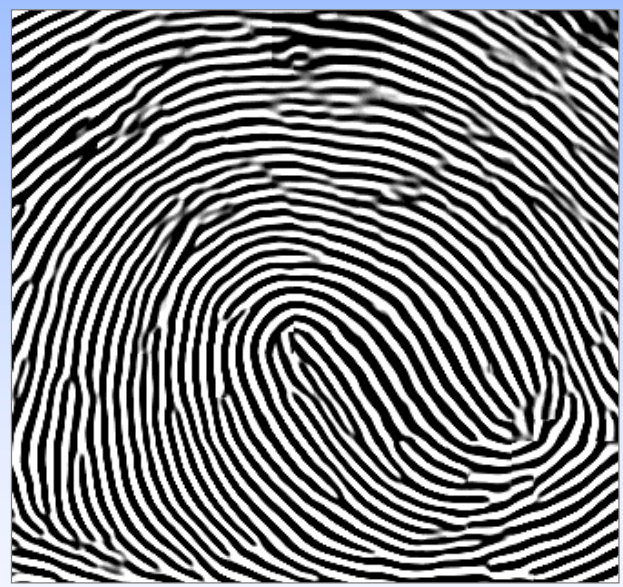
Fingerprint Enhancement

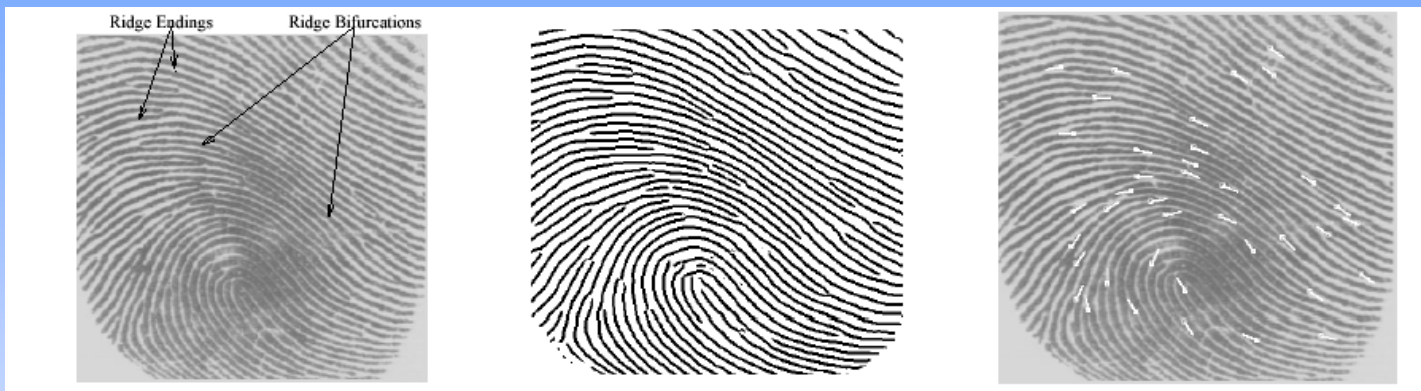
- To address the problem of poor quality fingerprints

