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Proposed method for digital image normalisation

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Image normalisation is considered as an important factor in the scope of image enhancement. In this research paper we introduced a proposed model used for image normalisation (contrast stretching) through two phases, design phase and implementation phase. First, the design phase consists of the proposed formulas used for processing the degraded images, where the first formula represents the processing of the darked image illuminations and the second one represents the processing of the highlighted image illuminations, the second part of the design phase we determined which formula has to be used for processing the image degradation. So here for processing this part, we used a K-means clustering machine learning algorithm. The second part is the implementation phase which is used for applying the proposed model and the final step comparing the obtained results with other determined normalisation algorithms.

Keywords: Normalisation, K-means Clustering, ML algorithm

1. INTRODUCTION

In the field of image processing, there are many factors that affects in the image quality and are considered as an important challenge [1]. To extract information, the determined image resolution has to be from high to medium range [2]. Image contrast stretching is considered as the first process in image processing, so enhancement of the image quality is important when the image is suffering from poor details, like the highlighted or darked images [3]. Any image can be analyzed through checking its structure of the histogram that represents the features and can be defined as a graph displaying the frequency of the image contents [4]. Images save a lot of information in order to help in improving the accuracy, this sometimes leads to the degradation case because of some affects that change some image features [5].

The term contrast is considered as an important factor in image quality enhancement in order to present the contained details in the image or to improve the contrasts of the highlighted or darked images [6]. A good digital image contrast stretching technique helps either in increasing the contained details or to process the low image contrast through increasing the resolution [7]. The effects of digital normalisation are more noticeable in the low lighted or high lighted images which makes it more difficult in image details explanation [8].

1.2 Gap statement and objectives

Dealing with darked-highlighted images lacks for accuracy and rapidity in processing, so the gap statement behind applying the proposed algorithm is through adding more procedures that provide high speed processing and accuracy to the output, these procedures include adding both two proposed equations for processing darked and highlighted regions in parallel at the same time. If we compare the proposed work with other researches we noticed that, first, in other researches there is no the concept of the parallel processing for both the highlighted and darked regions in the images at the same time, second, there is no researches provide a combination between the ML algorithms and normalization process as in the proposed work, so the objectives of the proposed research is providing high processing accuracy and parallel processing for both darked and highlighted regions, so the proposed contribution that has been applied in the research segments the regions of the image into clusters using K-means algorithm.

2. METHOD

In this paper a proposed model is presented for digital image normalisation through the following two phases, design phase and implementation phase. First, the design phase consists of the proposed formulas used for processing the degraded images, where the first formula represents the processing of the darked image illuminations and the second one represents the processing of the highlighted image illuminations as explained below:

$$\varphi = [(\Gamma - \delta)/255] * 10^{\lambda} \quad (1)$$

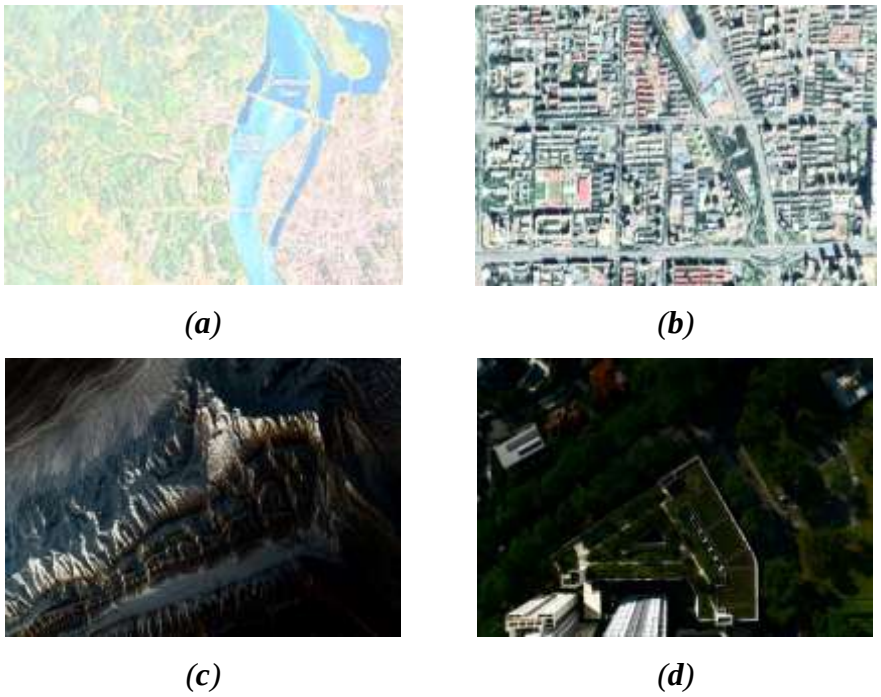
$$\varphi = [(\Gamma - \delta) * x] / 10^{\lambda} \quad (2)$$

