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Image Color Number Reduction Methods

by
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Abstract. *The reduction of the number of colors in an image is sometimes useful in practice. Two different methods for color reduction are discussed. The first one where the color reduction is performed on the whole image, and the second one where color reduction is performed separately on each resulting zone after image segmentation.*

Keywords: Image Processing, Color Quantization, Posterization

1. Introduction

These changes are necessary when you want to reduce as much as possible the number of colors without affecting too much picture quality.

Image color reduction is useful for industrial uses where a model is reproduced physically. For such industries having several hundred or thousand distinct hues is often not cost-effective. The reduction of the number of distinct hues to manageable levels while preserving as much as possible of the quality of the initial image is therefore desirable [3].

In the Image Processing domain [2,5] color reduction is known either as posterization [6] or as color quantization [4,7]. It consists of replacing groups of different gradation of hues to a small number of very distinct hues. Color quantization has been explored due to its usefulness in compressing and in porting images from devices that support a large number

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of different colors to devices that are more restricted in the number of distinct color hues that they can show [9,10].

Color reduction could reduce the number of different hues in a digital image to manageable levels for weavers and then an application could generate the weaving pattern from the resulting image.

Several methods have been proposed in order to approach this problem. Some of them are Median Cut, generalized Lloyd Algorithm, statistical data analysis, cluster analysis, octree [1], indexed color and the Voronoi regions.

2. Color reduction- Methods (Reduction strategies)

Color reduction is a complicated problem, when taking into account that the number of colors in the final image could be very small when compared to the number of colors in the initial image. Moreover, the method employed should preserve, as much as possible, the quality of the initial image. For instance, if the desired ratio between the initial number of colors and the final number of colors is 2,857 = 100.000/35 (see Table 1) the problem is difficult to solve if the quality of the final image should be comparable to that of the initial image.

If the color space of major colors present in the initial image is relatively large then it is strongly advised that the image is processed in order to reduce the color space (see Figure 1 – *preprocessing*).

If the general aspect of the image is modified by the processing algorithm (for example, the image becomes tinged with red) then an image segmentation should be performed in order to correct it (because aspect modifications of the initial image are undesirable). Image segmentation ([8]) is performed by dividing the image in multiple zones sharing similar colors. Color reduction will then be applied separately on each of the resulting zones while taking into account the colors used in other zones. There are several methods for Image segmentation: clustering, compression-based methods, histogram-based methods, region-growing methods, split-and-merge methods, and graph-partitioning methods to name a few of them.

One of the used ideas is the replacement of a large number colors perceived by the human eye as the same hue with a single color (see [8]). In practical terms for the color code of each channel (for instance, red, green and blue components if the red-green-blue color space is used) the last three or four bits are replaced with zero. This process greatly reduces the number of colors present in the image (see Figure 1 - *rarefying*).

One last processing method consists of an iterated process of color grouping (see Figure 1 – *grouping*) through which singular colors (i.e. colors found with a reduced frequency in the image) are replaced with the closest color extant in the image palette.

A useful method for avoiding the corruption of the image quality is called Dithering. Dithering consists of replacing singular colors not only with the closest color but with several different colors extant in the color palette. The probability that a given extant color will replace a singular color is dependent on the closeness of the two colors as well as the overall frequency of the presence of the extant color in the image.

3. Implementation

Human eye is for sensitive to light than to different color hues. Therefore, at least one of the processing steps presented should be performed in a color space that takes into account light intensity (thereby excluding the red-green-blue color space).

It is advisable that the application responsible for the posterization transform should be interactive allowing users to verify the effect of the color reduction algorithm at each step of the way. Despite the fact that the application allows its users to specify thresholds for color distances it is recommended that the visual effect of color reduction should be confirmed by the user. For performance enhancement a different distance metric than the Euclidean metric for computing color distances should be used. The Chebyshev or Canberra metrics are good candidates that reduce the execution time of the application while the distances computed do not differ noticeably from those computed using an Euclidean metric.

The three steps (i.e. preprocessing, rarefying and grouping) of the number of color reduction algorithm are presented in the diagram in Figure 1. Applying the described algorithm on the image depicted in figure 1, we obtain 769 distinct colors after the preprocessing phase whose color distribution can be observed in figure 2. Of these 769 colors there are a large number of very similar hues that are indistinguishable by the human eye. After applying the next step the color space is rarefied further reducing the number of distinct colors to 238.