Noisy image



Enhanced image

Motivation for Fingerprint Enhancement

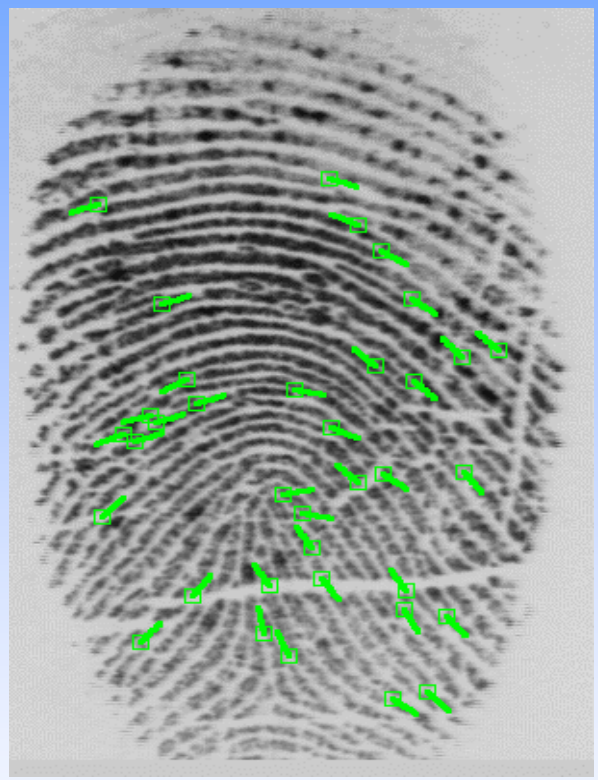


Minutia extracted from a good quality input image

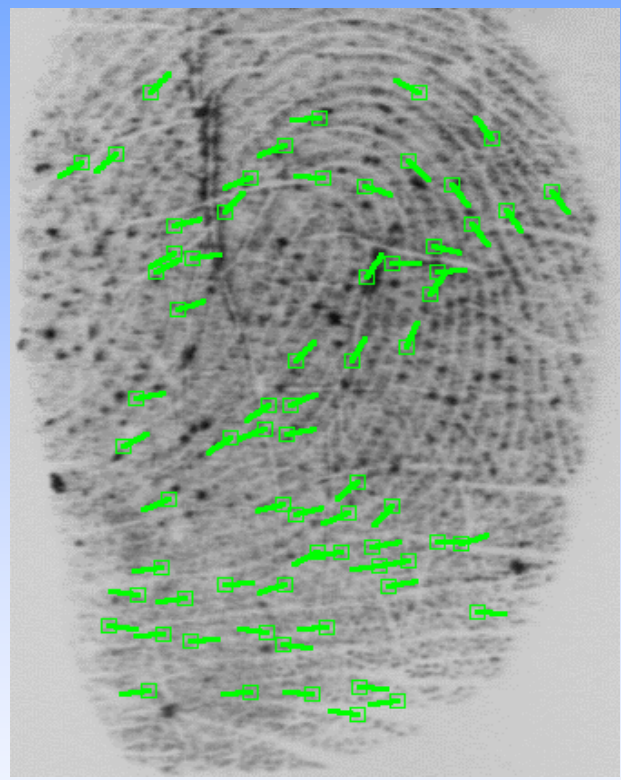
Minutia extracted from a poor quality input image

