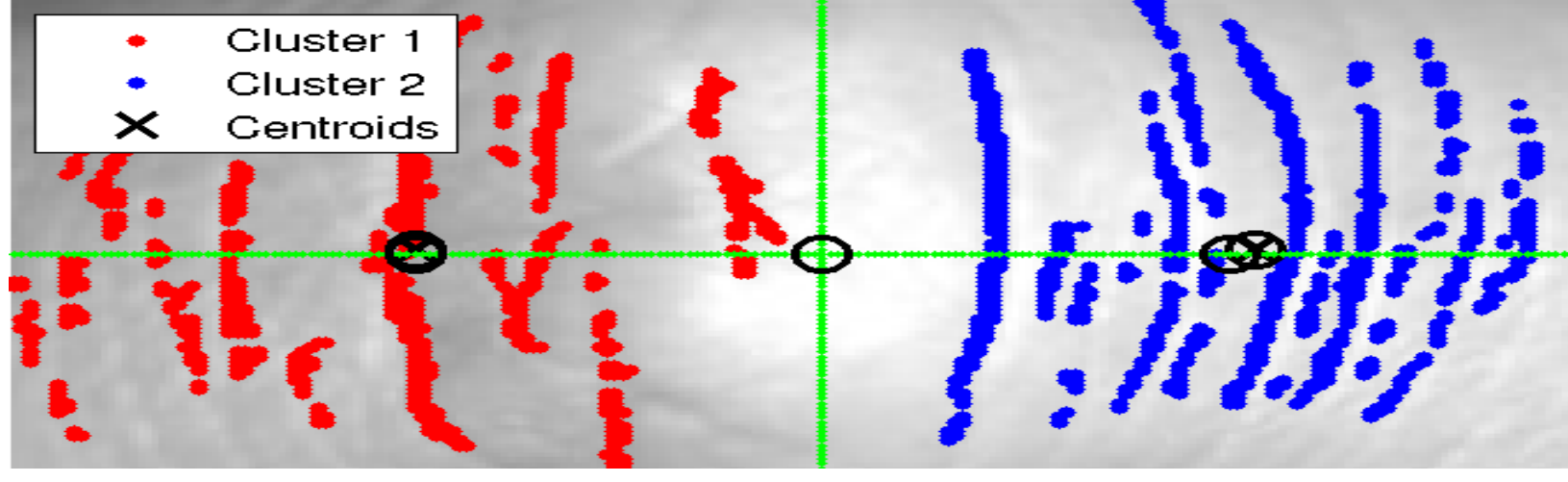
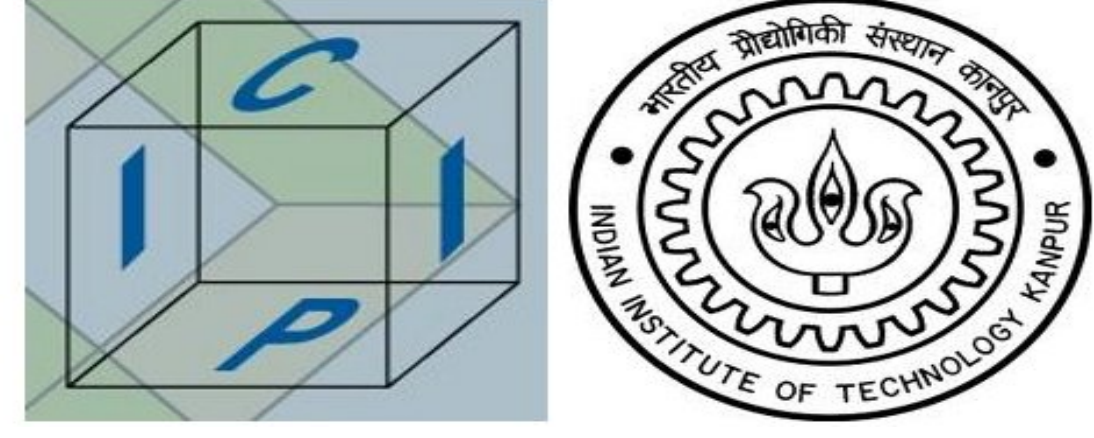


