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Analysis of Contrast Enhancement Method Using Modified Dynamic Histogram Equalization

Tarun Dewangan, M.A.Siddiqui, RCET Bhiali

Abstract: The proposed method is based on dynamic histogram equalization and for handling gray-level and color image as well. As far as HE methods for gray-level images are concerned, current methods tend to change the mean brightness of the image to the middle level of the gray-level range. To overcome this drawback of HE, Bi-histogram equalization methods for both preserving the brightness and contrast enhancement have been proposed. Although these methods preserve the input brightness on the output image with a significant contrast enhancement, they may produce images which do not look as natural as the ones which have been input. In order to overcome this drawback, a method is adopted, which consists of decomposing the input image histogram into several sub-histograms, and then applying the HE process to each one of them. This methodology performs a less intensive image contrast enhancement, in a way that the output image presented looks more natural. Experimental results show that mentioned method is better in preserving the brightness and producing more natural looking images than the other HE methods

I. INTRODUCTION

A. Contrast Enhancement of an Image

Contrast enhancements improve the perceptibility of objects in the scene by enhancing the brightness difference between objects and their backgrounds. Contrast enhancements are typically performed as a contrast stretch followed by a tonal enhancement, although these could both be performed in one step. A contrast stretch improves the brightness differences uniformly across the dynamic range of the image, whereas tonal enhancements improve the brightness differences in the shadow (dark), mid tone (grays), or highlight (bright) regions at the expense of the brightness differences in the other regions. Contrast enhancement processes adjust the relative brightness and darkness of objects in the scene to improve their visibility. The contrast and tone of the image can be changed by mapping the gray levels in the image to new values through a gray-level transform. The contrast and tone of the image can be changed by mapping the gray levels in the image to new values through a gray-level transform. The mapping function reassigns the current gray level GL to a new gray level GL′ (Fig. 1).

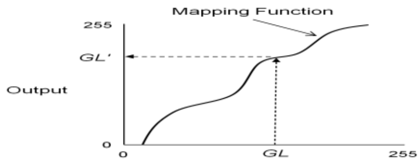

Fig 1: A gray-level transform maps the gray levels to new values

B. Histogram equalization

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

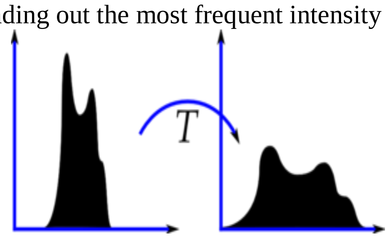

Fig 2: Spreading the intensity values

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Consider a digital image with gray levels in the range [0, L −1] , Probability Distribution Function of the image can be computed as equation :

$$P(r_k) = \frac{n_k}{N};\quad k = 0, \ldots, L-1 \qquad (1.1)$$

Where rk is the kth gray level and nk is the number of pixels in the image having gray level rk . Cumulative Distribution Function (CDF) can also be computed as followed:

$$C(r_k) = \sum_{i=0}^{i=k} P(r_i) \qquad (1.2)$$

k= 0,..,L-1, $0 \leq C(r_k) \leq 1$

Histogram Equalization (HE) appropriates gray level Sk to gray level rk of the input image using equation . So we have:

$$S_k = (L-1) \times C(r_k) \qquad (1.3)$$

Gray level Sk 's changes can be computed in usual histogram equalization method:

$$\Delta s_k = (L-1) \times P(r_k) \qquad (1.4)$$

Equation (1.4) means that distance between Sk and Sk+1 has direct relation with PDF of the input image at gray level rk .

Undesirable effects of the usual histogram equalization method (HE) are resulted from equation (1.2) because of the quantization operation and summarizing properties of this equation.

