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Adaptive Image Enhancement Using Image Properties and Clustering

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***Abstract*—**Image Enhancement is the method of improving the visibility of given image. Image Properties are used for the analysis of Quality of the given image. Various image Properties considered to improve the quality of the image. The Classification or grouping of images can be made by applying unsupervised image Classification algorithm. In our proposed method, various image properties are studied and an Adaptive K-means Clustering method is applied for Fractal image with Entropy Properties. The images are to enhanced on the basis of its grouping automatically. The resulted Classification can be acceptable by the user since the grouping is made on the type of the image i.e., Good Visible, Moderate and Blur images.

***Index Terms*—**Image Enhancement, Image Property, Normalization, Image Classification.

I. Introduction

Image Enhancement is required in medical, defense, security, space borne and other applications where the quality of visibility of images are needed. Enhancement can be done by edge sharpening, reducing noise, gray level manipulation, magnifying, pseudo coloring etc.,. There is no single image enhancement algorithm which can enhance all type of images. Image enhancement is subjective. Image Properties are used to extract the quality of the given image. Each image contains its own properties.

Image Classification algorithms are used to group the similar quality images into separate clusters. The images with same quality are grouped into a common cluster. Unsupervised image classification reduces the burden of user interaction for image classification. K-means Clustering algorithm classify the images into cluster with or without user interaction. Adaptive image enhancement algorithm enhances the images without user interaction based on the quality of image which are obtained by image properties.

In this paper, Section II provides the Literature survey details for Image Features, Image Enhancement, Adaptive algorithms and Image Classification. Section III provides the proposed method for image Enhancement and Classification. Section IV represents the basic Image properties which can be extracted from any image. In Section V, the approach to implement the proposed method is briefly explained. Basic Image Properties are described in Section V. Section VI provides sample output values with input images. Section VII briefs about the Conclusion of the proposed method.

II. Related Works

Discrete Robert M Haralick et.al.,[1] introduced Textural features for gray tone spatial dependencies. Three different images namely Earth Resources Technology Satellite multi-special images, hotomicrograph images and panchromatic aerial photograph images are used. A Fast Algorithm to enhance Finger print images automatically was proposed by Lin Hong et. al., [2]. The algorithm identifies the corrupted ridges of online fingerprint system for verification. Un-coverable areas are removed and improve the minutiae extraction. Estimated orientation for valleys and ridges are implemented by partial valid regions.

J Alex Stark[3] proposed an Adaptive contrast enhancement of Image using Generalization of Histogram Equalization. Cumulative Function is used to generate gray level mapping. Different variety of enhancements are obtained by selecting alternative cumulative functions. Bei Tang et.al.,[4] proposed Enhancement of color Images by separating color data into brightness and Chromaticity. Authors represented n-dimensional vector in which magnitude indicates pixel brightness and vector's direction for chromaticity. Authors also presented isotropic and anisotropic diffusion flows. Discrete Cosine Transform (*DCT*) based image contrast measure is presented in [5]. Image enhancement algorithm for compressed images such as *MPEG2*, *JPEG* and *H.261* is implemented. The proposed algorithm enhances the image in decompression stage and has low computational complexity.

The Curvelet Transform image enhancement is presented in [6]. Authors specify that the Curvelet Transform is suitable for multi-scale edge enhancement and represents edges better than wavelets. Authors also mention that the algorithm is not suitable for noiseless images. Zhou Wang et.al., [7] introduced Quality assessment based on Structural information of the image. Local luminance and contrast are used since these are independent of average Luminance and contrast of the image.

By the similarity information, cluster based image retrieval is proposed by Yixin Chen et.al.,[8]. Image retrieval is based on graph and Systematic Similarity Measure. Eun Kyung Yun et. al., [9] proposed an Adaptive Image Enhancement with image Quality Analysis for Fingerprint images. Authors considered four quality measures i.e., Mean, Variance, Block Directional Difference, Ridge Valley thickness ratio and Orientation change. Mean is used to measure the whole gray level, Variance for uniformity of gray values, Block Directional Difference for distinctness between ridges and valleys, Ridge Valley thickness for measurement of ratio for ridge and valley thickness Orientation change for measurement of ridge continuity.

