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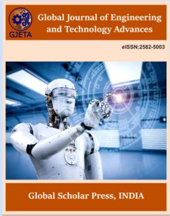

(Review Article)

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Subject review: White balance techniques of digital image

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Abstract

Due to un control environment during creating of the digital image make the resulting image have un real color cast, for that a white balance algorithm has been found to correct the unreal color cast create by non-canonical Lighting sources, In order to achieve satisfactory color of the digital image, a white balance required to adjust the image color either automatically or manually. for that researchers found an automatic and manual white balance algorithms, and even the Automatic white balance algorithm depending on analysis either low level features or high Level features, explaining An examples for Automatic white balance algorithm (Gray World Algorithm and The white patch Algorithm) and clarify each Algorithm suits different kind of Image.

Keyword: White Balance; Color temperature; Gray World Algorithm; The white patch Algorithm; Color constancy

1. Introduction

The notion of white balance holds great significance in the realm of television cameras. As the Internet of Things and multimedia sensors have grown, white balance has found widespread use in areas such as intelligent transportation, bar code and QR code reading, and more. [3], In addition, it was widely utilized in professional photography in the past and is currently widely employed in domestic electronic products (smart phones,

Digital video cameras for the home). [2]. When capturing an image with a digital camera, the purpose of the white balance is to eliminate color casts created by non-canonical lighting sources [5] the reaction of the camera sensors varies with each pixel's light. Furthermore, color temperature has a significant impact on the quality of the image that is taken. when a low temperature color is used to light a white item. In the captured image, it will appear reddish. While, in high temperature color, it will appear bluish. [1].

The accuracy and robustness of the subsequent image analysis will be impacted by the degree of variation that occurs between the true color of the image and the collected color when it is captured in different lighting situations. [16]

Color constancy is the term used to describe the human visual system's (HVS) capacity of recognizing white colors even in situations where an object's brightness varies due to illumination from various light sources. [1], another straightforward explanation is that even in situations where external lighting changes, the human visual system is still able to see the initial color of the object. [2].

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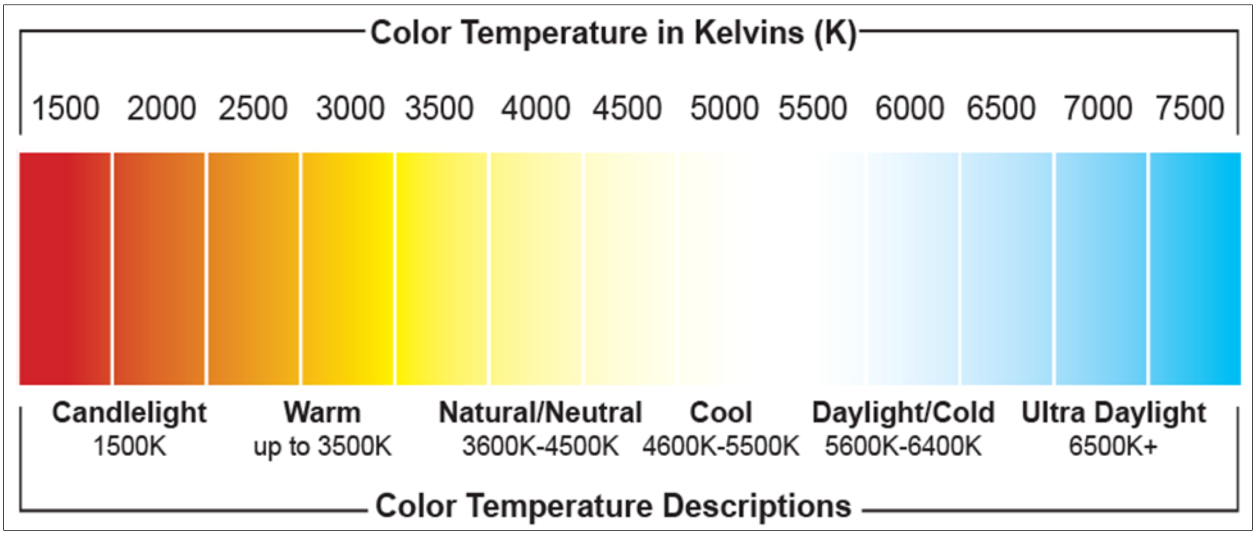

Figure 1 Color temperature range

That resilience and capability are lacking in computers and other processing devices. Therefore, scientists create algorithms to attain this goal in order to provide computers the unique function of the human visual system. [2].

