A Stylized Binarization Procedure for Black/White comics using HSV region extension

Dong-Sung Ryu, Hwan-Gue Cho
Dept. of Computer Engineering,
Pusan National University, Republic of Korea
dsryu@pearl.cs.pusan.ac.kr, hgcho@pusan.ac.kr

Abstract

Generally most of the black/white comics color in human's skin as white, while the dark region is filled with the irregular but regular patterns like hatching. Note that it is not enough for simple threshold method to perform this work. In this paper, we propose a simple and straightforward binarization procedure which can generate black/white comics from the video frame image. Our procedure is decoupled into two processes: region extension and binarization. First, the region extension based on mean shift segmentation is responsible to simplify and classify colors on the image. Second, we implement the dynamic binarization method to consider color information in HSV color model. Our novel black/white cartooning procedure was so successful to render comic cuts from a well-known cinema in a resonable time and manual intervention.

1. Introduction

Comics has been studied for a long time, as they are the oldest genre of non-photorealistic rendering. Recently, most of work relating to comic generation have focused on the color comics, but few results on black/white comics. Though black/white comics is not colorful, it is cheap and efficient media to make plain-paper based on the book, which reduces the printing process and final cost.

One of the famous book on comics like "Understanding Comics[9]" explains the traditional way of making comics and how to draw one own comics. As mentioned this book, to draw comics, there are lots of burdensome work for people such as making story-board, drawing characters, planning comic continuity and so on. Therefore those of hard-trained artists can only draw the commercial comics easily. In order to solve these problems relating to drawing, we propose a simple and straightforward binarization procedure for black/white comics from the video frame images.

(a) Color comic cut (b) black/white comic cut

Figure 1. Typical black and white comic cuts [10]

Figure 1, one of the famous comics,'H2', shows the features of typical black/white comics. We can show that the artists use simple color or regular patterns like hatching. Generally, most of images from the video frame are more colorful than general comics because they deal with real scenes. So we need some method to simplify and cluster this complicate color information. We summarized the features to be considered for making black/white comic cut from video stream as follows:

1. Black/white comics use simple color and regular but irregular pattern.
2. It should be rendered in the limited environment which we can use zero(off) and one(on).
3. Black/white comics should consider all of the channel information relating to color model.

We try to overcome these problems as follows:

1. In order to classify and simplify video frame images, we use the region extension method based on the mean shift segmentation.

2. We propose the binarization method based on a HSV color model.

3. The proposed procedure uses the neighbor pixels in the mask to consider the local information of the pixel.

2. Previous Work

2.1. Cartooning algorithm

Recent work on comic generation have focused on the color comics to show their excellent techniques of images processing, but few results on black/white comics. Lots of image segmentation and binarization were studied for a long time. Mean shift segmentation[3] and bilateral filter[14] are basic methods to convert an input image into a highly abstracted image. Wang *et al.* proposed a system for transforming an input video into a highly abstracted, spatio-temporally coherent cartoon animation with a range of styles like Figure 2[15]. This paper introduces an anisotropic kernel mean shift technique to segment the video data into contiguous volumes.

Figure 2. The result of video tooning[15].

Daniel *et al.* proposed the automated colorization method on the already designed black/white cartoon[13]. This method is able to automate colorization when new color information is applied on the already designed black/white cartoon as Figure 3.

2.2. Stroke Extraction

There are lots of studies to extract and stylize strokes from image. Actually while Canny's edge detector is generally considered the de factor standard for edge detectors[1], one may choose other edge detection method for line drawing. Holger *et al.* proposed the stylization method to make hand-drawn stroke[16]. They developed uncertainty functions to compute how much people to make a mistake when they draw lines. Gooch et al. presented a difference of Gaussians (DoG) filter based from Marr-Hildreth edge detector[4]. They used this filter in conjunction with binary

(a) (b) (c)

Figure 3. The result of a colorization method proposed by Daniel[13]. (a) Applied color image. (b) Original gray image. (c) Automated colorization result

thresholding to produce a black/white illustration. Henry *et al.* introduced a line drawing method from a photograph using anisotropic filter and tangent vector field[7]. Figure 4 shows that their method can stylize highly coherent lines from images.

(a) Original image (b) Tangent vectors (c)Result

Figure 4. The result of coherent stroke[7]

2.3. Comic Generation System

Recently, lots of system which transforms the video stream into comic cuts has been announced. 'Cinema Comics[6]' was the first system which used video stream as input. Sequently J. Preu proposed an excellent procedure which can transform the images of film into the comics[11] by combining a few well-known image processing techniques. For comics from 3D character model, Shamir proposed a comic generation system for 3D model input[12]. Since this system used 3D model and traced each transform, it took the advantage of various images based on viewing point.