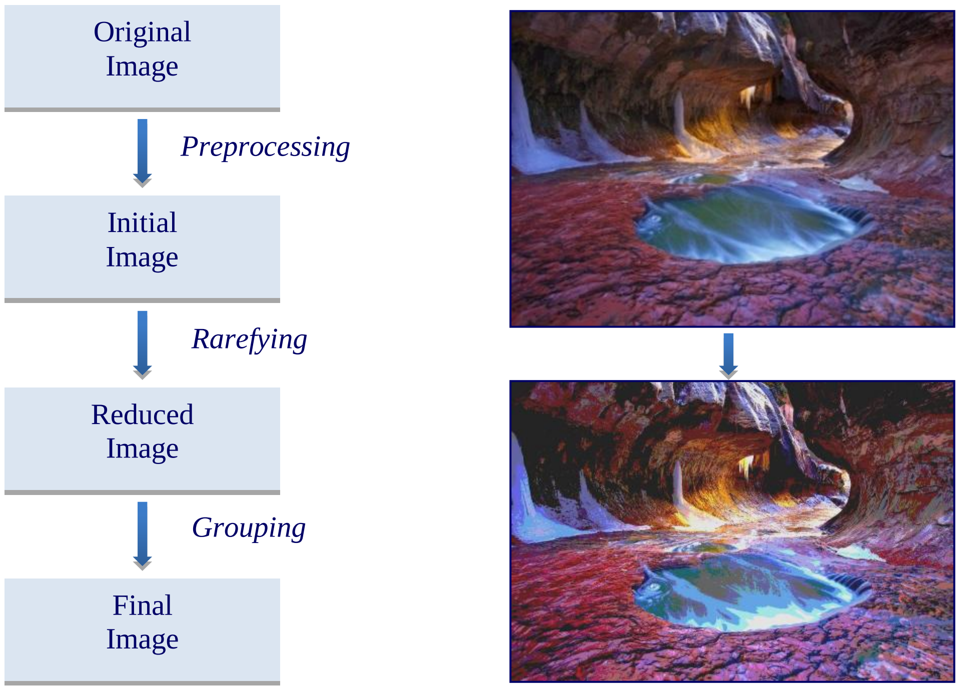

Figure 1. Steps of color reduction, and Initial and Final example

Every color subset of similar colors is replaced by a single hue (that will represent the whole subset). The color of the resulting hue is computed as being the weighted average of the colors, the weight representing the frequency with which each of the similar colors is present in the image. Other possibilities for computing the hue could be simply taking the hue with the most frequency or a simple (i.e. non-weighted) color average.

The final step in color reduction is performed iteratively for colors with a very low frequency whose replacement will therefore have only a slight impact on the overall look of the image. These hues whose frequencies are lower than a user-defined threshold will be replaced by the closest color or using a dithering algorithm to determine the hue with which it will be replaced.

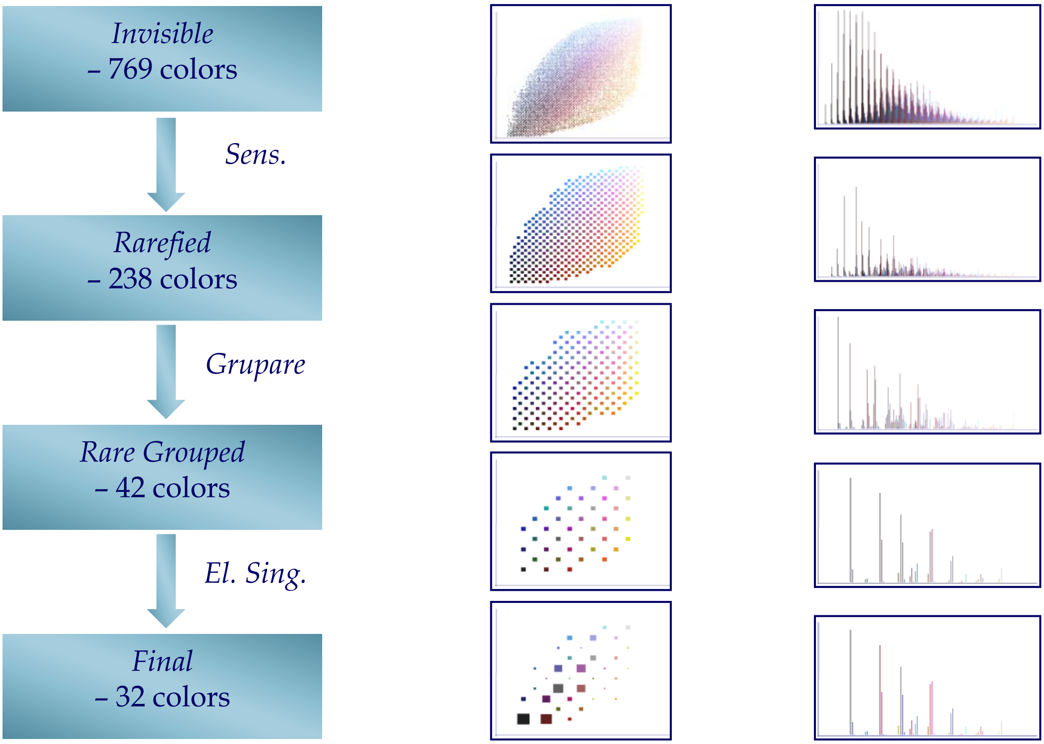

Figure 2. Number of colors, diagrams and histograms of the posterization analysis

