I-021

Colorization Using Landmark Pixels

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1. Introduction

A one-dimensional luminance scalar is replaced by a vector of a colorful multidimension for every pixel of a monochrome image, this process is colorization and is under-constrained. Consequently, colorization has not the only correct answer. Some priori knowledge or a reasonable constraint should be given.

In this paper, we consider giving some priori knowledge to the monochrome image. Colorization using optimization [1] is one of this sort. Their basic idea: neighboring pixels in space-time that have similar intensities should have similar colors. User draws some color scribbles to the monochrome image as some prior knowledge(fig.3(a)). The indicated colors are propagated in both space and time to produce a fully colorized image. It may colorize the monochrome image in the context of not segmenting it to regions directly. It is an effective algorithm for a simple monochrome image. However, it cannot effectively colorize the fig4(a) without repeating experiments for confirming the place of scribbles. Therefore, we propose an algorithm which is colorization using landmark pixels. It need not repeat experiments and automatically generates landmark pixels like scribbles. Finally, colorize the monochrome image according to user.

2. Algorithm

Landmark pixels [2] are extracted from the monochrome image using downsampling, k-means and upsampling method. And then the landmark pixels are classified using ward method. At last, the color image can be obtained by colorizing one landmark pixel of each cluster.

It costs much time if landmark pixels are extracted from an original image directly. Hence, degrade the monochrome image to low resolution image. The initial landmark pixels are extracted from the low resolution image using k-means. And then upgrade the resolution image, at the same time, we raise the number of landmark pixels. We repeat the above process until the result is the same as the resolution of the original image.

A monochrome imageI_0 is given. We build a gaussian pyramid I_0, I_1,...,I_d, where I_0 is the input monochrome image of the original image and I_d is the coarsest level in the pyramid. We classify the coarsest level image I_d using information on the value of each pixel and position of each pixel. K clusters are obtained using k-means. The centroid of each cluster is considered as the inital landmark pixels. Let set of the initial landmark pixels be X_d. The mean value is substituted for the values of all pixels of each cluster. Let the image be Φ_d. The residue image is obtained by eq.(1) when $i = d$.

$$E_i = | I_i - \Phi_i | \tag{1}$$

We divide E_d into small windows like fig.1. The size of each window is $h \times h$ pixels. Suppose the size of the input image is $M \times N$ pixels. We build a gaussian pyramid with a scale factor 2. Suppose that we set one landmark pixel to a window in the coarsest level image. c is the number of the landmark pixels. We will add at most $\frac{M}{2^k h} \times \frac{N}{2^k h}$ landmark pixels to small windows. Based on the idea, we can get h by eq.(2) and eq.(3). We set the same threshold to every small window. The value of the pixel should be memorized, if the mean value of pixel of the small window is larger than the threshold. The threshold is set at 30 based on experiments, if the number of landmark pixels is larger than 300. Otherwise, the threshold is set at 20. It is difficult to get the landmark pixels, if the threshold is too large. Otherwise, it will cost much time in order to extract many landmark pixels.

$$\sum_{i=0}^{d} \frac{M}{2^k h} \times \frac{N}{2^k h} = c \tag{2}$$

$$h = \sqrt{\frac{4MN}{3c}\left(1 - \frac{1}{4^{d+1}}\right)} \tag{3}$$

We can get the landmark pixels X_{d-1} from image E_d, Φ_{d-1} is obtained by segmenting I_{d-1} based on the set X_{d-1} of landmark pixels by K nearest neighbor. The residue image E_{d-1} can be obtained by eq.(1), when $i = d - 1$. In this way, until the landmark pixels X_0 are extracted from the image I_0 .

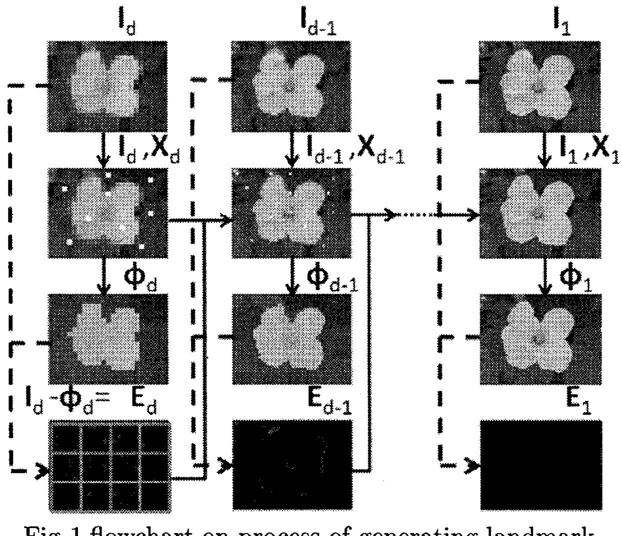

Fig 1.flowchart on process of generating landmark pixels

It is impossible to give every landmark pixel colorize the corresponding color as there are too many landmark pixels. But we find some landmark pixels should be set the same color. Based on the idea, we classify the landmark pixels to some clusters using ward method and define the landmark pixels of the same cluster into the same color. Finally, we colorize the monochrome image based on the colored landmark pixels using Levin method.

