Photograph decomposition using R
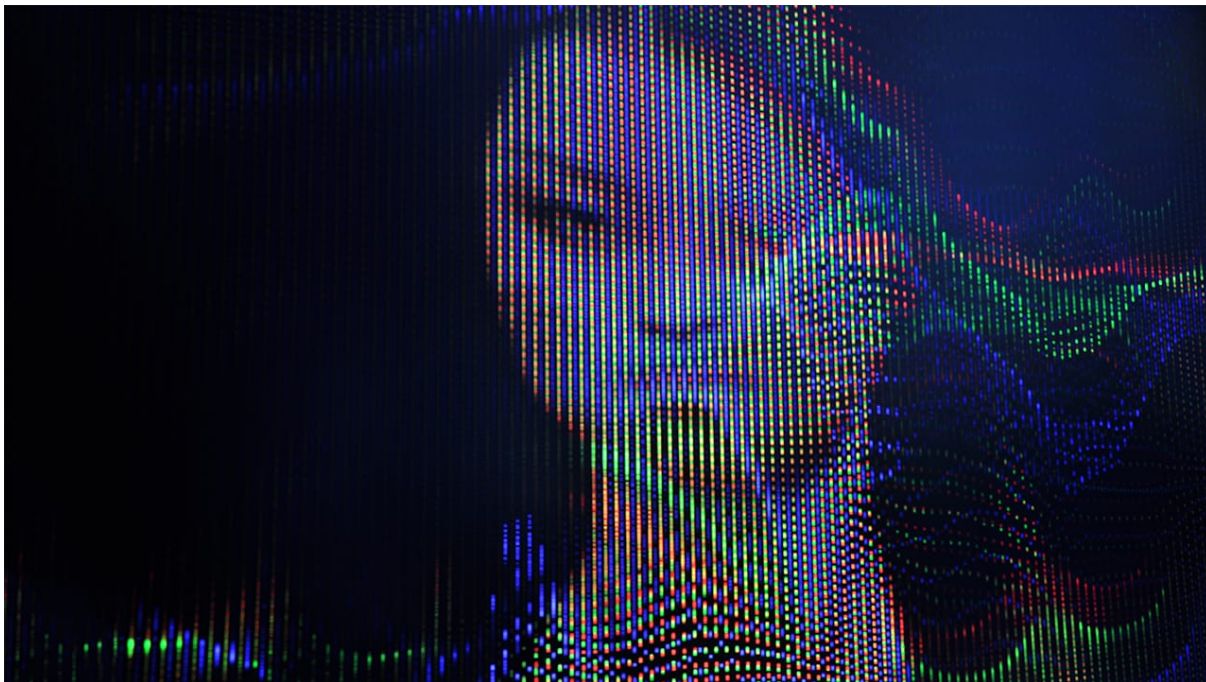
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RGB system in photographs

Every (colored) photograph can be viewed as a three-dimensional array. Each dimension represents the red, green and blue parts of the photo. Each dimension is a N x M matrix, where N is the length of the picture and M is the height of the picture. The height and the length of every picture is measured not in meters but in pixels. Every pixel has it's coordinates and the value of the pixel (usually from 0 to 1) indicates the intensity of either red, green or blue color. The "jpeg" package [1] in R [2] lets us easily import any jpeg format photo from our machine and decompose it into an array of 3 dimensions.

Figure 1: Picture of zebras

The size of picture in figure 1 is equal to 800 x 399 pixels.

```r
library(jpeg)

photo <- readJPEG("img/zebras.jpg")
dim(photo)
```

[1] 339 800   3

```r
dim(photo[, , 1])
```

[1] 339 800

```r
photo[, , 1][1:3, 1:3]
```

```
          [,1]      [,2]      [,3]
[1,] 0.2823529 0.2509804 0.2352941
[2,] 0.2313725 0.2039216 0.1882353
[3,] 0.2313725 0.2039216 0.1882353
```

As we can see from the code results, the *readJPEG* function reads the photo and gives us an output which represents how our computers see photographs. The shown matrix represent the first 3 x 3 pixels of the red colour. Notice that every value in the matrix is between 0 and 1. This simple decomposition of the photos to the RGB system lets us do powerfull things with it.

