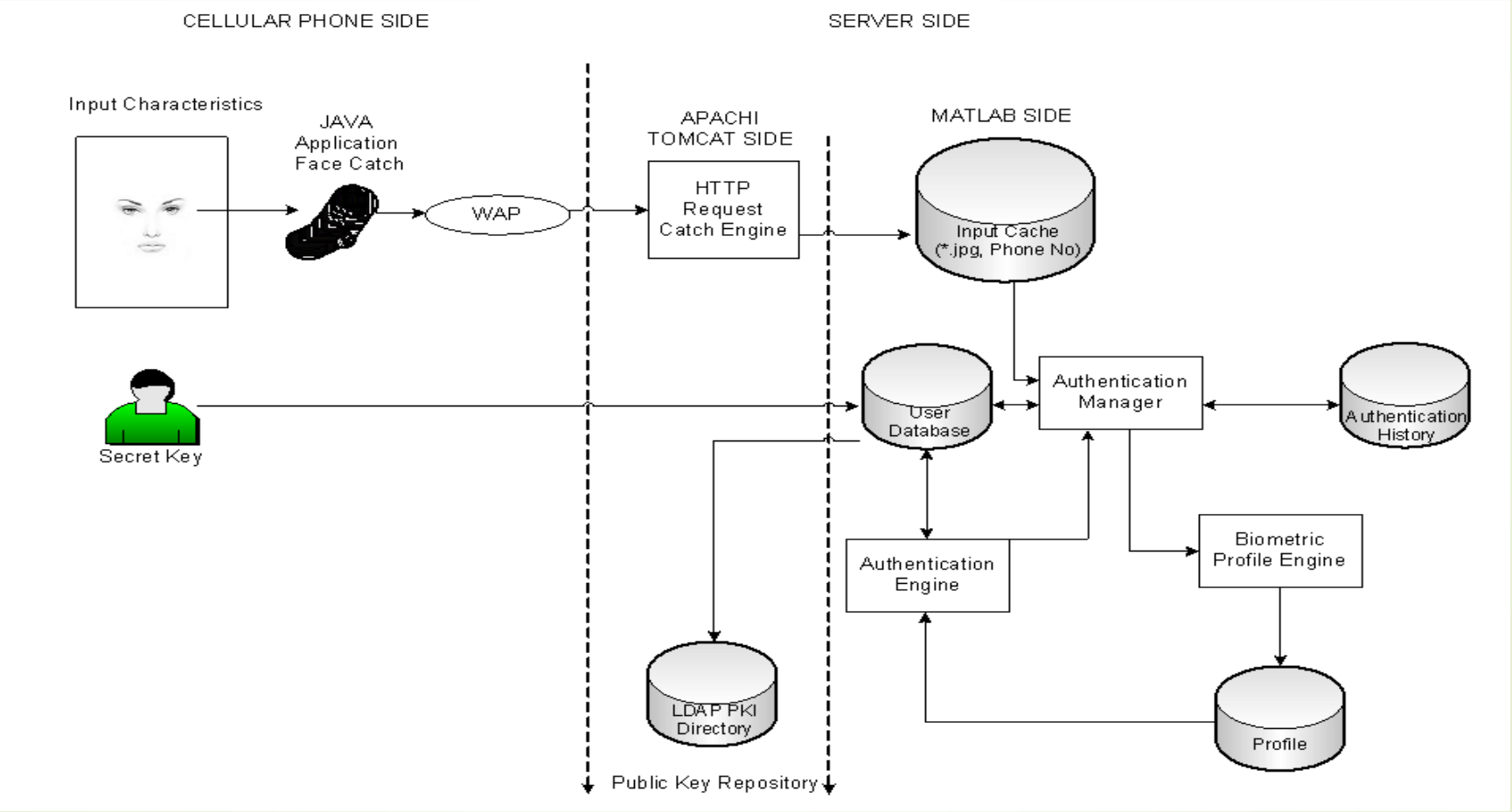
- At most a system, which is implemented **solely on mobile device**
- A Fast Face Recognition System on Mobile Phone
  - Used methods:
    - Support Vector Machines
    - Haar-like features with AdaBoost for face and eye detection
  - Disadvantages
    - low memory
    - limited battery
    - low computing power




B. Chen, J. Shen, H. Sun, "A fast face recognition system on mobile phone", International Conference on Systems and Informatics (ICSAI), 19-20 May 2012, Yantai, pp. 1783 – 1786, ISBN 978-1-4673-0198-5

# State-of-the-art

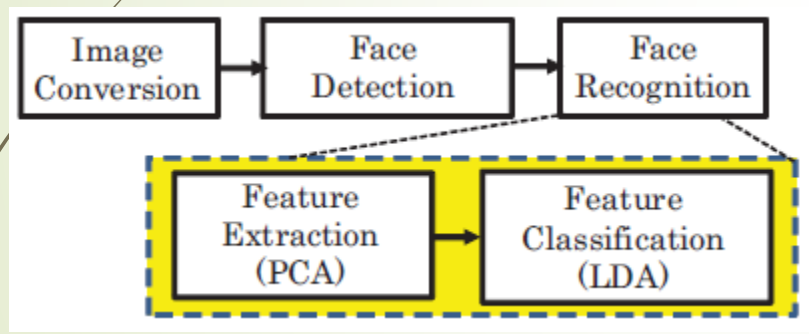
- Face Recognition Implementation for Client Server Mobile Application using PCA

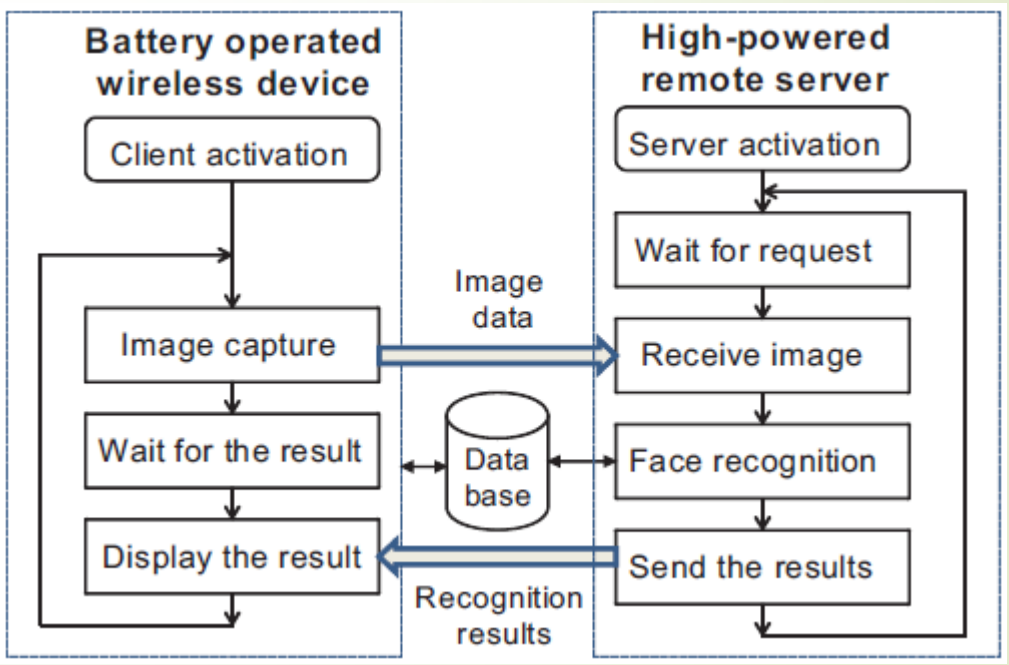



E. Kremic, A. Subasi, K. Hajdarevic, "Face recognition implementation for client server mobile application using PCA", 34th International Conference on Information Technology Interfaces (ITI), 25-28 June 2012, Cavtat, Dubrovnik, pp. 435 – 440, ISBN 978-1-4673-1629-3

# State-of-the-art

- Network-Based Face Recognition on Mobile Devices
  - PCA with LDA is used for feature extraction
  - Euclidean distance for classification

