Comparative Analysis of Image Enhancement Technique for Hyperspectral Palmprint Images

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ABSTRACT
Image Enhancement is one of the most important and difficult techniques, also the first stage in the pre-processing of images which have to be subjected to image recognition algorithms. The goal of image enhancement is to improve the quality of images. Palmprint image quality is an important factor in the performance of hyperspectral palmprint recognition system. To the best of knowledge there is no evidence of work specifically directed towards image enhancement techniques on hyperspectral palm print images. In this paper different thirteen types of image enhancement techniques are compared based on image quality measure (subjective and objective), subjective image quality measure based on histogram and objective quality measure is based on mean square error (MSE), Peak signal to noise ratio (PSNR), Normalized cross correlation (NK), Average difference (AD), Structural content (SC), Maximum difference (MD), Normalized absolute error (NAE). Such a comparison would be useful in determining the best suited image enhancement method for hyperspectral palmprint. Median filter gives good performance as compare to other image enhancement techniques. The performance of different thirteen image enhancement techniques are tested on PolyU hyperspectral palmprint database. The comparative results are tabled.

General Terms
Image processing

Keywords
Image Enhancement, image quality measure, Spatial and frequency Domain, Image restoration,

1. INTRODUCTION
Image enhancement plays an important role in digital image processing [1]. When any image is captured through device, the clarity of image can be affected by optic, weather, sensor limitations, and different illumination conditions. These may lead to image information lose or poor quality. The main aim of image enhancement is to get more details of an image that is hidden in an image and highlight the useful information. In this process input low quality images are passes and the output high quality images are used for specific application.

In day to day life there is frequent need in identifying and verifying person correctly, obviously high accuracy is required during the identification [2].

The work on hyperspectral palmprint recognition is quite limited in literature. Hyperspectral imaging offers new opportunities for palmprint recognition, hyperspectral images are rich in information, processing the hyperspectral data poses several challenging task. Hyperspectral imaging may be useful for increasing the accuracy because of its high dimensionality.

In this paper total different thirteen image enhancement techniques are used which is categorized in three types first spatial domain enhancement including negative Image, logarithmic transformation, power law transformation, second frequency domain enhancement like Butterworth low pass filter, Butterworth high pass filter, Gaussian Low pass filter, Gaussian High Pass filter, and third image restoration such as contrast limited adaptive histogram equalization (CLAHE), Adjusted Image, Median filter, 2D order statics, Adaptive filter, Decorrelation Stretch.

It is often necessary to measure the quality of the different thirteen image enhancement techniques this can be done by using, “Image quality measure”, which categorized into two types subjective and objective image quality measure [3]. In subjective quality measure the quality of image is evaluated by using histogram based on human observance while objective quality measure based on statistical parameter. However, Subjective quality measure is time consuming process, inconvenient and expensive, too slow for practical usage, and varies from person to person; therefore it is important to use objective image quality measure. Objective image quality is measured using seven different types of quality measure like Mean square error (MSE), peak signal to noise ratio (PSNR), maximum difference (MD), Normalized cross correlation (NK), Normalized absolute error (NAE), absolute difference (AD) [4].

The organization of this paper is given as follow Section 2 discusses the description of PolyU Hyperspectral palmprint database; Section 3 discusses the development of various image enhancement techniques. Section 4 reviews the image quality measure Section 5 result analysis and comparison; section 6 discussed the conclusion of the paper.

2. HYPHERSPECTRAL PALMPRINT DATABASE
A large hyperspectral palmprint database is developed by the Biometric Research Center at Department of Computing, the Hong Kong Polytechnic University. Images were collected from 190 individuals. The age distribution was from 20 to 60 years old. The samples have been collected in two separate sessions. The average time interval between the two sessions was around 1 month. In each session, the subject was asked to provide around seven cubes of each of his/her left and right palms, so the database contains 5240 images for each band from 380 different palms and the size of each palmprint is 128*128 pixels [5].