Decolorize

The most basic operation which can be done with any given photograph is to make it black and white. In order to do this we need to make a three dimensional array into a single dimension matrix. Let us remember the picture in figure 1 which dimension is 800 x 399 x 3 (the 3 means that it has the red, green and blue dimensions). We will denote the black and white picture as BW picture (short for black and white). Then one of the simplest methods to make a picture colorless is using the weighted mean:

$$BW_{NxM} = c_1 R_{NxM} + c_2 G_{NxM} + c_3 B_{NxM}$$

Where

R_{NxM} - an N x M matrix which values represent the intensity of the red color.

G_{NxM} - an N x M matrix which values represent the intensity of the green color.

B_{NxM} - an N x M matrix which values represent the intensity of the blue color.

$c_i \in R, \forall i$

In order to avoid 'dead' pixels the equality:

$\Sigma_{i=1}^{n} c_i = 1$

Should hold.

```
BW <- 0.3 * photo[, , 1] + 0.3 * photo[, , 2] + 0.4 * photo[, ,3]
writeJPEG(BW, target = "img/bw.jpg")
```

Figure 2: Decolorized picture of zebras

Decomposition of colours

When looking at a picture we can generally see what colours are the dominant. Going back to picture 1 we can clearly see that the red, orange and the mix of them dominates. This should imply that generally, the pixel values for the R matrix should be higher than the B and G values. To see which colours are most dominant in a picture we will use the cluster analysis [3]. Depending on the number of centers we choose, we want to cluster the data into that much spheres (because there are three dimensions - R, G and B).

In figure 3 we can see a barplot representing the dominating colours in picture 1. The length of the bar represents the "amount" of a certain colour in a picture - the longer the bar, the more colour there is. The names of the bars are the hex names of the colours.

As we can see from figures 3 and 4, the most dominant colours are shades of orange or red. This agrees with our initial thoughts about the photo in figure 1.

Decomposition of colours

#F4AB20
#EE4001
#862706
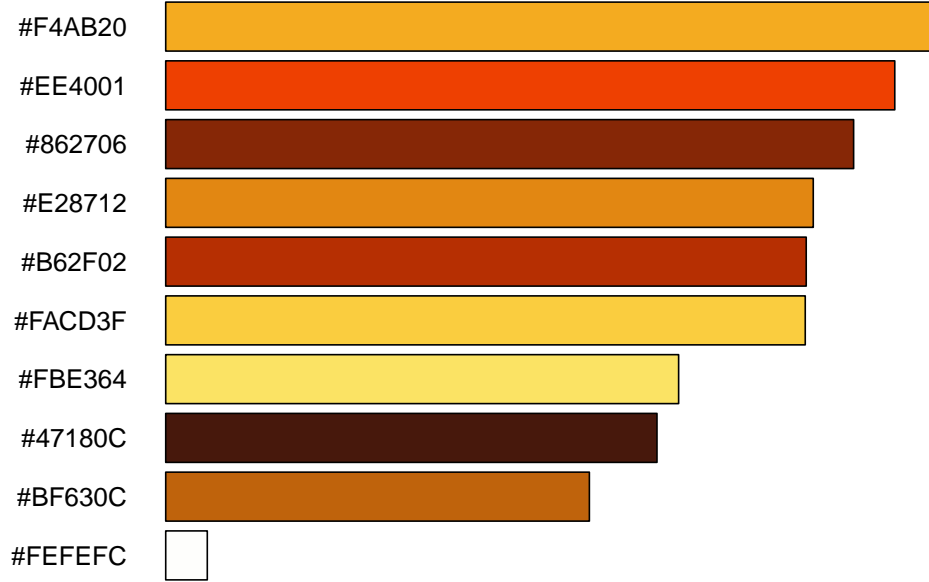#E28712
#B62F02
#FACD3F
#FBE364
#47180C
#BF630C
#FEFEFC