Global kernel k-means algorithm is proposed in [10] in which one cluster is added at each stage. This algorithm does not require Cluster initialization and locates the optimal solutions with less computation. Automatic Registration based on Temporal change [11] detection and multisensors fusion was proposed by Anna Brook et. al.,. Speedup Robust Feature method is use do extract the buildings and roads of the input images. Topological Map matching Algorithm is applied to find the control points of Space borne and airborne images. Robustness and Feature complexity are compromised which are main parameters for deformations.

Hongzhao Yuan et. al., [12] proposed an enhancement of Infrared images by using Adaptive Contrast enhancement. Images are separated into ground and sky part with Enhanced Vision System. The Threshold is obtained by the intensity of sky part for Plateau HE. Then for the ground part, Adaptive Plateau HE is applied. M Z Rashad et.al., [13] proposed a classification of plant based on their textural properties by using Learning Vector Quantization and Radial Base function. Authors states that the classification of plant can be made by considering small part of the leaf. Le Hoang Thai et. al., [14] introduced a method to classify an image by combining Support Vector Machine (SVM) and Artificial Neural Network(ANN). Feature vector obtained by ANN is further classified by SVM Classifier.

Chun-Ming Tsai [15] proposed an adaptive local power law transformation method for enhancing color images with high performance and low computational complexity. The proposed method is very efficient method to compute the local mean with low complexity. Hongteng Xu et. al.,[16] introduced an image enhancement method by generalized equation model generated by integrating contrast enhancement and white balancing using Histograms. The algorithm is suitable for tone correction and de-hazed images post processing. Zhi Zhou et al., [17] introduced an adaptive image enhancement method to improve the signal-to-noise ratio of images based on detecting the salient features of fibrous structures. Authors have shown that 3D morphologies of neurons and brain vasculatures can be more accurately and efficiently reconstructed using their adaptive enhancement method.

Sundararajan and Karthikeyan [18] proposed a method to classify the images by combination of Dynamic K-means and Firefly Algorithm. The approach can be used for known number of clusters as well as unknown number of clusters. Reduction of dimensions with accurate feature extraction methods in k-means clustering is proposed by Christos Boutsidis et. al., [19]. Authors specify that the approach is based on low rank approximations to form a cluster.

III. Proposed Methodology

In the Proposed method, the images with different visibility for the human eye i.e., good visible, Moderate and blur images are considered from the image depository as the test input images. Image Properties such as Standard Deviation, Entropy, Skewness, Spatial Frequency, Kurtosis, Brightness, Visibility and seven Moments are calculated. Classification Algorithm is used to classify the images automatically depending on the input image Properties. The Block diagram of Proposed method is given in Fig.1.

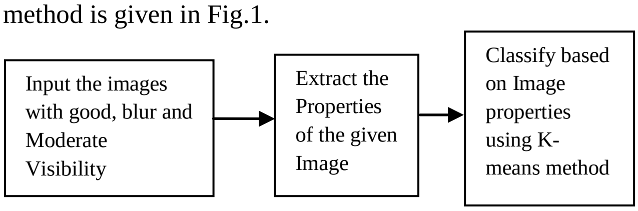

Fig.1. Block Diagram of Proposed Method

IV. Image Properties

Some of the basic Image Properties are obtained by following equations:

$$Std.Deviation = \frac{1}{MN}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}\left(I_{ij} - \bar{I}\right)^2 \quad (1)$$

Where I_{ij} represent the intensity of $(i,j)^{th}$ element, M *and* N represent the dimension of image and $\bar{I}$ is the average intensity of an image.

$$Entropy = -\sum P_k \, log_2 \, P_k \quad for\ k = 1\ to\ l \quad (2)$$

where P_k is the Probability value for random value k.

Mean and Mode or Mean and Median are used to find the Skewness.

$$Skewness = \frac{m_3}{m_2^{\frac{3}{2}}} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^3}{\left[\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2\right]^{\frac{3}{2}}} \quad (3)$$

where second and third moments are represented by m_2 and m_3, For i^{th} element, x_i is the Median. $\bar{x}$ represent sample mean.