False Minutiae

Quality Index = 0.96
False Minutiae=0

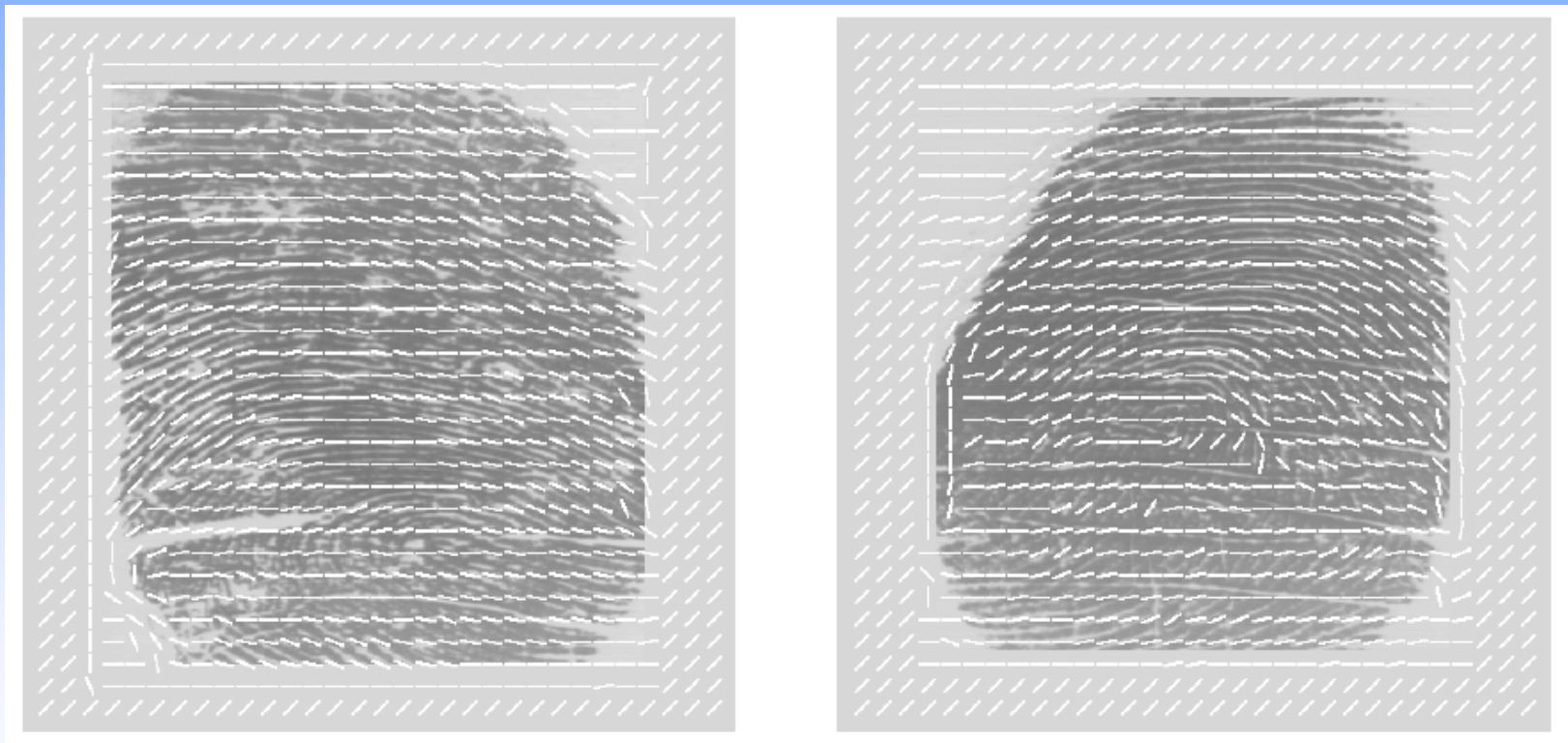


Quality Index = 0.53
False Minutiae=7

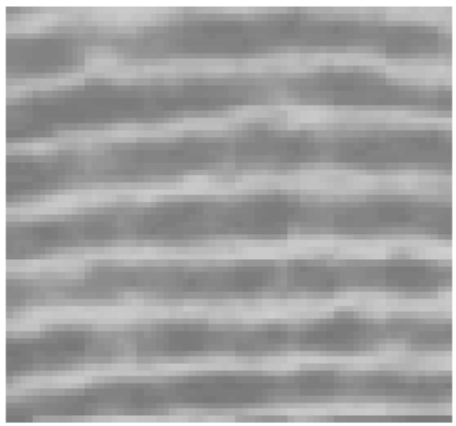


Quality Index = 0.04
False Minutiae=27

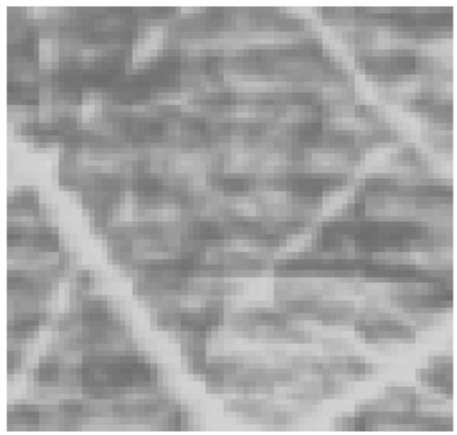
Difficulty in Orientation Field Estimation



