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Color Models in Color Image Segmentation

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Abstract

In this paper we analyze the influence of usage of the different color models on color image segmentation. We apply cellular neural network for removing noise and image segmentation of color aerial photographs. We will take into account and compare three color models: RGB, HSV and HSL.

In resulting images we will distinguish some objects like houses, roads, trees and others. The selection of the objects will be based on the color value. We show that the choice of color model influences the results.

1 Introduction

Color image processing causes more problems than monochrome image processing, since the color photos have some nonlinear information. During color image processing, the color images are transformed into three monochrome images: mostly red, green and blue comming from RGB color model (eg. [9]). Each monochrome image is then processed independently.

Neural networks and cellular neural networks (CNNs) are regarded as useful tools for image processing (eg. [7, 19]). CNNs were introduced by L.O. Chua and L. Yang [5, 6]. Recent years several applications of CNNs for image processing, like image restoration (eg. [5, 6]), image segmentation (eg. [9, 13, 17, 18]), object recognition (eg. [14]), or visual reconstruction (eg. [15]) have been proposed and tested. CNNs appeared to be useful in medical image processing [1, 2] and for volcanoes monitoring [3].

In contrast to applications where RGB model is used, in this paper we propose some application of different color models such as HSV or HLS in color image segmantation (distinguishing objects from background). In the experiment we will use CNNs as a tool for image segmentation. We will examine color aerial photographs, which are used for places identification in air-sports like aviation, gliding, paragliding. It will be shown that the results in image segmentation were improved in comparison to RGB color model.

2 Cellular Neural Networks

A CNN is an n-dimensional regular array of elements (cells), in two-dimensional case denoted as *c(i,j)* [16]. Any cell is connected only to its neighbor cells, the neighborhood ($N_r(i,j)$) of the cell $c(i,j)$ is defined as:

$$N_r(i,j) = \{c(k,l) : |k-i| \leq r \wedge |l-j| \leq r\}$$

An example of two-dimensional cellular neural network is depicted in Figure 1, while the scheme of the cell is shown in Figure 2. I is independent

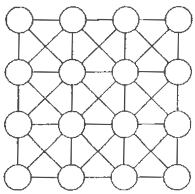


Figure 1: A topology of a two-dimensional cellular network

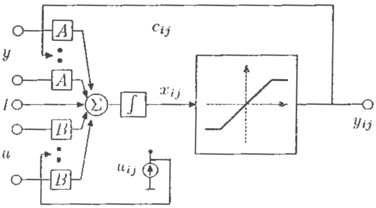


Figure 2: Block scheme of a cell

current source constant in time, A and B are called feedback operator and control operator, respectively, through which the signals of both outputs (y) and external inputs (u) of the cell are interchanged [11].

In the experiment we use a discrete time CNN (DTCNN) [10]. We assume that the values of states and output signals are changing in discrete, evenly spaced time points. The dynamic of the cell can be characterized by a set of the following equations [12]:

$$x_{ij}[(n+1)\Delta t] = x_{ij}[n\Delta t] + \sum_{k=-r}^{r}\sum_{l=-r}^{r} A_{i,j;i+k,j+l}\, y_{i+k,j+l}[n\Delta t] + \\ + \sum_{k=-r}^{r}\sum_{l=-r}^{r} B_{i,j;i+k,j+l}\, u_{i+k,j+l} + I \tag{1}$$

$$y_{ij} = f(x_{ij}) = \frac{1}{2}\left(|x_{ij}+1| - |x_{ij}-1|\right) \tag{2}$$

$$x_{ij} = E_{ij} \tag{3}$$

$$|x_{ij}(t=0)| \leq 1 \tag{4}$$

$$|u_{ij}(t)| \leq 1 \tag{5}$$

Equation (1) is state equation for a cell, (2) and (3) describe output and input equations, respectively. Constraint conditions are represented by (4) and (5).

3 Color Models

Color images provide more information than monochrome images. The techniques used for gray level images are extended for color images by using components of RGB model [4].

The RGB color model uses the additive model in which red, green, and blue light are combined in various ways to create other colors. The idea for the model itself and the abbreviation "RGB" come from the three primary colors in additive light models. The RGB model is a practical, convenient for display, therefore basing on this model the kinescopes work up to nowadays. However the components are highly correlated, and the model only approximates the true colors.

The HSV (Hue, Saturation, Value) model, also called HSB (Hue, Saturation, Brightness), defines a color space in terms of three constituent components:

- *Hue* — the color type (such as red, blue, or yellow).
- *Saturation* — the "vibrancy" of the color. The lower the saturation of a color, the more "grayness" is present and the more faded the color will appear, thus useful to define desaturation as the qualitative inverse of saturation
- *Value* — the brightness of the color.

It is a nonlinear transformation of the RGB color space, and may be used in color progressions. This model is more user-oriented then RGB, because of its similarities to the way humans tend to perceive color. In HSV model it is assumed that the components are orthogonal and independent from each other.

Similar to HSV model is HLS model, where HSL stands for Hue, Saturation, Lightness or Luminance. The two apexes of the HSL double hexcone correspond to black and white. Like HSV, HSL color model is a non-linear deformations of the RGB color cube. HSL seems to reflect better the intuitive notion of "saturation" and "lightness" as two independent parameters, and is therefore more suitable for use by artists, because the Saturation component goes from fully saturated color to the equivalent gray and the Lightness spans the entire range from black through the chosen hue to white [8].