Spatial Frequency is measured as:

$$Spatial\ Frequency = \sqrt{RF^2 + CF^2} \quad (4)$$

where Row Frequency (*RF*) and Column Frequency (*CF*) can be represented by equations (5) and (6).

$$RF = \sqrt{\frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}[I(m,n) - I(m,n-1)]^2} \quad (5)$$

$$CF = \sqrt{\frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}[I(m,n) - I(m-1,n)]^2} \quad (6)$$

where *M* and *N* are size of the Image I.

$$Kurtosis(x) = E\left\{\frac{(x-\mu)^4}{\sigma^4}\right\} \quad (7)$$

where μ is Standard Deviation , σ is deviation and *E* is Expectation for *x* random variable.

$$Brightness = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N} I(m.n)}{M*N} \quad (8)$$

where *M* and *N* are the dimension of the image *I*.

For Maximum and Minimum luminance (I_{max} and I_{min}), Visibility is calculated by the following formula:

$$Visibility = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \quad (9)$$

Image Moments are used to calculate the image properties such as Centroids, Variance, Kurtosis, Skewness etc.,. Gray Image Moments re calculated by the equation (10).

$$M_{ij} = \sum_x \sum_y x^i y^i\, I(x,y) \quad (10)$$

where $\bar{x}$ and $\bar{y}$ are the center of mass can be calculated by equation (11) and (12).

$$\bar{x} = \frac{M_{10}}{M_{00}} \quad (11)$$

and

$$\bar{y} = \frac{M_{01}}{M_{00}} \quad (12)$$

Normalization is used to assign uniform values in the given range for different set of values. It can be calculated by equation (13).

$$Normalize(x) = \frac{x - Min}{Max - Min} \quad (13)$$

where x is the element to be considered, *Min* and *Max* represents minimum and maximum value of the given set.

V. APPROACH

The images with different visibility to user with various sizes are stored in Image depository. Fractal, Weibull, Contrast and Intensity images are extracted for the given test images. The Image Properties such as Brightness, Contrast, Entropy, Skewness, Separability, Kurtosis, Spatial Frequency etc., are calculated for the resulted images. K-means Algorithm is used to classify the images in to separate groups. The number of Clusters can be defined by the user. The grouping is made on the basis of nearest cluster.

VI. RESULTS

In Image depository, different sizes of images are stored. Different images with good visible, moderate visible and blur images also stored in the depository. For the test input, 512X512 size images of Lena (Good Visible), Baboon, Airplane and Lena(Blur) are used and its Intensity, Contrast, Weibull and Fractal images are generated as in Fig. 2 to 6.

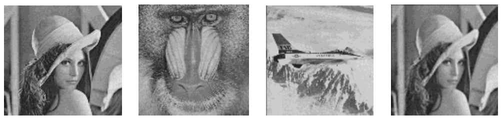

Fig.2. Lena (Good Visible), Baboon, Airplane and Lena (Blur) original Images

Fig.3. Lena (Good Visible), Baboon, Airplane and Lena (Blur) Intensity Images

Fig.4. Lena (Good Visible), Baboon, Airplane and Lena (Blur): Contrast Images

Fig.5. Lena (Good Visible), Baboon, Airplane and Lena (Blur) Weibull Images

Fig.6. Lena (Good Visible) Baboon, Airplane and Lena (Blur) Fractal Images

The Image Properties such as Brightness, Standard Deviation, Entropy, Skewness, Kurtosis, Separability, Spatial Frequency, Visibility, and Seven Moments for Test images are tabulated in Table 1 to 5. Normalized Outputs for Table 1 to 4 are tabulated in Table 6 to Table 9 respectively.

