Fingerprint Image Quality Parameters

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Abstract

The quality of fingerprint image determines the performance of the fingerprint recognition system. Poor quality of images results in high false reject rates (FRR) and failure to enrol (FTE) rates. Quality parameters of a fingerprint image gives the ability of a fingerprint scanner to acquire images that maximize the accuracy of automated recognition algorithms. In this articleparameters, a signal to noise ratio (SNR), Gray level uniformity, Spatial Frequency Response, Geometric Accuracy for fingerprint images is proposed. The merit of this approach lies in its ability to differentiate between the poor quality Images and the good quality images.

Keywords- *Biometrics, Modulation Transfer function, Fingerprint scanner, Parameters, Image Quality, Noise*

I. INTRODUCTION

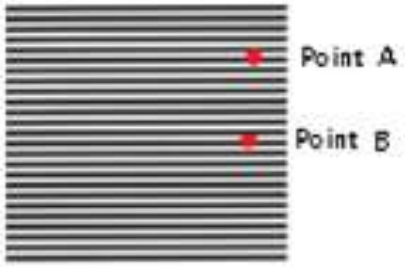
The Integrated Automated Fingerprint Identification System (IAFIS) Appendix F Standard and Personal Identity Verification (PIV) Specification are internationally acclaimed standards for validating the quality of the biometric images. These standards are used universally as a yardstick to determine the level of quality of the biometric images. Different test parameters are defined for enrollment and verification fingerprint scanners in the ISO/IEC 19794-4:2011 and PIV Specification.
Unique Identification Authority of India (UIDAI) has also specified these parameters. There are mainly six parameters defined in the ISO/IEC 19794-4:2011 which describes the overall quality of the captured fingerprint images

1. Gray scale Linearity Output
2. Geometric Image Accuracy
3. Signal-to-Noise Ratio
4. Spatial frequency response:
    - Modulation Transfer Function
    - Contrast Transfer Function
5. Gray Level Uniformity
6. Fingerprint image Quality

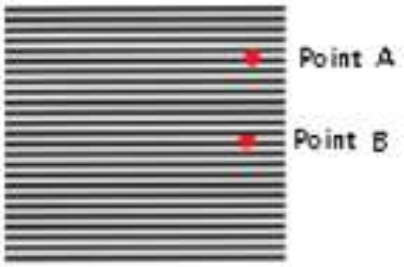
In this paper four parameters are used for the quality of fingerprint image scanners. Experimentation on the target images captured from the scanner is done on MATLAB.

1.1. Geometric Image Accuracy:

This parameter measures the absolute value of the difference "D", between the actual distance "X" between any two points on a target and the distance "Y" between those same two points as measured on the output scanned image of that target[3]. The requirement corresponds to a positional accuracy of plus or minus 1% for distance between 1,778mm (0.07inches)
The geometric image accuracy is measured using precision 1 cycle per millimetre Ronchi targets on white polyethylene terephthalate (mylar) reflective base.



X = Point A- Point B on the Target



Y = Point A- Point B on the Target image

Now D = X-Y which should be $D \leq 0.0007$ inch

Figure !

1.2 Spatial Frequency Response (SFR):

The Spatial frequency response is the measurement of the scanner's resolution. There are three types of targets that can be used to measure the Spatial Frequency response depending on the type of fingerprint scanner. For image quality testing of fingerprint scanners, following test targets are used:

- Continuous Sine wave target
- Bar Target
- Edge Target

In this paper we have used only Edge target for determining the quality of fingerprint images.

The spatial frequency response is measured using a continuous tone sine wave target denoted as Modulation Transfer Function (MTF) measurement.[1] If the scanner cannot obtain adequate tonal response from this target, in which case a bi-tonal bar target is used to measure the spatial frequency response, denoted as Contrast Transfer Function (CTF) measurement.

If the device cannot use a bar target or sine wave target, i.e., a useable/measurable image cannot be produced with one of these targets, then an edge target can be used to measure the MTF.

Frequency (f) in cy/mm at object plane[5]	Minimum CTF Modulation when using Bar Target	Minimum MTF Modulation when using Sine Wave or Edge Target
1.0	0.920	0.871
2.0	0.822	0.734
3.0	0.720	0.614
4.0	0.620	0.510
5.0	0.526	0.421
6.0	0.440	0.345
7.0	0.362	0.280
8.0	0.293	0.225
9.0	0.232	0.177
10.0	0.174	0.135

Table 1[4]

MTF/CTF measurement is the resolution described in the spatial frequency domain for the image sources like optical sensors, image processors etc. SFR is measured in both the horizontal direction and the vertical direction.