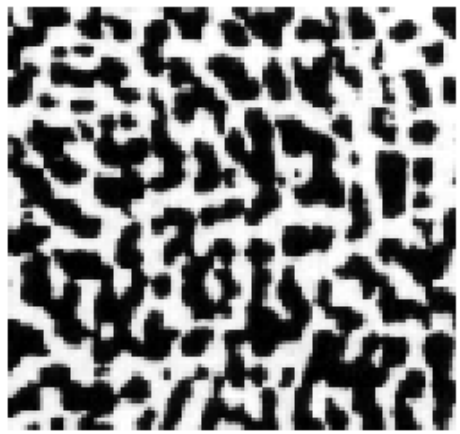
Fingerprint Regions



Well defined region



Recoverable corrupted region



Unrecoverable corrupted region

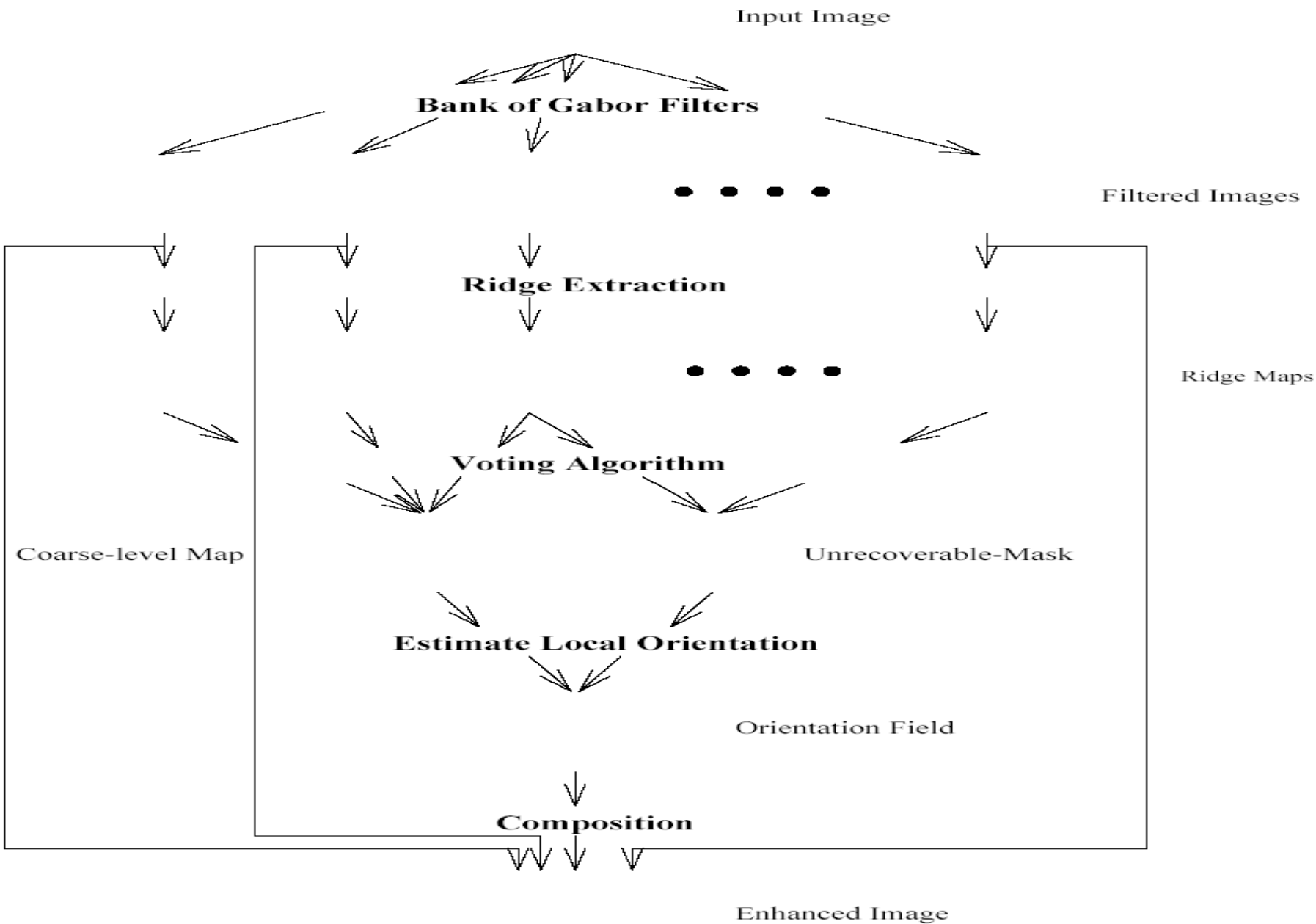
Fingerprint Enhancement Algorithm

- A bank of even-symmetric Gabor filters is applied to the fingerprint image
- A ridge extraction algorithm is applied to each of the filtered images and the corresponding ridge map is obtained
- A voting algorithm is used to generate a coarse-level ridge map and the unrecoverable region masks
- Orientation field estimation is applied to the coarse-level ridge map and from the computed orientation field enhanced images are obtained

