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A Hybrid Colour Image Enhancement Technique Based on Contrast Stretching and Peak Based Histogram Equalization

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Abstract: **Medical image enhancement technologies have attracted much attention since advanced medical equipments were put into use in the medical field. Enhanced medical images are desired by a surgeon to assist diagnosis and interpretation because medical image qualities are often deteriorated by noise and other data acquisition devices, illumination conditions, etc. Also targets of medical image enhancement are mainly to solve problems of low contrast and the high level noise of a medical image. Image enhancement plays an important role in computer vision and image processing. In this paper, the use of contrast enhancement techniques for colour images using RGB components is proposed. The histogram equalization (HE) is one of the most popular methods for image contrast enhancement. However, HE algorithm has two main disadvantages. To solve these problems, this paper presents an improved image contrast enhancement based on histogram equalization, which is especially suitable for multiple-peak images. Firstly, the input image is convolved by a Gaussian filter with optimum parameters. Secondly, the original histogram can be divided into different areas by the valley values of the image histogram. Thirdly, using of our proposed method processes images and finally the contrast enhancement Technique, partial contrast is applied to enhance the morphological features of acute leukaemia images to ease the leukaemia classification between Acute Lymphoblastic Leukaemia (ALL) and Acute Myelogenous Leukaemia (AML). The results show that partial contrast is the best technique that helps to improve the image visibility while preserving the significant features of acute leukaemia images. Hence, the resultant images would become useful to Hematologists for further analysis of acute leukaemia. The result demonstrates that the proposed algorithm has good performance in the field of image enhancement.**

Index Terms— **Contrast Enhancement, Histogram Equalization, Image Processing, Partial Contrast.**

I. INTRODUCTION

The term leukaemia refers to a group of cancers of the blood cells. It is characterized by abundance of abnormal white blood cells (blast) in the body [1]. Acute leukaemia is a rapidly progressing disease compared to the chronic leukaemia. It primarily affects cells that are not fully developed or differentiated. The two main types of acute leukaemia are Acute Lymphoblastic Leukaemia (ALL) and Acute Myelogenous Leukaemia (AML) [2]. Generally in leukemia diagnosis, Hematologists will look for the abnormal white blood cells to differentiate the types of leukaemia either ALL or AML. There are several morphological features that can be used to distinguish between ALL and AML such as size and shape of blast [2]. Leukaemia is of paramount importance in the healthcare industry. Currently, the microscopic investigation to identify the types and maturity of blood cells is performed manually by Hematologists through visual identification under the microscope. Specific type of leukaemia must be classified in order to provide the best treatment. However, the manual recognition method requires a lot of time and effort. This method is therefore inappropriate to be utilized in large hospitals. Several algorithms and techniques have been developed for blood cells recognition. Image enhancement at the preprocessing stage becomes the most important process for a successful feature extraction and diagnosis of leukaemia. In general, there are two requirements to be fulfilled for colour image enhancement [3]. The first one is to keep the colour structure of the original image. This can be done by simply keeping the ratios between R, G, and B components of every pixel. The second requirement is to present as much information as the original. This can be achieved by using the information in the luminance component as well as colour components [3]. Most works proposed the use of gray level image processing techniques to extract the blood cell features. However, the actual screening process by Hematologists is performed on stained slide where the leukaemia is detected based on colour and size of blast. Kumar, Verma, and Singh [4] stated that colour images are very rich source of information, because they provide better description of a scene. The conversion of the colour image to gray level image may cause some features that are based on colour to disappear.

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II. THE PROPOSED ALGORITHM

A. Gaussian Filter

In order to reduce the noise's interference and improve[5] the quality of input image, in this work we propose to use Gaussian filter convolving the image firstly. Gaussian filter reduces the difference in brightness between adjacent elements. It also can reduce blocking effects. As mask size is increased, blocking effects can be decreased. However, computation complexity is increased. Gaussian filter is calculated by using the following equation

$$G(i, j) = (1/\sqrt{(2\pi\sigma^2)})\exp(-(i^2+j^2)/2\sigma^2) \quad (1)$$

σ-standard deviation in the area of mask size.