Using MATLAB code is prepared for the calculation of Spatial frequency response which gives the SFR values for cycles in the target image. If the output result is with in the limits as prescribed in the standard then the quality of image is considered good. For all the frequencies between 1 to 10 cy/mm , the MTF and CTF values are shown. As per ISO/IEC 19794-4:2011 the specified limits for the scanners are indicated as under in Table-1.

1.3 Signal-to-noise (SNR)

The noise is the unwanted signal that accompanies the image and distorts it. This noise is calculated for both the white noise as well as the black noise[1]. As per IAFIS standard, the ratio of signal to white noise standard deviation and the ratio of signal to black noise standard deviation of the digital scanner shall be greater than or equal to 125 for authentication as well scanners[2].

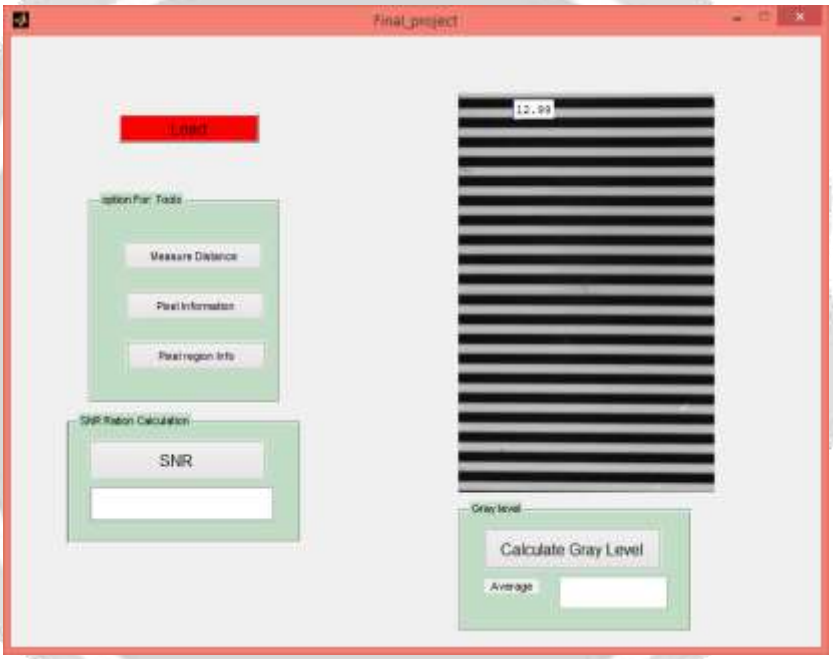
SNR can be calculated as under :
SNR = 20 log (μ/σ);
Where, μ = Mean Gray Level,
σ = Standard deviation

1.4 Fingerprint Gray Range

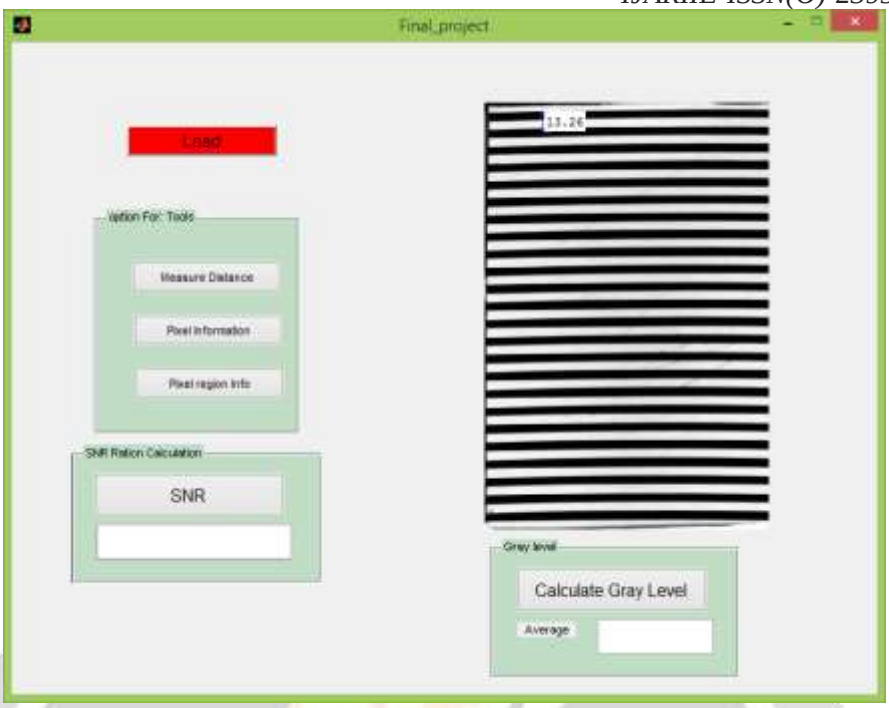
It is the total number of gray levels that have signal content from the fingerprint image. As per IAFIS standard ,at least 80% of the captured individual fingerprint images shall have a gray-scale dynamic range of at least 200 gray levels and at least 99% shall have a dynamic range of at least 128 gray levels MATLAB code gives the average gray level value of the fingerprint image.