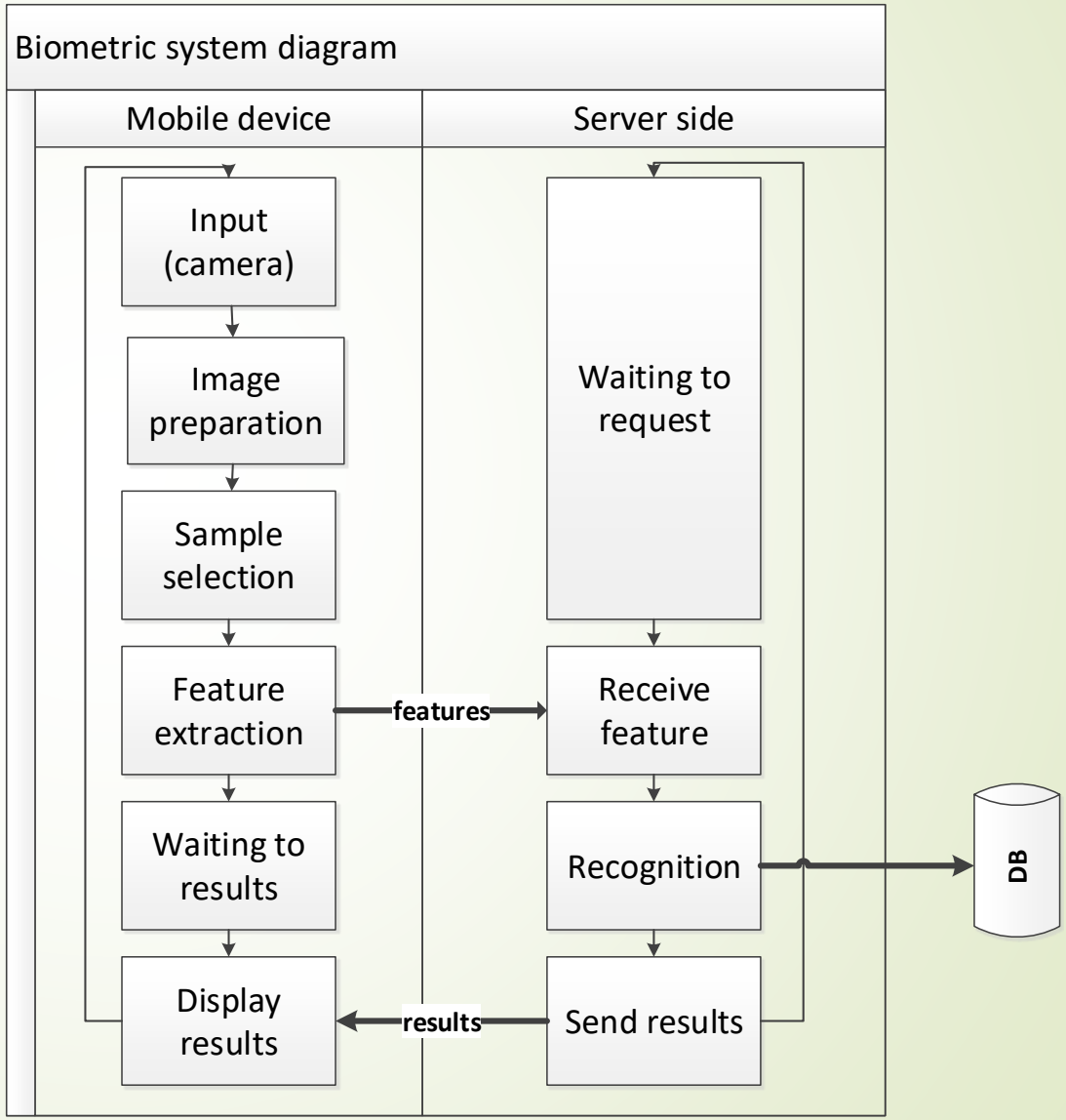


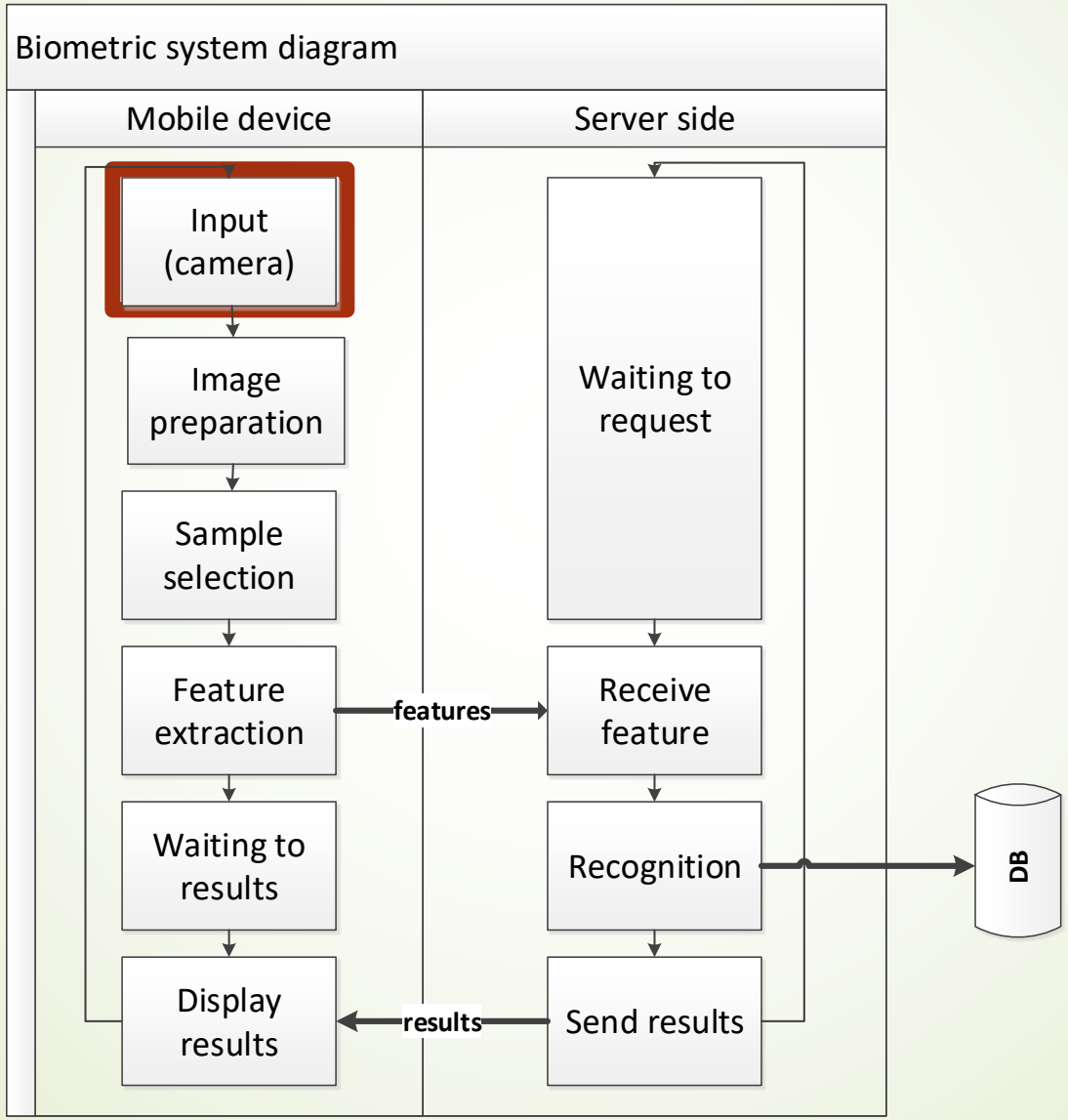

K. Imaizumi, V. G. Moshnyaga, "Network-Based Face Recognition on Mobile Devices", IEEE Third International Conference on Consumer Electronics 2013, 9-11 Sept. 2013, Berlin, pp. 406 – 409, ISBN 978-1- 4799-1411-1