B. Histogram Equalization (HE)

Histogram equalization employs a monotonic, nonlinear mapping which re-assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities (i.e. a flat histogram).It is a common technique for enhancing the appearance of images. A perfect image is one which has equal no. of pixels in all its gray levels. Hence to get a perfect image our objective is not only to spread the dynamic range but also to have equal pixels in all the gray levels. This technique is known as Histogram Equalization [1].

C. Image Histogram Segmentation

To make the processing of the image enhancement more purposed and adaptive, firstly we proposed to analyze the image histogram. Image histogram can be divided into several sub-layer images' histogram by local minimum gray level, as shown in figure1 (a) which is the histogram of an image. From the image we can see that there are three low points in it, so we can divide the histogram into four departments. If the histogram as shown in figure1 (b) in which there are some gray levels have much more number than others as plus, we will set a suitable value to constrained the max frequency of the gray-level. In this way, the proportion of low frequency gray level will be enhanced. This is the preparation for the next step. The schematic is shown in Figure1.

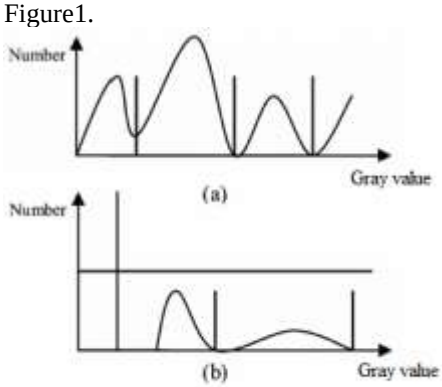


Fig 1. Histogram Segmentation Schematic

D. Partial Contrast

Partial contrast is a linear mapping function that is used to increase the contrast level and brightness level of the image. The technique is based on the original brightness and contrast level of the images to be adjusted. First the system will find the range of where the majority input pixels converge for each colour space. Since the input image is in RGB colour space, so it is necessary to find the pixels range between the red, blue and green intensities. Then, the average of these three colour space will be calculated to obtain the upper and lower colour values by using the following formula:

maxTH : (maxRed + maxBlue + maxGreen)/3
minTH : (minRed + minBlue + minGreen)/3 (2)

maxRed, maxBlue and maxGreen are the maximum colour level while minRed, minBlue and minGreen are the minimum colour level for each colour palette respectively. maxTH and minTH are the average number of maximum and minimum RGB colour space. maxTH and minTH will be used as the desired colour ranges for all the three colour palettes. Next is to start with the mapping process. The general linear mapping function is given in Equation 3.

$P_k = [(max-min)/(f_{max}-f_{min})][Q_k-f_{min}] + min$ (3)

P_k : Colour level of the output pixel
Q_k : Colour level of the input pixel
f_{max} : Maximum colour level values in the input image
f_{min} : Minimum colour level values in the input image
min : Desired minimum colour levels in the output image
max : Desired maximum colour levels in the output image

For partial contrast, the function in Equation 4 is used for the pixels transformation which is based on the concept of linear mapping function shown in Equation 3.

$$out(x,y)=\begin{cases}\frac{in(x,y)}{minTH}*NminTH & for\ \ in(x,y)<minTH\\ \left[\frac{(NmaxTH-NminTH)}{maxTH-minTH}*(in(x,y)-f\,min)\right]+min & for\ \ minTH<in(x,y)<maxTH\\ \frac{in(x,y)}{maxTH}*NmaxTH & for\ \ in(x,y)>maxTH\end{cases} \quad (4)$$

in(x, y) : Colour level for the input pixel
out(x, y) : Colour level for the output pixel
maxTH : Upper threshold value
minTH : Lower threshold value
NminTH : New lower stretching value
NmaxTH : New upper stretching value