C. Bi Histogram Equalization (BHE)

Bi Histogram Equalization is considered as an improved histogram equalization (HE) method for contrast enhancement in this section. This method divides the image histogram into two parts as shown in Fig.1.6. In this method, the separation intensity XT is presented by the input mean brightness value, which is the average intensity of all pixels that construct the input image. After this separation process, these two histograms are independently equalized. By doing this, the mean brightness of the resultant image will lie between the input mean and the middle gray level. BHE first finds average point in histogram of the image and then divides histogram to two segments based on this point. After that histogram equalization operation is applied on each segment

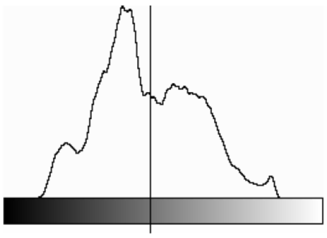

Fig. 3. Bi-histogram equalization

There are two cumulative distribution functions for two segments. Gray level (rk) under the average point are pointed to the new gray level (Sk) as it can be seen in equation (5).

$$S(k) = (L_1) \times C_1(r_k) \qquad (1.5)$$

$$C_1(r_k) = \left(\sum_{i=0}^{k} n_i\right) / \left(\sum_{j=0}^{L_1} n_j\right); \qquad (1.6)$$

k=0,1,…,L1

Where L1 is the average of gray levels of the histogram and it can be computed as in equation (1.7)

$$L_1 = \sum_{k=0}^{L-1} P(r_k) * r_k \qquad (1.7)$$

Gray level (rk) above the average point are pointed to the new gray level (Sk) as it can be seen in equation (1.8).

$$S_k = (L-1-L_1) \times C_2(r_k) + L_1 \qquad (1.8)$$

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$$C_2(r_k) = \left(\sum_{i=L_1+1}^{k} n_i\right) / \left(\sum_{j=L_1+1}^{L_1} n_j\right); \quad (1.9)$$

$$k = L_1 + 1, \ldots, L - 1$$

Results of applying BHE method comparing to HE and proposed method are depicted in results section.

II. DHE(DYNAMIC HISTOGRAM EQUALIZATION)

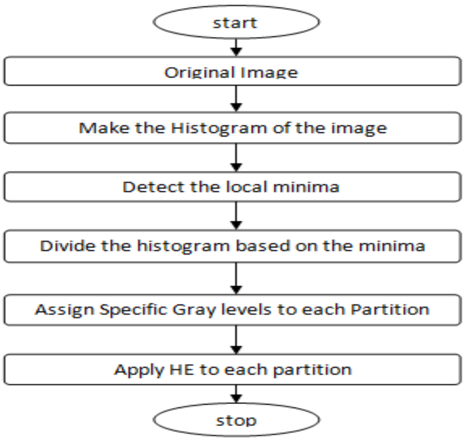

Fig 4: Flow chart of DHE Method

Modified DHE

Modified DHE can understand by following steps:

i. ***Identify image is color or not.***

The very first step is identifying the image is color or not. If the image is color the algorithm converts it into intensity files. And proceed to next step of the algorithm. if it is gray image then it bypass the step of conversion into intensity files.

ii. ***Make the histogram of image & normalize it.***

In this step we make the histogram of the given image & normalize it with the help of filter, because the histogram of the digital image is normally fluctuated and also the probability for some brightness levels is missing.[11]

iii. ***Detect local minima & divide the histogram based on it.***

The histogram is divided into sub-histograms based on local maximums. We choose to use local minimums as the separating intensities this selection is better in maintaining the mean brightness. Let *m0*, *m1*,…,*mn* are (*n*+1) gray levels correspond to the local maximums detected in the previous step. If the original histogram before the smoothing is in the range of [*Imin*, *Imax*], then, the first sub-histogram is in the range of [*Imin*, *m0*], the second sub-histogram in the range of [*m0*+1, *m1*], the third one [*m1*+1, *m2*], and so on until the last sub-histogram [*mn*+1, *Imax*].[11]

iv. ***Calculate mean & standard deviation to avoid dominating portion.***

To test the presence of any dominating portion, we first find the mean, μ, and standard deviation, σ, of the GL frequencies (histogram components) of each sub-histogram regions. If in a sub-histogram the number of consecutive gray levels having frequencies within the range from (μ–σ) to (μ+σ) becomes more than 68.3% of the total frequency of all gray levels of that sub-histogram, then we can consider it to have a normal distribution of frequencies [18] and there is no dominating portion of histogram that might affect others. However, on the other hand, if this percentage is less than 68.3%, we may be worried about the presence of some dominating portion in the sub-histogram. In this case, DHE splits the sub-histogram into three smaller sub-histograms by partitioning it at gray levels (μ–σ) and (μ +σ).[10]

v. ***Assign specific gray level to each partition***

However, the equalized version of these sub-histograms does not assure a very good enhancement, because sub histograms with small range will not be enhanced significantly by HE. Hence, following the same concept as DHE, This method spans each sub-histogram first before the equalizations are taking place. The spanning function used is based on the total number of pixels contained in the sub-histogram. This function is described by the equations given below, as suggested by [10]:

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$$span_i = high_i - low_i$$

$$factor_i = span_i \times \log_{10} M$$

$$range_i = (L-1) \times factor / \sum_{k=1}^{n+1} factor_k$$

Where *high i* is the highest intensity value contained in the sub histogram *i*, low_i is the lowest intensity value in that section, and *M* is the total pixels contained in that section. The dynamic range used by the sub-histogram *i* in input image is given by $span_i$, while the dynamic range used by in output image is $range_i$. Let the range of the output sub-histogram *i* is [$start_i$, end_i]. If we set the first sub-histogram of the output image is in the range of [0, *range1*], then the $start_i$ and end_i (for *i*> 1) can be calculated as follow:[11]

$$start_i = \sum_{k=1}^{i-1} range_k + 1$$

$$end_i = \sum_{k=1}^{i} range_k$$

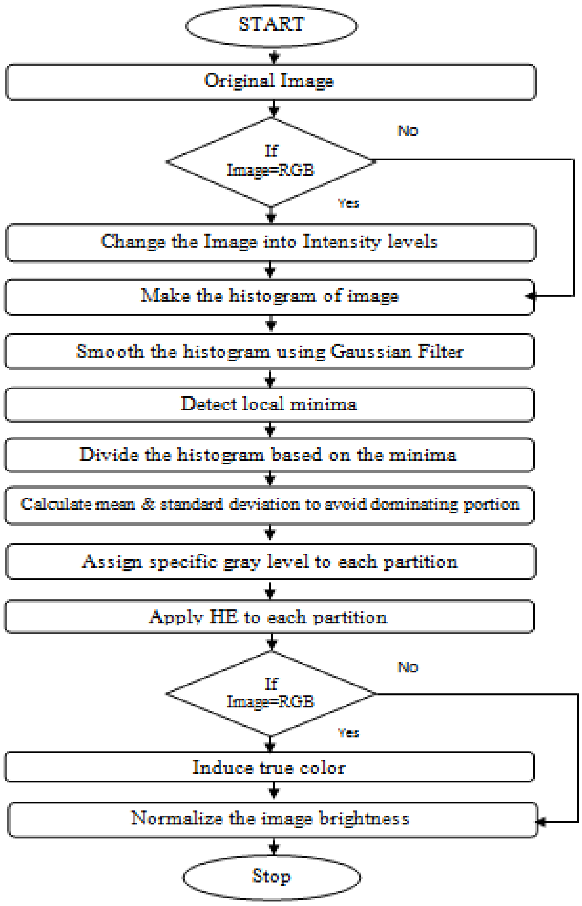

Fig 5 : flow chart of proposed method

vi. Apply HE to each partition

HE is applied to each sub-histogram, but its span in the output image is allowed to confine within the allocated GL range that is designated to it

vii. Induce true color

If the image is RGB then induce the true color of the original image. If not i.e. in case of gray image skip the step and continue with the next one.

viii. Normalize the image brightness

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In this step, the mean brightness of the input, Mi, and the mean brightness of the output obtained after the equalization process, Mo, is calculated. In order to shift back the mean brightness to the mean brightness of the input, we apply the brightness normalization, as define by equation:

$g(x, y) = (Mi / Mo) f(x, y)$

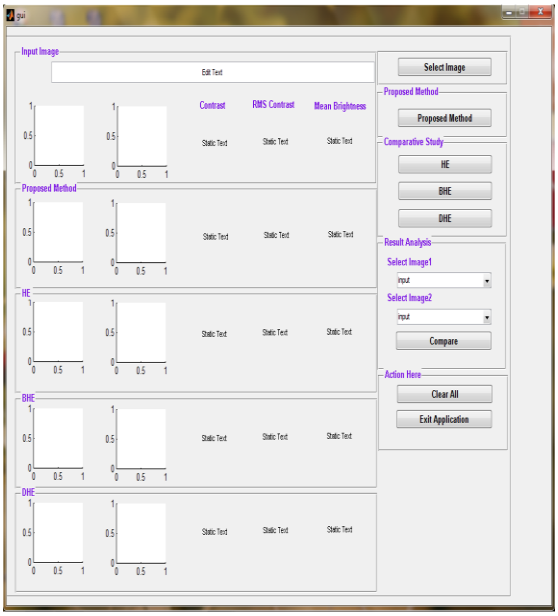
Where g (x, y) is the final output image and f (x, y) is the output just after the equalization process. This normalization will make sure that the mean output intensity will be almost equal to the mean input intensity.[11].

III. RESULTS AND DISCUSSIONS

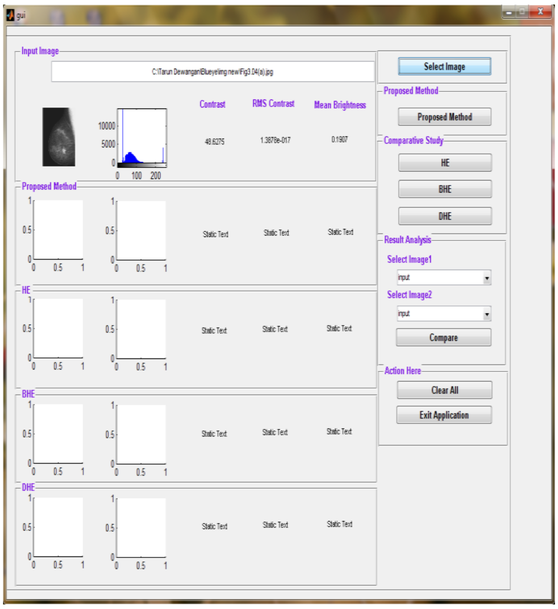
In addition to this method, I am also implemented other methods, HE, BHE and DHE, to demonstrate the performance of the proposed method and calculate the contrast, rms contrast & mean brightness of each resulting image.

Result of gray image:

1. GUI

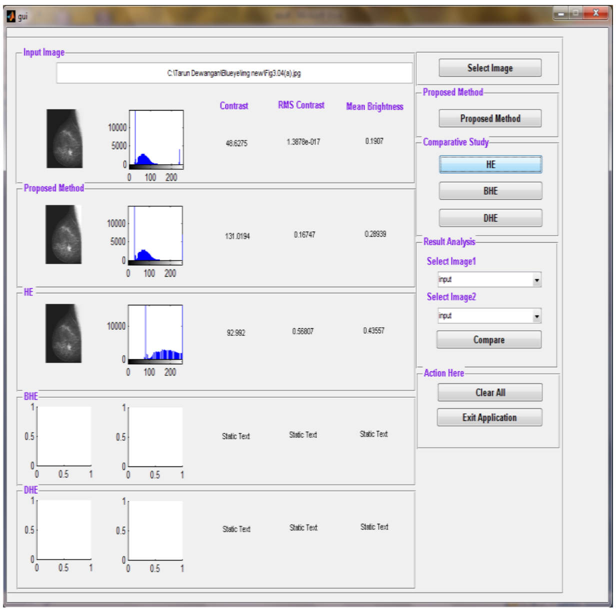


2.Load the image from data base



3.After appling proposed method.

