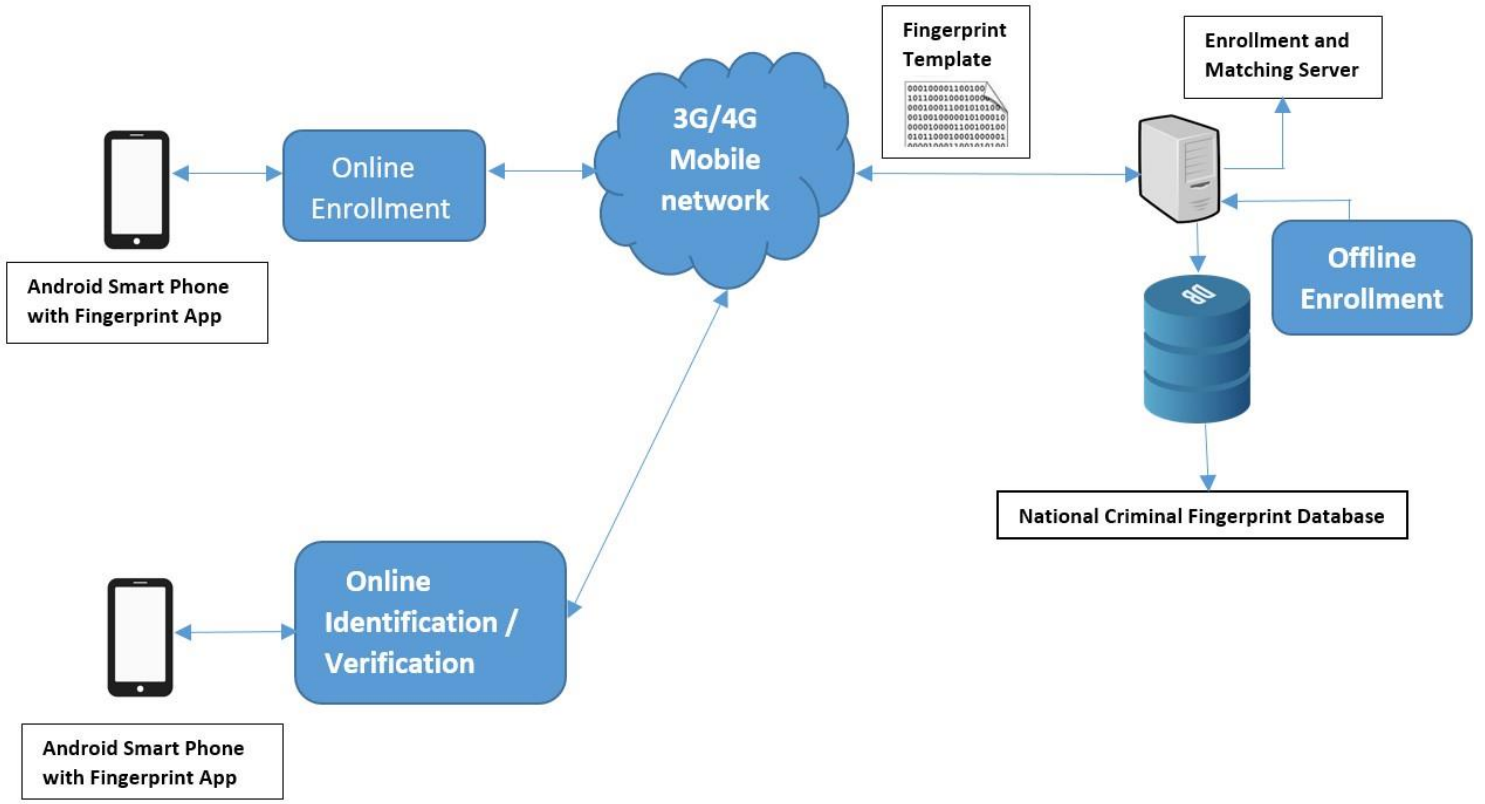
Touchless Fingerprint Recognition System