II. RESULTS

Geometric accuracy is measured as under:



a) Distance of two points on target image (X)



b) Distance of two points on target (Y)

Figure 2: Geometric Accuracy Measurement

D=X-Y here X=13.26 pixels and Y= 12.99 pixels

D= 13.26-12.99=0.27 = .0028 inches

SNR of white image measurement is shown in figure 3.

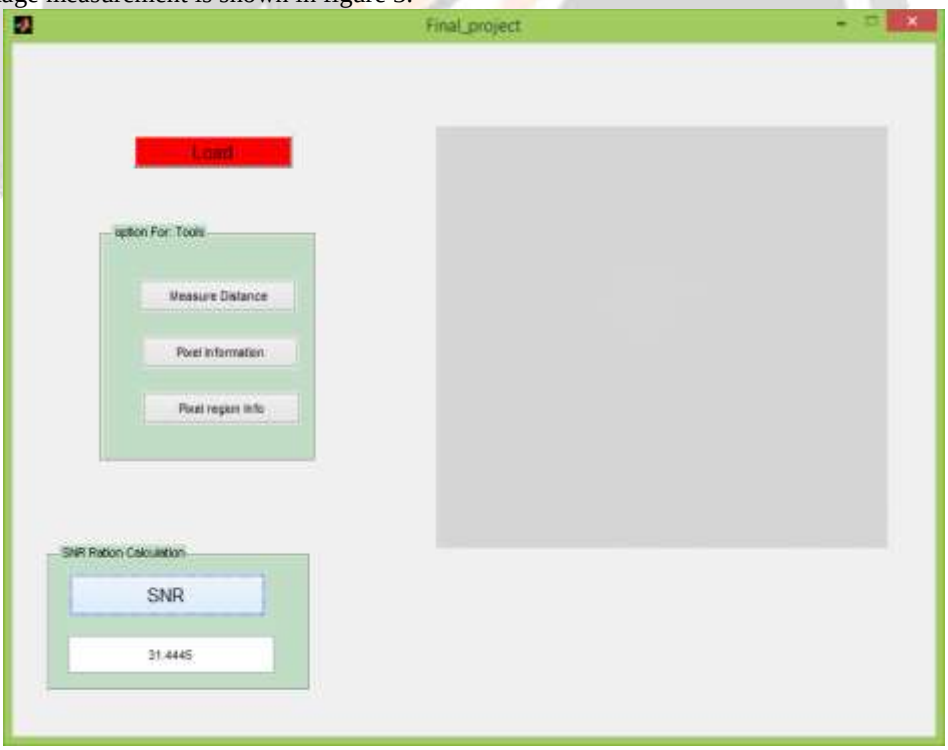


Figure 3

SNR of black image is shown in figure 4.