3. IMAGE ENHANCEMENT

The reason for doing image enhancement are higlighting interesting detail in images, removing noise and making images more visually appealing, and find out the best image enhancement technique based on image quality measure for hyperspectral palmprint images. The Different image enhancement technique as fallows

3.1 Spatial Domain Enhancement

Spatial domain enhancement method is based on direct manipulation of pixels in an image.

$$g(x, y) = T[f(x, y)] \quad (1)$$

Spatial domain image enhancement techniques are categorized into three types as fallows.

3.1.1 Negative Image

Negative images are useful for enhancing white or grey detail embedded in dark regions of an image; each value of the input image is subtracted from the L-1 and mapped onto the output image.

3.1.2 Logarithmic Transformation

The log transformation maps a narrow range of low input grey level values into a wider range of output values [6]. The inverse log transformation performs the opposite transformation; they are especially useful for bringing out detail in an image.

3.1.3 Power law Transformation

Map a narrow range of dark input values into a wider range of input values or vice versa, where c and γ are positive constants.

$$s = c * r ? \quad (2)$$

3.2 Frequency Domain Enhancement

Frequency domain techniques are based on the manipulation of the orthogonal transform of the image rather than the image itself. The basic model for filtering is:

$$G(u, v) = H(u, v)\, F(u, v) \quad (3)$$

Frequency domain image enhancement techniques are categorized into four types as fallows.

3.2.1 Butterworth low pass filter

The transfer function of a Butterworth low pass filter of order n with cut off frequency at distance D0 from the origin is defined as

$$H(u,v) = \frac{1}{1+[D(u,v)/D_0]^{2n}} \quad (4)$$

3.2.2 Gaussian Low pass filter

The transfer function of a Gaussian low pass filter is defined as:

$$H(u,v) = e^{-D^2(u,v)/2D_0^2} \quad (5)$$

3.2.3 Butterworth Highpass filter

The Butterworth high pass filter is given as:

$$H(u,v) = \frac{1}{1+[D_0/D(u,v)]^{2n}} \quad (6)$$

3.2.4 Gaussian High pass filter

The Gaussian high pass filter is given as:

$$H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2} \quad (7)$$

3.3 Image Restoration

It deals with improving the appearance of an image. The Image is corrected using different image restoration technique with improving the appearance of an image.

3.3.1 Contrast limited Adaptive Histogram Equalization

Contrast Limited Adaptive Histogram Equalization (CLAHE) is a generalization of Adaptive Histogram Equalization and used to prevent the problem of noise. By using this method the hidden features of the image more visible. The method has three parameters.

3.3.2 Median filter

As the name clear the median filter is statistics method. In median filter the median of the pixel the replace the pixel by median of the gray levels in their neighborhood of that pixel [7]. Median filter is best because of its excellent noise reduction ability from the images. By the filtering it keeps the edges while removing the noise.

3.3.3 Adjusted Image

Adjust image maps the intensity values in image to new values in such that 1% of data is saturated at low and high intensities of input image. This increases the contrast of the output image.

3.3.4 2D-Order-statistic Filter

2D order statistic filter working with large domain matrices that do not contain any zero-valued elements, ordfilt2 can achieve higher performance if input image is in an integer data format (uint8, int8, uint16, int16). The gain in speed is larger for uint8 and int8 than for the 16-bit data types.

3.3.5 2D- Adaptive Filter

Adaptive Wiener method based on statistics estimated from a local neighborhood of each pixel, and the objective is to find an estimate f^ of the uncorrupted image f such that the mean square error between them is minimized. This error measure is given by

$$e2 = E\{(f - f^\wedge)\, 2\} \quad (8)$$

3.3.6 Decorrelation Stretch

A decorrelation stretch is a linear, pixel-wise operation in which the specific parameters depend on the values of actual and desired (target) image statistics. The vector a containing the value of a given pixel in each band of the input image A is transformed into the corresponding pixel b in output image B as follows:

$$b = T * (a - m) + m\_target. \quad (9)$$

4. IMAGE QUALITY MEASURE

Image Quality measure are essential for most image processing application, is a characteristic of an image that measures the perceived image degradation compared to an ideal or perfect image [8]. There are two types of image quality measure.