BY MEET HARIA

UNDER THE GUIDANCE OF PROF. VIKRAM M. GADRE

Touchless Fingerprint Recognition System



Fingerprint Recogntion

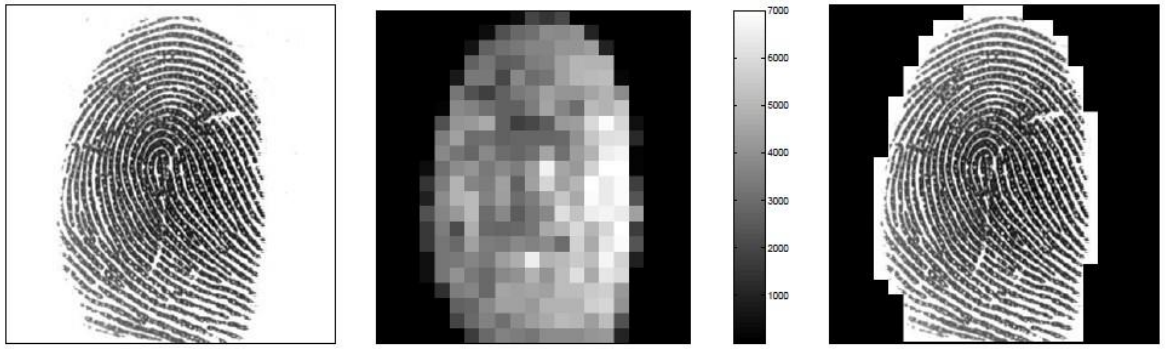
1. Pre-processing
2. Feature Extraction (Minutiae Extraction)
3. Matching

Finger Image Enhancement

1. Segmentation
2. Normalization
3. Estimation of Ridge Pixel Orientation
4. Estimation of Ridge Frequency
5. Gabor Filtering
6. Binarization
7. Thinning

Finger Image Segmentation

$$V(k) = \frac{1}{W^2} \sum_{i=0}^{W-1} \sum_{j=0}^{W-1} (I(i,j) - M(k))^2$$



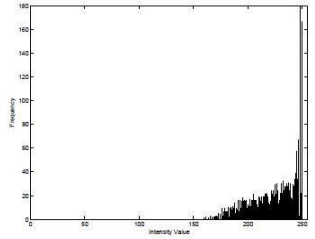
(a) Original image (b) Variance image (c) Segmented image

Grey Level Value Normalisation

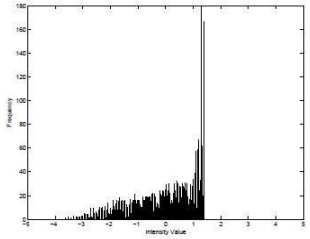
$$N(i,j) = \begin{cases} M_0 + \sqrt{\frac{V_0(I(i,j)-M)^2}{V}} & \text{if } I(i,j) > M, \\ M_0 - \sqrt{\frac{V_0(I(i,j)-M)^2}{V}} & \text{otherwise,} \end{cases}$$