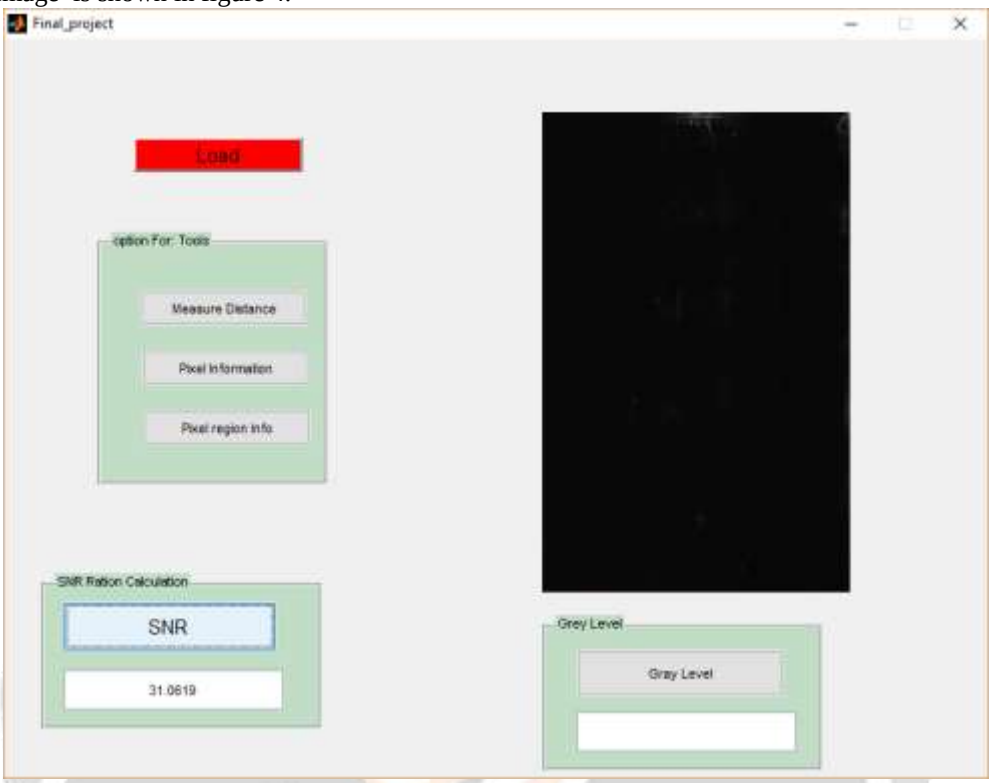


Figure 4

Fingerprint Gray Range is measured as shown in figure 5.

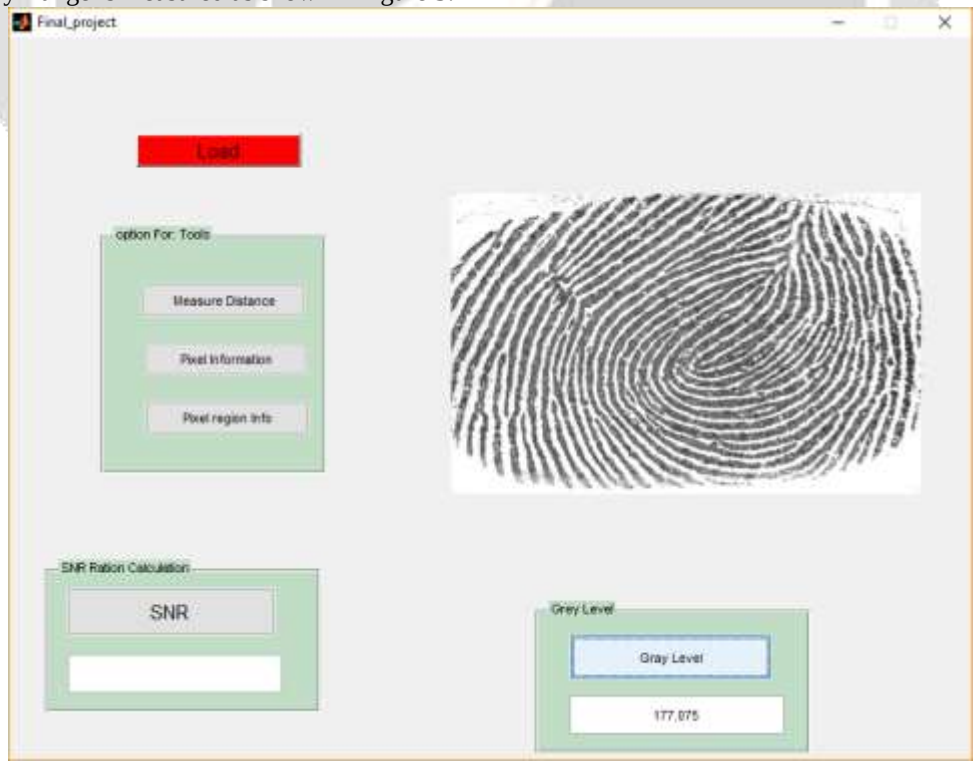
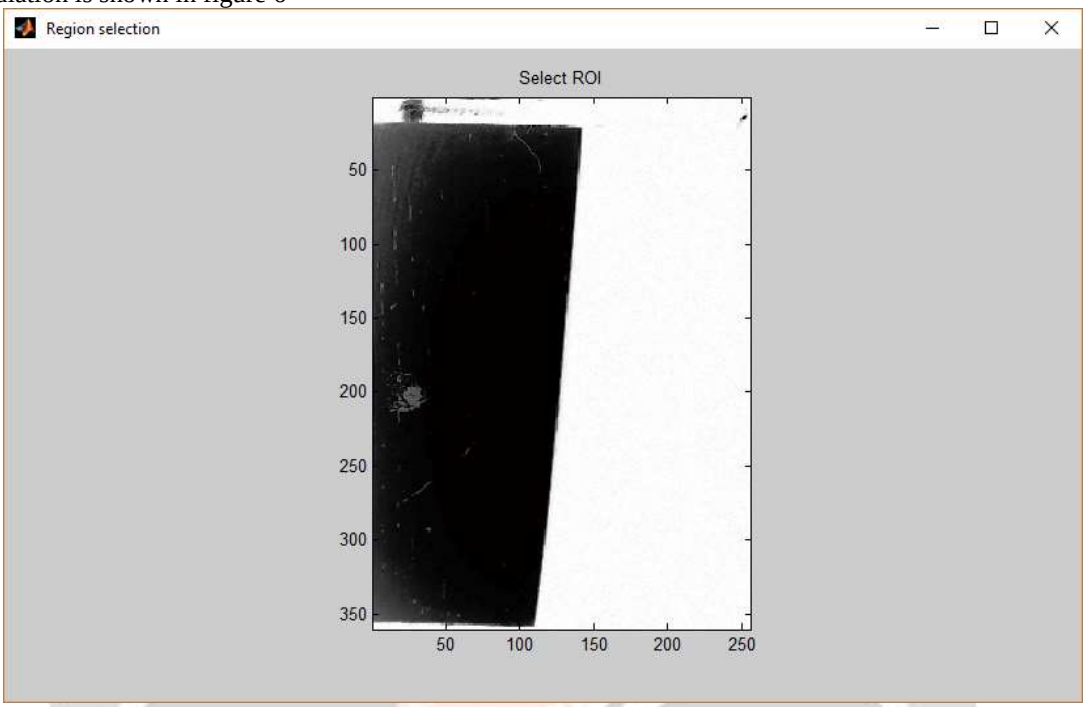