QUALITY ASSESSMENT OF KNUCKLEPRINT BIOMETRIC IMAGES

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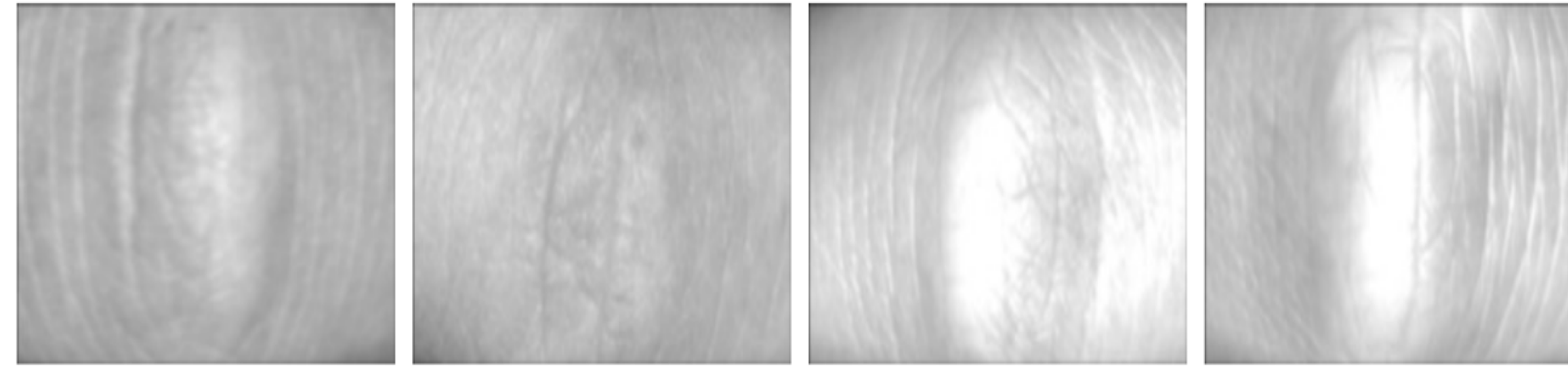
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PROBLEM DEFINITION AND MOTIVATION

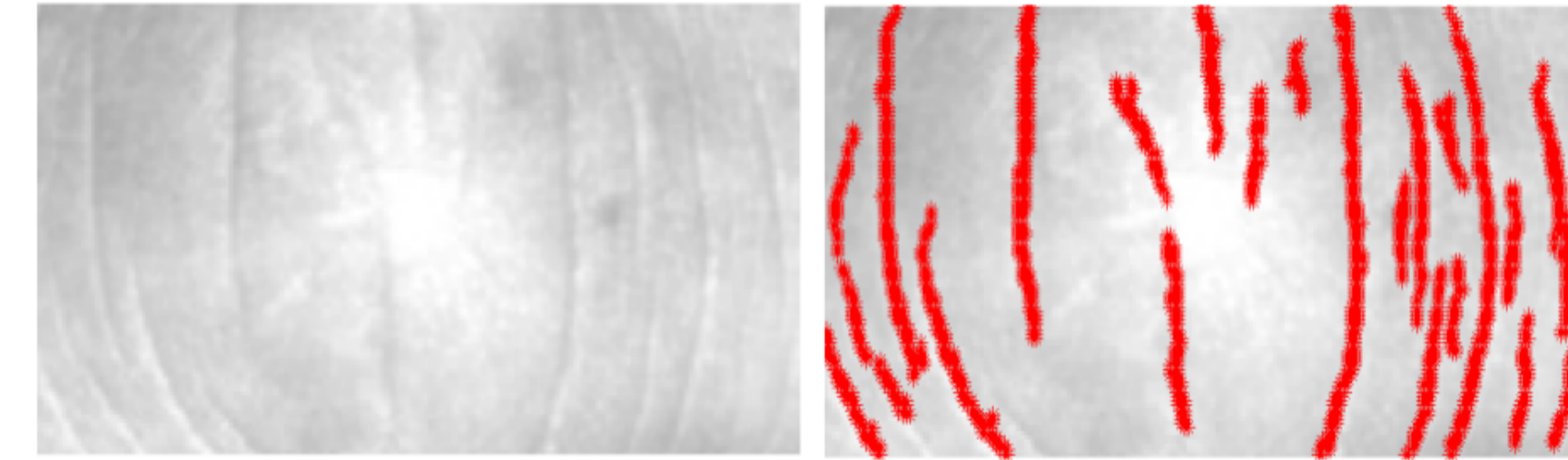
- Image quality plays key role in the performance hence it is done during acquisition phase so as to discard/recapture bad quality images.
- Quality parameters can reveal the type of deficiency that can be used to perform the suitable enhancement technique to reduce its effect.
- The quality of knuckleprint images mainly depends upon the vertical line like features, focus, contrast and reflections produced by the camera flash.
- To our knowledge this is the first work to identify, estimate and quantify some of these quality attributes and later fusing them to obtain an overall quality score for any knuckleprint image.



