Provide a critical discussion on histogram equization of a true colour image.

→

Histogram equal equalization is a technique used to enhance the contrast of an image by adjusting the intensity levels of the pixels. It is commonly used in image processing to improve the visibility of low-contrast images. The basic idea behind histogram equalization is to redistribute the intensity levels of the pixels in an image such that the histogram of the image is spread out over the entire intensity range (0-255).

The mathmathe mathematical equation for histogram equalization is given by: $S = T(r) = (L-1) * (\text{sum}(h(i))/M*N)$ where S is the output intensity level, $T(r)$ is the transformation function, r is the input intensity level, $h(i)$ is the histogram of the image, L is the number of intensity levels (Given type of image is true color, thus L = 256), M and N are the number rows and columns in the image, and the operator "sum" denotes the cumulative sum of the histogram values up to the intensity level r.

This equation is used to calculate the new intensity level for each pixel in the image. The cumulative sum of the histogram values, up to the intensity level r, is multiplied by $(L-1)/(M*N)$ to scale the histogram to the full intensity range.

When applied to a true colour image, histogram equalization is typically applied separately to each colour channel (red, green, and blue) to enhance the overall contrast of the image.

However, this can also lead to a colour shift in the image, as the intensity level of the individual colour channels are adjusted independently.

The algorithm for histogram equalization can be summariz-ed in the following steps:

1. Convert the true colour image to a greyscale image.
2. Compute the histogram of the image.
3. Compute the cumulative distribution function (CDF) of the histogram.
4. Compute the transformation function, $T(r)$, using the equation above.
5. Apply the transformation function to the image to get the equalized image.

It's worth noting that histogram equalization is sensitive to noise, so it's better to use it on images that have been preprocessed to remove noise. Sometimes histogram equalization can cause the image to look washed out as it tends to increase the brightness of the image.

The time complexity of histogram equalization depends on the specific implementation used.

The basic algorithm for histogram equalization involves the following step:

1. Computing the histogram of the image, which has a time complexity of $O(MN)$ where $M$ and $N$ are the number of rows and columns in the image, respectively.

2. Computing the cumulative distribution function (CDF) of the histogram, which also has a time complexity of O(MN).

3. Applying the transformation function to the image, which again has a time complexity of O(MN).

So, overall the time complexity for the basic histogram equalization algorithm is O(MN) which is linear with respect to the number of pixels in the image.

Its worth noting that the time complexity can be further optimized by using techniques such as parallel processing or approximating the histogram. Additionally, the time complexity of Adaptive Histogram Equalization (AHE) algorithm is a bit different, it depends on the size of the window and the number of pixels in the image, so it's not possible to provide a specific time complexity.

Here is an example of code (Matlab) that applies histogram equalization to a true colour image

```
1. I = imread('image.png');
2. I = rgb2gray(I);          % convert to gray-scale
3. J = histeq(I);            % apply
4. imshow(J);
```

```
1. I = imread('image.jpg');
2. R = I(:,:,1);    % red channel
3. G = I(:,:,2);    % green channel
4. B = I(:,:,3);    % blue channel
5. R = histeq(R);   % apply histogram equalization to the red channel
6. G = histeq(G);   % apply histogram equalization to the green channel
7. B = histeq(B);   % apply histogram equalization to the blue channel
8. I = cat(3,R,G,B); % recombine the channels
9. imshow(I);       % display the image
```

In summary, histogram equalization can be an effective technique for enhancing the contrast of an image, but it should be used with caution. ~~It is best to apply it to grayscale images or use adaptive histogram equalization to colour images~~. as it can also introduce artifacts and colour shifts in the image. ~~It is best to apply~~ It is best to apply it to grayscale images or use adaptive histogram equalization to colour images.