# Our proposed solution

- based on client-server architecture
- implemented for Android OS

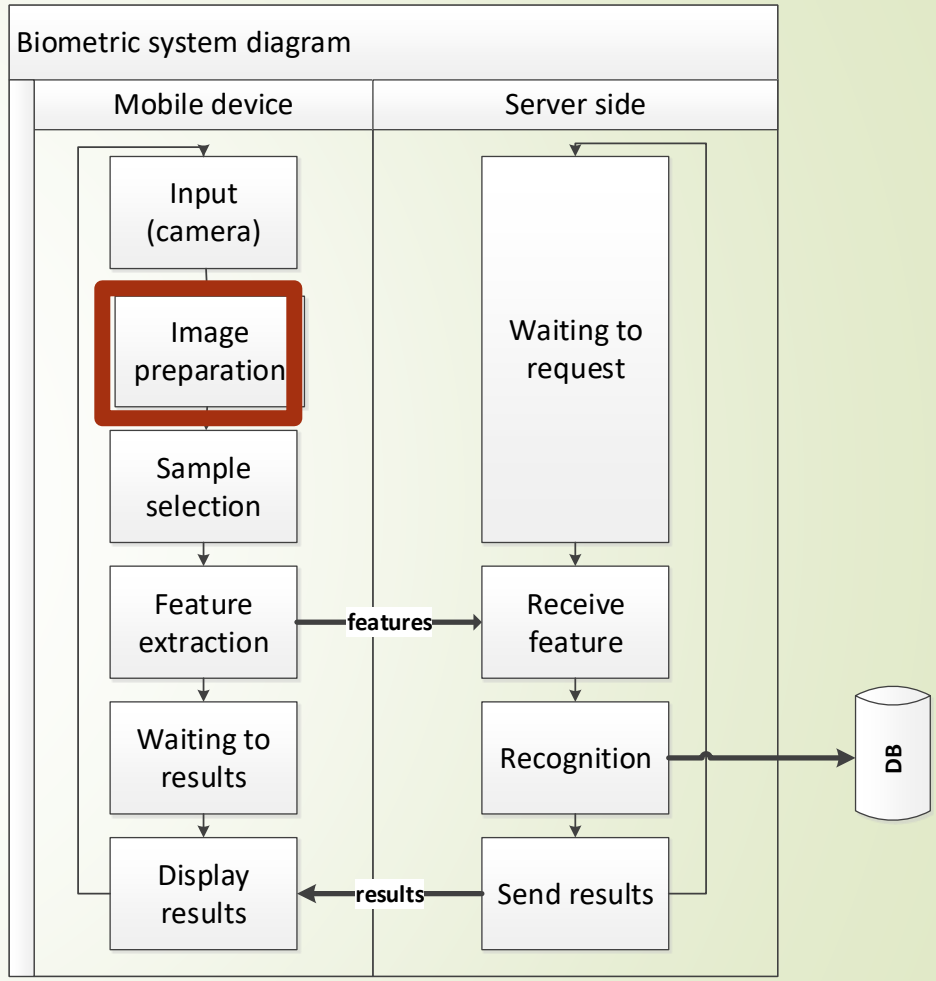


# Input


Biometric system diagram
Mobile device
Server side
Input (camera)
Image preparation
Sample selection
Feature extraction
Waiting to results
Display results
Waiting to request
Receive feature
Recognition
Send results
features
results
DB

# Preprocessing

- Face detector:
  - Android
  - OpenCv
  - LBP
- Color scheme from RGB to greyscale
- Resizing image
- Histogram equalization

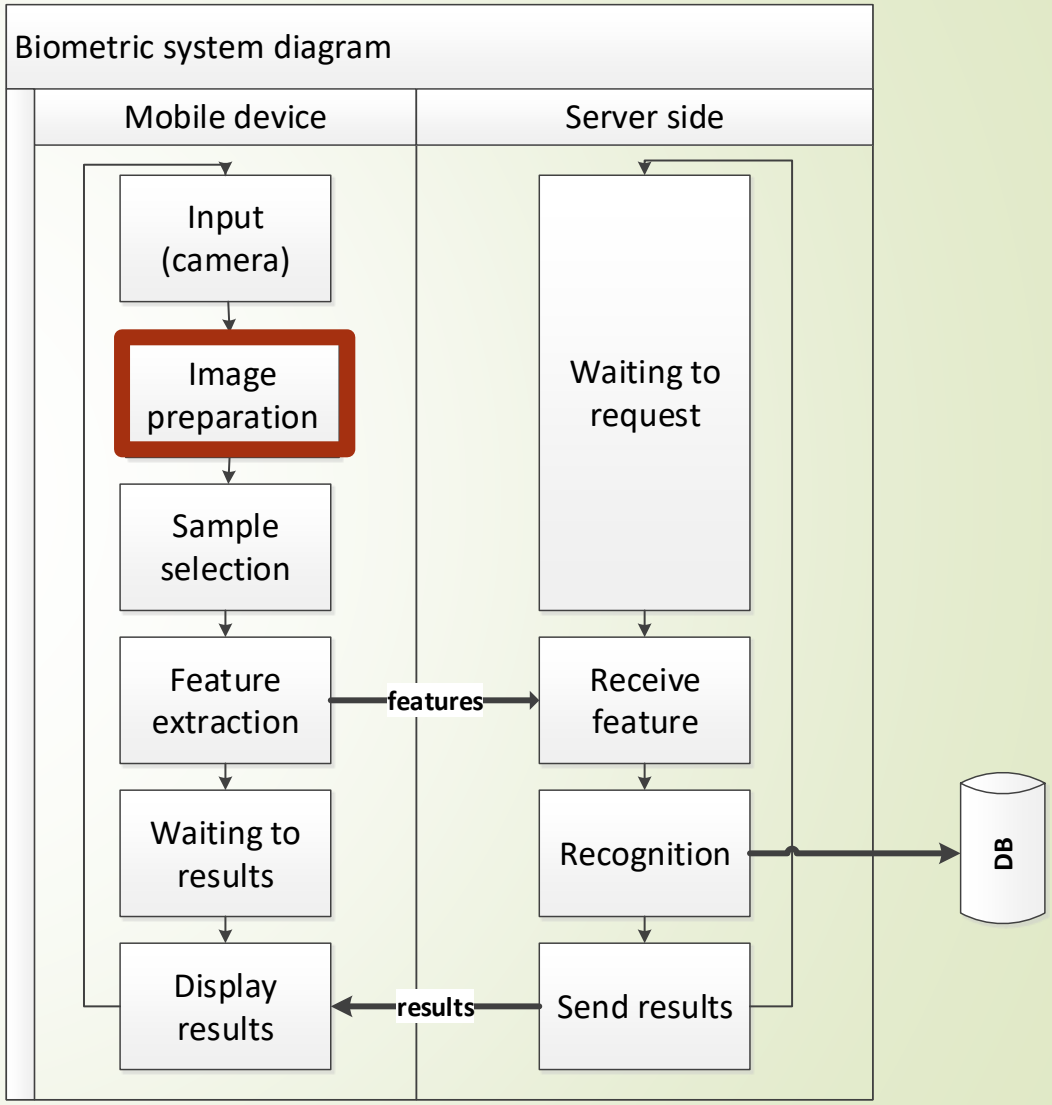


# Preprocessing

detect face &
remove unnecessary
background

crop image &
convert to grayscale

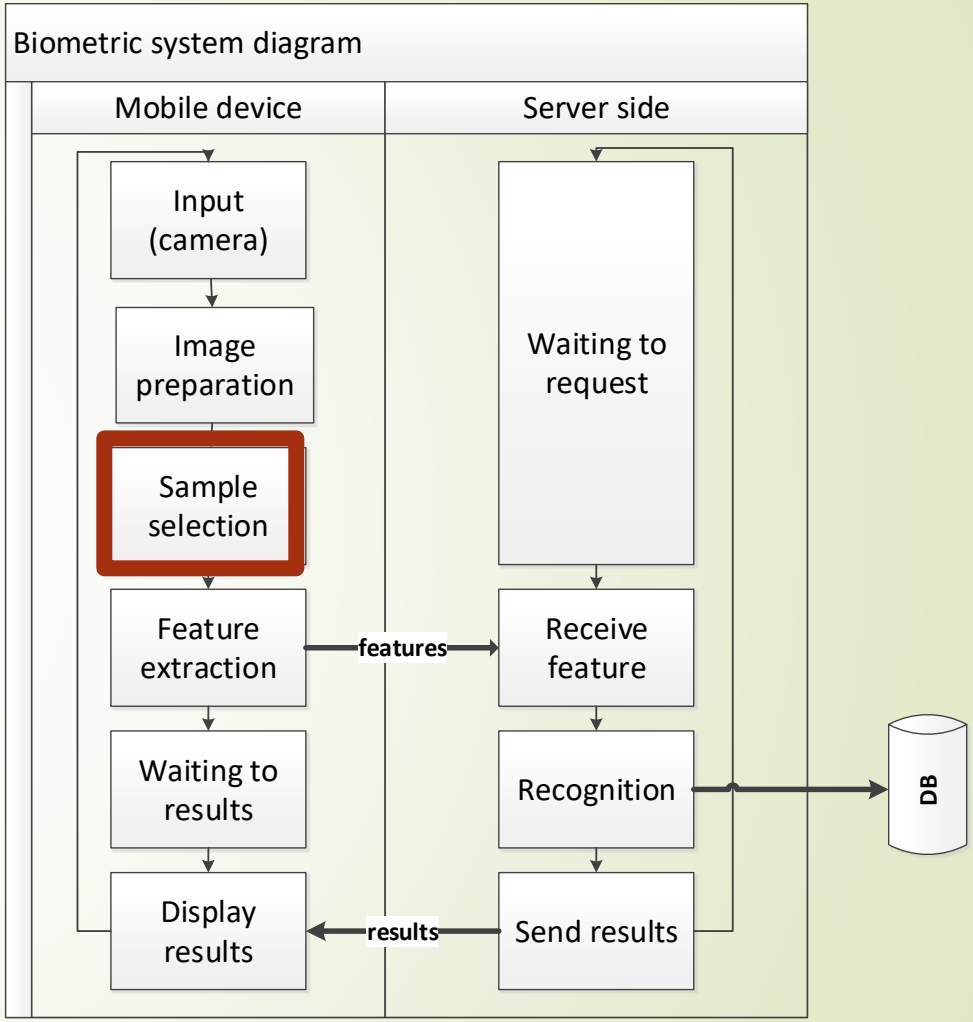
resize image to 64x64 px
& equalize histogram