4 Experiment

In this experiment we will remove noise and segment color aerial photos. At the beginning every pixel of considered image is decomposed to three components (Red, Green, Blue for RGB model Hue or Saturation, Value for HSV model and Hue, Luminance and Saturation for HLS model). Every image transformed in that way can be presented as a monochromatic one, with only one components' value changing. Such images constitute the network's input.

Then we apply the DTCNN to remove noise (6),as discussed in [21] and convert monochromatic image into black–and–white one (7),as examined in [20]. We use the following cloning templates[1]:

$$A_1 = 0 \qquad B_1 = \begin{bmatrix} \frac{1}{16} & \frac{1}{8} & \frac{1}{16} \\ \frac{1}{8} & \frac{1}{4} & \frac{1}{8} \\ \frac{1}{16} & \frac{1}{8} & \frac{1}{16} \end{bmatrix} \qquad I_1 = 0 \tag{6}$$

$$A_2 = \begin{bmatrix} 0 & 0.1 & 0 \\ 0.1 & 0.9 & 0.1 \\ 0 & 0.1 & 0 \end{bmatrix} \qquad B_2 = 0 \qquad I_2 = 0 \tag{7}$$

[1]Cloning template is a repeating structure of connections between the cells and their weights

After transformation of all 3 layers (components), the results are put together. This way regions of 8 colors are created.

During the experiment several aerial photos were used. Due to space limitation we restrict ourselves to consider here only one photo — a roundabout in Warsaw. The monochromatic version of the photograph is shown on Figure 3.

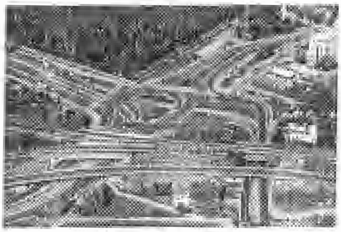
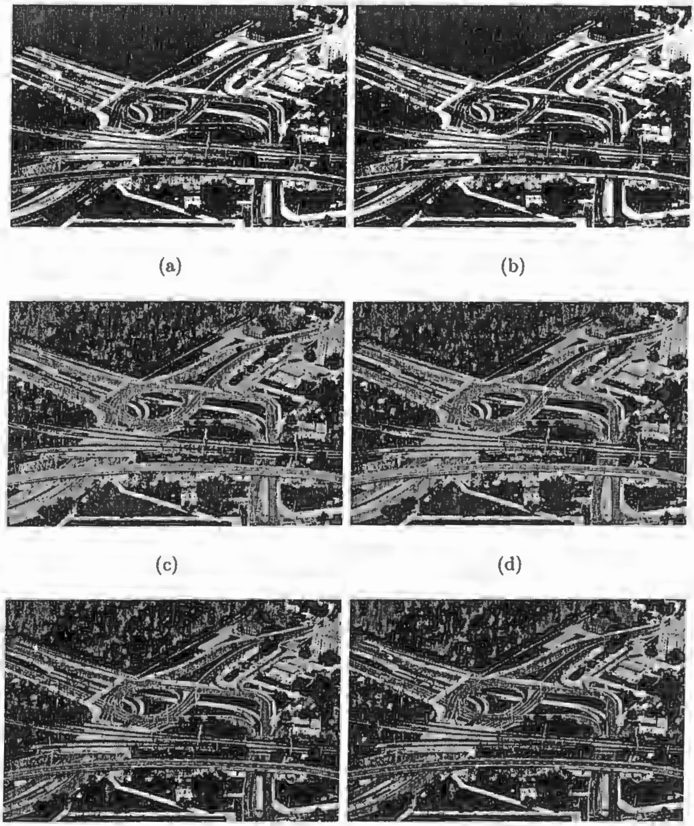


Figure 3: The monochromatic version of color photo used in the experiment

Figure 4 shows the obtained results. Figures 4(a) and 4(b) were obtained if RGB color model was considered, however in the second image noise is removed. Figures 4(c) and 4(d) utilize HSV model without and with noise removal procedure, respectively. Figures 4(e) and 4(f) were based on HLS color space, again with removed noise in case of image 4(f).

In all resulting images roads can be easily distinguished. However, when HSV or HLS models were considered, the roads differ themselves from the trees and grass. The railway track is poorly seen on all three images, however the best results can be observed on image 4(d). The original image contained some houses and cars as well. Houses are most clearly visible in the image



(a) (b) (c) (d) (e) (f)

Figure 4: Results

4(f). Cars are mostly removed or treated like noise, as they are very small.

5 Conclusions

In this paper we apply DTCNN for noise removal and image segmentation of color images. We examined the results when three color models: RGB, HSV and HLS were used.

From the carried out tests it appears, that the choice of the color model influences the results. The results are better for HSV and HLS models, because in the real world images, which we have considered, the colors are soft and dull. More objects can be distinguished. Moreover, in the HLS model the noise is better removed, although in all three cases the same tools were applied. If an artificial image with vivid (basis) colors was given to the network, the better results were obtained for the RGB model.

We suppose, that in the HSV and HLS color models only two values for the Hue component are not enough. In our further research we will focus on solving this problem and classification of the selected objects.

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