E. PDF and CDF

Probability density function (PDF) is calculated as follows

$$p(r_k)=\frac{n_k}{N} \qquad k=0,...,L-1 \qquad (5)$$

Where N is the total number of pixels in the image, n_k is the number of pixels that have gray level r_k, and L is the total number of possible gray levels in the image.

$$p'(r_k)=[\frac{p(r_k)}{p_{max}}]^{\gamma}\times p_{max} \qquad k=0...L-1. \qquad (6)$$

Where P_{max} is the max value of sub-lays' PDF. If the image histogram includes certain high frequency which as shown in figure1 (b), we will set a suitable value to limit it and we call this suitable value as P_{max}. We will use this formula to calculate the probability of gray-scale. The aim is to enlarge the distance between two adjacent gray levels of the PDF values. Each element of the proportion in the image can be improved to varying degrees. Hence it can reduce the difference the shape of probability density distribution. Cumulative Distribution Function (CDF) can also be computed from equation (7):

$$C(r_k)=\sum_{i=0}^{i=k}p(r_i) \qquad k=0,...,L-1 \qquad (7)$$

We assume $C(r_k)$ satisfies the following conditions:
(a) $C(r_k)$ is single-valued and monotonically increasing in the interval
(b) $0\le C(rk) \le 1$ for k=0…….,L-1
Transformation can be computed from the equation (8):

$$T(r_k)=r_0+(r_{L-1}-r_0)\times C(r_k)+0.5 \qquad k=0,...,L-1 \qquad (8)$$

F. The proposed algorithm can be explained in seven steps

I. Capture the acute leukemia slide image at 40x magnification and save as Bitmap(*.bmp) of JPEG(*.jpg) format.
II. The input RGB image is sub divided into R, G and B layers of the image.
III. A 3X3 Gaussian mask is convolved with the R, G and B components of the image.
IV. PDF and CDF are calculated for the three layers(RGB).
V. Each element of the proportion in the image is improved to varying degrees.
VI. Intensity histogram from original image is obtained to get the threshold value.
VII. Partial Contrast enhancement technique is applied for the image modified by multiple peaks

III. Experimental Results

The hybrid image enhancement technique has been applied on acute leukaemia images. The qualities of images were determined based on human visual interpretation and intensity histogram plot. The proposed method can be used to improve the contrast of nucleus, Auer rode and nucleoli.

Figures 2(a) and 2(b) show the original input image and its intensity histogram for Acute Lmphoblastic Leukaemia (ALL). Figures 2 (c), 2(d), 2 (e) and 2(f) show the gaussian filtered image, its histogram, first layer and second layer for Red(R) component of the input RGB image. Figures 2 (g), 2(h), 2 (i) and 2(j) show the gaussian filtered image, its histogram, first and second layers for Green (G) component of the input image. Figures 2 (k), 2(l), 2 (m) and 2(n) show the gaussian filtered image, its histogram, first and second layers for Blue (B) component. Figure 2(o) shows the resulted output image of Acute Lmphoblastic Leukaemia (ALL) from the proposed hybrid image enhancement technique.

Figures 3(a) and 3(b) show the original input image and corresponding histogram for Acute Myelogenous Leukaemia (AML). Figures 3 (c), 3(d), 3 (e) and 3(f) show the gaussian filtered image, its histogram, first and second layers for R component. Figures 3 (g), 3(h), 3 (i) and 3(j) show the gaussian filtered image, its histogram, first and second layers for G component. Figures 3(k), 3(l), 3 (m) and 3(n) show the gaussian filtered image, its histogram, first layer and second layers for B component. Figure 3(o) shows the resulted output image of Acute Myelogenous Leukaemia (AML).

The resultant, images become clearer and the features of leukemia cells can easily been seen and improved from the original images. Nucleus and cytoplasm of immature white blood cells become clearer. Hence, they can easily been discussed by hematologists.

