Quality of medical microscope Image at different lighting condition

Shahad Ahmed Abd-Alameer 1, Hazim G Daway 2, Hayfa G. Rashid 3

1-3Physics Department, Education College, Al-Mustansiriyah University
2Department of Physics, College of Science, Mustansiriyah University, Baghdad, Iraq
1 Shuhadahmed9090@gmail.com, 3 hazimdo@uomustansiriyah.edu.iq, 1 hayfa_gh_rasheed@yahoo.com

Abstract. A no-reference quality metrics is one of the challenging fields in image quality assessment. The aim of the research is measuring the quality of the microscope medical image such as blood smear and sample texture, at different lightness conditions by using two types of light sources are Tungsten and LED. To find the best light level at imaging, the no-reference quality metrics are calculated by using the histogram in a HL component in the wavelet transform. This measure is compare with the other no-reference algorithms as entropy and average gradient by calculating the correlation coefficient between the subjective and objective methods. The results show that the proposed algorithm is a good measure of the quality of the medical microscope images at different lighting condition.

Keywords: Image quality assessment; Blood slides; colon disease slides; microscope for a LED light; microscope for a tungsten light; wavelet domain.

1. Introduction

Many theoretical concepts play an important role in image formation, analysis and enhancement [1,2,3,4]. Color in the digital images is mostly represented by a tri components, for instance, Red Green and Blue (R, G, B) this components is sensitive to changes in illumination. In previous years, incandescent light was the only lighting, while proper lighting is essential for light microscopy. Today, the LED light has been used Because of its high efficiency, it has become the best lighting in the light microscopy. The LED is extremely durable and has a narrow bandwidth. The white LED, with a color temperature ranging from 2,600 up to 5,000 K is an excellent choice for bright field illumination, this makes them ideal sources of microscopic light. This review proposed method to determine no reference image quality by calculating the entropy for a gray level image taken from the camera where the lighting was changed continuously and the image with the best contrast was selected [5]. Yang et.al. 2010, Proposed an image enhancement approach depending on the wavelet transform using Haar transform to overcome the main problem of medical images i.e. low contrast and poor quality. This method can effectively maintain its advantages [6]. Yang 2012, introduced the method to enhance sharpen in the digital image by using an adapting mask-filtering, depending on the derivatives between the target pixel and its neighbors were mapped by the cubic root of a sinusoidal function as an alternative to the traditional linear one. The obtained final image has clearer fine characteristics but much less overshooting that is usually found in the conventional technique. The demonstrated technique was useful for various applications, such as medical image enhancement, remote sensing and microscopic image sharpness [7]. In 2014 Negi and Gupta, suggested spatial domain algorithm for digital image enhancement, by using point processing techniques as spatial filtering and histogram processing, more effective image enhancement can was achieved by a combination of enhancement methods [8]. Headlee et.al.2015, Introduce a localized blind image improvement metric to score different image enhancement algorithms. These scores have been used to fuse many enhanced images...
with each other to make an overall superior enhancement process. Their result shows that fused images score higher using the blind metric and have also superior subjective measure [9]. Yang et al. 2018, introduced a deep neural network model capable of predicting an absolute measure quality of image depending on a single image in isolation, that is not using specified parameters. The method operates at the sub-image level, and also outputs a measure of prediction certainty, enabling interpretable predictions[10]. Recently Saja et al. 2018, increase nuclear tracks image vision by introducing two technique. The first method, saja et.al. construct light system experiment setup based on LED light instead of fluorescent light in an optical microscope. Results illustration that high vision and an extra number of tracks were obtained during shooting. Due to the high dynamic range of LED light. The second method proposed bind Image quality metric depending on wavelet transform as the scale for nuclear tracks counting [11]. In this study, a no-reference quality scale was suggested to increase the clarity of medical images Based on suggested wavelet transformation, by using four methods, Entropy (EN) measurement, Measure of Enhancement (ME), the Blind or no-Reference Image Spatial Quality Evaluator (BRISQUE), Locally-Mean Sigma-Mu (LSM) model.

2. Image Quality Measurement (IQM):

The suggestion of many techniques for measuring image quality is not ideal for measuring quality, as in the field of image processing, image quality assessment plays an important role in the images techniques. Subjective and objective are important kinds of Image quality metrics, the HVS (human visual system) is an example of subjective IQM. The difference between original and distorted image are related to with IQM and is called reference and no reference IQM, respectively [12]. The other unrelated IQM with can be classified as follows:

2.1 Full Reference image quality:

Image quality is interpreted by the full evaluation of the reference image quality as a accuracy with an ideal image in some sensory space. Modeling the visual physiological and psychological features of the HVS system through which the algorithms attempt to evaluate the image quality. The problem of evaluating the image quality is dealt with by the methods of the full reference image quality with it as a problem in the accuracy of the information [13,14]. The full reference scale is suitable for comparing the image coding scheme. This comparison is made when measuring the distance between the two signals in a feasible way [15].

