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# Application of Machine Learning to Identify General Characteristics of Digital Landscape Images

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## Abstract:

Digital Images belonging to landscape genre are analyzed based on the contrast and brightness of individual Red-Green-Blue components of each image. Two different data sets are used and results are compared. New patterns and correlations are identified. Primitive Machine learning is employed to generate the analytics.

*Keywords* — **machine learning, image characteristics, contrast, brightness, histogram**

## I. INTRODUCTION

In modern times, most images are taken digitally. With the advent of cheap and capable Point-and-Shoot Cameras and Mobile phones, it has become very easy to take photographs. Every genre of photography like landscapes, portraits etc has its own uniqueness in terms of image characteristics like brightness, contrast etc. In this paper, an attempt is made to identify such characteristics for landscape images using simple statistical and machine learning techniques.

## II. IMAGE CHARACTERISTICS

Human beings perceive an image based on the light falling on their retina and the different colors are result of different wavelengths of light. The visible spectrum has light ranging from wavelength of 350 nm to 700 nm. There are infinitely many colors possible in this small bandwidth of electro-magnetic radiations. But, all these infinite wavelengths are sensed using only three main color stimuli corresponding to red, green and blue color. Each identifiable color can be reproduced using these three colors. Similarly, every pixel in a digital image is mapped to a color using a three element tuple consisting of the Red, Green and Blue channels. Every color image, however simple or complex, can be reduced to a two-dimensional array of such pixels which in turn can be represented as a three element tuple. This is true for every image irrespective of the nature of equipment used to capture the image (CCD, CMOS sensors etc).

## III. PERCEIVABLE IMAGE PROPERTIES

The main properties of an image which affect its appearance are the brightness, contrast and saturation of colors. Brightness is a relative measure of overall lightness or darkness in an image. Contrast measures the difference between the brightest and darkest pixels in an image. Contrast aids in clear differentiation of boundaries between objects and other elements in an image. Saturation, which is applicable to color images only, is the intensity of a particular color in the image. These three characteristics decide how a image is perceived by human eye and hence play major role in deciding if an image is "better" than another.

## IV. RESEARCH METHODOLOGY

The scope of this paper is to identify certain characteristics which are consistent throughout landscape images which are accepted as "good". Using simple statistical and machine learning methods, perceivable properties like brightness and contrast are measured and studied. The present study is on two distinct set of images – "Golden Hour" (Figure1, landscape photos captured during the golden hour, 29 images in data set) and "Mountains" (Figure 2, landscape photos of mountains during daylight, 48 images in data set). MATLAB (r2015a version) is used for extracting data and Microsoft Excel (2010 version) with additional data analytics tool-kit is used for statistical and machine learning process. The overall workflow followed is described below

Figure 1. Sample photos from Mountain data set

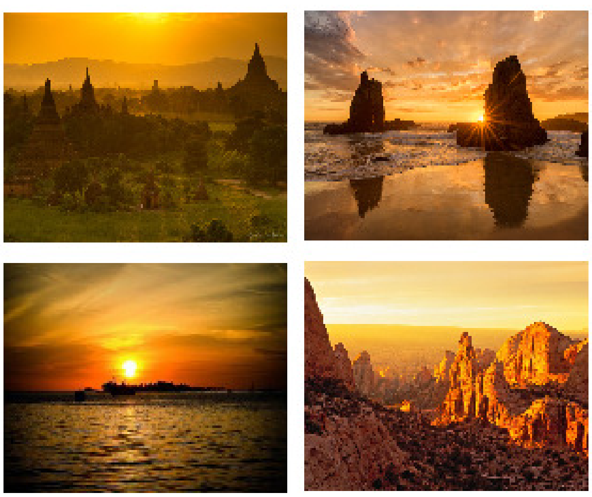


Figure 2. Sample photos from Golden Hour data set

### *A. Image Normalization*

All images in each dataset are reduced to fixed dimensions where the longest edge, either the width or height, is 800 pixels at most. Images having long edge smaller than 400 pixels are not used.

### *B. Quantifying Characteristics*

Although brightness and contrast are perceivable properties and heavily dependent on the sensitivity of the eyes of the observers and the capabilities of the display device, basic formulas exist to give a numerical representation.

The following information was extracted from every image, of height M and width N, where each pixel consists of the (R,G,B) tuple where R is Red intensity, G is Green intensity and B is Blue intensity represented by values in the range of 0 to 255 with 0 being least possible intensity and 255 being the highest possible intensity.