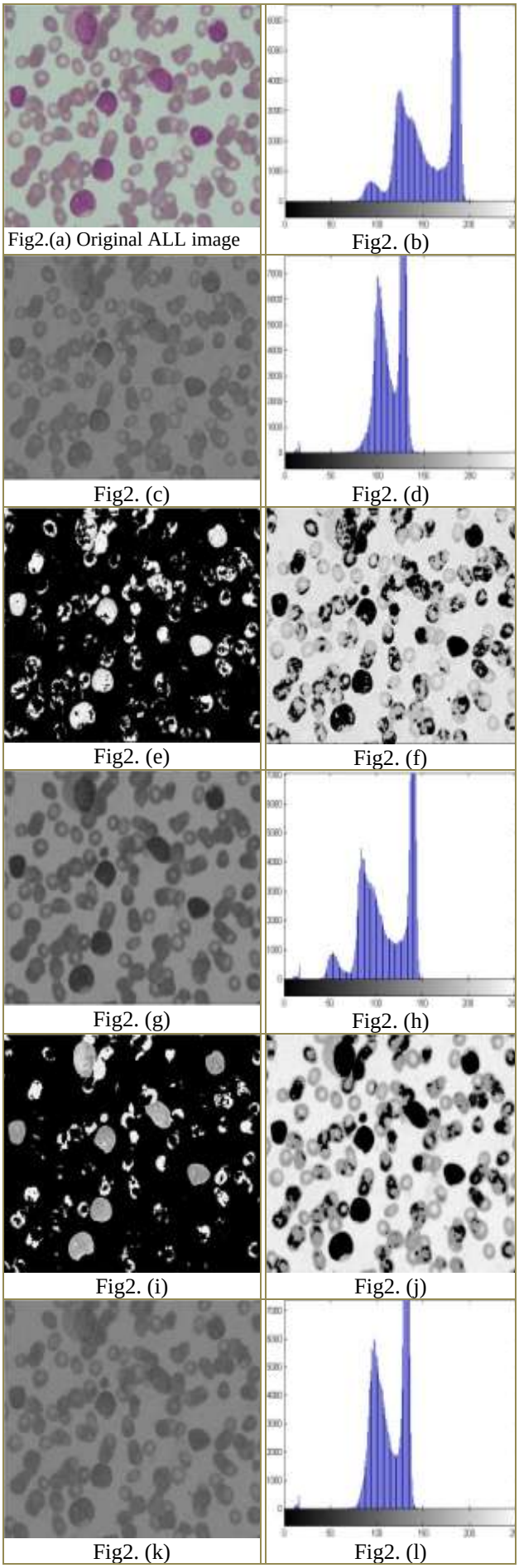


Fig2.(a) Original ALL image
Fig2. (b)
Fig2. (c)
Fig2. (d)
Fig2. (e)
Fig2. (f)
Fig2. (g)
Fig2. (h)
Fig2. (i)
Fig2. (j)
Fig2. (k)
Fig2. (l)

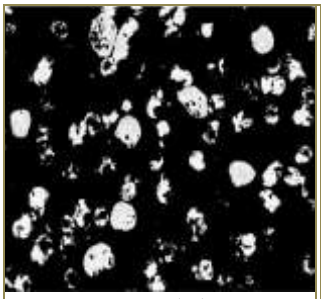


Fig2. (m)

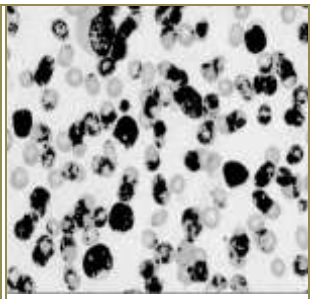


Fig2. (n)