These algorithms go by the name "White Balance Algorithm," and they can be divided into two categories: automated and manual versions. The white balance algorithm typically involves two phases. The first step is to estimate the illumination; the second is to adjust the image using the previous step's output. [4], maintaining color constancy is the goal of these methods since it is essential to many processing and computer vision applications, including image classification, feature identification, object tracking, and enhancement. [11]

The white balance algorithms have a problem regarding digital image where is negatively affects the performance of object recognition in digital images [6]

2. Digital Photography Colour Capture

Three components make up each individual pixel (x, y) in a digital camera image: the spectral power distributed (SPD) of the light source¸ (x, y, λ), the surface's spectral reflectance S(x, y, λ), and the spectral sensitivity of the camera sensor C(λ). [12] The visible spectrum is determined by the light source's wave length. The color of each pixel in an image taken by a digital camera sensor is directly related to the object's color as well as the color temperature of the light source [13].

2.1. Source of Light.

A light source, or illuminant, is needed to provide a very good representation of the visual data in a digital image. The illumination can be produced as a function of wavelengths when the distribution of light at different wavelengths is equal, resulting in a color-mapped spectral power distribution. [7]. The functional relationship between spectral density and wavelength is represented by the spectral power distribution of the light source, while the spectral density itself represents the radiation energy per unit wavelength range, in other words, the SPD of Light source represent its light quality [8]. There are many different types of light sources, but the most widely used ones are the standard daylight light source, which has a continuous spectrum across the visible range; the other typical light source is the tungsten light, which has a very smooth spectrum; and fluorescent lamps, which have a power distribution spectrum with sharp spikes.

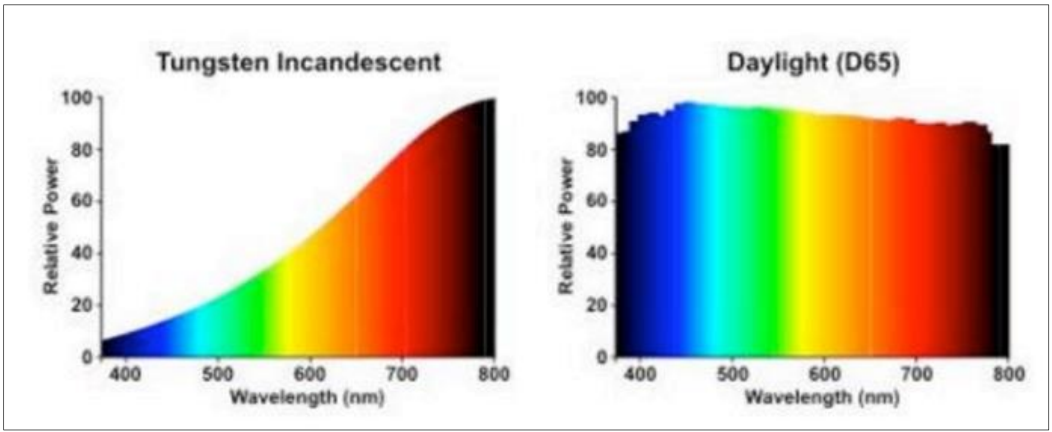

Figure 2 Light source spectral power distribution

2.2. Object Reflectance / Transmittance

The International Lighting Vocabulary of the [CIE] (International Commission on Illumination) defines reflectance as the ratio of the incident flux to the reflected radiant flux or luminary flux under the specified conditions, Conversely, "the ratio of the transmitted radiant flux or Luminous flux to the incident flux in the given conditions" is the definition of transmittance. The relationship between the two quantities and radiant flux (Ø) [9]. An object that is struck by electromagnetic waves from a light source will either transmit, reflect, or absorb the same percentage of the spectrum's wavelengths. Because of this, an object's spectral reflectance, also known as its transmittance, can be expressed as a function of wavelength, an illustration of a red object's spectrum reflectance or transmittance would be that it reflects all high frequencies while absorbing practically all low frequency components (blue and green). Because there are very few reflected low frequency components, the visible color is a bright red.