4.1 Subjective Image Quality

Subjective measurements are the result of human experts providing their opinion of the image quality but the result vary person to person. In subjective measurements the quality of image is decided by using histogram. Histogram manipulation can be used effectively for image enhancement technique.

Histograms are simple to calculate in software and also lend themselves to economic hardware implementations, thus making them a popular tool for real-time image processing. Histogram is the graphical representation of gray level values (0-255) of image against frequency. Histogram is categorized into four basic gray-level characteristics: dark, light, low contrast, and high contrast [9].

In Dark image the components of the histogram are concentrated on the low (nearer 0) side of the gray scale. Similarly, the components of the histogram of the bright image are biased toward the high side of the gray scale. In low contrast the component of the histogram will be centered toward the middle of the gray scale. Histogram in the high-contrast image cover a broad range of the gray scale and, further, that the distribution of pixels is not too far from uniform, with very few vertical lines being much higher than the others. High contrast image gives the good quality.

4.2 Objective Image Quality

Objective measurements are performed with mathematical algorithms. The objective Image Quality measure (IQM) can be classified into full-reference, reduced-reference and no-reference. FR criteria are also a function of the original image which is assumed to be free from distortions (called the "reference image"). RR criteria require a partial knowledge of the reference image (this knowledge is called the "reduced reference"). At last, NR criteria don't have any information about the reference image [10].

The simplest and most widely used full-reference quality metric is the mean squared error (MSE), computed by averaging the squared intensity differences of distorted and reference image pixels, along with the related quantity of Peak Signal-to-Noise Ratio (PSNR). These are appealing because they are simple to calculate, have clear physical meanings, and are mathematically convenient in the context of optimization.

5. RESULTS AND ANALYSIS

The image of hyperspectral palmprint is of high resolution and useful data are presents in a spectral band. To enhance the quality of palmprint image, different thirteen types of image enhancement technique are used, and the quality of the image is decided by using image quality measure.

As show in fig 1 the histogram component of negative and logarithmic transformation is low contrast because the histogram component will be centered toward the middle of the gray scale, so the quality of the image is poor, while power law transformation having dark image, In case of adjust image and Decorrelation stretch the component of the histogram some people think like the image low contrast or may be light image so the decision varies from person to person, because result by subjective image quality measure are human observer and time consuming, objective quality measure are used to find out the best image enhancement technique for hyperspectral palmprint recognition. Hyperspectral PolyU database contain 69 spectral bands (420-1100) but the first ten and the last five spectra are removed due to the low quality of images [8], therefore 54 spectral bands (520-1050), are used for experiment.

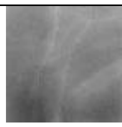
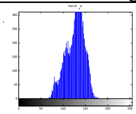
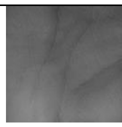
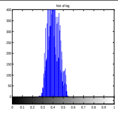
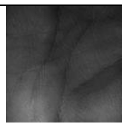
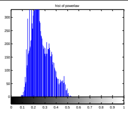
Spatial Domain Enhancement	Enhanced Image	Histogram of Enhanced Image
Negative Image		 Low Contrast
Logarithmic Transformation		 Low Contrast
Power Law Transformation		 Dark mage

Fig 1: Spatial Domain Enhanced Image and its histogram

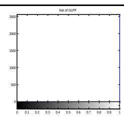
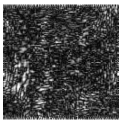
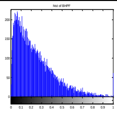
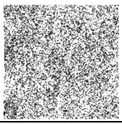
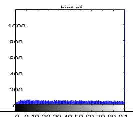
Frequency Domain Enhancement	Enhanced Image	Histogram of Enhanced Image
Gaussian Lowpass Filter		
Butterworth Highpass filter		
Gaussian Highpass Filter		

Fig 2: Frequency Domain Enhanced Image and its histogram

Table 1 shows the seven objective image quality measure and there parameter based on that, the quality of image depends on the lower and higher score value.