# Sample Selection

- Why?

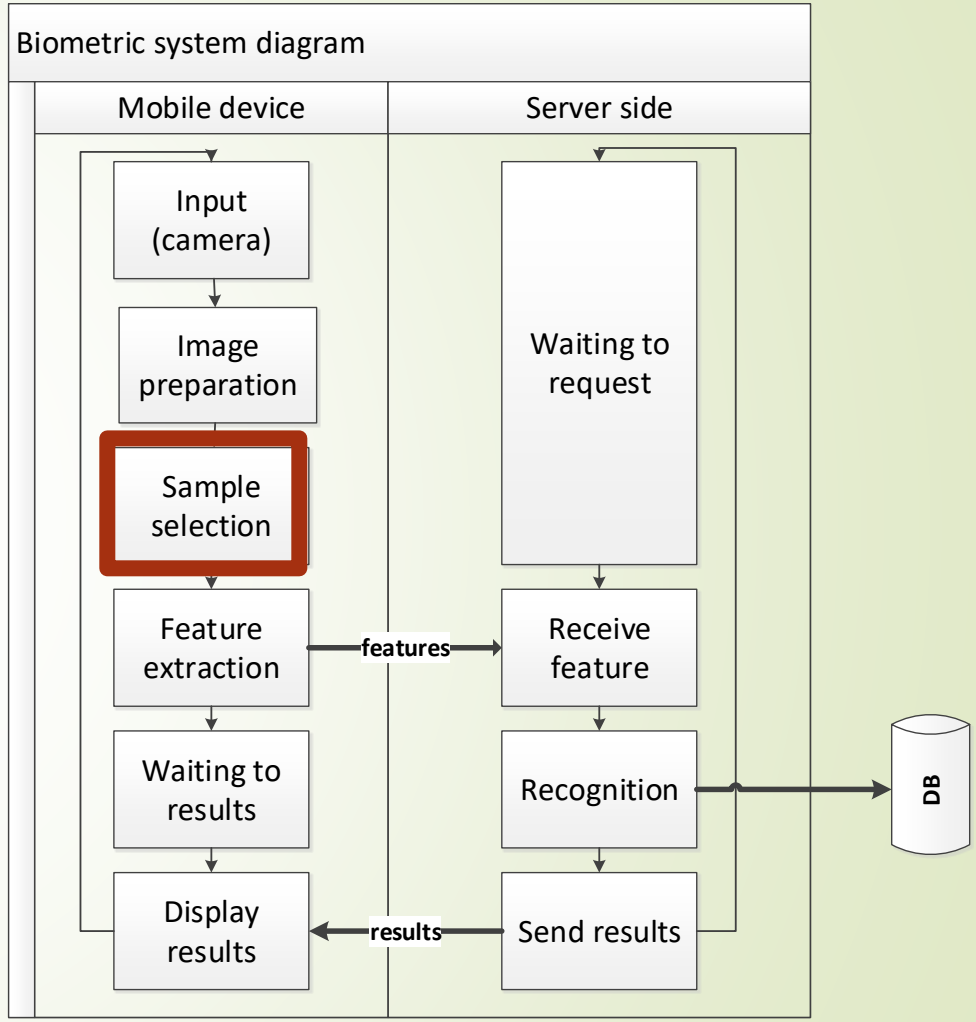
- system needs a few representative images of subject (representative & not blurred)
- clustering algorithms - to identify clusters or classes in input dataset
- the centers of computed clusters are chosen to be sent to the server



# Sample Selection

- Clustering algorithms
  - K-means
  - C-means
  - Density-based spatial clustering of applications with noise (DBSCAN)
  - Self-Organizing Map (SOM)

- *also random selection is possible…*

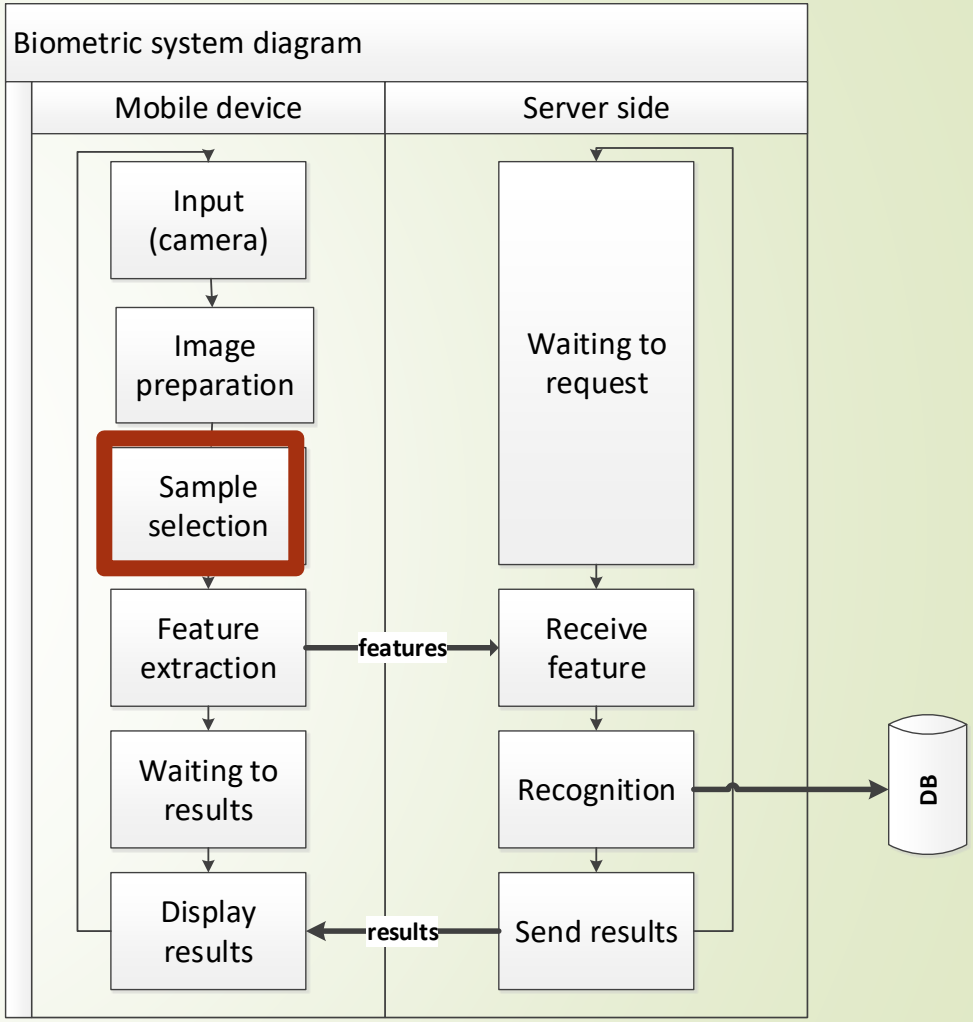


# Sample Selection

K-means

*(selected centers of clusters and real images from database)*

- Simple algorithm
- Low computational complexity
- Convergence to a local minimum