Table 1. Intensity Properties

Sl. No.	Property Name	Airplane	Baboon	Lena
1	Brightness	169.89	127.32	124.05
2	Standard Deviation	39.866	36.345	47.857
3	Entropy	6.486	7.139	7.446
4	Skewness	1.165	0.554	0.288
5	Kurtosis	0.714	0.642	-0.815
6	Separability	0.832	0.682	0.699
7	Spatial Frequency	15.559	31.433	14.531
8	Visibility	2276.10	3371.42	4653.8
9	Moment 1	6.898	6.656	6.618
10	Moment 2	21.229	19.539	18.950
11	Moment 3	17.691	16.846	16.756
12	Moment 4	16.526	15.687	15.600
13	Moment 5	33.634	31.954	31.778
14	Moment 6	27.141	25.515	25.078
15	Moment 7	39.710	35.348	36.802

Table 2. Contrast Properties

Sl. No.	Property	Airplane	Baboon	Lena
1	Brightness	17.278	41.178	16.995
2	Standard Deviation	26.789	29.451	20.909
3	Entropy	5.225	6.587	5.233
4	Skewness	1.680	1.042	1.804
5	Kurtosis	8.813	1.395	14.323
6	Separability	0.741	0.695	0.672
7	Spatial Frequency	19.296	20.921	15.430
8	Visibility	47921.29	16399.22	37661.48

Table 3. Weibull Properties

Sl. No.	Property	Airplane	Baboon	Lena
1	Brightness	195.026	156.103	118.009
2	Standard Deviation	55.540	48.451	57.550
3	Entropy	6.920	7.517	7.701
4	Skewness	1.230	0.735	0.309
5	Kurtosis	1.420	0.036	-0.814
6	Separability	0.811	0.651	0.696
7	Spatial Frequency	22.825	21.935	16.649
8	Visibility	2486.58	3164.64	6044.90

Table 4. Fractal Properties

Sl. No.	Property	Airplane	Baboon	Lena
1	Brightness	141.972	120.158	147.472
2	Standard Deviation	22.110	19.399	22.307
3	Entropy	4.231	5.813	5.396
4	Skewness	1.752	1.458	1.631
5	Kurtosis	1.566	11.051	14.185
6	Separability	0.626	0.523	0.545
7	Spatial Frequency	19.889	18.920	20.388
8	Visibility	1298.655	1671.508	1416.723

Table 5. Lena (blur) Image Properties

Sl. No.	Property	Intensity	Contrast	Weibull	Fractal
1	Brightness	122.910	9.499	120.29	157.865
2	Standard Deviation	45.636	12.914	56.230	26.800
3	Entropy	7.392	4.558	7.678	5.393
4	Skewness	0.135	1.995	0.231	1.354
5	Kurtosis	-0.838	28.541	-0.798	7.651
6	Separability	0.599	0.605	0.695	0.703
7	Spatial Frequency	6.582	6.343	13.125	20.364
8	Visibility	4518.26	59607.8	5742.9	1747.51

Abbreviations used in the Table 6 to 9 are: Im. No.– Image Number, Brt-Brightness, St.Dv-Standard Deviation, Entr-Entropy, Skn-Skewness, Krt-Kurtosis, Spb-Seprarability, Spt.Frq-Spatial Frequency and Visb-Visibility.

Table 6. Image Properties- Intensity

Im. No.	Brt	St. Dv	Entr	Skn	Krt	Spb	Spt. Frq	Vis b
1	0.84	0.02	0.14	0.25	0.34	0.37	0.01	0.01
2	0.98	0.11	0.46	0.11	0.15	0.39	0.06	0.06
3	0.13	0.69	0.9	0.88	0.32	0.68	0.63	0.75
4	0	0.7	0.91	1	0.5	0.57	0.66	0.83
5	0.24	0.33	0.79	0.52	1	0	0.59	0.3
6	0.49	0.04	0.26	0.64	0.4	0.34	0.01	0.03
7	0.88	0.02	0.12	0.38	0.43	0.62	0.01	0.01
8	0.14	0.81	0.97	0.8	0.18	0.88	0.39	0.89
9	0.98	0.01	0.15	0.41	0.44	0.2	0.02	0.01