Where, φ represents the new illumination value, Γ: old illumination value, δ: determined minimum illumination value, x: determined maximum value and λ: impact value. Now in the second part of the design phase we determined which formula has to be used for processing the image degradation. So here for processing this part, we used a K-means clustering ML algorithm. K-means algorithm generates clusters that are considered important in regions recognition [9]. To determine the darked and highlighted regions in the image, first we used the Ecluidian equation:

$$d(x_2,x_1) = sqrt[(x_2-x_1)^2] \quad (3)$$

centroid points $\lambda_1 = 50$, $\lambda_2 = 200$, Clusters K_1, K_2

Where, K_1 represents the cluster of the darked illuminations, K_2 represents the cluster of the highlighted illuminations. x_1 represents the determined illumination value, x_2 represents (λ_1 and λ_2) values. Presenting a weighted factors for each pixel depending on their distance from the centered point enhance the development of the algorithm [10]. The clustering procedure is considered as an important field in unsupervised ML applications [11].



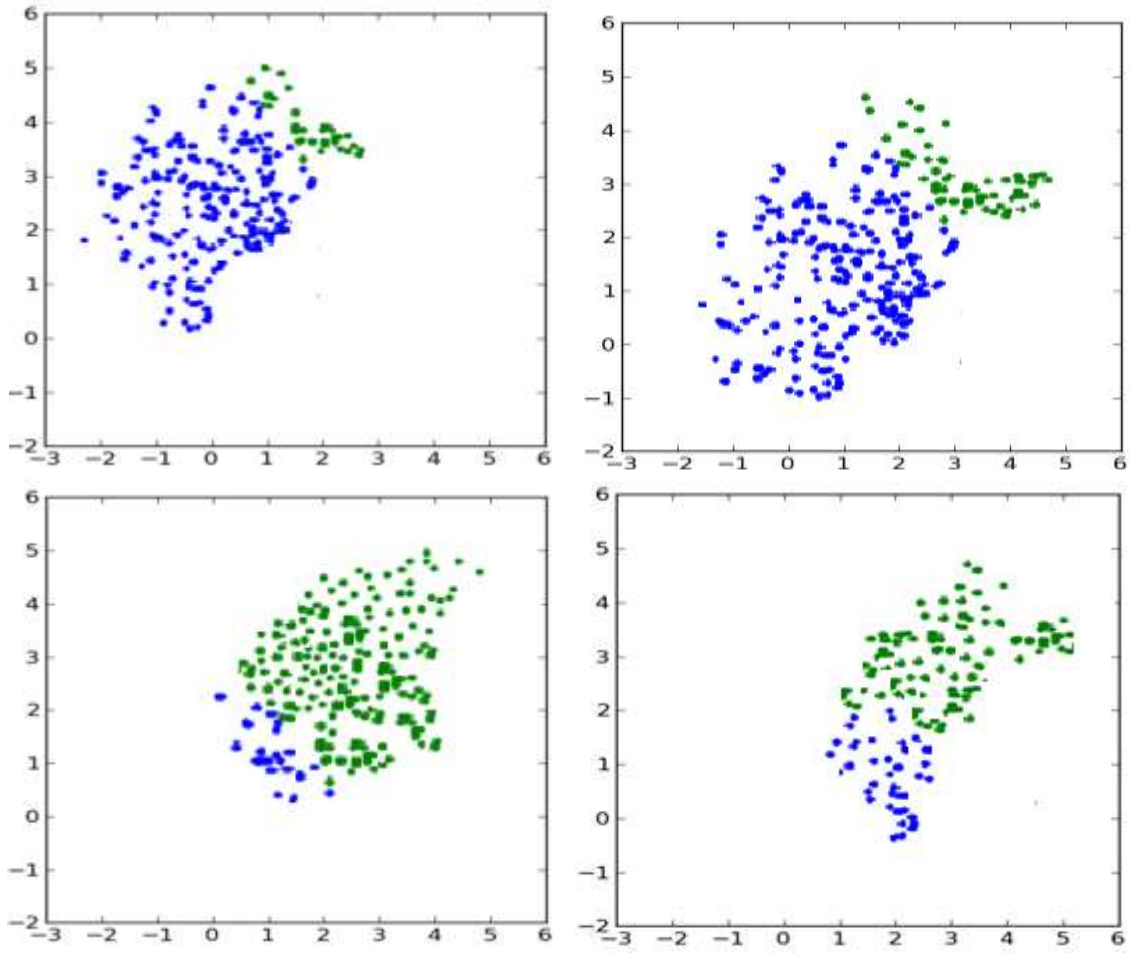
(a) ***(b)*** ***(c)*** ***(d)***

Figure 1. degraded images (darked and highlighted illuminations)