Table 1. Image Quality Parameter

Sr. No	IMAGE QUALITY MEASURE	QUALITY OF IMAGE
1	Mean Square Error	Lower MSE Value provide Lower Quality
2	Peak Signal to noise Ratio	Higher PSNR value provide higher Quality
3	Normalized Cross correlation	Score Value range of one higher quality
4	Average Difference	Higher MD value provide lower Quality
5	Structural Content	lower SC Value provide higher quality
6	Maximum difference	Higher MD value provide higher Quality
7	Normalized Absolute Error	large value of NAE means that image is poor quality

As shown in table 2 the image quality assessment of 54 spectral bands and their objective quality measure, for median filter image enhancement technique. Similarly for remaining image enhancement technique objective quality measure are calculated. As show in table 3 the median filter image enhancement technique gives good result as compare to other image enhancement technique, the MSE value for median filter is 14.6, PSNR= 36.6, NK= 0.99 and so on, therefore according to the table 1 median filter gives good quality of image which is used for the feature extraction and further process of hyperspectral palmprint images.

Table 2. Comparison of Objective Image Quality Metrics for Median filter

Original Image+ Median filter							
Spectral Band	**MSE**	**PSNR**	**NK**	**AD**	**SC**	**MD**	**NAE**
520	31.96	33.08	0.997	0.15	1.003	151	0.024
530	15.78	36.15	0.999	0.07	1.001	157	0.016
540	27.64	33.72	0.998	0.02	1.001	166	0.025
550	13.22	36.92	0.999	0.08	1.002	155	0.015
560	18.03	35.57	0.998	0.07	1.002	159	0.02
570	13.7	36.76	0.999	0.05	1.001	153	0.016
580	50.75	31.08	0.996	0.18	1.006	138	0.036
590	18.15	35.54	0.998	0.12	1.003	142	0.021
600	16.5	35.96	0.998	0.12	1.003	140	0.02
610	12.79	37.06	0.999	0.11	1.002	142	0.017
620	14.43	36.54	0.998	0.1	1.002	126	0.019
630	15.65	36.19	0.998	0.12	1.003	114	0.02
640	9.455	38.37	0.999	0.09	1.002	137	0.014
650	10.63	37.87	0.999	0.11	1.002	141	0.015
660	13.17	36.94	0.998	0.15	1.003	140	0.018
670	9.397	38.4	0.999	0.13	1.002	132	0.014
680	10.45	37.94	0.999	1	1.002	134	0.015
690	11.74	37.43	0.999	0.15	1.003	130	0.017
700	11.53	37.51	0.998	0.17	1.003	132	0.016
710	9.417	38.39	0.998	0.15	1.003	136	0.014
720	10.43	37.95	0.998	0.16	1.003	126	0.016
730	9.441	38.38	0.999	0.14	1.002	135	0.014
740	13.11	36.95	0.998	0.18	1.003	114	0.019
750	10.83	37.78	0.998	0.16	1.003	126	0.016
760	17.96	35.59	0.998	0.18	1.004	85	0.022
770	20.61	34.99	0.997	0.2	1.004	93	0.024
780	13.88	36.71	0.998	0.14	1.003	105	0.019
790	16.78	35.88	0.997	0.24	1.005	105	0.022
800	15.25	36.3	0.998	0.17	1.003	130	0.02
810	11.75	37.43	0.998	0.17	1.003	125	0.017
820	17.63	35.67	0.997	0.21	1.004	99	0.022
830	19.72	35.18	0.997	0.23	1.005	97	0.024
840	21.59	34.79	0.997	0.23	1.005	89	0.025
850	24.34	34.27	0.997	0.26	1.005	82	0.027
860	7.469	39.4	0.999	0.1	1.002	173	0.011
870	10.98	37.73	0.998	0.18	1.003	128	0.016
880	12.19	37.27	0.998	0.17	1.003	126	0.018
890	13.25	36.91	0.998	0.19	1.004	112	0.019
900	15.03	36.36	0.998	0.2	1.004	103	0.02
910	14.62	36.48	0.998	0.18	1.003	96	0.02
920	13.59	36.8	0.998	0.17	1.003	95	0.019
930	7.264	39.52	0.999	0.09	1.001	167	0.011
940	8.902	38.64	0.999	0.13	1.002	117	0.014
950	8.299	38.94	0.999	0.13	1.002	120	0.014
960	8.06	39.07	0.999	0.11	1.002	122	0.013
970	8.259	38.96	0.999	0.12	1.002	123	0.014
980	11.92	37.37	0.998	0.15	1.003	123	0.018
990	12.03	37.33	0.998	0.14	1.003	125	0.018
1000	12.1	37.3	0.998	0.13	1.003	127	0.018
1010	14.04	36.66	0.998	0.15	1.003	128	0.019
1020	10.53	37.91	0.999	0.09	1.002	146	0.016
1030	13.49	36.83	0.998	0.14	1.003	126	0.018
1040	14.95	36.38	0.999	0.1	1.002	131	0.019
1050	17.91	35.6	0.998	0.18	1.004	129	0.021
MEAN	**14.68**	**36.79**	**0.998**	**0.14**	**0.258**	**173.9**	**0.018**