(a) Original image

(b) Normalised image

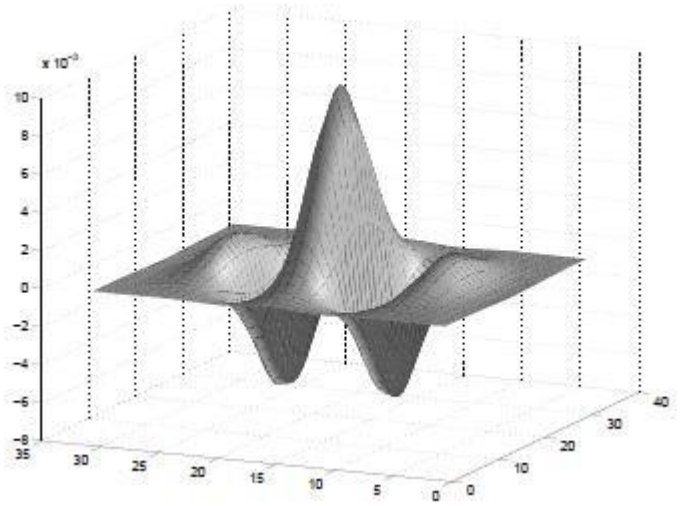


(c) Histogram of the original image



(d) Histogram of the normalised image

Gabor Filter

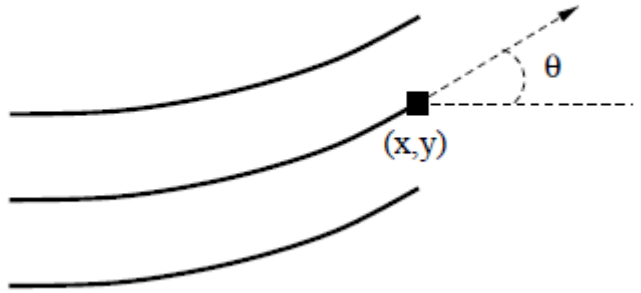


$$G(x, y; \theta, f) = \exp\left\{-\frac{1}{2}\left[\frac{x_\theta^2}{\sigma_x^2} + \frac{y_\theta^2}{\sigma_y^2}\right]\right\}\cos(2\pi f x_\theta),$$

$$x_\theta = x\cos\theta + y\sin\theta,$$

$$y_\theta = -x\sin\theta + y\cos\theta,$$

Estimation of Ridge Pixel Orientation



Estimation of Ridge Pixel Orientation

$$V_x(i,j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} 2\partial_x(u,v)\partial_y(u,v),$$

$$V_y(i,j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} \partial_x^2(u,v)\partial_y^2(u,v),$$

$$\theta(i,j) = \frac{1}{2}tan^{-1}\frac{V_y(i,j)}{V_x(i,j)},$$

Estimation of Ridge Pixel Orientation

$$\Phi_x(i,j) = cos(2\theta(i,j)),$$

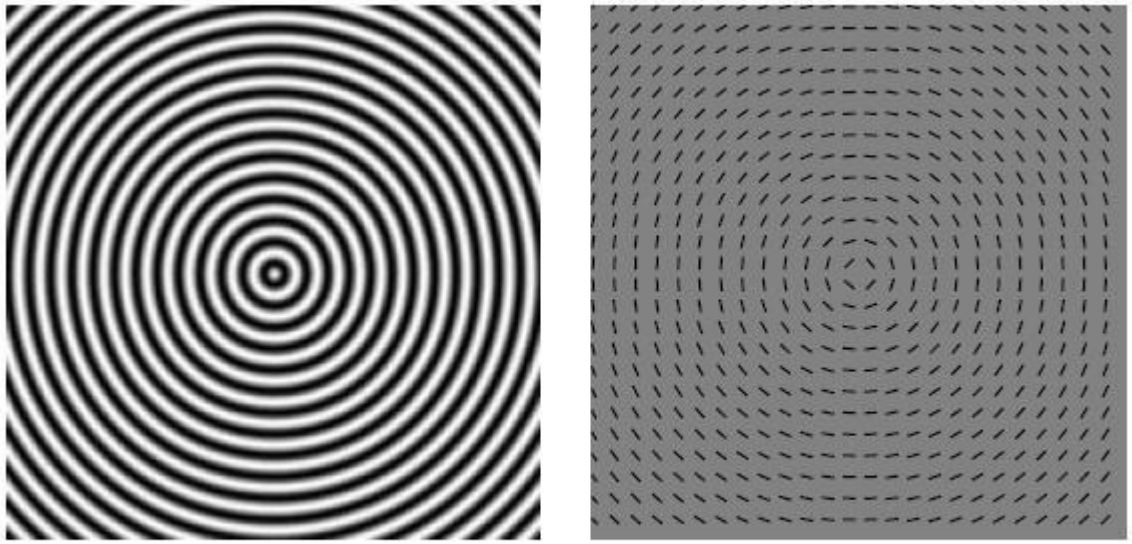
$$\Phi_y(i,j) = sin(2\theta(i,j)),$$

$$\Phi'_x(i,j) = \sum_{u=-\frac{w_\Phi}{2}}^{\frac{w_\Phi}{2}} \sum_{v=-\frac{w_\Phi}{2}}^{\frac{w_\Phi}{2}} G(u,v)\Phi_x(i-uw, j-vw),$$

$$\Phi'_y(i,j) = \sum_{u=-\frac{w_\Phi}{2}}^{\frac{w_\Phi}{2}} \sum_{v=-\frac{w_\Phi}{2}}^{\frac{w_\Phi}{2}} G(u,v)\Phi_y(i-uw, j-vw),$$