#### *1. Brightness$_{mean}$*

As described in [1], it is the average intensity of three colors. This is calculated for the every pixel and the average value of all pixels is taken as Brightness$_{mean}$ for the entire image and given by

$$Brightness\ (Mean) = \frac{R+G+B}{3} \quad \text{...(Eq 1)}$$

#### *2. Brightness$_{BT.601}$*

This formula is used by the International Telecommunication Union for CRT televisions [3]. This is calculated for the every pixel and the average value of all pixels is taken as Brightness$_{BT.601}$ for the entire image and given by

$$Brightness\ (BT.601) = 0.299R + 0.587G + 0.114B \quad \text{...(Eq2)}$$

#### *3. Brightness$_{BT.807}$*

This formula is used by the International Telecommunication Union for HDTV televisions [2]. This formula gives more prominence to the intensity of green color as our eyes are most sensitive to green color. This is calculated for the every pixel and the average value of all pixels is taken as Brightness$_{BT.807}$ for the entire image and given by

$$Brightness\ (BT.807) = 0.2126R + 0.7152G + 0.0722B \quad \text{...(Eq3)}$$

#### *4. Contrast*

Contrast for calculated for individual color channels. The image is split into three color channels and contrast of each is calculated and recorded. It is calculated using the RMS formula

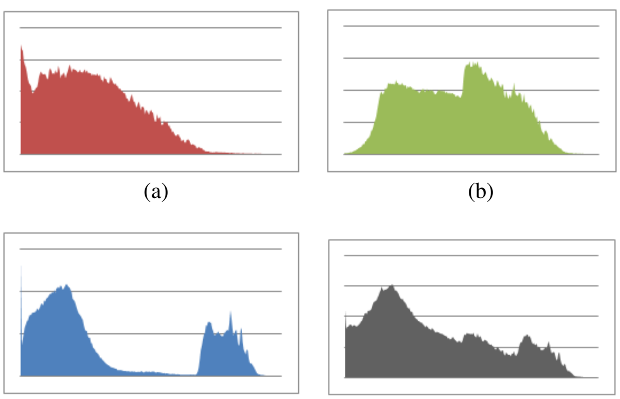
$$Contrast\ (RMS) = \sqrt{\frac{1}{MN}\sum_{i=1}^{N}\sum_{j=1}^{M}(Iij - Imean)^2}$$

Where $I_{ij}$ is the intensity of the $(i,j)^{th}$ pixel and $I_{mean}$ is the average intensity of the image

### *5. Histogram*

A histogram is generated for each color channel (Figure 4) for each image and binning is done for values ranging from 0 to 255 with bin width of 1. After performing outlier analysis, the starting and ending 1% of bins are rejected. This reduces the bin size to range of 7 to 248.

Figure 3. A sample photo from Mountain data set



(a) (b)

(c) (d)

Figure 4. Four Histograms of the sample image. One for each color and one for overall intensity (a) Red (b) Green (c) Blue (d) Overall

TABLE 1
DATA FOR SAMPLE PHOTO

| | |
|---|---|
| Brightness(Mean) | 65.67 |
| Brightness (BT.601) | 83.72 |
| Brightness (Bt.807) | 83.87 |
| Brightness (Red) | 69.66 |
| Brightness (Green) | 113.16 |
| Brightness (Blue) | 85.18 |
| Contrast (Red) | 10.01 |
| Contrast (Green) | 10.76 |
| Contrast (Blue) | 8.84 |

### *C. Analysis and Interpretation*

Various combinations of characteristics are analysed for possible patterns, correlations and implications using the Analysis ToolPak add-in for Microsoft Excel. The results obtained are discussed below.

## V. RESULTS

The following patterns which could be termed "interesting patterns" were identified in the study.

### *A. Inverse correlation between Red channel and Green Channel contrast percentages in Golden Hour Images*

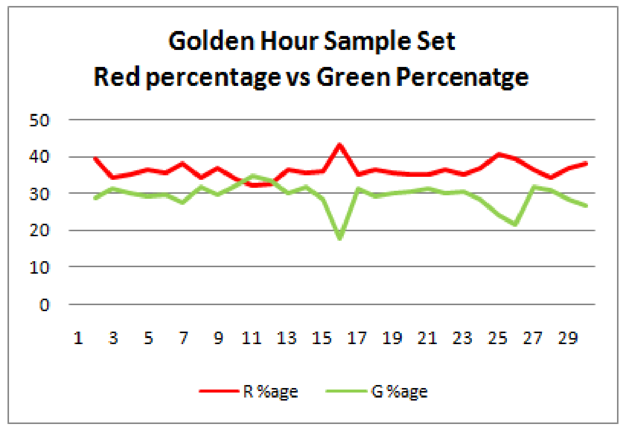



Figure 5. Graph of Red percentage against Green percentage in "Golden Hour" Image Set

The correlation was found to be -0.9191 which indicated very strong inverse correlation (Fig 5).

### *B. Distribution of Red, Green and Blue contrasts is more uniform in "Mountains" than "Golden Hour"*

TABLE 2
PERCENTAGE DISTRIBUTION FOR "MOUNTAINS" DATA SET

| | Red | Green | Blue |
|---|---|---|---|
| **Percentage of total intensity** | 33.239 | 33.965 | 32.795 |
| **Color standard deviation** | 1.525 | 1.147 | 1.683 |
| **Channel standard deviation** | 0.590 | | |

TABLE 3
PERCENTAGE DISTRIBUTION FOR "GOLDEN HOUR" DATA SET

| | Red | Green | Blue |
|---|---|---|---|
| **Percentage of total intensity** | 36.374 | 34.218 | 29.407 |

| | | | |
|---|---|---|---|
| **Color standard deviation** | 2.300 | 1.544 | 3.364 |
| **Channel standard deviation** | 3.566 | | |

As it is tabulated above, there is almost equal distribution of Red, Green and Blue contrasts in "Mountains" but heavy inclination is shown towards Red in "Golden Hour".