Table 3.Tabular comparison of image enhancement technique

		Objective Image Quality Measure						
Sr. No	**Image enhancement Technique**	**MSE**	**PSNR**	**NK**	**AD**	**SC**	**MD**	**NAE**
1	Median Filter	14.67723	36.79143	0.998148	0.144341	0.258116	173.9074	0.018386
2	CLAHE	427.1094	21.88987	1.086433	-11.0797	0.83706	48.40741	0.131588
3	Adjust Image	3292.278	12.97137	1.353912	-40.2397	0.525462	74.7963	0.375438
4	Order-statistic	36.02105	33.04606	1.027262	-3.76181	0.946508	14.59259	0.034942
5	Adaptive filter	17.42081	36.1917	0.997404	0.193351	1.004173	19.96296	0.024507
6	Decorrelation stretch	1747.315	15.83629	1.015908	3.938905	0.917725	86	0.269973
7	Butterworth Lowpass	3878.773	12.24386	0.525608	62.24485	3.5422	64	0.486288
8	Butterworth Highpass	6813.176	9.810128	0.557271	55.20869	2.219829	126.9074	0.568169
9	Gaussian Lowpass	16528.97	5.948344	1.94471	-127	1.002839	68.92593	0.992187
10	Gaussian Highpass	11539.28	7.521595	1.48391	-66.4453	0.379608	166.4074	0.767809
11	Negative Image	1600.96	16.087	0.94471	1.00012	1.015429	117.1481	0.254807
12	Logarithmic Transformation	651.5633	19.99125	0.804218	24.62499	1.544981	46.44444	0.192383
13	Power low Transformation	16239.4	6.025113	0.01651	126.16	1883.501	164.7778	0.985625
	Min Value	14.67723	5.948344	0.01651	-127	0.258116	14.59259	0.018386
	Max Value	16528.97	36.79143	1.94471	126.16	1883.501	173.9074	0.992187