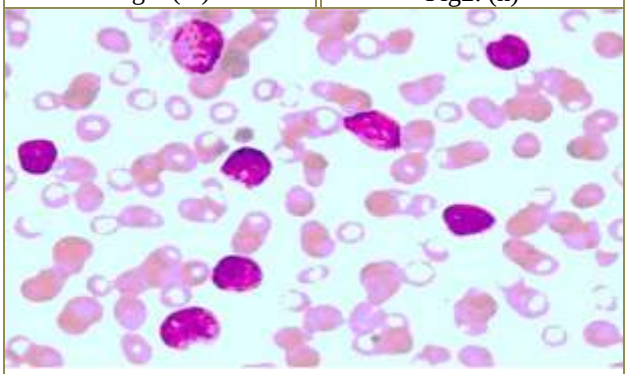


Fig2. (o) Output ALL image

Figure2.Images of Acute Lmphoblastic Leukaemia (ALL)

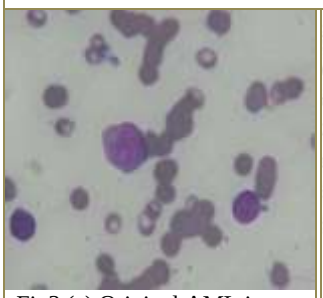


Fig3.(a) Original AML image

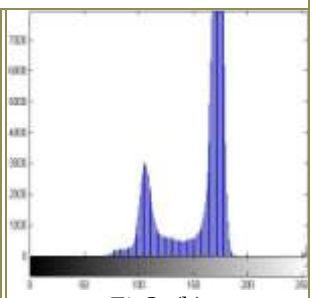
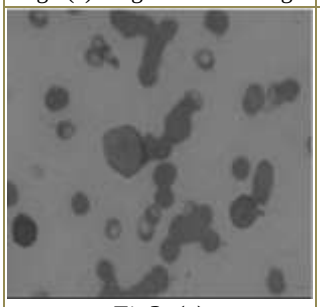


Fig3. (b)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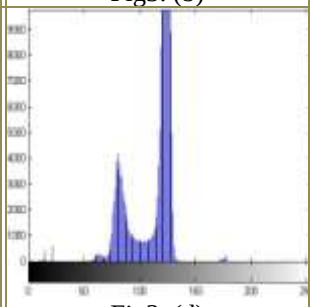
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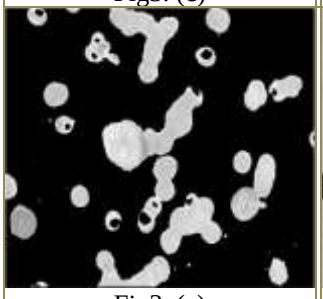
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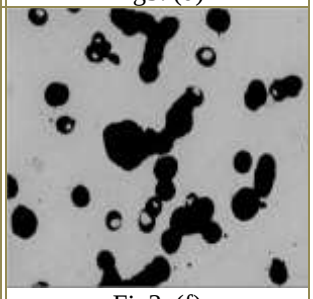
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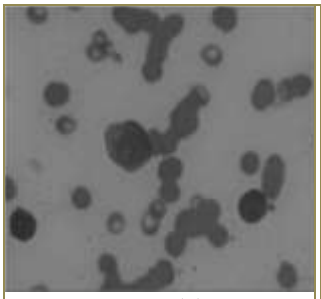
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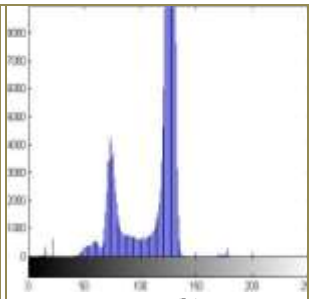
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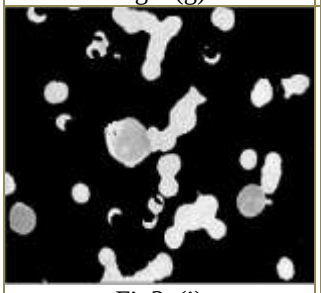