4. Practical Applications

A possible practical application of the color reduction method is in the development of weaving patterns from digital images. Weaving patterns are specifications that tell the user (for example, a handweaver) what are the colors of each point of the interlocked warp and weft threads. The usefulness of weaving patterns consists in the simplification of the reproduction of complex images by providing users with instructions in order to know which color thread should be weaved at any particular point of the weave. Weaving patterns are usually depicted as a series of characters in order and a legend which specifies for what color each character stands for.

For industrial applications representing the resulting colors after the application of the color reduction algorithm is useful. In practice each color will be represented by a different letter or other ASCI character. Also for industrial applications it is useful to know the frequencies of each of the final colors due to the fact that it informs on the quantity of different materiel needed in order to reproduce this image physically (for example by the textile industry).

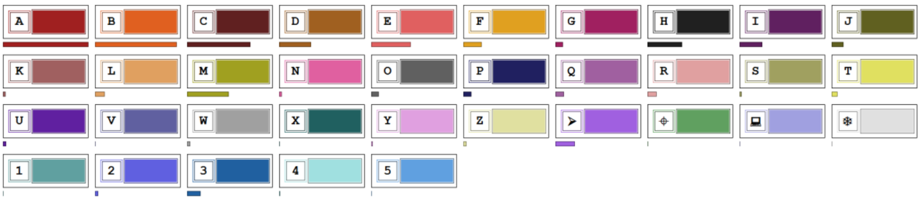

Figure 3. Color coding and frequency

For industrial reproduction it is essential that each pixel can be clearly distinguished. Therefore, the application must permit the user to zoom in to see every pixel. The area that is zoomed is depicted by the application using a dotted square.

After each color hue is codified each of the pixels in the image is replaced by the corresponding color code. For each square zone of the image the list of codes is printed. Using this list of printed codes and a legend that specifies the correspondence between a color and a character any user can determine the correct order of the colors and potentially reproduce them (see Figure 5).