(a) Defocus (b) Less Features (c) High Reflection (d) Poor Uniformity

VERTICAL LONG EDGES (vle)

- The knuckleprint image quality is obtained by computing the amount of well focus edges **F**, amount of clutter **C**, distribution of focused edges **S**, block-wise entropy of focused edges **E**, reflection caused by light source and camera flash **Re** and the amount of contrast **Con**.
- The most important and vital features in knuckleprint images are vertical long edges (**vle**).
- Pixel set that corresponds to only vertical strong edge pixels is computed using vertical direction sobel kernel over the input image (I) and then the connected components are computed.
- Finally out of all the connected components only long enough (more than an empirically selected threshold t_{cc}) components are retained that constitute the pixel set **vle**.

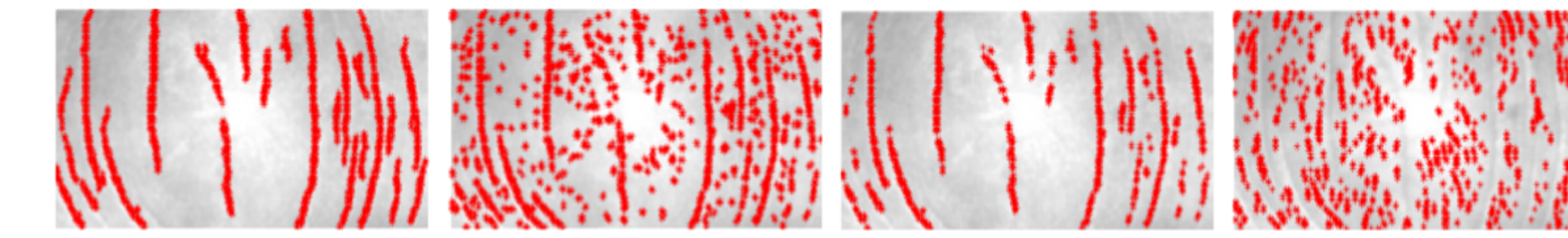


[1] FOCUS (F) AND [2] CLUTTER (C)

- Sample image is convolved by the proposed kernel K and the set of well focused pixels wf is obtained.

$$K = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & -8 & -8 & 1 & 1 \\ 1 & 1 & -8 & -8 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{pmatrix} \quad (1)$$

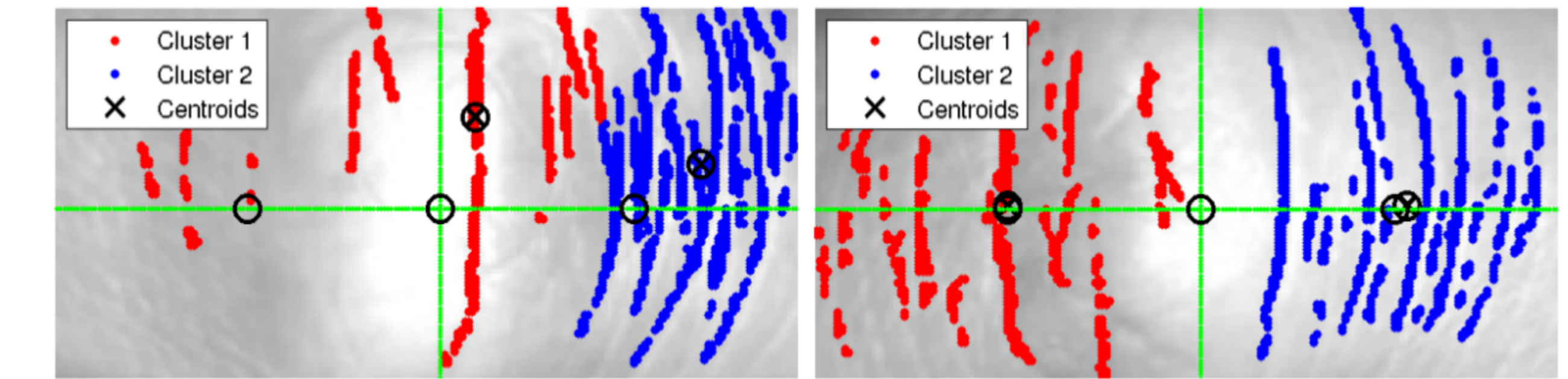
- Focus map F_{map} is the intersection set of two pixel sets vle and wf .
- Focus quality parameter F is defined as the number of well focused vertically aligned long edge pixels.
- Short focused vertical edge pixels degrades the image quality as they are present due to abrupt discontinuity in the edge structure.
- The quality parameter clutter (C) is defined as the ratio of long vertically aligned strong edge pixels and the shorter ones.