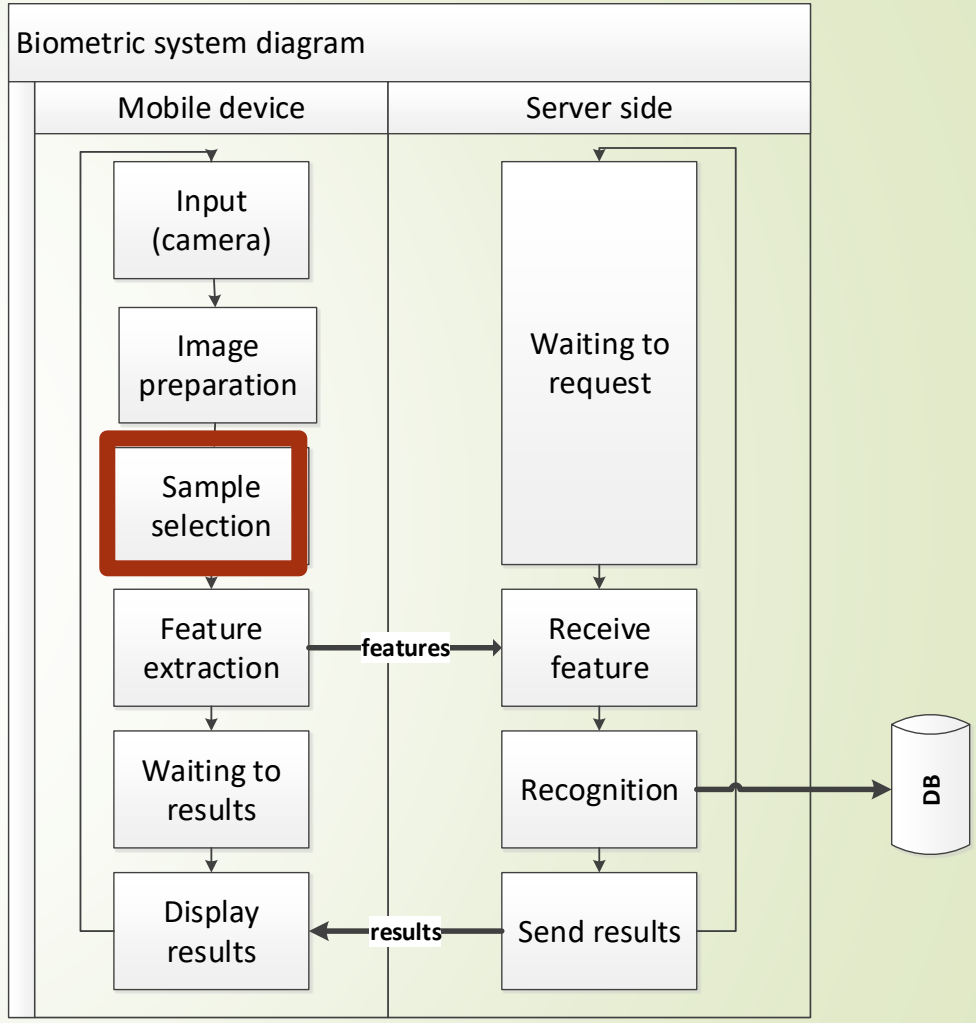

K. Venkatalakshmi and S. M. Shalinie, "Classification of multispectral images using support vector machines based on PSO and k-means clustering," in Proc. Int. Conf. Intell. Sens. Inf. Process., Jan. 2005, pp. 127–133.

# Sample Selection

## C-means

*(selected centers of clusters and real images from database)*

- Simple algorithms
- Low computational complexity
- Convergence to a local minimum



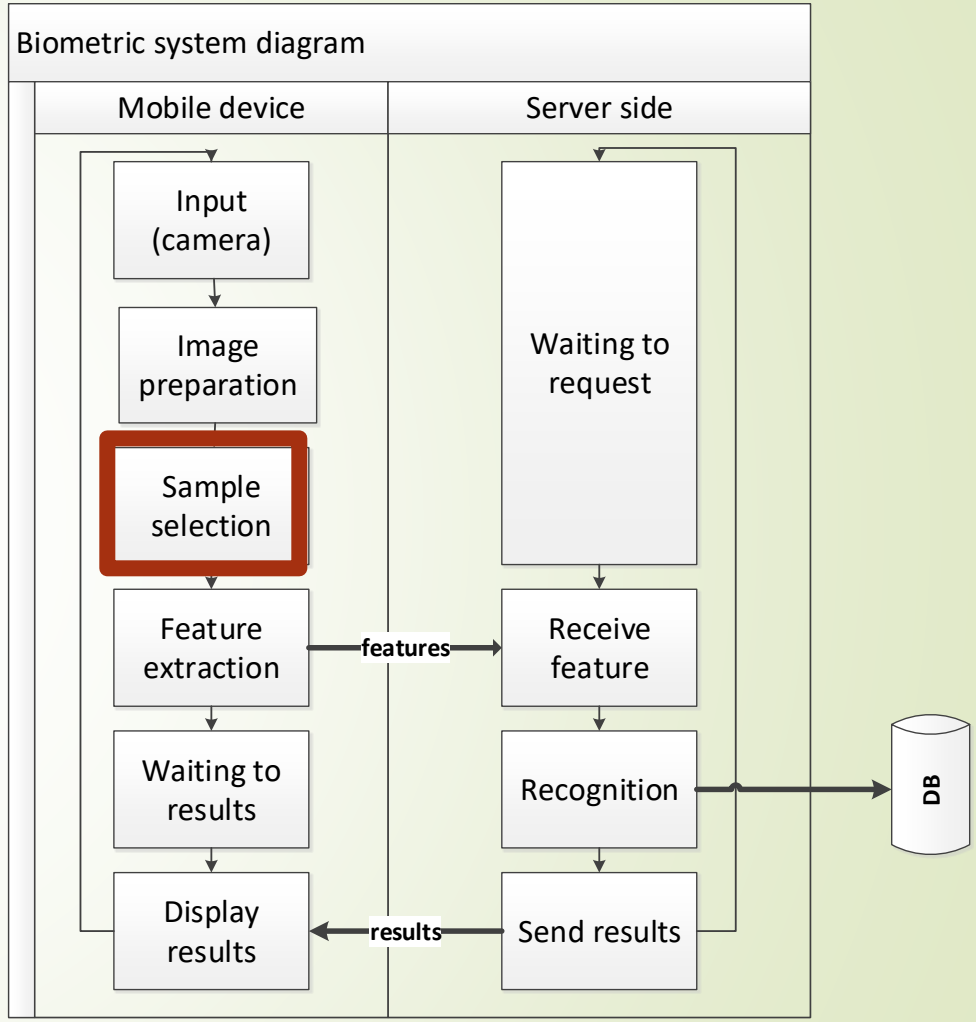

J. Lu, X. Yuan, and T. Yahagi, "A Method of Face Recognition Based on Fuzzy C-Means Clustering and Associated Sub-NNs," IEEE Trans. Neural Networks, vol. 18, no. 1, pp. 150-160, Jan. 2007.

# Sample Selection

## Density-based spatial clustering (DBSCAN)

*(selected centers of clusters and real images from database)*

- Arbitrary shaped clusters
- Notion of noise
- Dataset with large differences in densities ( minPts-ε combination )



