H-048

Grayscale Facial Image Colorization System

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1. INTRODUCTION

There are many portrait grayscale photos taken in the past. And many photos still have taken in that format for any reason. At time, we might wish to transform some of these photos into coloring photos. For colorization several techniques have been proposed [1][2].

In this paper, we proposed a simple and automatic grayscale facial image colorization system that changes the hue channel value in color range of the skin and facial elements.

2. PROPOSED SYSTEM SPECIFICATIONS

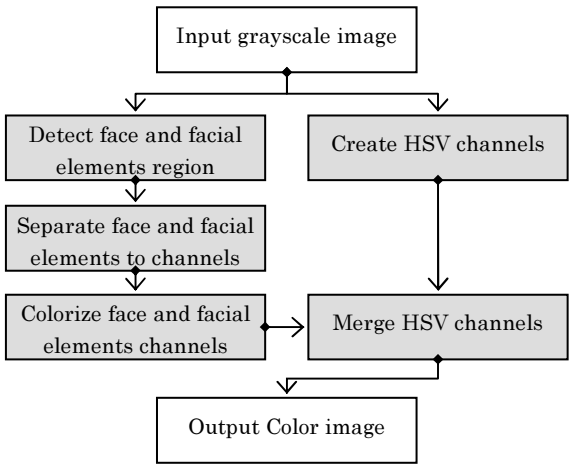

Fig. 1　System block diagram

A system block diagram we propose is shown in Fig. 1. our colorization system consists of five subsystems: (1) Create HSV channels for grayscale input image; (2) Detect face and facial elements region by the Viola and Jones object detection framework in the OpenCV library; (3) Separate face, eyes and mouth outline region pixels to single channel by image threshold method; (4) Colorize face and facial elements channel by hue value of skin, lip, iris or fur colors; (5) Merge Hue, Saturation and Value channels to output color image;

2.1　Create HSV channels

HSV (Hue, Saturation and Value) – defines a type of color space. It is similar to the modern RGB and CMYK models. The HSV color space has three components: hue, saturation and value. ‘value’ is sometimes substituted with ‘brightness’ and then it is known as HSB. In HSV, hue represents color and value is an angle from 0 degrees to 360 degrees.

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Saturation indicates the range of grey in the color space. It ranges from 0 to 100%.

Value is the brightness of the color and varies with color saturation. It ranges from 0 to 100%.

HSV is the most widely used color space in object detection and colorization field. Thus HSV space is used in this paper.

2.2　Detect face and facial elements region

Because of the fastest detection speed and availability for the low resolution and gray-scale images, the Viola and Jones face detection approaches has wide-spread acceptance of open source implementation, especially the OpenCV library. The library provides functions that they used to train classifiers for their face and facial elements detection called Haar Training Cascade of Classifiers. The training data is a XML file format dataset and there are different datasets for frontal face, eyes, eye pair, nose and mouth detection. So, in doing research for face, eyes and mouth region detection we directly used the OpenCV library.

2.3　Separate face and facial elements to channels

Since face and facial elements region are detected, implementation of separate region pixels to single channel work begins with threshold method. But there is some difference on the saturation in different region. To avoid erroneous thresholding, we use different threshold progress for different region [3].

① Threshold progress for eye region: The auto brightness/ contrast algorithm (Fig 2.b) implemented to eye region and then use the threshold procedure (Fig 2.c);

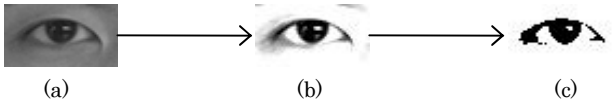

Fig. 2　Eye region threshold progress. (a) eye region (b) brightness/contrast adjusted eye region (c) binary version

② Threshold progress for eyebrow region: Use background subtraction algorithm to get darker eyebrow over uniform bright background (Fig 3.b), then use histogram equalization method (Fig 3.c) to adjust the image contrast, and then threshold it using Otsu’s method (Fig 3.d);

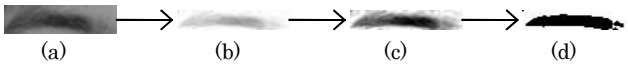

Fig. 3　Eyebrow region threshold progress. (a) eyebrow region (b) background subtraction (b) contrast adjust (c) binary version

③ Threshold progress for mouth region: Use background subtraction algorithm to get darker mouth over uniform bright background (Fig 4.b), then use histogram equalization method

(Fig 4.c) to adjust the image contrast, and then using the threshold procedure (Fig 4.d);

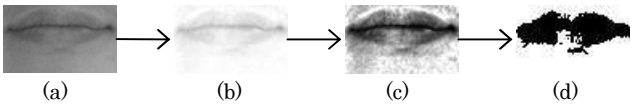

Fig. 4 Mouth region threshold progress. (a) mouth region (b) background subtraction (c) contrast adjust (d) binary version

④ Threshold progress for iris region: Use Hough Circle Transform [4] to get iris circle region (Fig 5.b) and split it (Fig 5.c) from threshold eye region, then use flood fill operation (Fig 5.d) to fill-up the holes in iris region;

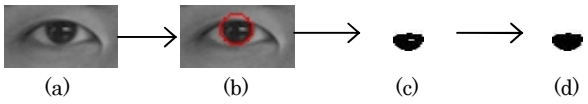

Fig. 5 Iris region threshold progress. (a) eye region (b) iris circle (c) iris region (d) filled iris binary version

After threshold, we create single channels for face region, eye region with eyebrow without iris, iris region and mouth region, as shown Fig. 6.