The second part is the implementation phase, first we applied the K-means clustering ML algorithm. Clustering analysis technique is based on functions of matching or mismatching measures in different domains [12]. depending on the proposed centroid values λ_1 and λ_2, we distributed the illumination values in order to determine the right formula as explained in table1:

Table 1. Determining the cluster through random illumination values

Random illumination values	Distance to λ_1	Distance to λ_2	Cluster
45	5	155	K_1
70	20	130	K_1
220	170	20	K_2
50	5	145	K_1
90	40	110	K_1
128	78	72	K_2
230	180	30	K_2
40	10	160	K_1
190	140	10	K_2



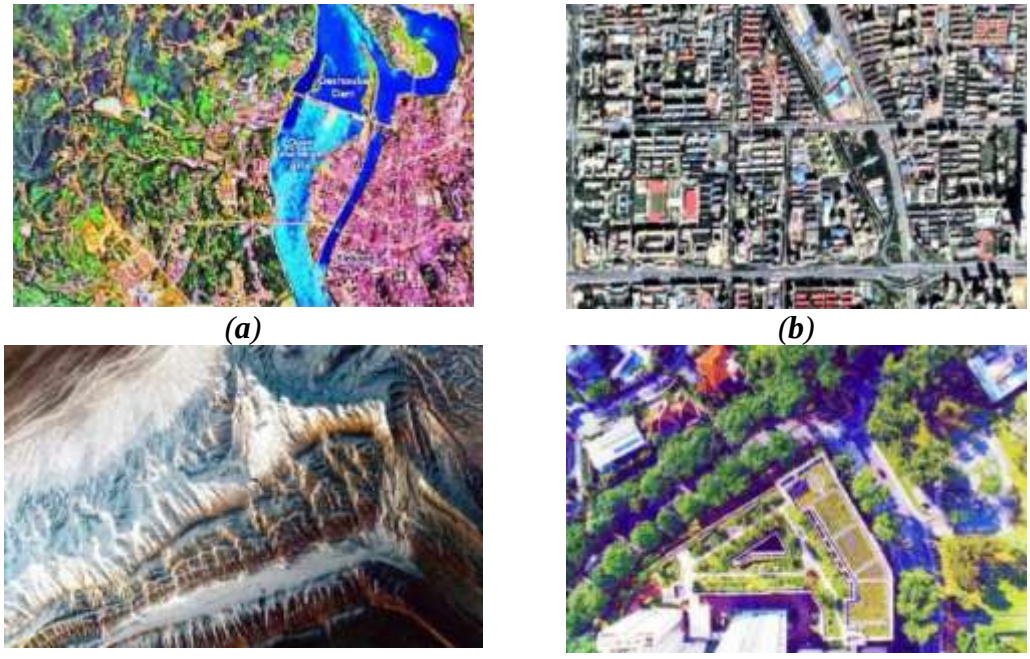
Cluster K_1 , Cluster K_2

Figure 2. Clustered illumination values distribution for figure1

3. RESULTS AND DISCUSSION

3.1. RESULTS

The idea behind clustering term is to group all the data that have the same charcteristics [13]. Depending on the distribution as explained in table1 and displayed in figure 2, we selected the minimum value that refers to the distance to the determined and proposed centroid points (λ1 for darked region and λ2 for highlighted region), then depending on the result from the previous step we can determine which cluster will be selected (closer to that region) so depending on this procedure we can determine which equation will be used in order to process the (darked or highlighted) region, choosing cluster K1 for example means that this illumination value will be processed using equation1 in order to process the darked illumination values. We enhanced the low contrast images as explained in figure 3:



(a) ***(b)*** ***(c)*** ***(d)***

Figure 3. Normalized images based on the proposed model

The data has been processed using some procedures that make it easy to understand like, noise reduction, data organizing (through distributing it into two clusters for both highlighted and darked regions using K-means clustering) and finally reconstructing the processed regions in order to obtain the processed image. we used Python for applying the proposed work using true color (double data type) as explained in figure3, we displayed a segment of resulted pixel values of figure3 (a), as explained in figure4:

	Red	Green	Blue	Red	Green	Blue	Red	Green	
1	0.5419	0.5119	0.4398	0.6112	0.6293	0.7611	0.5187	0.6617	0.6
2	0.6626	0.8713	0.5481	0.6771	0.7432	0.5212	0.6514	0.5372	0.5
3	1.0000	1.0000	0.8623	0.8711	0.6926	0.6618	0.5593	0.7724	0.5
4	0.7712	0.6214	0.9241	0.3764	1.0000	0.4433	0.6624	0.7629	1.0
5	0.9275	0.6129	0.7369	0.5591	1.0000	1.0000	0.8442	0.7391	0.5
6	1.0000	0.9945	0.8981	0.7813	0.7611	0.9921	0.5217	0.0588	0.0
7	0.0156	0.1176	0.1960	0.7058	0.8627	1.0000	0.9411	0.3921	1.0
8	0.5607	0.8235	0.0000	0.0000	0.0392	0.4313	0.6666	0.4313	0.2
9	0.2352	0.0000	0.4352	0.2784	0.6313	0.4117	0.0392	0.2745	0.0
10	0.0431	1.0000	0.0000	0.0000	0.0588	1.0000	0.2941	0.0000	0.1
11	0.7450	0.0000	0.4392	0.0000	0.0235	0.7843	0.2352	0.0000	0.5
12	0.0392	0.0000	0.4509	0.6862	0.2784	0.7843	0.2394	1.0000	0.1
13	1.0000	0.4117	0.4352	0.1607	0.8274	0.4431	0.7882	0.4156	0.7
14	0.1294	1.0000	1.0000	0.8196	0.3882	0.8509	0.3450	0.9568	1.0
15	0.0431	0.0980	0.1843	0.3882	1.0000	0.7686	0.7882	0.8588	0.3
16	0.7333	0.0000	0.0000	0.7287	0.8431	0.0509	0.1849	0.9764	0.9
17	0.8705	0.3450	0.1803	1.0000	0.3498	0.8420	0.0000	0.9224	0.8
18	0.9340	1.0000	0.0441	0.9812	0.0549	0.0120	0.0509	0.8711	0.6
19	0.9899	1.0000	0.5419	0.8711	0.3233	0.2188	0.5519	0.8120	0.8
20	1.0000	0.8972	0.6631	0.5829	0.0000	0.1147	0.2291	0.8452	1.0
21	0.7612	0.9115	0.9962	1.0000	1.0000	0.3341	0.2276	0.5629	0.4
22	0.6523	0.3349	0.7611	0.8819	0.0000	0.0000	0.2238	0.9891	0.0
23	0.3451	0.2287	1.0000	0.6562	0.0231	0.9915	1.0000	0.6349	0.7

Figure 4. processed illumination values based on the proposed algorithm

The term quality is considered important factor for recognizing and enhancing any image [14]. Image metrics are considered as an important factor in the estimation of image processing procedures [15]. We applied the performance metrics for estimating the proposed model as explained in table2:

Table 2. Estimating the performance of the proposed model

Metric	Image(a)	Image(b)	Image(c)	Image(d)	Avg
PSNR	18.97	12.76	13.38	15.22	15.082
MSE	0.005	0.007	0.004	0.006	0.005
SSIM	0.824	0.794	0.822	0.919	0.839
HVS(CSF)	1.430	1.971	1.762	1.77	1.733
UIQI	0.458	0.655	0.831	0.901	0.711
NCC	0.899	0.821	0.932	0.994	0.911