Table 7. Image Properties- Contrast

Im. No.	Brt	St. Dv	Entr	Skn	Krt	Spb	Spt. Frq	Visb
1	0.01	0.01	0.08	0.93	0.85	0.69	0.01	0.58
2	0.08	0.2	0.28	0.57	0.17	0.69	0.21	0.8
3	0.51	0.75	0.79	0.14	0.01	0.36	0.61	0.45
4	0.6	0.79	0.83	0.12	0.01	0.41	0.73	0.33
5	0.74	0.73	0.9	0.11	0.01	0.3	0.65	0.1
6	0.02	0.01	0.12	0.9	0.79	0.61	0.01	0.64
7	0.01	0.18	0.04	0.65	0.23	1	0.2	1
8	0.37	0.59	0.7	0.2	0.01	0.36	0.46	0.54
9	0.04	0.02	0.14	0.92	0.84	0.63	0.02	0.45

Table 8. Image Properties- Weibull

Im. No.	Brt	St. Dv	Entr	Skn	Krt	Spb	Spt. Frq	Visb
1	0.24	0.06	0.27	0.15	0.37	0.31	0.17	0.21
2	0.77	0.57	0.98	0	0.14	0.43	0.34	0.21
3	0.39	0.6	0.82	0.81	0.23	0.67	0.52	0.53
4	0.23	0.63	0.84	1	0.34	0.61	0.68	0.73
5	0.52	0.06	0.14	0.47	1	0	0.47	0.01
6	0.1	0.01	0.12	0.25	0.39	0.33	0.02	0.26
7	0	0	0	0.55	0.17	0.78	0.1	0.43
8	0.44	0.79	0.79	0.76	0.14	0.86	0.69	0.62
9	0.65	0.14	0.36	0.24	0.67	0.07	0.35	0.01

Table 9. Image Properties- Fractal

Im. No.	Brt	St. Dv	Entr	Skn	Krt	Spb	Spt. Frq	Visb
1	0.05	0.04	0.07	0.96	0.94	0.95	0.04	0.57
2	0.1	0.04	0.16	0.91	0.86	0.86	0.06	0.4
3	1	0.93	0.85	0.67	0.38	0.38	0.87	0.01
4	0.94	0.84	0.92	0.57	0.27	0.12	0.92	0.02
5	0.67	0.78	1	0.25	0	0.15	0.83	0.14
6	0.49	0.08	0.34	0	0.47	0	0.27	0.01
7	0.17	0	0	0.84	0.81	0.79	0.08	0.19
8	0.97	0.78	0.81	0.64	0.4	0.27	0.77	0
9	0	0.05	0.1	1	1	1	0	1

K-means Clustering is unsupervised clustering method. The given set of data can be grouped by providing the number of clusters required. The grouping is made on the basis of nearest neighbour cluster centroid by calculating the distance between given data with centroid. Fig. 7 represents the Clustering of Fractal images with Entropy Properties for different number of clusters.

No. Of Clusters	Centroids	Clustering
2	C1 = 0.1 C2 = 0.8	Group 1: 0.07, 0.16, 0.34, 0, 0.1 Group 2: 0.85, 0.92, 1, 0.81
3	C1 = 0 C2 = 0.3 C3 = 0.8	Group 1 : 0.07, 0.16, 0, 0.1 Group 2 : 0.34 Group 3 : 0.85, 0.92, 1, 0.81
4	C1 = 0 C2 = 0.3 C3 = 0.8 C4 = 0.9	Group 1: 0.07, 0.16, 0, 0.1 Group 2: 0.34 Group 3: 0.85, 0.81 Group 4: 0.92, 1

Fig.7. K-Means Clustering of Fractal Images with its Entropy Property for different number of Clusters.

VII. CONCLUSIONS

The Contrast images, Intensity Images, Fractal images and Wiebull images are extracted from the Image depository. Image depository contains the good visible, moderate visible and blur images with different image sizes. Image Properties are obtained for these resulted images. K-means clustering s applied to Fractal Images with Entropy property is calculated. We observed that combination of two or more properties give the better classification method. The proposed method gives the adaptive classification of images which can be acceptable by the users for grouping of images. The rule based image enhancement algorithm is used to enhance the image depending the particular cluster.

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