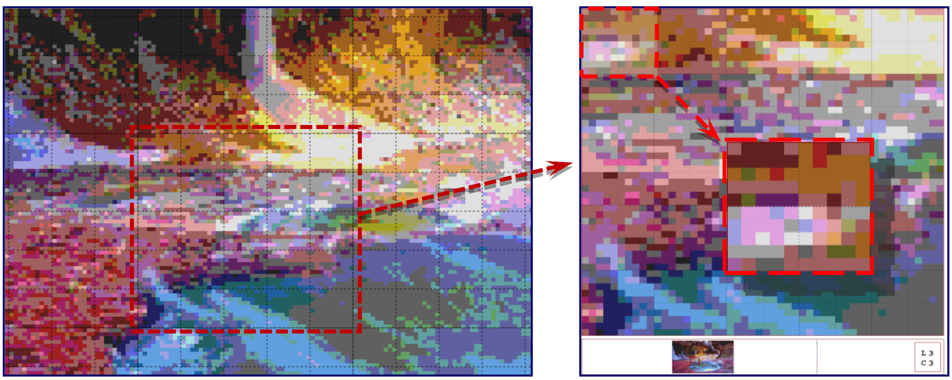

Figure 4. Image scaling to showcase pixel hues

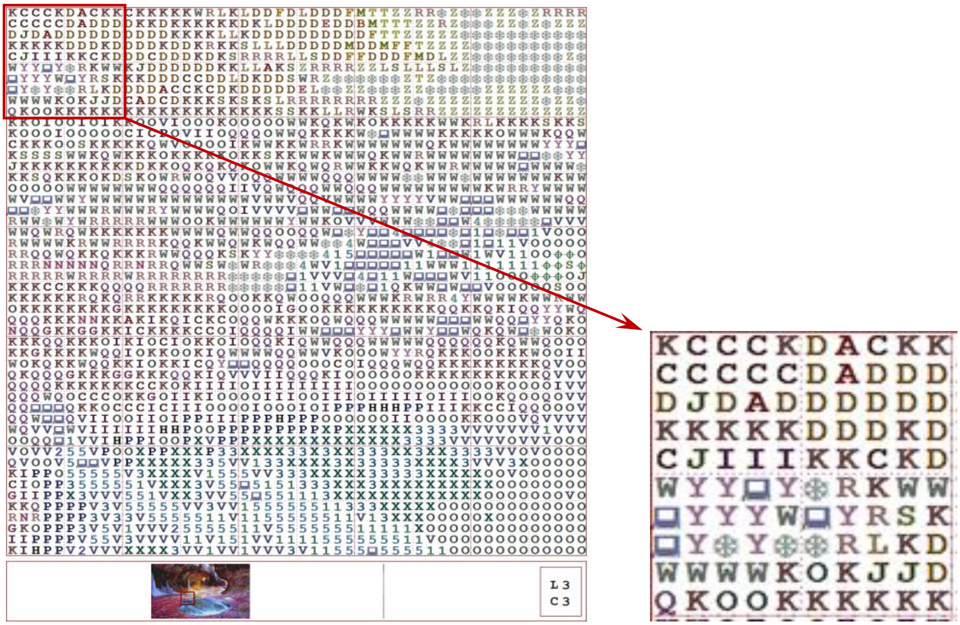

Figure 5. Color coded map

5. Conclusions

The presented image color number reduction methods have been employed in an application that was also extended in order to codify the resulting image in a series of different character codes and the associated color with that character. As can be seen in Table 1 the processing steps have led to significantly reduced number of distinct colors which has resulted in a much smaller file size of the resulting images. The number of distinct color hues of the initial image has been reduces by almost 82 times. For the example image a reduction to 35 distinct colors was performed. For very dynamically colorful complex images a final distinct color hue number smaller than 100 is considered acceptable.

The efficacy of the techniques presented on an example image is illustrated in tabular form in Table 1 as well as in a graphical form in Fig. 6.

Table 1. The reduction in number of colors and the size of the image

Imagine	*Colors number*	*Size (KB)*	*Rap. Col. Number*	*Rap. Size*
Initiala	2,867	835	81.90	5.76
Invizibila	769	224	21.97	1.54
Rarefiata	238	190	6.80	1.31
Grupata	42	147	1.20	1.01
Finala	35	145	1.00	1.00

The Histogram in Figure 6 graphically showcases the efficacy of the applied techniques for the studied example. It illustrates both the shrinking of the number of colors (shown in yellow) as well as the smaller resulting file sizes (shown in dark blue) for each phase of the processing algorithm.

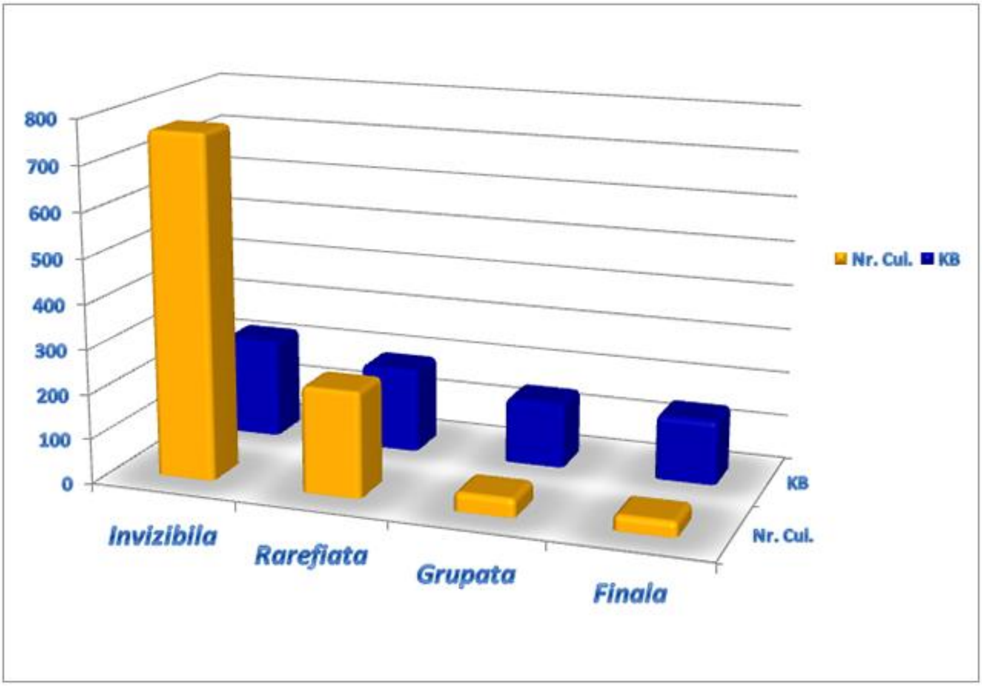

Figure 6. Image color and size histogram

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