### C. *Histograms of "Mountains" correlate more with Red channel and Histograms of "Golden Hour" Correlate more with Blue and Green Channel*

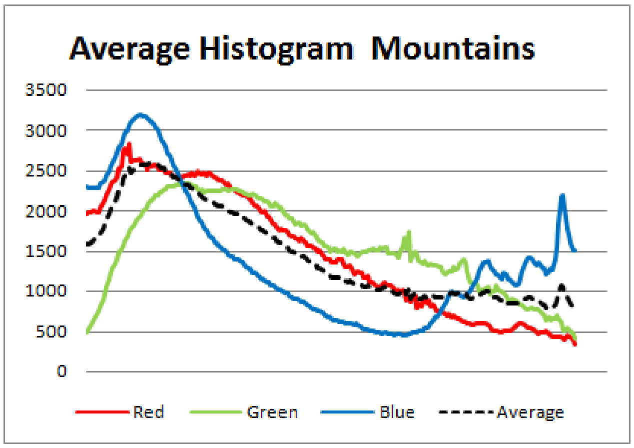



Figure 6. Average Histograms of each color channel along with average histogram of whole image for "Mountains"

TABLE 4
CORRELATION BETWEEN HISTOGRAMS OF EACH COLOR CHANNEL AND IMAGE HISTOGRAM – MOUNTAINS

| | Red | Green | Blue |
|---|---|---|---|
| **Correlation with Full Image Histogram** | 0.962 | 0.730 | 0.788 |

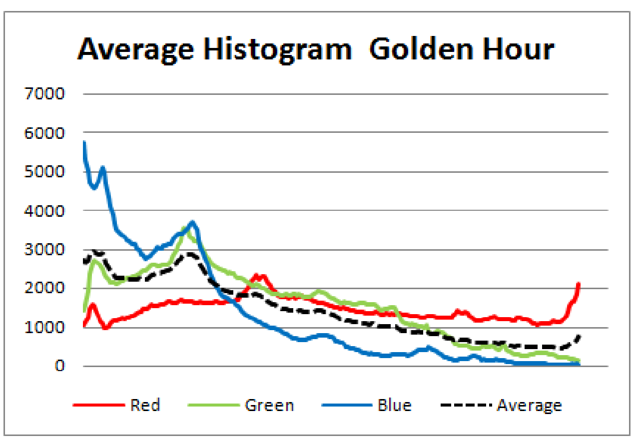



Figure 7. Average Histograms of each color channel along with average histogram of whole image for "Golden Hour"

TABLE 5
CORRELATION BETWEEN HISTOGRAMS OF EACH COLOR CHANNEL AND IMAGE HISTOGRAM – GOLDEN HOUR

| | Red | Green | Blue |
|---|---|---|---|
| **Correlation with Full Image Histogram** | 0.369 | 0.937 | 0.940 |

The result of correlation analysis between individual color histograms and full image histograms is surprising. Although "Mountain" images are visually more of blue and green colors, the image histogram correlates excellently with Red (Fig 6). On the other hand, the "Golden Hour" Images are mostly yellow to perceive but correlate very well with Blue and Green Channels (Fig7).

### D. *Brightness of an image correlates with Blue channel in both "Mountains" and "Golden Hour" Data Set*

TABLE 6
CORRELATION BETWEEN BRIGHTNESS OF EACH COLOR CHANNEL AND IMAGE BRIGHTNESS (BT709) – "MOUNTAINS"

| | Red | Green | Blue |
|---|---|---|---|
| **Correlation with Full Image Histogram** | 0.687 | 0.832 | 0.969 |

TABLE 7
CORRELATION BETWEEN BRIGHTNESS OF EACH COLOR CHANNEL AND IMAGE BRIGHTNESS (BT709) – "GOLDEN HOUR"

| | Red | Green | Blue |
|---|---|---|---|
| **Correlation with Full Image Histogram** | 0.548 | 0.798 | 0.934 |

The Brightness is used as per BT709 standard as it is applicable to the high resolution displays of modern screens in laptops, televisions and mobile phones.

This result is different to what was found out in previous result. The Blue color brightness correlates very well with overall image brightness. This is surprising as Eq2 gives very less weightage to Blue color.

## VI. LIMITATIONS

The major limitation of this study is the size of sample space. The sets "Mountains" and "Golden Hour" had 48 and 29 images respectively. If each set had at least 100 images, better results could be obtained. Use of

Artificial Intelligence and Deep Learning algorithms can give better insights.

## VII. CONCLUSION AND FUTURE WORK

The study has been successful in identifying a few patterns concerning landscape images which are discussed above. More patterns can be identified using larger data set and different approaches. The same kind of study can be performed using the Hue-Saturation-Luminance (HSL) color space as Saturation was not a part of this study . Another possibility is to use the numerical values obtained for image characteristics as target values and adjust any image to reach that value with the intention of achieving the same visual impact as professional grade images.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