Figure 3: Decomposed colours

Intensify colours

If we want to intensify the shades of red, green or blue we can adjust the colours through the multiplier λ. Let us say that we want to intensify the red colour in a picture. Let us denote the red colour pixel matrix as R. The the new R^* matrix will be calculated as:

$$R^* = R(1 - \lambda) + \lambda$$

Then, if $\lambda = 1$, then the values of R^* will be 1. This would intensify the red colour maximally. The equation above can be applied to the green and blue pixel matrices.

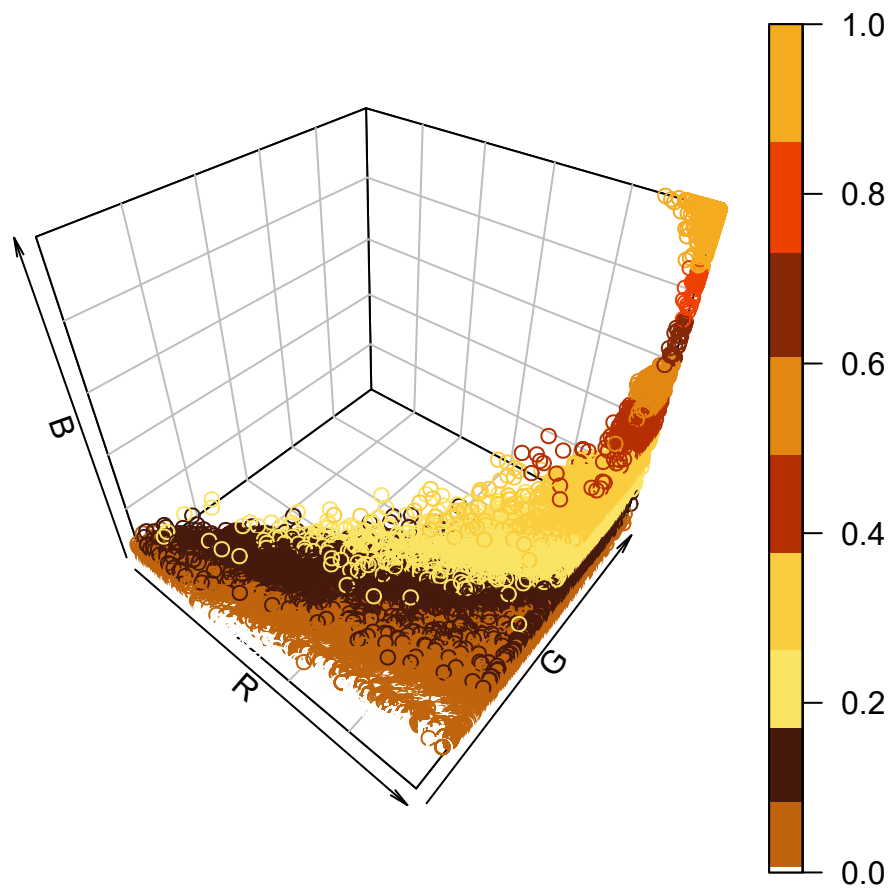When $\lambda = 0.4$ for the red pixel matrix the results can be seen in figure 5.

Figure 4: 3D decomposition of colours

Figure 5: Inensified picture

References

[2] R Core Team. *R: A Language and Environment for Statistical Computing.* R Foundation for Statistical Computing. Vienna, Austria, 2016. URL: https://www.R-project.org/.

[3] Pang-Ning Tan, Michael Steinbach, Vipin Kumar. *Cluster Analysis: Basic Concepts and Algorithms.* Michigan State University. USA, 2006. URL: https://www-users.cs.umn.edu/~kumar/dmbook/ch8.pdf.

[1] S. Urbanek. *jpeg: Read and write JPEG images.* R package version 0.1-8. 2014. URL: https://CRAN.R-project.org/package=jpeg.