Fingerprint Enhancement Algorithm

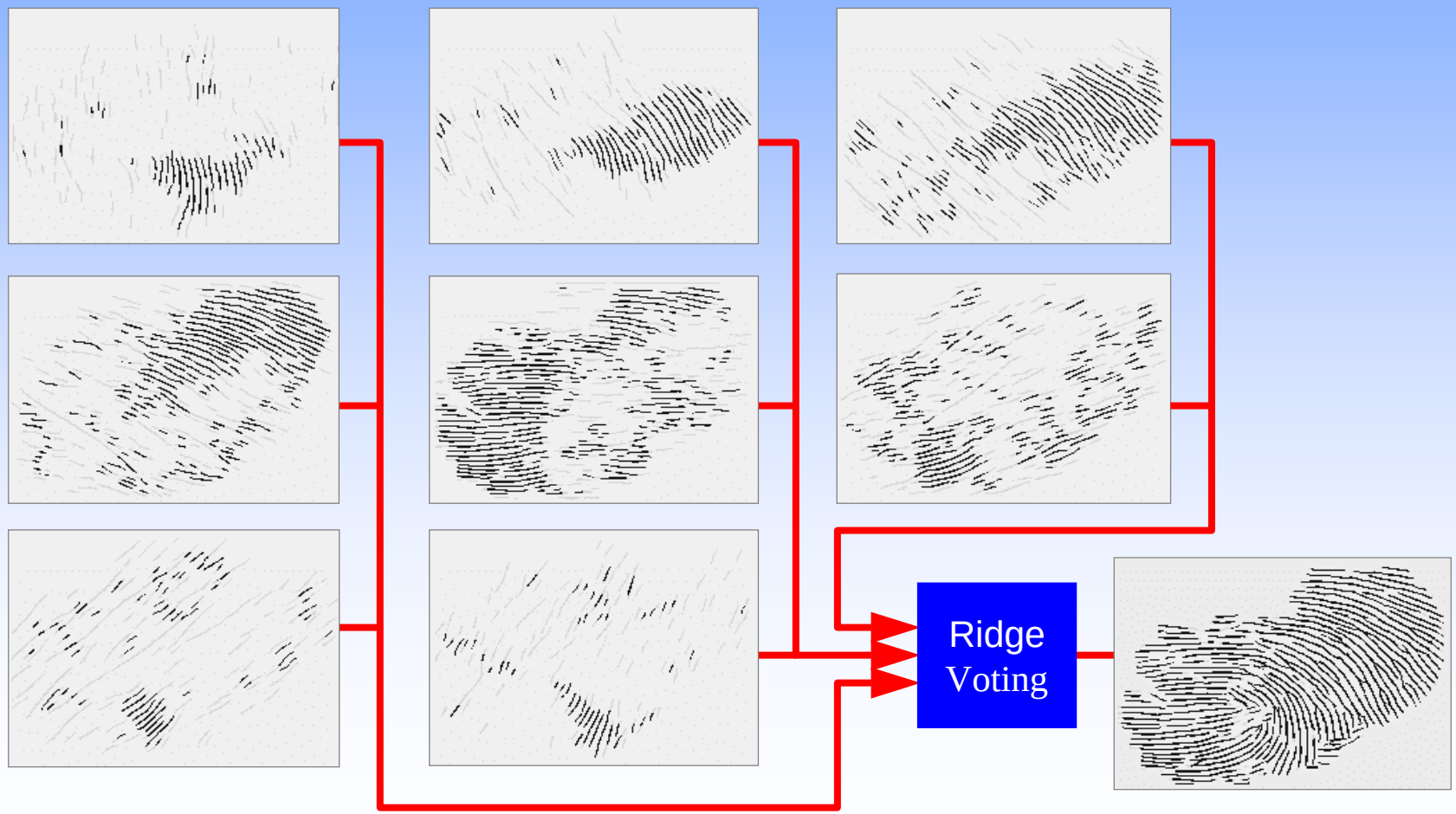
- Gabor filters are both frequency and orientation selective
- A Gabor filter with the correct local orientation and local frequency can remove noise while preserving the true ridges
- The algorithm is computationally intensive and therefore applied only to the template image
- A fast enhancement algorithm is applied to the input images during live verification

Enhancement Algorithm

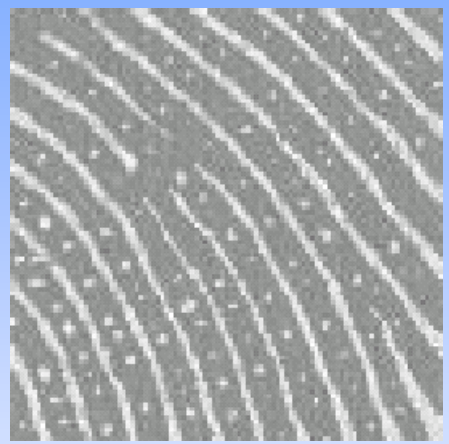


Fingerprint Enhancement

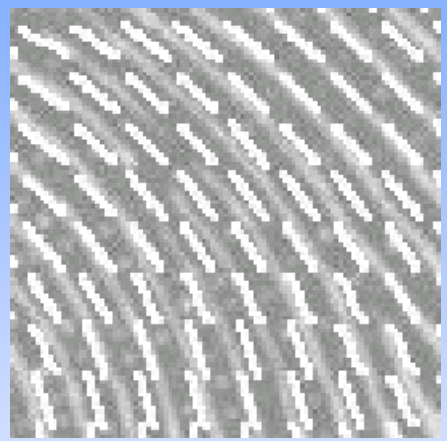
A set of 8 Gabor filters with different orientations is used