Figure 5

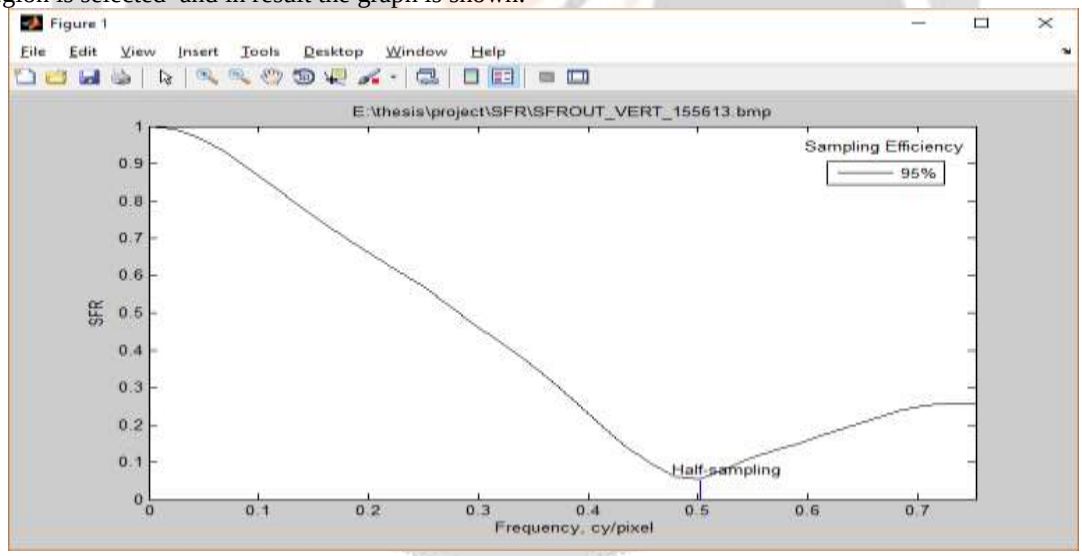
Average gray range should be greater the 150

MTF calculation is shown in figure 6



a) ROI selection

Desired region is selected and in result the graph is shown:



b) Result

From this graph MTF at specified cycles can be calculated.

III. CONCLUSION

The paper described the parameters defined in the ISO/IEC 19794-4 2011(E) standard with the help of the MATLAB which is used for the code simulation. By this the quality of the fingerprint image captured from a fingerprint scanner can be determined and the scanner not fulfilling the standard's requirements can be rejected.

REFERENCES

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