The gray item is the one whose spectral reflectance remains roughly constant at different wavelengths. [1]

2.3. Sensor's Spectral Response

The spectral response of color digital camera is an important topic in optics and computer vision, the spectral response of digital camera is the result Of the comprehensive influence of optical lens, (most often an RGB Bayer filter), imaging filters sensor and image processing parts inside the Camera [10], Different optical lenses and filters will cause variations in the spectral response function of the entire imaging system, even for the same camera, The link between the ambient Light Source data and the R, G, and B values of the camera response can be determined by the imaging sensor's spectral sensitivity.

The issues facing automatic white balance algorithms in digital photography are defined by the requirement for digital cameras to "adapt" not only to varying color stimuli but also to the spectral response of various sensors.

3. Automatic white balance types

The automated white balance Algorithms are classified into two types (group) [12]. Each type has advantages and disadvantages, and the choice of algorithm depends on various criteria such as the complexity of the lighting condition, processing resources available, and application requirements.

One benefit of AWB is the reduction in time needed to manually change an image's white balance. These algorithms examine a picture to ascertain its overall color temperature and make adjustments to make it look more realistic.

3.1. Low-Level image Feature Automatic white balance

These algorithms operate at the pixel level and rely on analyzing individual pixels or tiny patches of pixels to determine the appropriate color balance correction. They have numerous properties, including:

- These approaches are based on statistics.
- A dataset is not necessary for them.
- They don't produce an aesthetically pleasing outcome when there are several illuminations.

- Algorithms example:- Gray world Algorithm, Max-RGB, white Patch [12]
- Low computational cost.
- They are better suited for applications like consumer digital cameras and smartphones where computing power is limited.
- Law Level Feature Like, color Temperature, color constancy, Local contrast, Gray world Assumption, Edge detection, texture Analysis.
- These algorithms do not take high-level semantics into account while extracting information from pixel values.
- For illuminant estimation, use achromatic color, or the neutral color.
- Process information more quickly.
- It is suitable for situation with high real time requirements such as digital Camera and cell phone.

3.2. high-level image features Automatic white balance

Gamut Mapping, color by correlation and neural network based color constancy, these are algorithms does not relies on individual pixel characteristics, it based on analyzing more abstract properties of the Image, Like Scene classification, Object Recognition, Semantic segmentation, Color Harmony Analysis, Light Source Identification, These algorithms use the assumption of estimate the illuminant depending on use certain areas of the image and that lead to errors as the illumination might not distribute evenly throughout the scene and neglecting some regions in the image might Loose important information. These algorithms have many Properties like:-

- Produce better result than Low-level image Feature AWB.
- Have higher computer cost.
- Analyzing high-level of Features of the image rather than simply relying on pixel-Level statistics where they consider feature Like, objects, scenes, textures, edges.
- These method required a dataset, this data consist of images captured under various Lighting conditions and color temperature, this dataset required for training and validation [14]
- These approaches offer a more sophisticated and context -aware any way of adjusting color balance in images.
- These approaches play vital role in various field where accurate color reproduction is essential, Like Artificial Intelligence, Robotics, Broadcasting, Entertainment, Medical Imaging, computer vision.
- Its take more time during execution than Low Level image Feature AwB.
- They are not suitable for real time application requirement due to large amount of calculations.

4. Automatic white balance algorithm examples

There are many algorithm used to achieve image white balance such as

4.1. Gray World Algorithm

The principle behind the gray world algorithm, a traditional method of color constancy, is that since the average reflectance of all surfaces in the world is assumed to be achromatic, the average of the three color channels—Ravg, Gavg, and Bavg—should be equal. And in order to create the color balance, this assumption is achieved by scaling the red, green, and blue channels.