2.2 Blind Image Quality:

Blind image quality refers to the visual quality of image without any reference to an original optimal quality image. This is the most difficult problem in the field of image objective analysis [16]. Since, many factors offered the role of human perceptions quality [17]. Such as high resolution image assessment quality, of, Compressing of JPEG image. All to gather factors has blind image quality depends on lightness and contrast of image [18]. There are four blind scales used:

a. Entropy (En) measurement:

The entropy is defined as follows [1]:

\[ E_n(r) = \sum_{k=1}^{n} p_t(r_k) \log_2 \left( \frac{1}{p_t(r_k)} \right) \]  

(1)
Where \((r)\) is a discrete random variable with possible outcomes \(r_1, r_2, ..., r_n\); \(p_t(r_s)\) is the probability of the outcome \(r_s\).

**b. Measure of Enhancement (ME):**

Measure of enhancement by entropy (EM) is an extension of Measure of enhancement, for a certain circumstances, Measure of enhancement shows a characteristic of range dependent which changing itself based on the maximum and minimum range[19]. This is thus not being ideal for measuring the image enhancement in all circumstances. Therefore, the measure of enhancement which is based on the concept of entropy, the new image quality index, EM is given by Equation (2) [19]. \(\alpha\) is a constant and equivalent to 0.8 as suggested by the authors. The high value of EM indicates the better image quality [19].

\[
EM = \frac{1}{k_1 k_2} \sum_{l=1}^{k_2} \sum_{k=1}^{k_1} \alpha \left( \frac{l_{\text{max},k,l}(\theta)}{l_{\text{min},k,l}(\theta)} \right)^{\alpha} \log \frac{l_{\text{max},k,l}(\theta)}{l_{\text{min},k,l}(\theta)}
\]

where \(l_{\text{min},k,l}\) and \(l_{\text{max},k,l}\) , \(l_{\text{min}}(\theta)\) and \(l_{\text{max}}(\theta)\) are the minimum and maximum intensity levels of the image \(x(n,m)\) inside the block after processing the block by \(\theta\) transform based enhancement algorithm.

c. BRISQUE:

The Blind/Referenceless Image Spatial Quality Evaluator BRISQUE conversion algorithm is used to blindly reduce noise to blind blindness algorithm. Blind noise reduction algorithms seek to reduce the amount of noise present in damaged images, without any additional information such as noise contrast. Although noise reduction in the image is a well-studied problem with image processing [20-24]. Reference [25] describe in details the proposed method.

d. Locally-Mean Sigma-Mu (LSM) model:

In this model, the quality is calculated by plotting the relationship between the average of standard deviation (Sigma) and the Mean of image (Mu), for each region in the image, after dividing it into several regions. From this scheme when the value of the average of standard deviation (Sigma) and the value of the Mean of image (Mu) increases from one point to another, the quality increases. Form this model, when the value of the average of standard deviation (Sigma) increases only, the value of contrast increases, and the value of the Mean of image (Mu) increases only, the value of lighting in the image increases, as in show the figure. The main holdback to this no-reference model is the absence of a numerical value for the quality scale. Where it is considered a descriptive model, that compares the low-light image at a certain point according to the coordinates of the rate LSM to another point where the lighting increases and the contrast is considered an ideal region [26]. In this research, We have improved this model from a descriptive model to a digital model by calculating the quality vector from the point of origin while converting the modified values into normalization values as follows:

\[
\bar{\sigma}_N = \frac{\bar{\sigma}}{\sigma_{\text{max}}}
\]
\[ L = \sqrt{(\sigma_0 - \sigma_n)^2 + (\mu_0 - \mu_n)^2} \]  \hspace{1cm} (4)

The distance from the origin \((\sigma_0, \mu_0 = 0)\) to the point \((\sigma_n, \mu_n)\).

\[ L = \sqrt{(\sigma_n)^2 + (\mu_n)^2} \]  \hspace{1cm} (5)

3. Materials and Methods:

In this work, blood and colitis slides were used with many different lighting images in the optical microscope. The first one utilizing tungsten light, with captured images specifications as follows:

Item type: JPEG image, Size 178 KB, Dimension 2592*1944, Width 2592 pixels, Height 1944 pixels, Horizontal resolution 96 dpi, Vertical resolution 96 dpi, Bit depth 24. The second method contains LED light with specification of images as follows:

Item type: Bitmap image, Size 14.4 MB, Dimension 2592*1944, Width 2592 pixels, Height 1944 pixels, Bit depth 24. As this lighting is an electromagnetic wave of both frequency and length, light is emitted from the body by illumination and luminosity [27]. The optical microscope contains two sources of lighting, the first being light LED light have made their way into numerous lighting

![Figure 1](image-url)
applications including exit signs, traffic signals, under-cabinet lights, and various decorative applications. Energy is emitted as light when charged carriers (n-type) and some by positively charged carriers (p-type) [28] as shown in the figure (2).

LED lights produce "white light" when it emits visible light in a very narrow spectral band. This is accomplished with either a red-blue-green array or a phosphor-coated blue LED lamp [29].