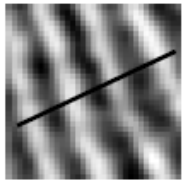
Estimation of Ridge Pixel Orientation

$$O(i,j) = \frac{1}{2} tan^{-1} \frac{\Phi'_y(i,j)}{\Phi'_x(i,j)}$$

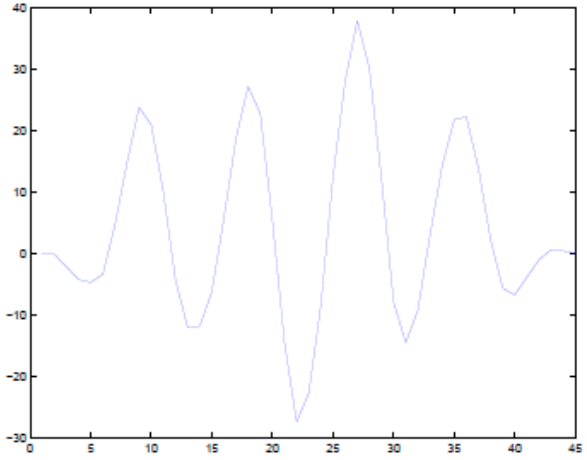


(a) Original image (b) Orientation image

Estimation of Ridge Frequency



(a)

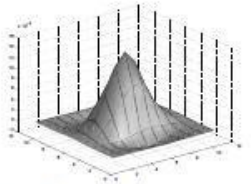


(b)

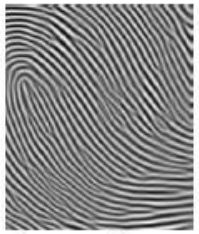
$$F(i,j) = \frac{1}{S(i,j)}.$$

(a) Original image

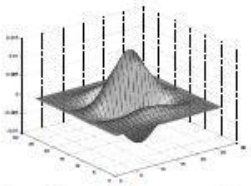
(b) Enhanced image ($k_x = 0.2$, $k_y = 0.2$)



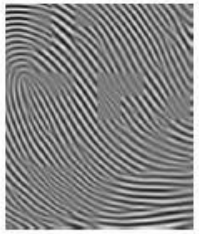
(c) Gabor filter ($k_x = 0.2$, $k_y = 0.2$)



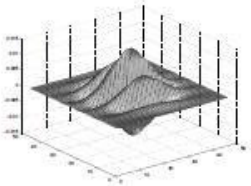
(d) Enhanced image ($k_x = 0.5$, $k_y = 0.5$)



(e) Gabor filter ($k_x = 0.5$, $k_y = 0.5$)



(f) Enhanced image ($k_x = 0.9$, $k_y = 0.9$)



(g) Gabor filter ($k_x = 0.9$, $k_y = 0.9$)

$$E(i,j) = \sum_{u=-\frac{w_x}{2}}^{\frac{w_x}{2}} \sum_{v=-\frac{w_y}{2}}^{\frac{w_y}{2}} G(u,v;O(i,j),F(i,j))N(i-u,j-v),$$

Choice of Standard Deviation

$$\sigma_x = k_x F(i,j),$$

$$\sigma_y = k_y F(i,j),$$

Choice of Filter Size

$$w_x = k * \sigma_x$$

$$w_y = k * \sigma_y$$

Binarization and Thinning Over Enhanced Image

(a) Enhanced image

(b) Binary image

(c) Thinned image

Binarization and Thinning Over Enhanced Image

(a) Original image

(b) Binary image

(c) Thinned image

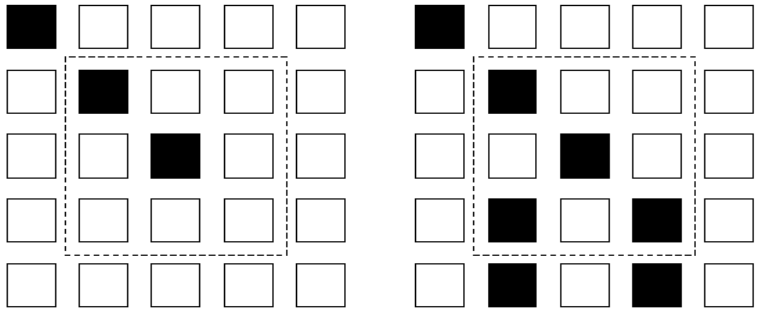
Minutiae Extraction

CN	Property
0	Isolated point
1	Ridge ending point
2	Continuing ridge point
3	Bifurcation point
4	Crossing point