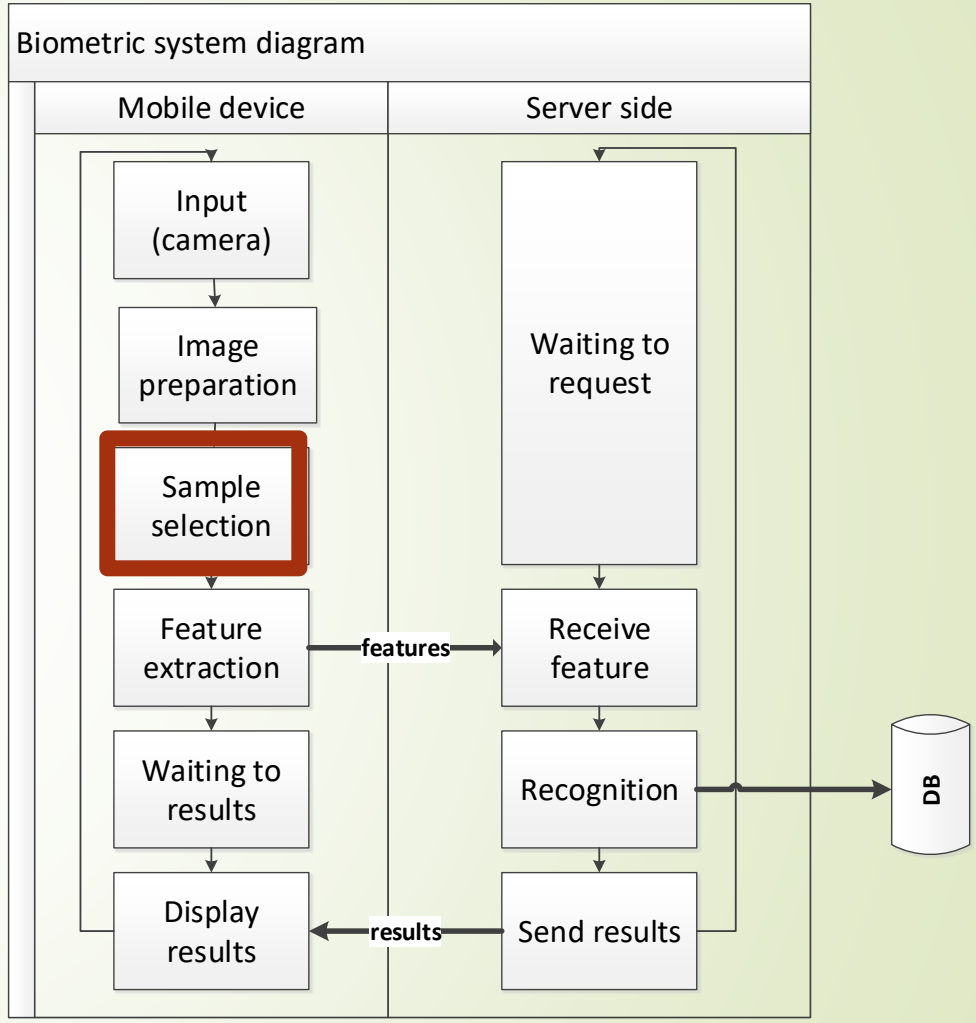

M. Ester, et al. "A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise", in Proceedings of the Second Int. Conf. on Knowledge Discovery and Data Mining (KDD-96). AAAI Press. pp. 226–231., 1996

# Sample Selection

## Self-Organizing Map (SOM)

*(selected centers of clusters and real images from database)*

- Less sensitive to noise and initialization than K-means or C-means
- More complicated algorithm

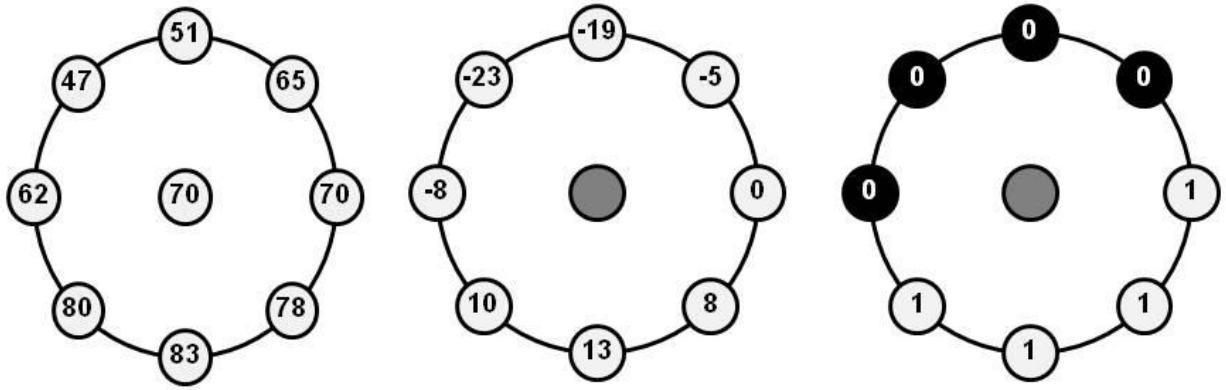



KOHONEN T., "Self-organizing formation of topologically correct feature maps," Biological Cybernetics, vol. 43, pp.59–69, 1982

# Feature extraction

The value of the LBP code of a pixel $(x_c, y_c)$ is given by:

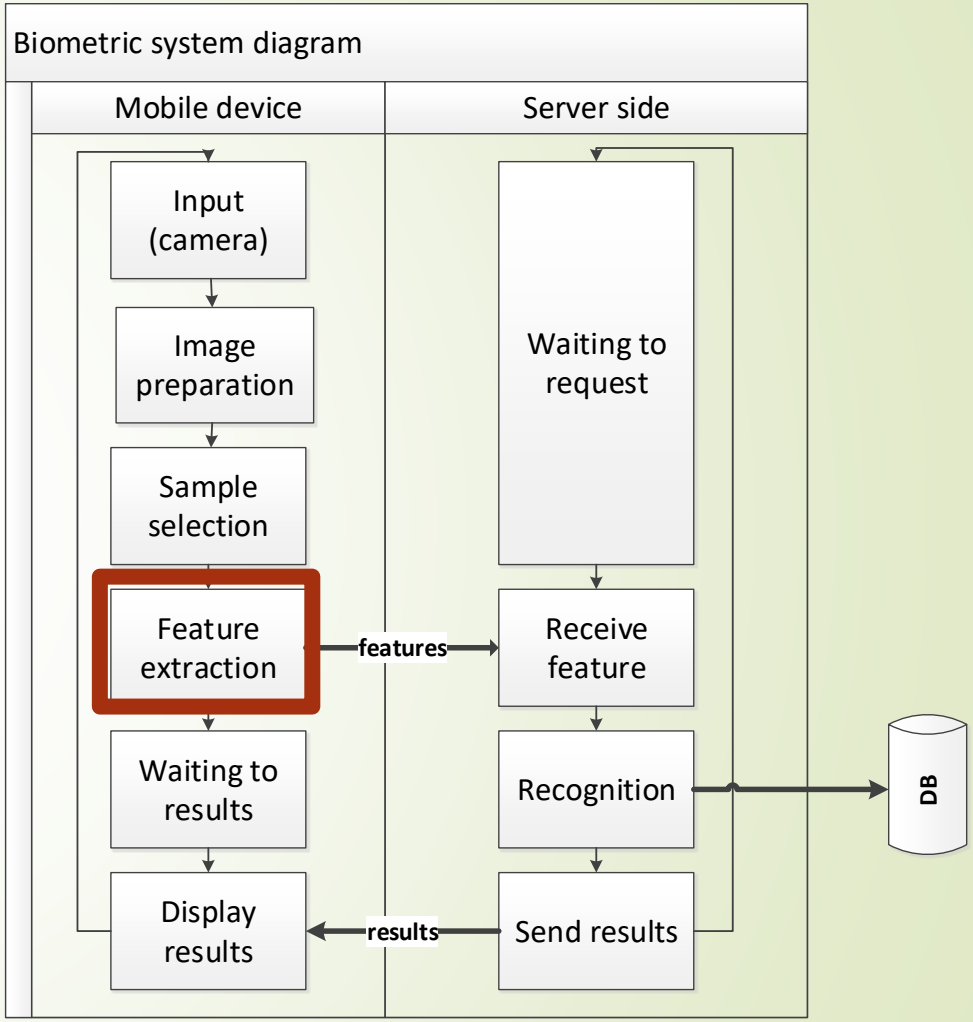
$$LBP_{P,R} = \sum_{p=0}^{P-1} s(g_p - g_c)2^p \qquad s(x) = \begin{cases} 1, if\ x \geq 0; \\ 0, otherwise. \end{cases}$$