High Quality Image   Poor Quality Image

6. CONCLUSION

In this paper, 13 image enhancement techniques have been applied to improve the quality of hyperspectral palmprint image, to decide the quality image quality measure like subjective and objective image quality measure are used subjective analysis can't be relied on because it varies from person to person on the basis of their image perception and visual assessments and also time consuming, therefore subjected the enhanced image to objective quality measure like MSE, PSNR, NK, AD, SC, MD, NAE, on the basis of them different thirteen image enhancement technique are compared. As per finding 2D median filter is the best image enhancement technique for hyperspectral palmprint image as compare to the other technique. In future, In future feature extraction technique like 2D PCA and 2D LDAs are applied on best image enhanced technique 2D median filter.

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Appendix

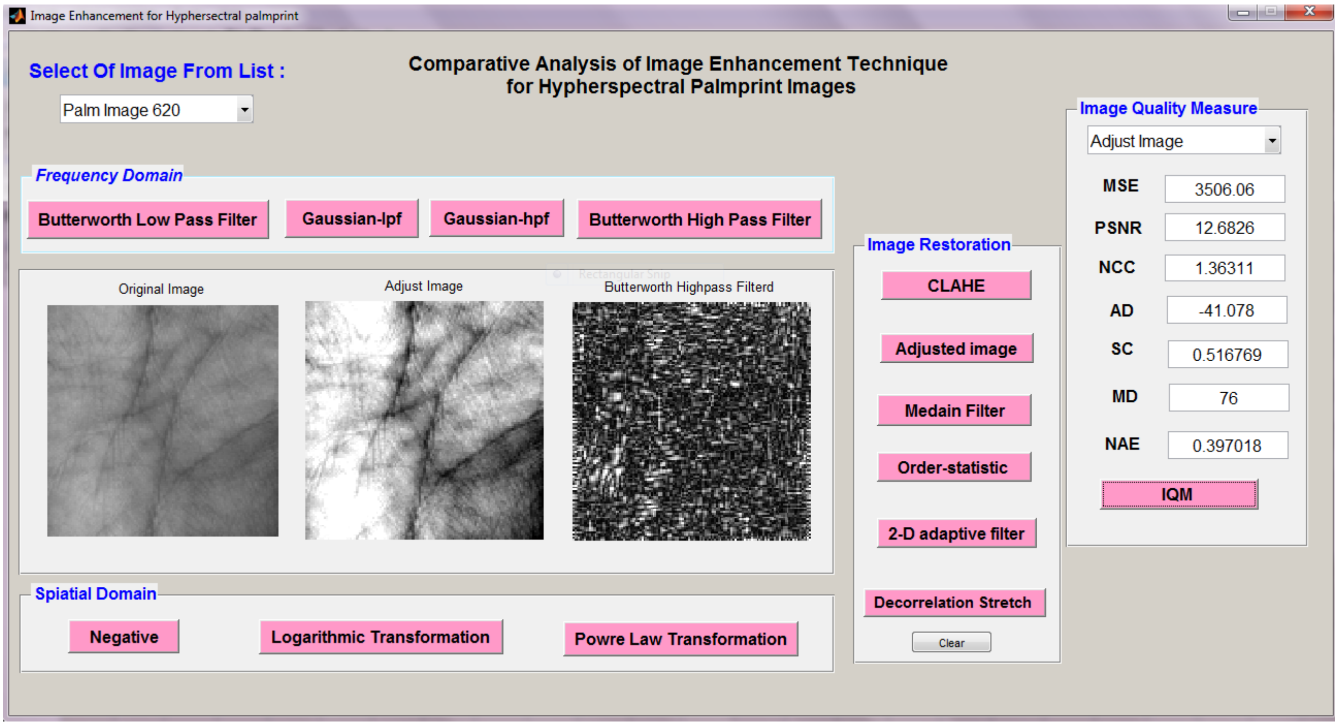

Figure. GUI (Graphical User Interface) for Hypherspectral palmprint Enhancement