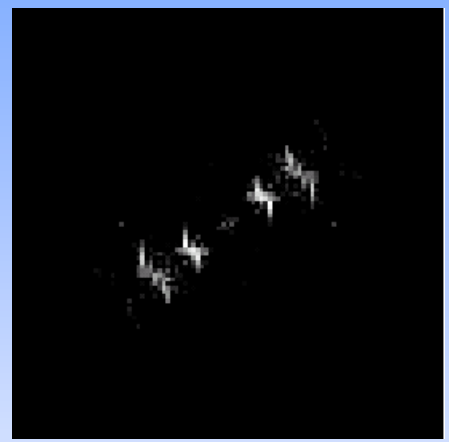
Fingerprint as Oriented Texture



(a) Ridges in local region



(b) Ridge directions in (a)



(c) Fourier spectrum of (a)

The ridge pattern in a fingerprint may be viewed as an oriented texture pattern having a fixed dominant spatial frequency and orientation in a local neighborhood. The frequency is due to the inter-ridge spacing present in the fingerprint and the orientation is due to the ridge flow pattern

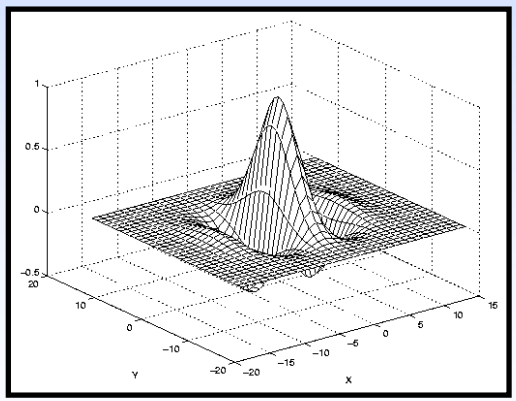
Even-symmetric Gabor Filters

$$G_{\theta,f}(x,y) = exp\left\{\frac{-1}{2}\left[\frac{x'^2}{\delta_x^2} + \frac{y'^2}{\delta_y^2}\right]\right\} cos(2\pi f x'),$$

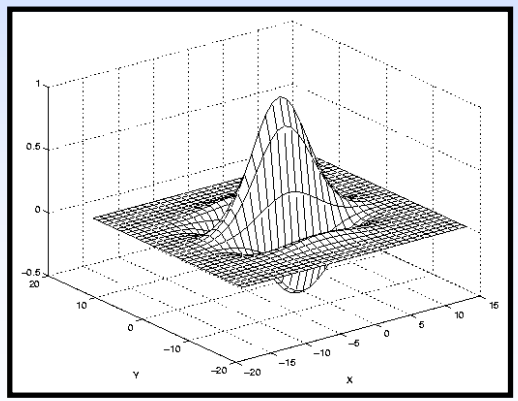
$$x' = xsin\theta + ycos\theta,$$

$$y' = xcos\theta - ysin\theta,$$

where f is the frequency of the sinusoidal plane wave at an angle θ with the x-axis, and δ_x and δ_y are the standard deviations of the Gaussian envelope along the x and y axes, respectively.