(a) vle (b) wf (c) F_{map} (d) Clutter

[3] UNIFORMITY QUALITY ATTRIBUTE (S)

- There are several images having well focused left or right half only.
- The focus parameter F may produce higher scores even though half of the image is of very poor quality. Hence uniformity in texture distribution should have to be given some importance.
- The pixel set F_{map} as defined in focus parameter is clustered using K-Means algorithm using $K = 2$, because knuckleprint images have some symmetry *w.r.t* Y axis.
- Then some statistical and geometrical parameters of the two clusters (*Mean location and Std Dev.*) are used to obtain the value of S .



(e) Non Uniform Texture(0.221) (f) Uniform Texture(0.622)

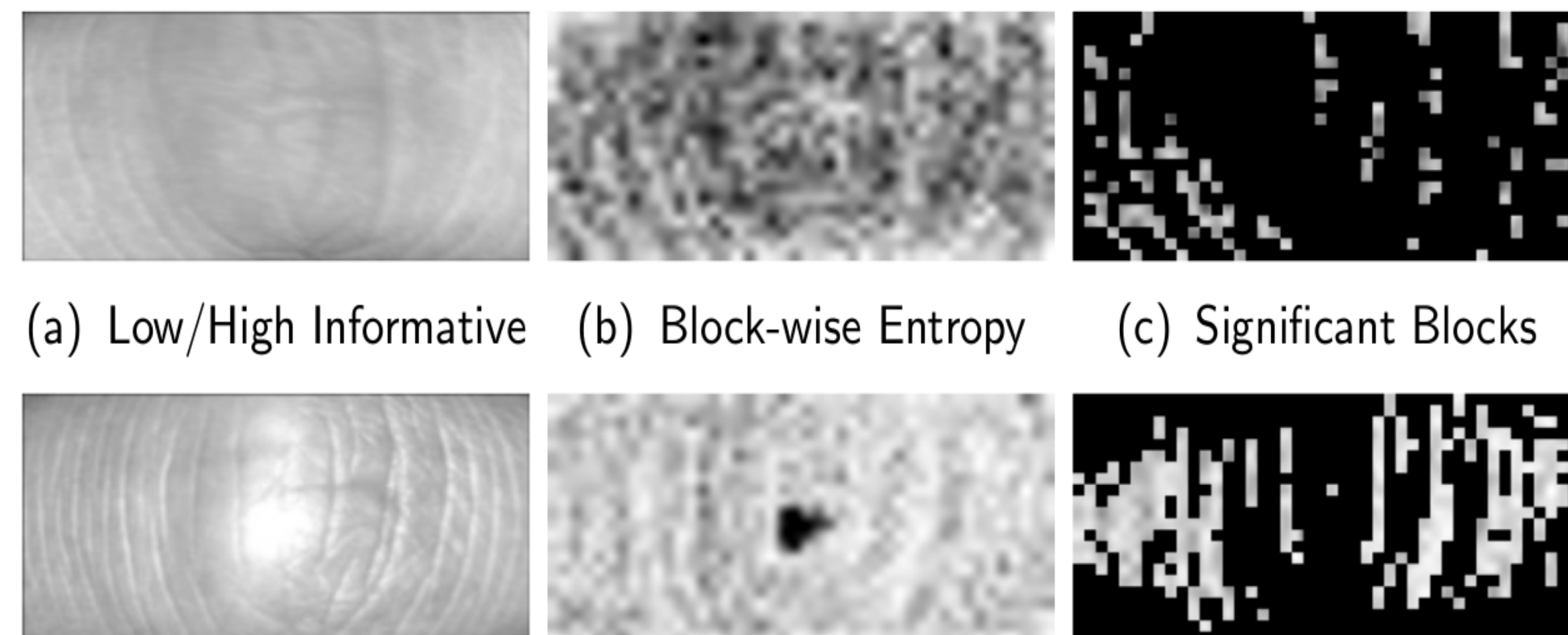
[4] ENTROPY QUALITY ATTRIBUTE (E)