1. Sample | 2. Difference | 3. Threshold

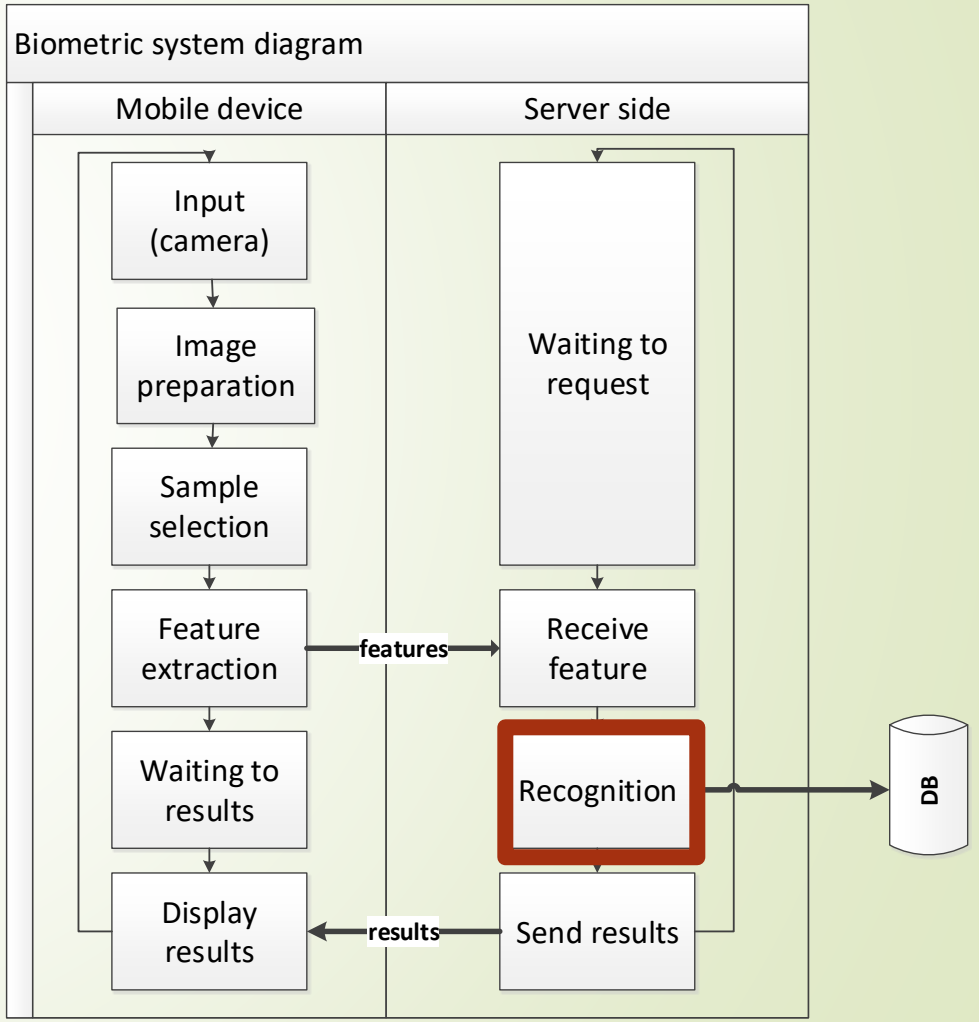
1*1 + 1*2 + 1*4 + 1*8 + 0*16 + 0*32 + 0*64 + 0*128 = 15

4. Multiply by powers of two and sum



# Classification (recognition)

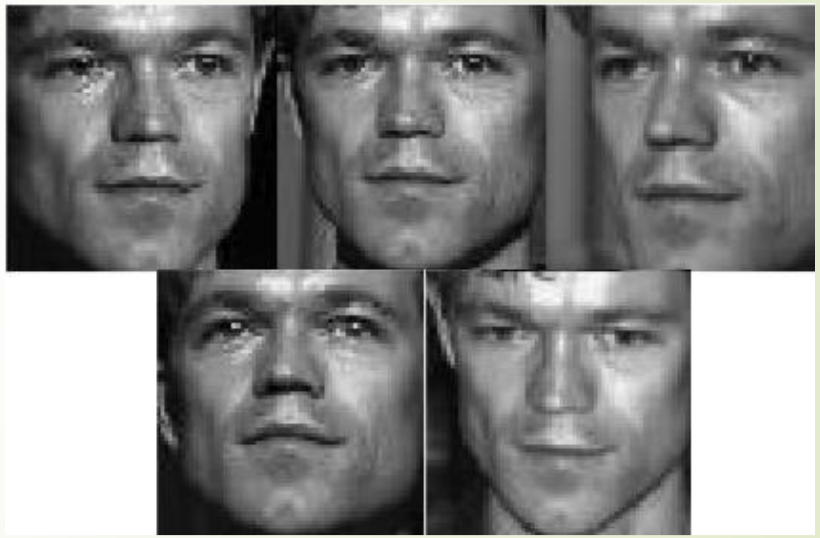
- Server side:
  - Enough memory
  - High computer power
- Methods
  - Manhattan distance
  - Euclidean distance



# Testing databases

- CMU Pose, Illumination, and Expression (PIE) database
  - 68 subjects
  - 13 poses
  - 43 illumination conditions
  - 4 expressions
- EURECOM
  - 52 subjects
  - 9 expressions
  - 3 poses

# CMU Pose, Illumination, and Expression (PIE) database

In our tests we used the images of five different poses (C05, C07, C09, C27 and C29)

SIM T., BAKER S. BSAT M., The CMU Pose, Illumination, and Expression (PIE) database. Automatic Face and Gesture Recognition. pp. 46-51, 2002.

# EURECOM database


rgb_0016_s1_Neutral.bmp

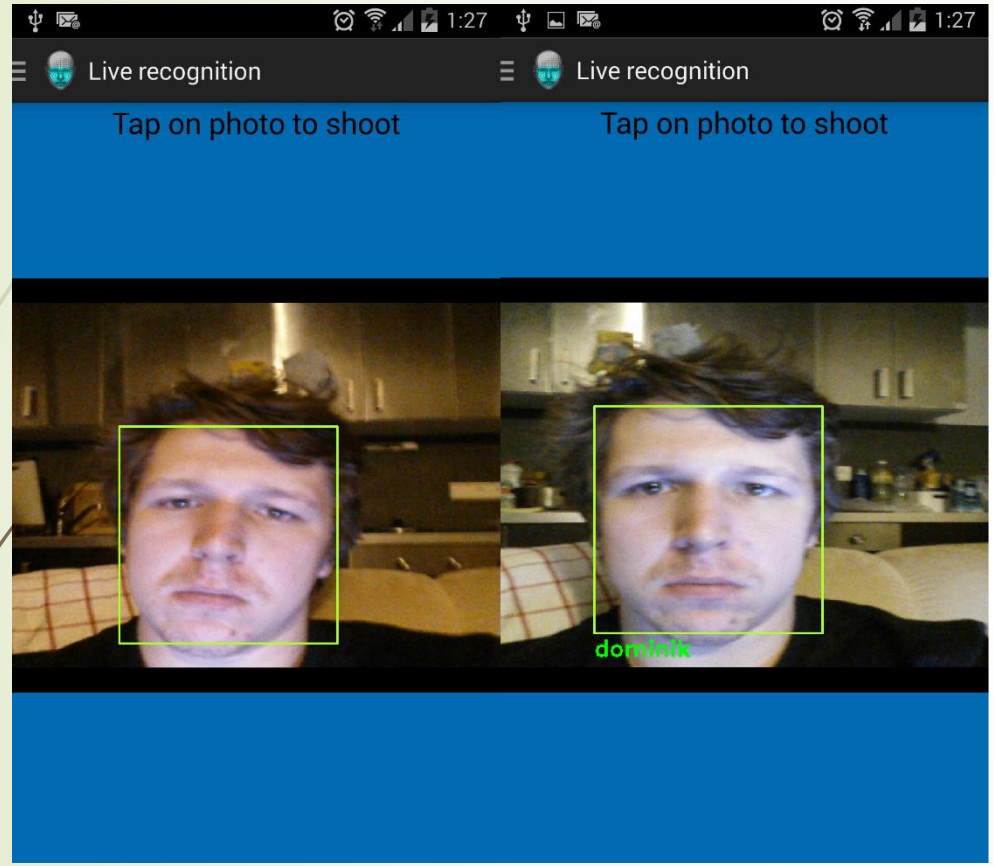
| | |
|---|---|
| 99 | 115 |
| 143 | 115 |
| 120 | 139 |
| 105 | 160 |
| 141 | 159 |
| 124 | 194 |

rgb_0016_s1_Neutral_Points.txt

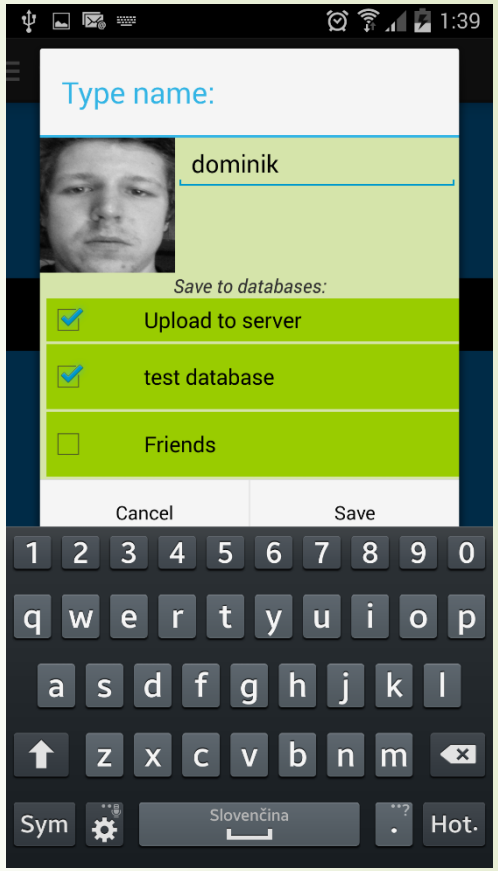
- 9 states of different facial expressions, different lighting and occlusion conditions:
  - neutral, smile, open mouth, left profile, right profile, occlusion-eyes, occlusion-mouth, occlusion-paper, and light

