Analysis and Evaluation of Contrast Enhancement methods in Digital Images

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Abstract—Digital Cameras that gradually replace conventional cameras store photographs in digital format. As a result, captured images can be more easily processed. Consequently the quality of image is more important. In this paper, we present an overview of image quality attributes of different contrast enhancement in gray level images. Moreover, we present results of analysis for some contrast enhancement methods. We also present the evaluation of existing contrast enhancement methods with regard to these attributes.

Keywords— Tone Mapping; Contrast enhancement; Brightness; Reproduction of details; Image quality.

I. INTRODUCTION

There are many attributes of image quality, such as brightness, contrast, noise, reproduction of details, reproduction of colours, visual acuity simulation, glare simulation and artifacts. Among all digital image procedures, contrast enhancement plays a very important role in increasing the visual quality of an image. For this reason, many contrast enhancement techniques have been proposed [4, 5, 7, 8, 9, 10, and 11] for either high dynamic range images (HDRIs) or low dynamic range images (LDRIs).

We compare these methods by brightness, contrast, and, reproduction of details, to evaluate their qualities and performance. The paper is organized as follows. In Section 2 overview the related works on a survey of the most important image attributes for digital image and comparison of contrast enhancement methods. Section 3, we show the results of these experiments, and finally in Section 4 concludes this paper.

II. RELATED WORKS

Some researches had done for evaluating the image quality in the pass decade [1, 2, 3, and 12]. Such as, M. Cadik, M. Wimmer, L. Neumann, A. Artusi [3] addressed a scheme of the relationships between image attributes for tone mapping as shown Figure 1. Also their have proposed a measure as a combination of these attributes based on psychophysical experiments. In Figure 1, we can see that brightness, contrast, reproduction of details, and reproduction of colours have important relationships mutually for image quality.

Figure 1. Relationships between image attributes.

Ahmet M. Eskicioglu and Paul S. Fisher [1] had evaluated the usefulness of some of the objective quality measures in difference formats. Their concerning the usefulness of a number of objective quality measures for grayscale image with compressed.

Shen-Chuan Tai et al. proposed some methods for image contrast enhancement [8, 9, 10, and 11]. We describe some concepts of these methods bellow:

- **Method 1:** High Dynamic Range Compression with Detail Refinement in Network Communication (Jen-Hao)
  
  The method proposed a new algorithm for tone reproduction problems. That can be solved the data communication problem of wireless network. This new algorithm is based on the level set method and Barladian’s algorithm; we modify the integrated algorithm with adding three more steps. These three steps are: adaptive gain control, dodging-and-burning, and local contrast enhancement.

- **Method 2:** An efficient local region enhanced algorithm (Li-Wei)
  
  The method proposed an effective algorithm for local contrast enhancement by using Histogram Equalization and Histogram Stretching technology. This algorithm also combines a tone mapping method for High dynamic range image. The benefits of this algorithm are: the scheme of algorithm is simple and easy to implement, high performance, and get better image quality.

- **Method 3:** A Two-Stage Contrast Enhancement Algorithm for Digital Images (Yen-Cheng)
The method proposed a local contrast enhancement algorithm with logarithm-based curves for both high dynamic and low dynamic images and this algorithm can adaptively change the curvature with local information. The method also defines two parameters to decide the level of contrast enhancement in the tone mapping procedure. For halo artifact which is suffered from local operator, a two-stage procedure is designed to solve the problem.


In 2004, Ming-Long Huang [4] proposed a new and simple tone reproduction (tone mapping) algorithm based on tone synthesis. An input high dynamic range (HDR) image may be decomposed into two sub-images. One is the base layer and the other is the detail layer. The base layer is compressed by the tone reproduction operator. After that, the weighted base layer and weighted detail layer are synthesized to get a better low dynamic range image. The whole algorithm is simple but effective.

## III. EXPERIMENTAL AND RESULTS

We estimate these four methods for evaluating the image quality. We use the statistical way to evaluate these methods.

### Tests of statistical significance

In order to evaluate the algorithms’ performances, we are interested in investigating the qualities of “contrast”, “brightness”, and “represent of detail”. The paired-observation t tests are employed to test paired difference. Through the t test, the statistical parameters in concern include the mean intensity and its standard deviation for the difference between the two observations for each image tested. The t statistic:

\[
    t = \frac{\bar{d} - \mu_d}{s_d / \sqrt{n}}
\]

where \(\bar{d}\) is the sample average difference between each pair (algorithm) of observations, \(s_d\) is the sample standard deviation of these differences, and the sample size \(n\) is the number of pairs of observations (here, the number of images in the experiment). The \(\mu_d\) is the population mean difference under the null hypothesis, therefore here the \(\mu_d\) is 0.

The relationships of original images and enhanced images by variation methods are shown Figure 2. In Figure 2, the axis of vertical level represents the overall contrast (brightness, or represent of detail) of original images. The axis of horizontal level represents the overall contrast (brightness, or represent of detail) of enhanced images. Figure 2 shows the results of method 2 (LiWe) are apparent than others in “contrast”, and “represent of detail”, because of the result curves is similar to original image.

For HDR and LDR problem, the paper compared the mean of “contrast”, “brightness”, and “represent of detail” for paired data, respectively. The results respectively show as Tables 1 and 2. In table1, we can see that method 2 (LiWe) also are apparent than others at contrast ratio in both of HDRI and LDRI. For represent of detail part, the method 3 (YenCheng) can represent more details than others. Figure 3 shows the some of examples of testing images for both of HDRI and LDRI.

## IV. CONCLUSIONS

The field of contrast enhancement assumes comprehensive knowledge of various image attributes and approaches from diverse scientific areas. In this paper, we have presented some contrast enhancement methods evaluation for images quality. We have verified these methods by statistical of some image attributes experiments.

### REFERENCES


### TABLE I. ORIGINAL AND PROCESSED IMAGES—HDR

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Contrast</th>
<th>Brightness</th>
<th>Represent of detail</th>
</tr>
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<tbody>
<tr>
<td>Li-Wei</td>
<td>.0488*</td>
<td>3684</td>
<td>.5973</td>
</tr>
<tr>
<td>Yen-Cheng</td>
<td>.1038</td>
<td>3708</td>
<td>.0108*</td>
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<tr>
<td>PITR2005</td>
<td>.0100*</td>
<td>9520</td>
<td>.0947</td>
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<tr>
<td>Jen-Hao</td>
<td>.1760</td>
<td>6272</td>
<td>.5800</td>
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</tbody>
</table>

(a). Contrast ratio for HDRI.  
(b). Brightness ratio for HDRI.  
(c). Represent of detail ratio for HDRI.

(d). Contrast ratio for LDRI.  
(e). Brightness ratio for LDRI.  
(f). Represent of detail ratio for LDRI.

Figure 1. Relationships of original images and enhanced images by variation methods. The axis of vertical level represents the overall contrast (brightness, or represent of detail) of original images; the axis of horizontal level represents the overall contrast (brightness, or represent of detail) of enhanced images.

<table>
<thead>
<tr>
<th>Images</th>
<th>Original image</th>
<th>Li-Wei</th>
<th>Yen-Cheng</th>
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</thead>
<tbody>
<tr>
<td>HDR</td>
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<td>Bristolb</td>
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<td>HDR</td>
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<td>HDR</td>
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<td>Morning</td>
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<td>GrayLevel</td>
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Figure 2. Some examples of gray level testing images.