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Fig.2 shows the process of algorithm. It is carried out according to the followig procedure.

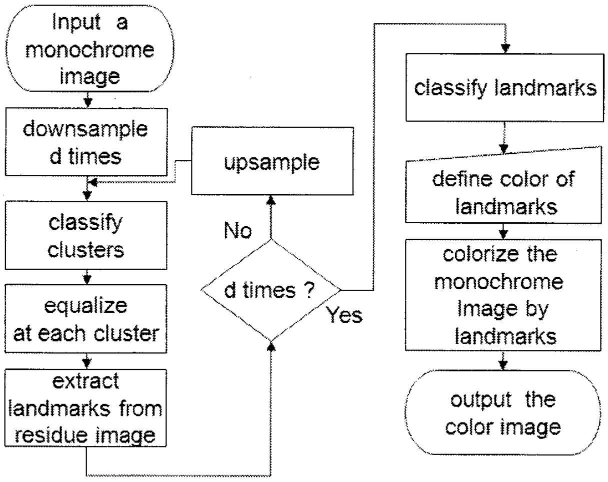

Fig 2.flowchart on process of proposal algorithm

3. Expriment

Fig.3(a) shows the monochrome image with scribbles and its result with colorization from [1]. We draw some colored scribbles to the monochrome image freely like Fig.4(a). We cannot obtain the result such as Fig.3(b) while obtain Fig.4(b). So we know it is not easy to get the result like Fig.3(b). Experiments should be done until the result like Fig.3(b) is obtained. Only by appropriately drawing the colored scribbles, Fig.3(b) can be obtained. But our proposal does not consider the above problem. Our algorithm can generate landmark pixels automatically like fig.5(a). We just colorize one landmark pixel of each cluster and then can obtain the result like Fig.5(b). Some parameters of our proposal are given:the number of landmark pixels is c=700, threshold is T=20, the number of levels is d=4, the size of a small window is h=13, the number of clusters is n=25.

Fig 3(a).the monochrome image with scribbled colors

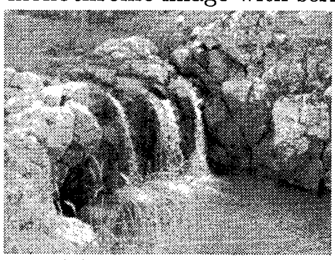

Fig 3(b).resulting color image

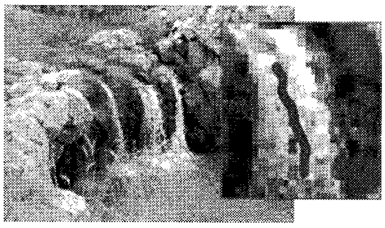

Fig 4(a).the monochrome image with scribbled colors

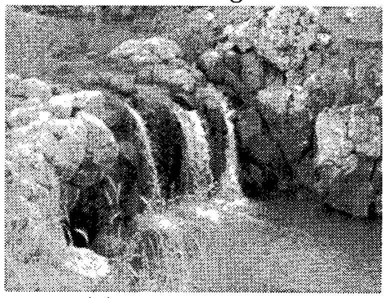

Fig 4(b).resulting color image

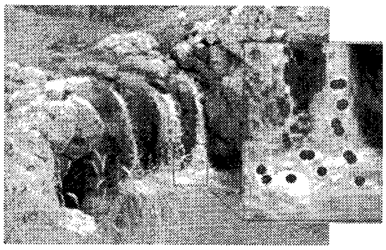

Fig 5(a).the monochrome image with landmark pixels

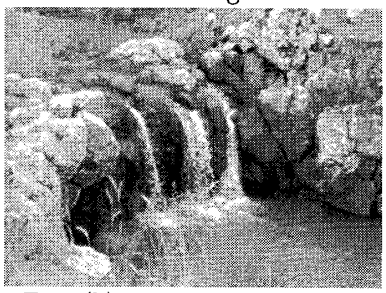

Fig 5(b).resulting color image

4. Conclusion

In this paper, we present an effective colorization method using landmark pixels. Automatically generating landmark pixels is the advantage of the algorithm. However, we must define a color in the one landmark pixel of each cluster manually. Therefore, automatically defining a color in the one landmark pixel of each cluster is the subject of future research.

References

[1] A.Levin, D. Lischinski, and Y.Weiss. Colorization using optimization. *ACM Trans. Graph.*, 23(3):689-694,2004.

[2] T. Huang, H. Chen. Landmark-baased sparse color representations for color transfer. *ICCV*, 2009.