Rui Min, Neslihan Kose, Jean-Luc Dugelay, "KinectFaceDB: A Kinect Database for Face Recognition," Systems, Man, and Cybernetics: Systems, IEEE Transactions on , vol.44, no.11, pp.1534,1548, Nov. 2014, doi: 10.1109/TSMC.2014.2331215

# Application




Screenshot from the application:
on the left unrecognized face, on the right successfully recognized face




Adding new person to the database:

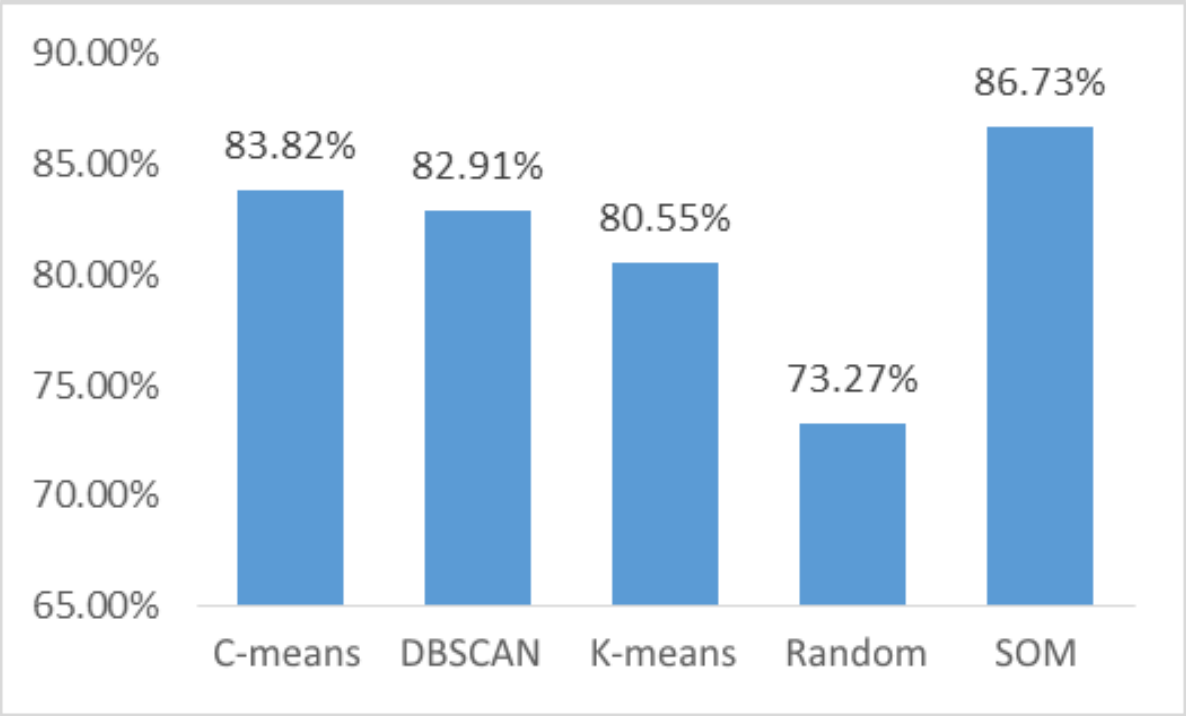
- store photos into local database
- or upload features of these images to database on server

M. Oravec, D. Sopiak, V. Jirka, "Face recognition on mobile devices based on client-server architecture", 9th International Workshop on Multimedia and Signal Processing Redžúr 2015, 22-23 april 2015, Smolenice, Slovakia, pp.15-18, ISBN 978-80-227-4346-4

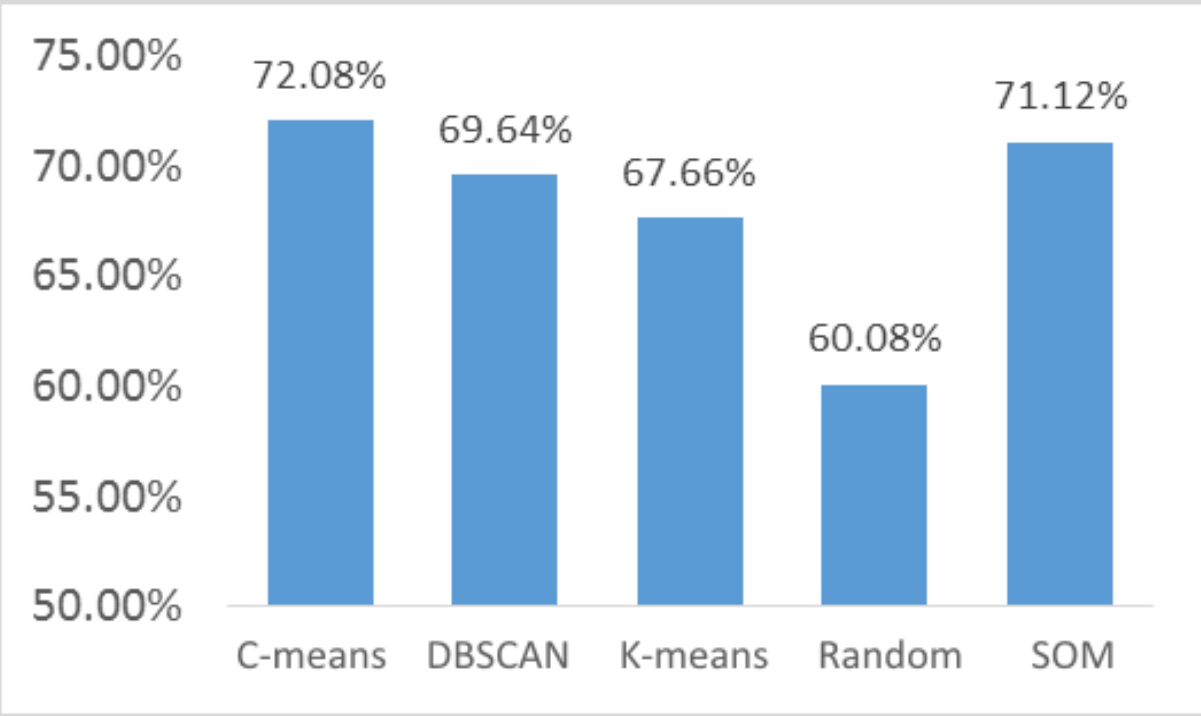
# Testing

- Images from face databases as input
- The same client on PC (memory)
- 5 images selected by clustering algorithms were saved to DB
- LBP used as feature extraction
- Recognition accuracy evaluation with Manhattan distance

# Results




Recognition accuracy of face recognition based on clustering algorithms tested on PIE database




Recognition accuracy of face recognition based on clustering algorithms tested on EURECOM database

# Conclusion

- A client-server approach for face recognition in mobile devices
- Clustering algorithms increase recognition accuracy
- K-means and C-means
  - Simple algorithms
  - Low computational complexity
  - Convergence to a local minimum
- DBSCAN
  - Arbitrary shaped clusters
  - Notion of noise
  - Dataset  with large differences in densities ( minPts-ε combination )
- SOM
  - Less sensitive to noise and initialization than K-means or C-means
  - More complicated algorithm

# Future work plan

- Decreasing running time (optimization, implementation issues)
- Implementation collection of methods that cover widely used face recognition algorithms
- Addition of other biometrics into existing system (e.g. iris)
- Testing new methods like CNN (convolutional neural networks)

# References

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