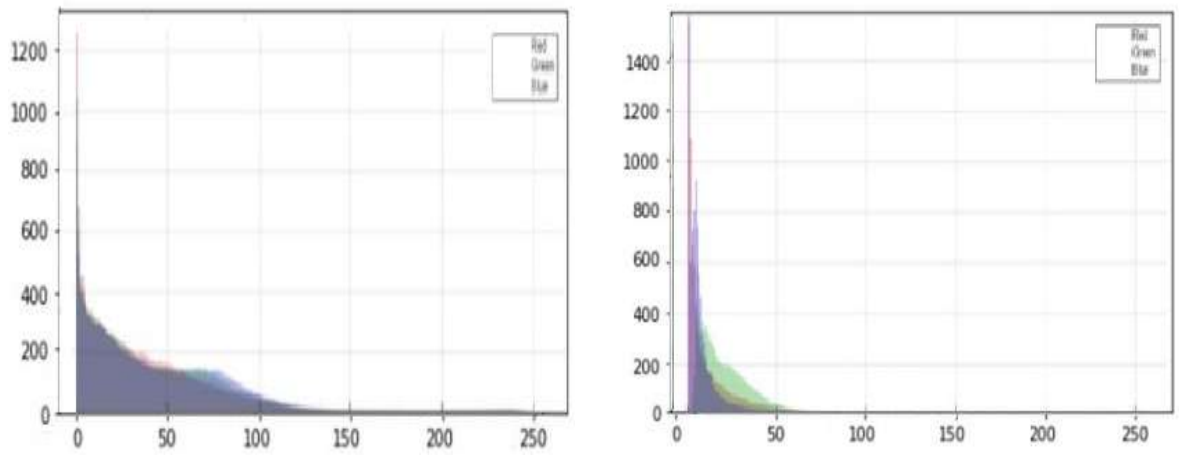
Depending on the determined images we calculate the average for the performance metrices as explained in table2.

3.2. DISCUSSION

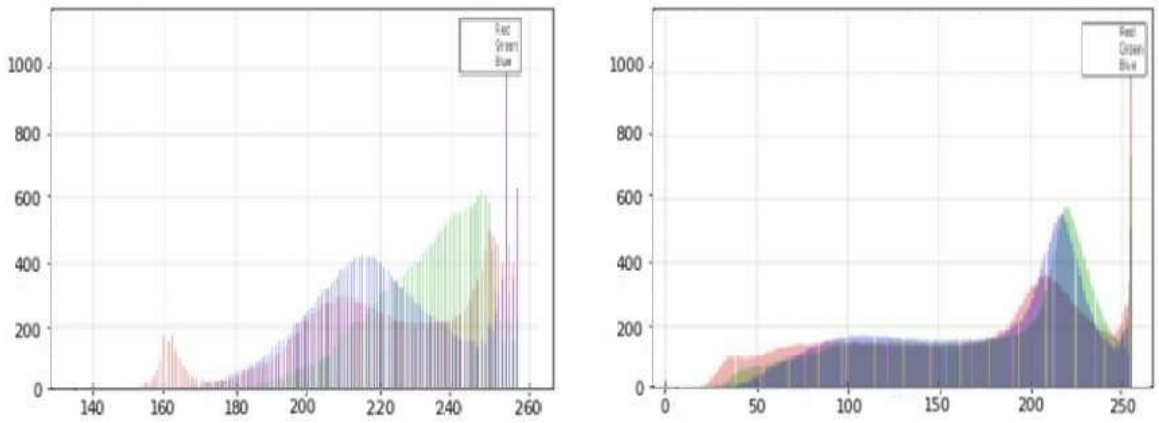
The research tries to propose an enhancing method or model for processing the degraded images in both cases (darked and highlighted), so after applying the proposed model we compared the derived results that obtained from the determined metrics with other normalization processing algorithms, we noticed that the proposed work in some cases matches the performance of the other techniques or extended to better as explained in table3, depending on the determined metrics, we noticed that the obtained values satisfy the research contribution through comparing the results of some standard algorithms that displayed in table3 with the proposed work and we noticed that: the HVS metric for the proposed model was 01.73 and is considered the best among other determined algorithms, also the MSE metric for the proposed model is 0.005 which is considred the lowest value compared to other algoithms, also the Normalized Cross Correlstion NCC metric was closer to 1 and that has been considered good among others..etc, so these results give a sign that the proposed contribution (parallel processing and combination with ML algorithm) provide more processing accuracy and rapidity. The histograms distribution for the four sampled after applying the proposed model on all the range from 0-255 were also very good as displayed in figure 6.