Fig3. (i)

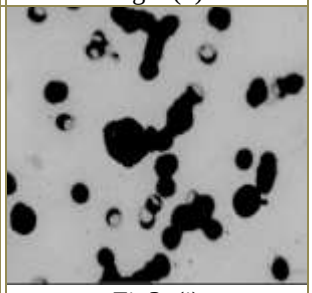


Fig3. (j)

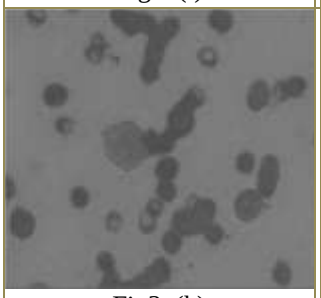


Fig3. (k)

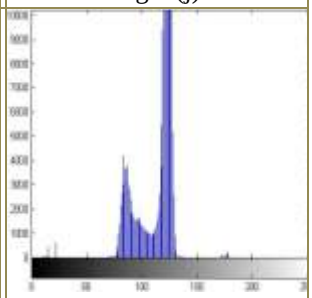
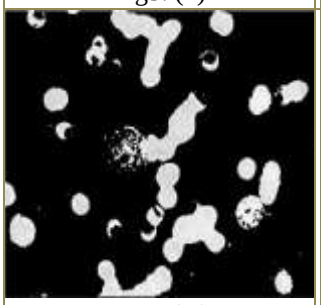


Fig3. (l)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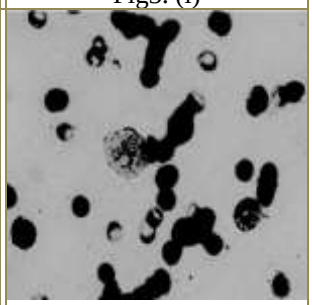
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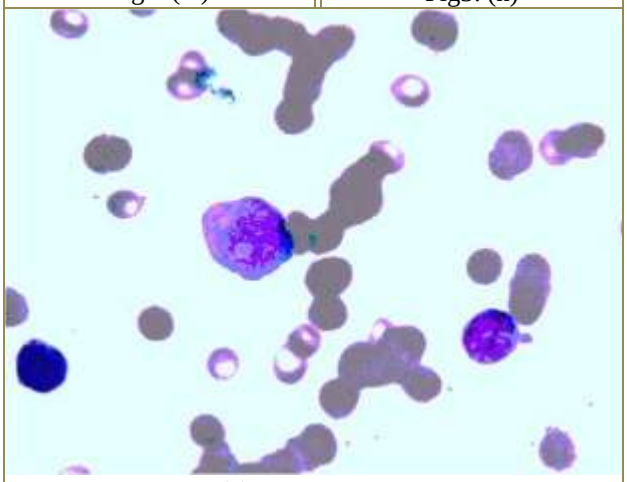
Fig3. (o) Output AML image

Figure3.Images of Acute Myelogenous Leukaemia (AML)

IV. CONCLUSION

When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular method works. Hematologists will look for the large number of abnormal white blood cells on stained slide. The appearance of white blood cells and red blood cells can be distinguished based on color where WBC tends to appear in blue or purple. Then, specific morphological features will be observed in order to classify the leukemia as either ALL or AML. The characteristic of these features include the size and shape of white blood cells nucleus and the presence of Auer rode and multiple nucleoli inside the nucleus are prominent in AML. The proposed algorithm can help the doctors to judge and decide the level of abnormality and better diagnosis.

V. FUTURE SCOPE

The developed algorithm can be further extended to measure the diameter of the cells so that number of cells in bigger diameter can be counted automatically to avoid ambiguity and human errors associated with the image perception. Edge detection and segmentation algorithms can be developed so that by image fusion algorithms further better perception can be achieved.

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