0º orientation filter



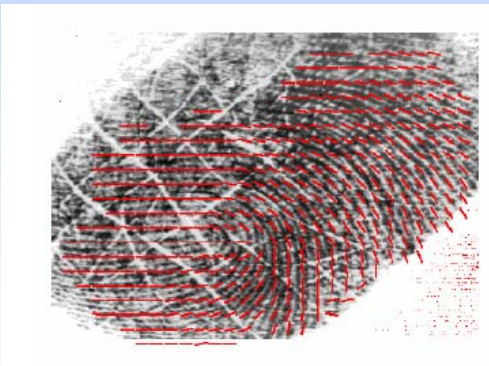
45º orientation filter

Results of Enhancement

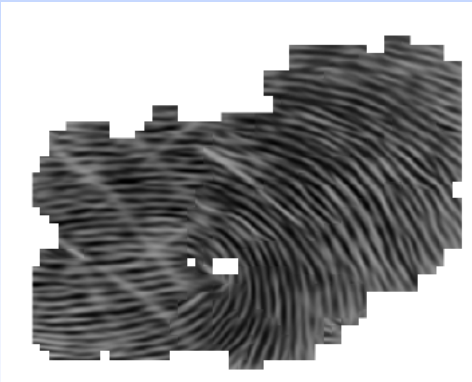
Input image

Coarse ridge map

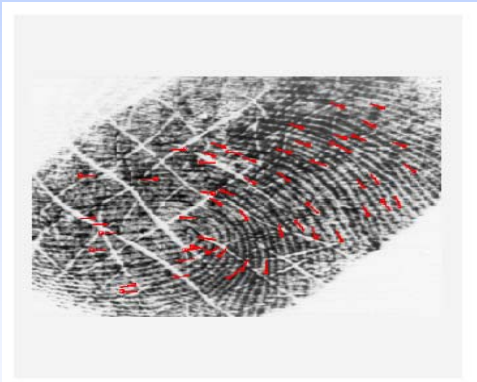
Unrecoverable region mask



Estimated orientation field

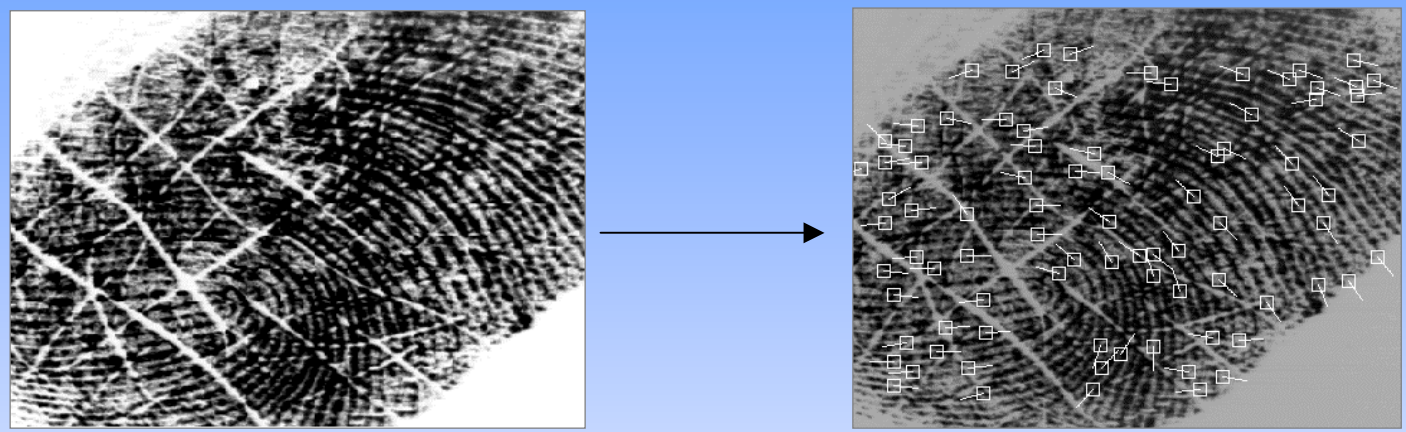


Enhanced image