Table 3. Performance comparison

Metric	M-M	PW	HE	Proposed
PSNR	9.22	8.98	10.23	15.08
MSE	0.015	0.017	0.007	0.005
SSIM	0.772	0.543	0.792	0.839
HVS(CSF)	2.21	1.76	2.76	1.733
UIQI	0.691	0.551	0.713	0.711
NCC	0.812	0.776	0.892	0.911



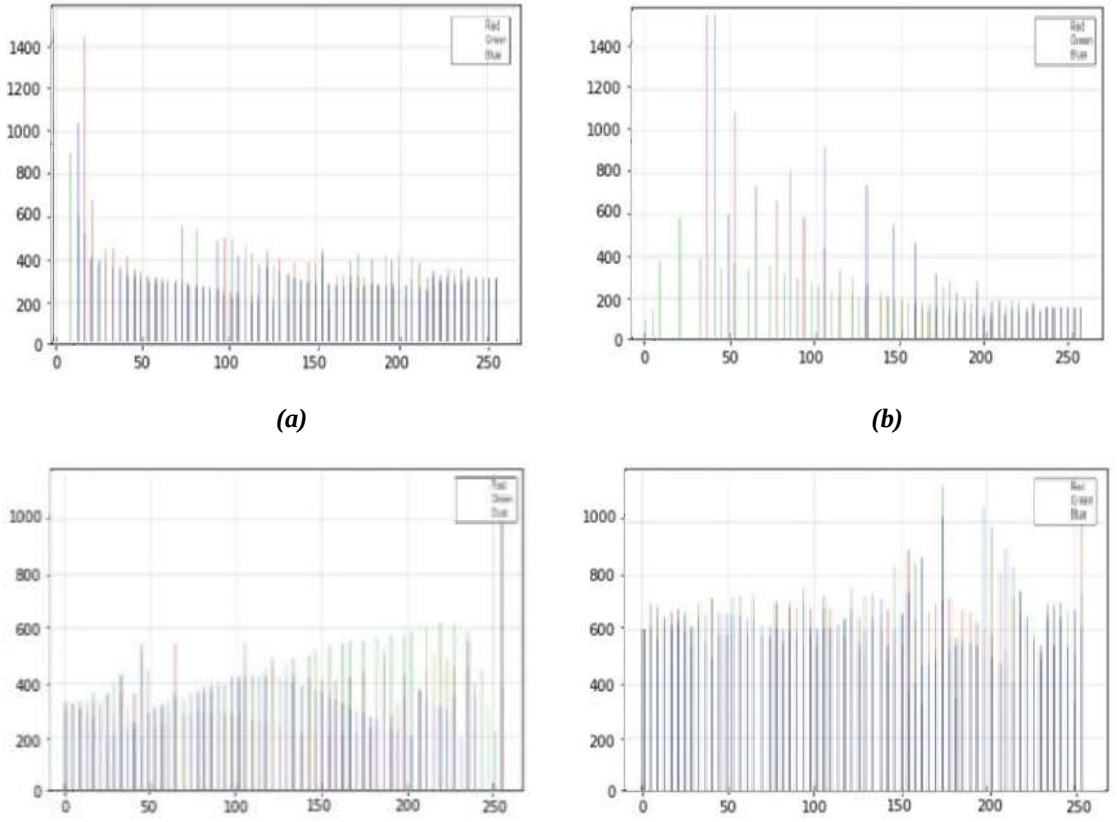
(a) ***(b)***



(c) ***(d)***

Figure 5: Histogram distribution for degraded images

Figure 5 shows the histogram distribution for both darked and highlighted images and depending on the proposed method we processed the degradation case as explained below in figure 6:



(a) ***(b)***

(c) ***(d)***

Figure 6: Histogram distribution for the normalized images

From figure 6, we noticed that the determined degraded images after applying the proposed model are stretched (normalized) across among all the distribution range as displayed in the above fogure3.

3. CONCLUSION

In this research aproposed method for digital image normalisation is presented through using the K-means clustering algorithm. Depending on the comparison with other normalisation (contrast stretching) algorithms, Histogram Equalization (HE), PieceWise (PW) and Min-Max (MM) algorithms that have been obtained from the

four sampled digital images and compared with the previous mentioned algorithms as displayed in table3, we noticed that the merging between the normalisation technique with the machine learning algorithms gave us better performance through accuracy and rapidity, so additional conclusions, We noticed that there is a consistent between the proposed work with other standard algorithms, but the achieved contribution that is considered as a strength point (parallel processing for both darked and highlighted regions in the image) at the same time added more accuracy to the work thorugh the using of the ML (K-means clustering) algorithm, so finally we can apply this proposed work in many image processing fields that need to deal with the concept of processing rapidity like recoreded video segments or online stream like video survilliance systems that need to high speed processing.
Also as a future ideas, the proposed work can be integrated or combined with other algorithms in order to extraxt new features.

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