- Entropy in any gray scale image (I) can be defined as:

$$e = - \sum_{i=0}^{255} hist[i] * \log(2 * hist[i]) \quad (2)$$

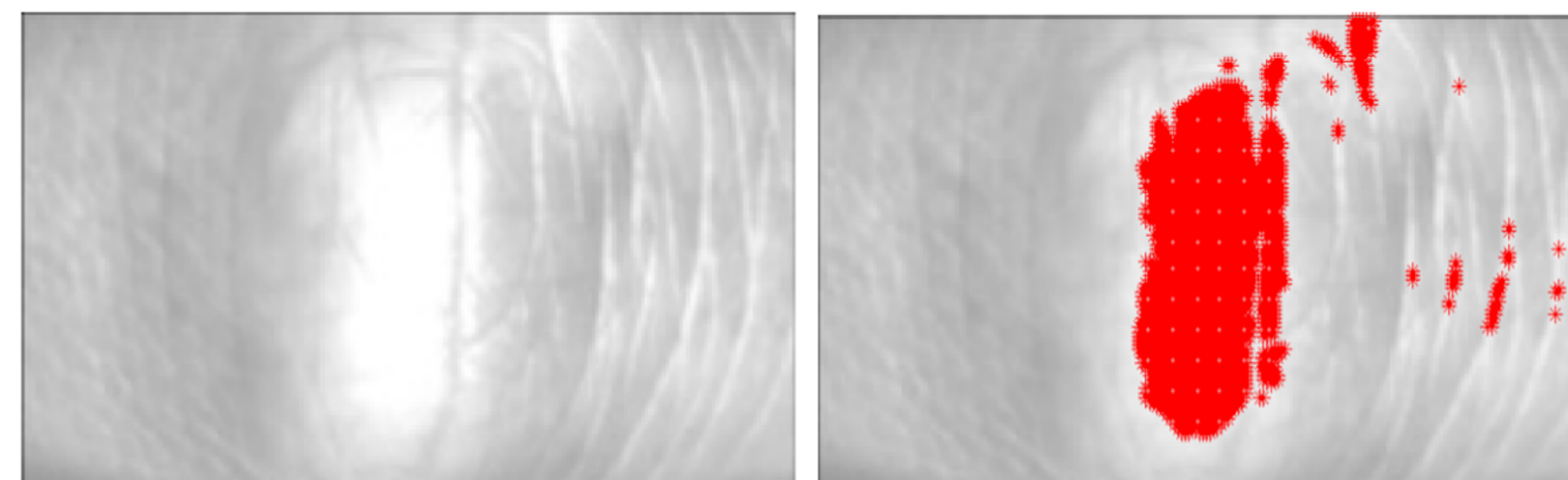
where $hist[i]$ is the i^{th} element of 256 valued gray level histogram $hist$ of the input image I . Block-wise (5×5) entropy computation is done.

- The Entropy of all significant blocks (having focused long vertical edges more than t_{fm}) is summed up, to obtain Quality attribute (E).



[5] REFLECTION QUALITY ATTRIBUTE (Re)

- The sample knuckleprint image is repeatedly thresholded in order to estimate the most accurate reflection patch intensity level starting from a high gray level and gradually reducing it. After each thresholding step number of pixels are calculated.
- This count keeps on changing significantly as some of the nearby area around the reflection patch may not be captured by the previous threshold. This thresholding procedure got terminated when this count got saturated (*i.e* do not change significantly).
- The reflection based quality attribute (Re) is defined as the fraction of pixels belonging to the reflection patch.



[6] CONTRAST QUALITY ATTRIBUTE (Con)

- Often the knuckleprint image quality got severely affected by very poor or heavy lighting conditions. Large illumination variation can reduce the discriminative line based features and hence degrading the overall uniqueness of biometric images.
- Contrast of the input image (I) can give some information about the dynamic gray level range present in the image. Hence, it can be used to infer that image is either too dark or light. Basically, we can use it to estimate the uniformity in illumination through-out the image. Maximum and minimum gray levels are ignored for its estimation.
- The whole gray level range is divided into three groups (0, 75), (76, 235), (236, 255). The contrast based quality attribute (Con) is defined as the fraction of pixels belonging to the mid gray level range (*i.e* (76, 235)) because it indicate the moderated intensity range.

QUALITY BASED RECOGNITION ANALYSIS

- The quality of a match between two images I_1 and I_2 is defined as $\min(Quality_{fused}(I_1), Quality_{fused}(I_2))$.
- Finally the quality of a match obtained is divided into 7 quality levels $q_i \forall i \in 1 \dots 7$ with q_7 as the best quality.
- 7 ROC curves are drawn by considering matchings of quality level (q_i) at-least up-to $q_i \forall i \in 1 \dots 7$.