And the second source of lighting is tungsten light, nearly all light microscopes are equipped with a halogen lamp (10–100W) either for general use or as an addition to another light source. A wide range of optical contrast methods can be driven with this type of light source, covering all wavelengths within the visible range but with an increase in intensity from blue to red. Additionally, the spectral curve alters with the used power to achieve similar looking colours in the prevalent brightfield microscopy; the power setting should be kept at one level, e.g. 9V (TF= 3200 K; the colour temperature at +9V). This light intensity level is often marked at the microscope frame by a photo pictogram [30].

Figure (2) Shows LED ceiling light size (52 x 31) mm and basic components of and light path through an inverted fluorescence microscope.

4. Suggested no-reference image quality assessment:

In this study, a no-reference scale was suggested to measure the quality of medical images taken with an optical microscope, as this scale depends on the wavelet transformation. First, the image is converted to the lighting component, and second, the wavelet transformation of that component is found. This proposed scale depends on the value of the standard deviation of the component (HL) in the wavelet transformation, as shown in the figure (3). The following steps can be used below to calculate the quality scale as follows:
1. Input color image $c(i, j, k)$; where $k = 1, 2, 3, \ldots$ 
2. Convert $c$ image from lightness (R,G,B) to (HSV) image by using
\[ I = \max (R, G, B) \] 
(6)
3. Calculating wavelet transform for $I$ component.
4. Estimating HL component only.
5. Finding quality by using HL component
\[ Q = 1 / \text{std} (HL) \] 
(7)

Where (LL) is the Low-low Approximation image component, (HL) is the high-low component, (LH) is low-high component and (HH) is the high-high component. Figure (4), shows the proposed change in the quality scale that depends on the wavelet transformation with the luminance value of the optical microscope images taken with LED light for different lighting cases, where we notice the increase in the quality value by increasing the luminance value for certain cases.

The figure shows the application of the proposed quality measure based on the wavelet transformation with the lighting value of the optical microscope images captured by light for different lighting conditions. We note that the quality value increases by increasing the lighting for these specific cases.

Figure(3). Wavelet transform of blood slide image in four other images.

Figure(4). Images of a colitis slide captured with LED light for different lighting conditions.
Where the illumination value (LUX) for the medical image captured by the optical microscope is measured by using Digital lux meter, as shown in the figure.

Figure (5) Digital lux meter Model (LX1330B) china.

5. Result and discussion :

There are two types of optical microscope to enhancement the lighting system in medical imaging, the first type of microscope contains tungsten light, four groups (40 photos) were taken at different lighting conditions, and the second type of microscope contains LED light four groups (56 photos) were taken at different lighting conditions, where a no-reference quality measure based on the wavelet transform was suggested, using four methods, Entropy (EN) measurement, Measure of Enhancement (ME), the Blind/Referenceless Image Spatial Quality Evaluator (BRISQUE), locally-Mean Sigma mu (LSM) model, as shown in the figure.

Figure.6(1) Show a set of images captured in the optical microscope of LED light at different lightness values.
The curves below represent the relationship between quality measures and the maximum illumination value of a group of medical image slides captured by LED light and tungsten light. Where we note that the highest quality value in blood slide imaging is at the value LSM, That is the closer the proposed scale is to (LUX=413) we get the highest correlation coefficient.

Figure(7). The curves for a group of Blood and Colitis Slides captured by LED light.
Figure (8). The curves for a group of Blood and Colitis Slides captured by Tungsten light.

We note the first match of the proposed measures compared to other measures.

The tables below show the correlation coefficient for LED light and Tungsten light.

### Table 1. Correlation coefficients for different No-Reference scales comparing with quality measures for LED light.

|       | EN   | BRISQUE | ME   | WQ   |
|-------|------|---------|------|------|
| Value | 0.0072 | -0.8413 | -0.8483 | 0.1736 |
|       | -0.0699 | -0.5904 | -0.7118 | 0.2450 |

### Table 2. Correlation coefficients for different No-Reference scales comparing with quality measures for Tungsten light.

|       | EN   | BRISQUE | ME   | WQ   |
|-------|------|---------|------|------|
| Value | 0.9969 | -0.9706 | -0.9949 | 0.9370 |
|       | 0.6948 | 0.5941  | 0.3157 | 0.8289 |

### 6. Conclusion

In this paper, we compared the lighting of LED and tungsten lights, as we demonstrated that imaging with a (LED) light is better than imaging using tungsten light. This is because the light (LED) has a higher correlation coefficient than the tungsten light correlation coefficient. It is for this reason that LED lights have gained popularity in our homes and have begun to move to research laboratories and hospitals. Thanks to its ease of use, long life and low waste, you will continue to take on the role of a traditional mercury arc lamp.
As for the proposed quality scale that depends on the wavelet transformation, it is the best measure compared to other measures, and it can be seen that the best lighting values for light (LED) at LUX= (246, 323, 386, 444, 493, 605, 691, 745, 793, 862, 1117,1233 and 1889), and when the tungsten light LUX= (156, 184, 240, 259, 291, 321, 350, 408, 490 and 573), we have found that increasing the value of quality by increasing the illumination for some situations, therefore, there are lighting levels that make the image quality.

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