Minutiae Extraction Algorithm

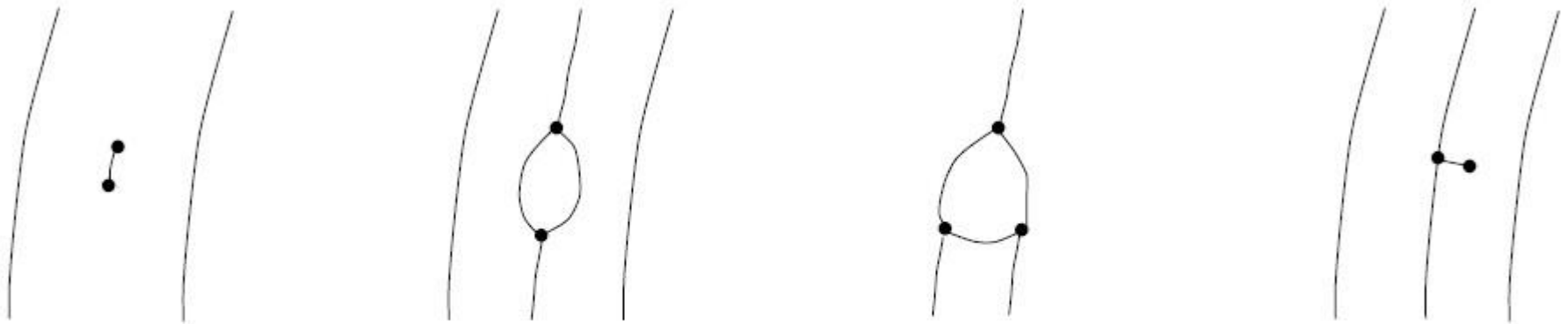
P_4	P_3	P_2
P_5	P	P_1
P_6	P_7	P_8

$$CN = 0.5\sum_{i=1}^{8}|P_i - P_{i+1}|, \qquad P_9 = P_1$$



(a) CN = 1 (b) CN = 3

False Minutiae



(a) Spur (b) Hole (c) Triangle (d) Spike

Minutia Matching

1. Fingerprint Image Registration

2. Computing Matching Score

Android App Implementation

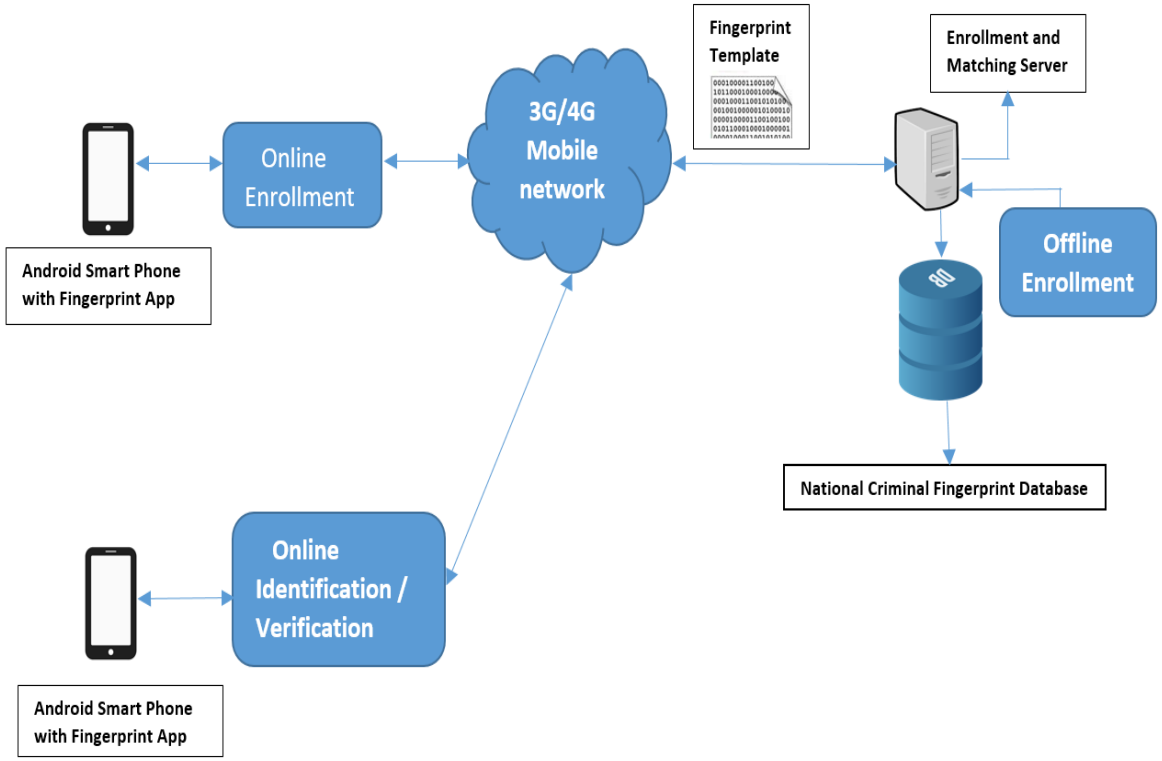
Processor	***Octa-core Qualcomm Snapdragon 616***
Speed	***1.5 GHz***
RAM	***3 GB***
Android Version	***5.1.1***
Code name	***Lollipop***
API Level	***21***

Source Compatibility Java Version	***1.8***
Target Compatibility Java Version	***1.8***
Min SDK Version	***21***
Min API Level	***21***

Android Studio Version	***2.3.1***
Java Version	*1.8 (Jack Enabled)*
Compiled SDK Version	***24***
Build Tools Version	***25.0.0***
Target SDK Version	***24***
Build Gradle Version	***2.3.1***