4.After HE



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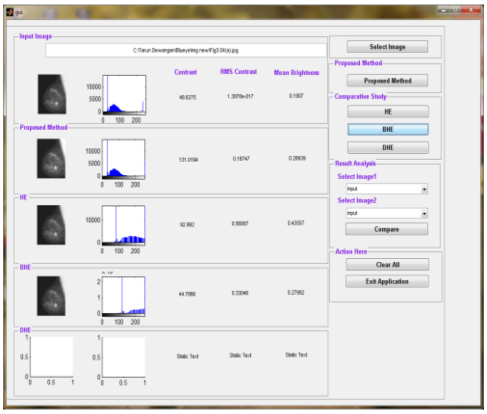
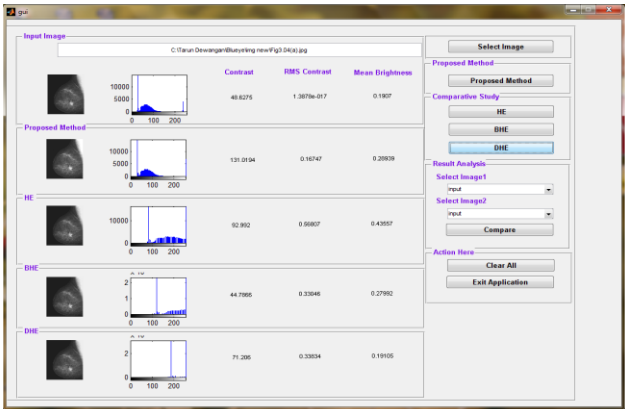
5.After BHE.

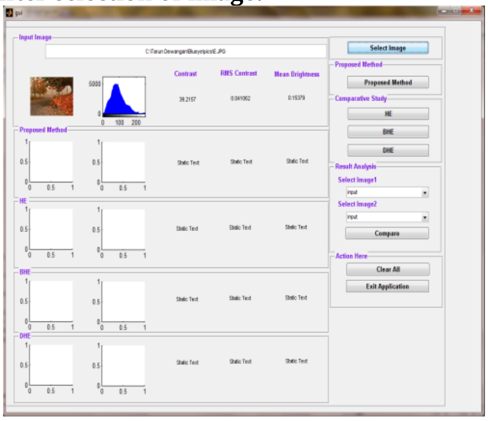


6.After DHE

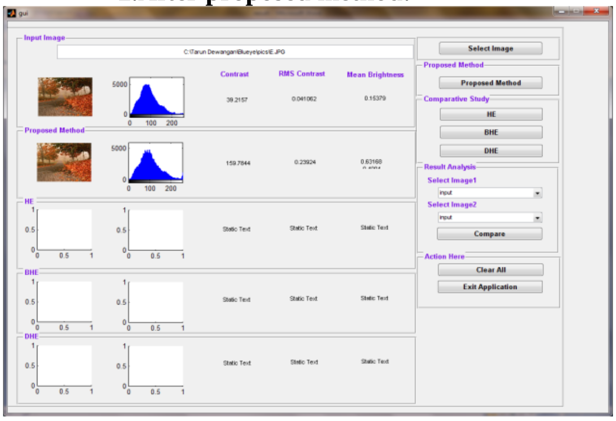


B. Result of COLOR Imageer

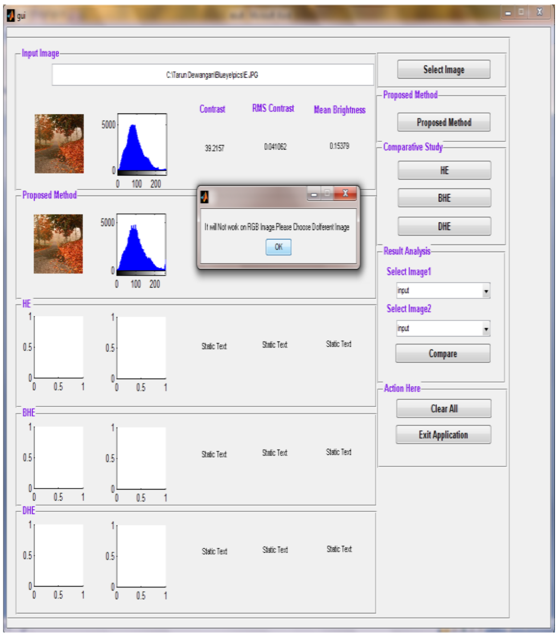
1.After selection of image:



2.After proposed method:



3.After HE,BHE& DHE:



Calculation of Contrast

S.No.	Image	Original	PM	HE	BHE	DHE
1.	m 1.JPG	23.92	104.5697	87.1908	30.3555	52.7321
2.	m 3.JPG	44.7059	149.4742	76.4162	55.8611	84.5514
3	m 4.JPG	53.725	116.54	76.083	38.2287	53.9638
4	M 5.JPG	45.098	178.211	82.5629	74.7025	99.2782
5	M 6.JPG	35.6863	176.1369	87.4936	69.8547	91.3348
6	M 7.JPG	9.8039	86.6168	88.4399	19.7786	9.2179
7	M8.JPG	46.6667	113.0308	75.1583	35.6836	59.0785
8	M9.JPG	37.2549	187.577	102.3419	77.0978	96.4005
9	M10.JPG	37.2549	158.1455	87.8806	61.3753	86.8467
10	M11.JPG	45.8824	122.5176	75.188	40.7887	68.4051
11	M12.JPG	20.3922	126.5281	98.4707	41.3734	50.7036
12	M13.JPG	24.3137	126.1029	96.0081	41.4529	64.1626
13	M14.JPG	20	111.3078	97.083	32.8914	49.829
14	M15.JPG	30.9804	146.6821	96.4325	53.7715	75.6579
15	M16.JPG	44.7059	165.5864	82.362	64.7943	96.3803
16	M17.JPG	43.1373	142.8738	75.8536	52.155	82.5938
17	M18.JPG	59.6078	161.2613	75.3002	68.4941	84.1955
18	12.JPG	25.4902	145.2332	98.9523	51.8588	65.179
19	13.JPG	40	117.7741	88.8097	38.168	72.5899
20	14.JPG	49.8039	153.2396	81.2974	59.6766	95.1257
21	15.JPG	42.3529	96.0713	75.8186	26.0265	47.194
22	16.JPG	6.667	67.8442	18.7561	9.3037	2.7036
23	17.JPG	51.3725	191.1174	84.6916	86.5869	100.2673
24	18.JPG	44.7059	158.8066	99.3389	63.47	87.9447
25	19.JPG	45.8824	143.3088	83.5389	52.7762	89.145
26	20.JPG	33.7255	134.9329	97.7493	47.6235	79.9285
27	21.JPG	30.1961	109.9941	92.0726	33.9406	64.0684
28	22.JPG	32.9417	97.5531	75.7143	26.5114	58.122
29	24.JPG	21.9608	76.3697	80.6364	15.4163	40.075
30	25.JPG	48.2353	114.1949	76.1802	36.1815	67.325
31	26.JPG	45.098	87.481	75.7137	21.4666	35.4992
32	27.JPG	51.3725	115.8178	76.7195	37.4796	65.5636
33	28.JPG	50.5882	99.7372	75.4762	28.3439	49.2247
34	A1.JPG	45.098	84.0723	71.0977	18.5957	26.9062
35	A2.JPG	27.8431	126.976	93.6475	43.0113	53.8755
36	A3.JPG	52.15689	73.9016	75.2214	14.0468	24.2704
37	A4.JPG	34.5098	134.3728	86.4701	47.3412	76.0071
38	A5.JPG	58.0392	196.7106	102.4408	92.6588	110.6395
39	A6.JPG	38.8235	73.771	75.2981	13.6885	27.9917

The results show that this method successfully enhanced the images without introduce undesirable artifacts, such as saturation effect, changing of image focus, and also enhancement of the partial volume effect.

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IV. CONCLUSION

This paper is an extension to DHE. This method is similar to DHE in terms of spanning the dynamic range. However, unlike both HE and DHE, this method utilizes brightness normalization in order to keep the input mean intensity. One advantage of this method is that there is no parameter need to be tuned. Experimental results shows that this method can enhance the images without introducing unwanted artifacts, while at the same time maintain the input brightness. Furthermore, similar to other HE based algorithms this method is easy to implement and can be used in real time system because of its simplicity.

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AUTHOR BIOGRAPHY

Tarun Dewangan, Mtech Scholar from Department of Electronics & telecom. RCET Bhilai, having 7 year of experience in the field of Teaching.

Majid Ahmad Siddiui, reader, Department of electronics & telecom, RCET Bhilai, having 8 year of experience in the field of Teaching.