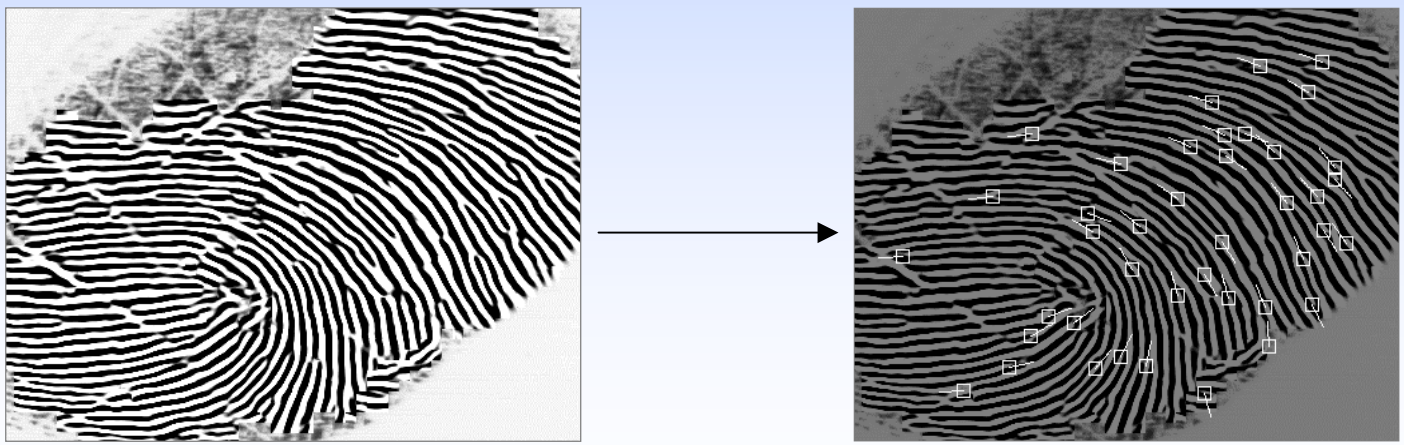


Extracted minutiae

Fingerprint Enhancement

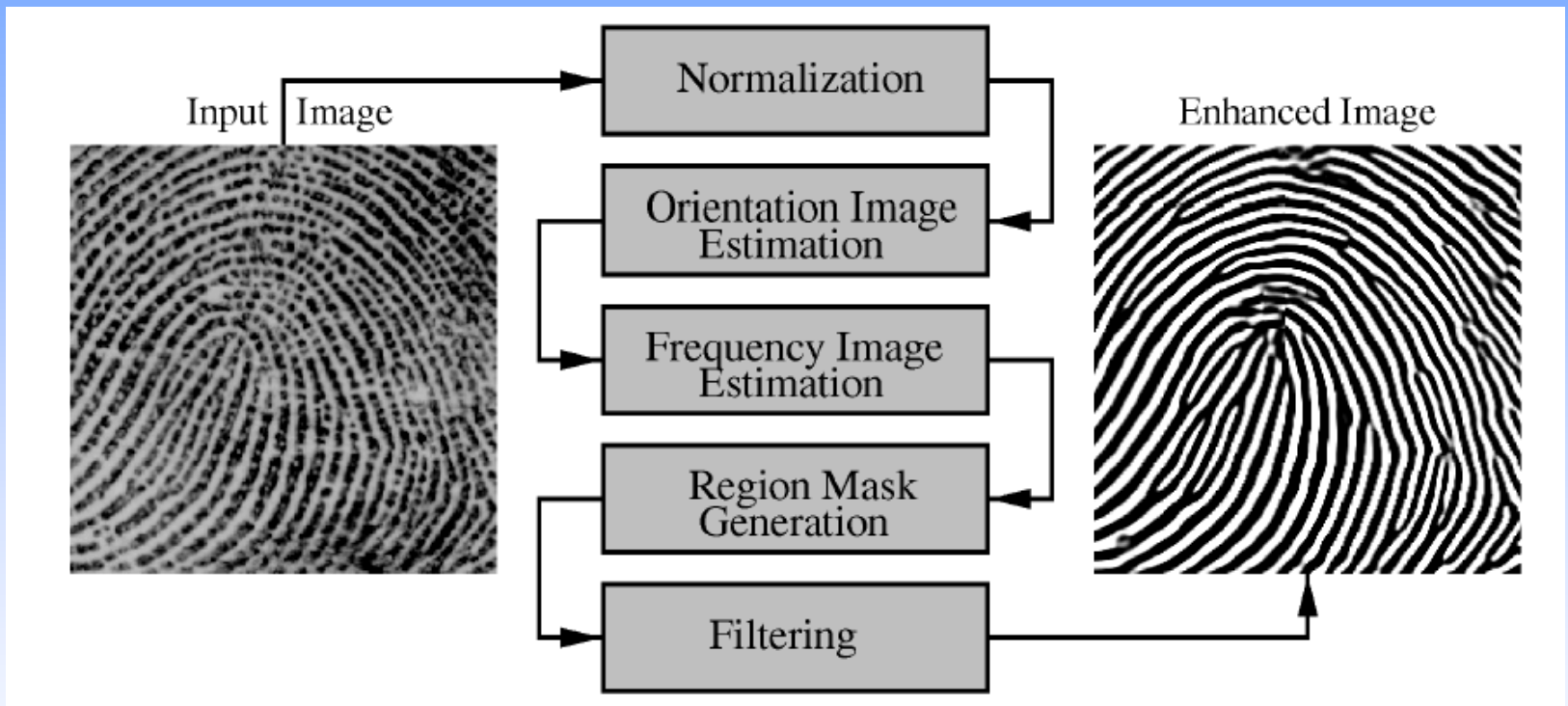


Minutiae extraction before enhancement



Minutiae extraction after enhancement

Fast Enhancement Algorithm



Results of Fast Enhancement Algorithm

Performance with Enhancement

Quantitative evaluation of enhancement module