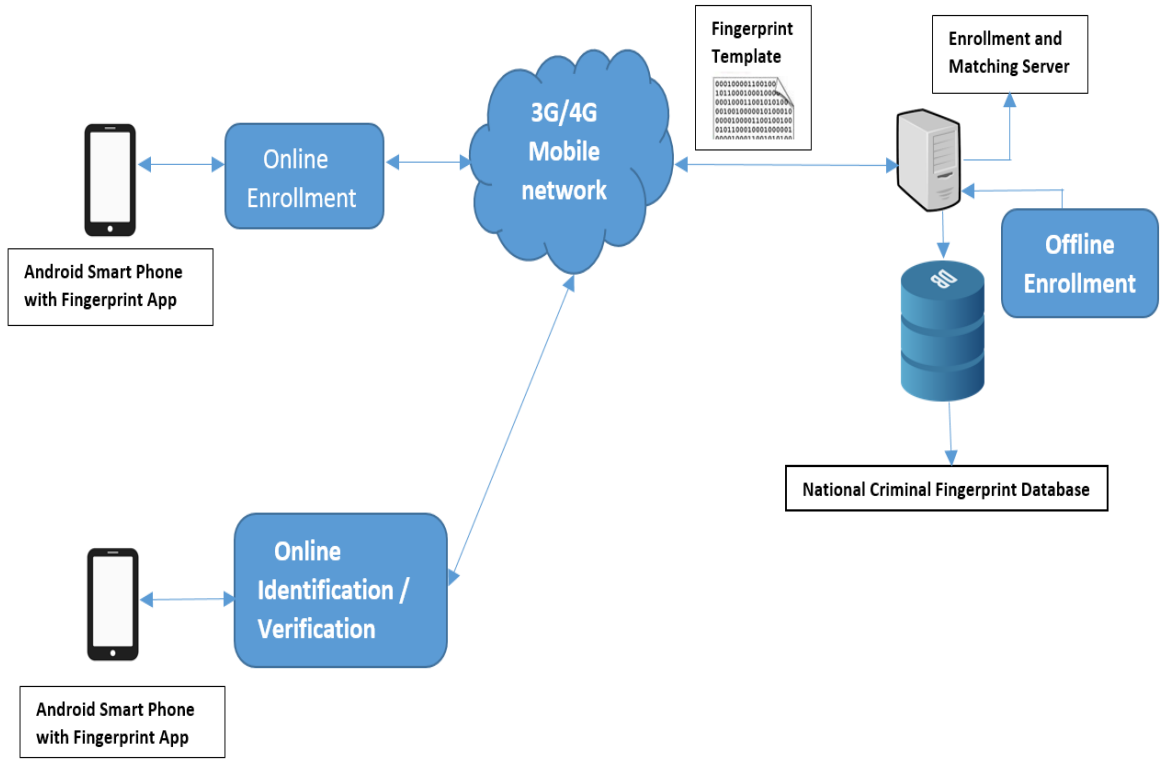
Web Server and Database

1. XAMPP
2. PHP
3. MySQL
4. phpMyAdmin

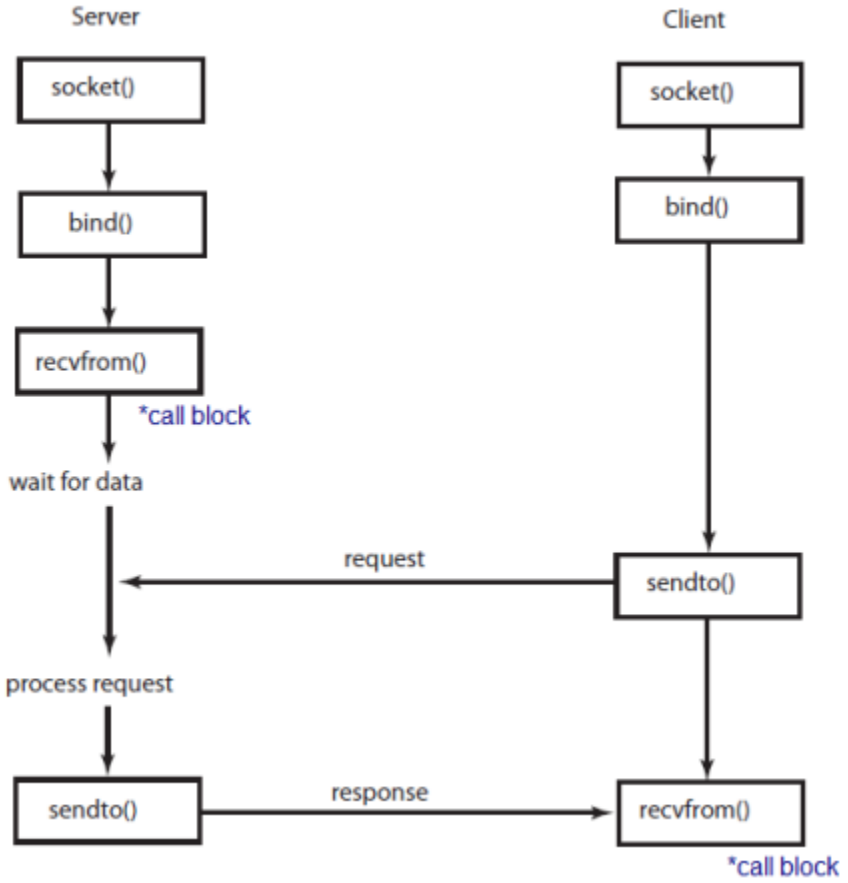


Mobile-Server Communication: HTTP URL Connection

1. HTTP URL Connection
2. JSON Object to GSON String
3. UTF-8 Encoding
4. GSON string to JSON Object



Java Socket Communication



Conclusion

1. Touchless acquisition is much more superior to touch based
2. Feasibility and Convenience due to mobile phones
3. Replaces costlier scanners
4. Feasible solution to mobile banking transaction, Criminal Identification System, mobile phone locks and much more

Future Work

1. No-tap Image Acquisition
2. Monogenic Wavelets based Pre-processing
3. Incorporation of Palmprint Biometric in the current App
4. Machine Learning Approach to Fingerprint Matching
5. Study of finger knuckles, building its identification system and thereby incorporating in the App.

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Thank
you