The following steps can be used to summarize the gray world algorithm:

- Calculate the Average color.

The gray color is approximately is equal to the mean value reflection of the average reflection of the natural scene, the average value of RGB is chosen as gray value under standard and Light source,

$$Gray = R_{avg} + G_{avg} + B_{avg} \text{ ....(1)}$$

- Determine the scaling factors.

A scaling factor is determined as the ratio between the actual light source (e) and the standard light source (e') in order to balance out the image's overall cast.

$$\frac{e'_R}{e_R} = \frac{Gray}{R_{avg}} \text{ .... (2)}$$

$$\frac{e'_G}{e_G} = \frac{Gray}{G_{avg}} \quad (3)$$

$$\frac{e'_B}{e_B} = \frac{Gray}{B_{avg}} \quad (4)$$

- Apply the scaling factors.

When the white balance algorithm is implemented, the image is adjusted to the standard light source as the purpose of applying the scaling factors.

The following is a summary of the general characteristics of this algorithm:

- Pros
  - Simple and computationally efficient.
  - Assumes that the image's typical color is gray, which is frequently a fair assumption for scenes that are common.
- Cons:
  - May become unbalanced due to sensitivity to the presence of strong regions of a single dominant color.
  - Makes the assumption that the image's average color is gray, which isn't always the case.
- When it works best:
  - Pictures that feature multiple colors rather than just one main color
  - Scenes where the color spectrum is dispersed uniformly.
- When it doesn’t work:
  - Images with a large area of a single dominant color, which may cause the algorithm to over-correct.
  - Scenes with a specific color cast, where the average color is not gray.

4.2. Max RGB (The white patch Algorithm)

The white color balancing technique takes each channel's brightest pixels and sets them to white. It then corrects each channel's pixel color to support the hypothesis that white is the brightest pixel in the image.

This is how it operates.

- White area identification:
  - The image's white or neutral gray area is identified as the algorithm's supposition.
- Choosing the brightest region
  - To satisfy the presumption that the image's white reference region is the brightest part.
- Color channel normalization.
  - The image's white reference patches served as the foundation for normalizing the image's color channels.
- Adjusting Color Cast
  - By utilizing the three processes mentioned above, the white patch algorithm neutralizes color casts and improves balance and naturalness in the image.

The following is a summary of this algorithm's general properties

- Pros
  - Simple and easy implement
  - Functions effectively when there is a definite bright area in the image.
  - Effective in correcting white balance issues in images with a prominent white area or neutral gray area.
- Cons
  - Assumes that white is the image's brightest color, even though this isn't always the case.
  - Can result in odd colors or artifacts from overcorrection if the assumption is incorrect.
  - May cause color shifts or other abnormalities in specific picture regions.
- When it functions optimally
  - Scenes with a regulated setting in which white is recognized as the brightest point.
  - When there is uniform lighting throughout the picture.
- When it is ineffective
  - When the image has a variety of lighting conditions or light sources.
  - When the lighting conditions are not indicative of the entire reference region.

- When there are variations in the illumination throughout the picture.

5. Conclusion

White balance is one of the components and methods of image processing. A variety of algorithms, including the White Patch and Gray-world algorithms, are employed to produce image white balance, which vary in their presumptions and approaches, and whose selection and effectiveness rely on the kind of image and the circumstances surrounding its creation. Because the white patch algorithm assumes that the brightest point in the image represents a white or neutral color, it works well with photos that contain direct lighting, a white item, or even a white reference point. whereas the Gray-world Algorithm, which relies on the general gray color of the image to reflect the average of the three colors (red, green, and blue) of the image, it will be used with photos where overall lighting is rather uniform or images which have different colors, But, it performs poorly on photographs with odd color casts, uneven scene color distribution, or large dominant color patches. Conversely, the white patch algorithm performs poorly on images lacking a pure white reference or over exposed images.

The White Patch Algorithm outperforms the Gray World Algorithm in controlled conditions with a known white reference area, while the Gray World Algorithm performs better in general when the images have a balanced distribution of colors.

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