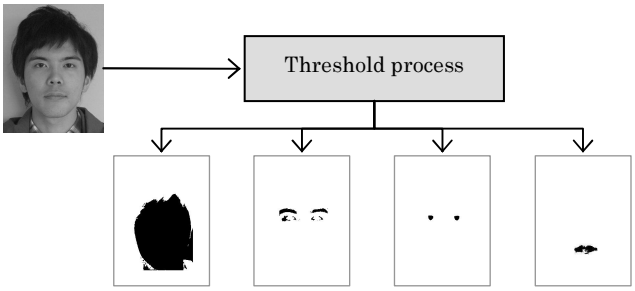

Fig. 6 Separate face and facial elements to single channels

2.4 Colorize face and facial elements channels

The face, eyes, iris and mouth threshold single channel created, we change channel value in corresponding hue range to colorize these channels. There are number of values range of human skin [5], lip [6] and iris [6] color was analyzed, as shown blow.

Skin color ranges:

- Wangand Yuan (2001)
  H∈ [0, 50]; S∈ [0.2, 0.68]; V∈ [0.35, 1];
- Herodotou et al. (1999)
  H∈ [0, 50] and H∈ [340, 360]; S∈ [0.2,1]; V∈ [0.35,1];
- Tsekeridou and Pitas (1998)
  H∈ [0, 25] and H∈ [335, 360]; S∈ [0.2, 0.6]; V∈ [0.4, 1];
- Sobottka and Pitas (1998)
  H∈ [0, 50]; S∈ [0.23, 0.68]; no limitation on the V value;

Lip color range:

The hue range value of the lip is H∈ [160, 180];

Iris color range:

The hue range value around the eye centre is H∈ [100, 130];

Eyebrow and eye edge color range:

Eyebrow and eye edge (include eyelash) color range always concentrated in dark brown and black;

After changing face, eye, iris and lips channel value in corresponding hue range, we merge these channels to one and count as hue channel of the facial image.

2.5 Merge HSV channels

Grayscale intensity is stored as an 8-bit integer giving 256 possible different shades of gray from black to white. So we can store grayscale image's value to colorized image's value channel.

Sometimes the HSV intensity value is calculated from 0 to 1. When the value is 0 the color is grey, and when the value is 1 the color is a primary color. A faded color is due to a lower saturation level, which means the color contains more grey. So for the saturation channel, we get the values from inverted value (brightness) channel directly and adjust to saturation range.

After the hue, saturation and value channels defined, the image will be change to colorized image, as shown Fig. 7.

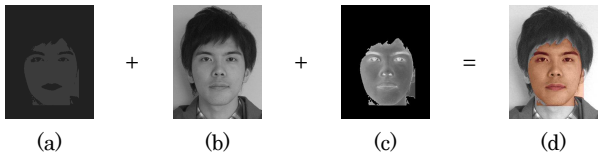

Fig. 7 Merge hue, value and saturation channels. (a) hue channel (b) value channel (c) saturation channel (d) colorized image

3. COLORIZATION RESULTS

Demonstration of the proposed system can colorize grayscale facial image atomically, and the colorization results is quite close to the original color image from which the test grayscale image that generated removing color components.

Because we can change HSV value freely, so the facial image can be colorized like Asian, African, European, .etc.

4. CONCLUSIONS AND FUTURE WORK

In this paper we proposed simple and automatic colorization system, which detect facial area and change the hue value in hue channel based on hue value range of the skin, lip and iris color.

So far, the proposed colorization system can only be used for grayscale facial area and hue channel. In the future, we'd like to extend it to hair and background with saturation adjustment, brightness adjustment and color blending for edge.

REFERENCES

[1] Michal Kawulok, Bogdan Smolka, "Competitive Image Colorization", Image Processing (ICIP), 2010 17th IEEE International Conference on, pp. 405 – 408 (2010).

[2] Hadhoud M.M, Semary N.A, Abbas A.M, "Fully Automated Black and White Movies Colorization System", Informatics and Systems (INFOS), the 7th International Conference on, pp. 1 – 6 (2010).

[3] A.S.M. Sohail, P. Bhattacharya, "Detection of Facial Feature Points Using Anthropometric Face Model", IEEE International Conference on Signal-Image Technology and Internet-Based Systems, Tunisia, December, 2006, pp 656–665.

[4] Rahib Abiyev, Kemal Kilic, "Adaptive Iris Segmentation", Lecture Notes in Computer Science, Vol.5576 (2009).

[5] B.Smolka, K.Czubin, J.Y.Hardeberg, K.N.Plataniotis, M.Szczepanski, K.Wojciechowski, "Towards Automatic Redeye Effect Removal", Pattern Recognition Letters, Vol.24 Issue 11, July 2003.

[6] Wen-Tao Wang, Chao Xu, Hong-Wei Shen, "Eye Localization Based On Hue Image Processing", International Symposium on Intelligent Signal Processing and Communication Systems, pp. 730 – 733, 2007.