Other conventional comic generation tools were summerized by Lee[8]'s master thesis. These tools such as 'Comic Book Creator', 'Comic Works' and 'Manga Studio' have been used for easy and flexible drawing and animations in the low-level editing.

3. Our Cartooning Procedure

Most of typical video frame image has unclear boundaries as well as various color information. But most of general comics are drawn using by clear boundaries and simple regular patterns. Therefore we need to simplify the complicate color information and to cluster into similar colors.

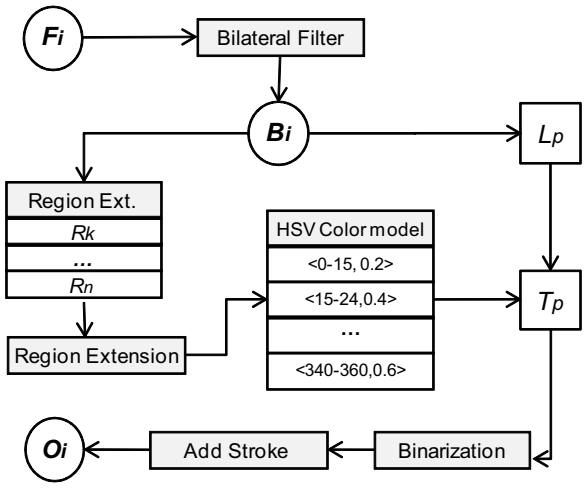


Figure 5. The overview of our binarization procedure. The proposed algorithm is decoupled into two stages: region extension based on mean shift segmentation and binarization procedure considering HSV color model.

Figure 5 explains our cartooning procedure. The main idea behind our approach is to take into account the clustered color information to binarize the video frame image. First, the i-th frame image on the video stream, F_i is filtered by bilateral filter to suppress noise color variation and reserve boundaries[14]. Since the mean shift segmentation is responsible to cluster pixels into similar colors, we perform vectorization for each regions using by mean shift. But since there are lots of segmented regions on the B_i after segmentation, R_k, these regions are merged into more extended region considering by HSV color and the geometric adjacency between each regions. Then the threshold value T_p for each pixel's binarization is calculated. Finally, we complete a black/white comic cut by adding edges on the binarized image.

3.1. Region Extension

Generally, most of comic cuts are drawn with simplified and classified color information as Figure 1. Therefore our approach is focused on the clustering method of color information[9, 10]. Algorithm 1 and 2 explain the merge method for the segmented regions. First, the frame image F_i is filtered by bilateral Filter to suppress noise color variation and enhance boundary information[14]. Second, we use mean shift segmentation to cluster each region by similar color information on the image[3]. Then we perform the vectorization for these region R to calculate their topology. We consider the convex polygon of each region which can represent their topology information. Figure 6 shows the process of our region extension. If there are some intersection area between each region's convex, we assign a edge to link each node. In order to implement this procedure, we use graph data structure whose nodes are region and edges present the relating nodes are adjacent.

Algorithm 1 Region Extension for black/white comics

procedure EXTENDREGION(B_i) → B_i is the segmented image
  R= MeanShift(B_i) → Apply mean shift segmentation
  SortRegionOrderByConvexArea(R)
  $Graph <$ Region r, edge $e > G$
  for all $r \subseteq R$ **do** → Assign nodes to region graph G
    G.NewNode(r)
  end for
  LINKADJREGION(G) → Assign the edge for graph G
  for all Node $n \subseteq nodes(G)$ **do** → Merge adjacent nodes
    for all Node $m \subseteq n$.isLinked() **do**
      MergeRegion(m,n)
    end for
  end for
end procedure

Algorithm 2 The procedure to decide whether two region R_i and R_j are merged or not.

procedure LINKADJREGION(G)
  for all Node $n \subseteq nodes(G)$ **do** → Merge adjacent nodes
    for all Node $m \subseteq n$.isLinked() **do**
      if n.isIntersectByConvex(m) **then**
        LinkNodes(m,n)
      end if
    end for
  end for
end procedure

Now then, we decide whether two adjacency regions are merged or not. In order to solve this problem, we define merge function as Equation 1. Let $H()$, $S()$, $V()$ be hue,

saturation, value channel in HSV color model and h,s,v are the constants to normalize each channels, respectively. The constants w_h, w_s and w_v are the weights of color channels which are defined by user. Since hue is measured by the angle, we use the gap of angles between two regions. Figure 6 shows that our region extension method makes the segmented regions more clustered by considering their topological adjacency.

$$M(R_i, R_a) = e(w_h \frac{Theta(H(R_i), H(R_a))}{h} + w_s \frac{\|S(R_i) - S(R_j)\|}{s} + w_v \frac{\|V(R_i - R_j)\|}{v}), \quad (0 \leq k \leq 1.0)$$
$$R_a = adj(R_i) \tag{1}$$

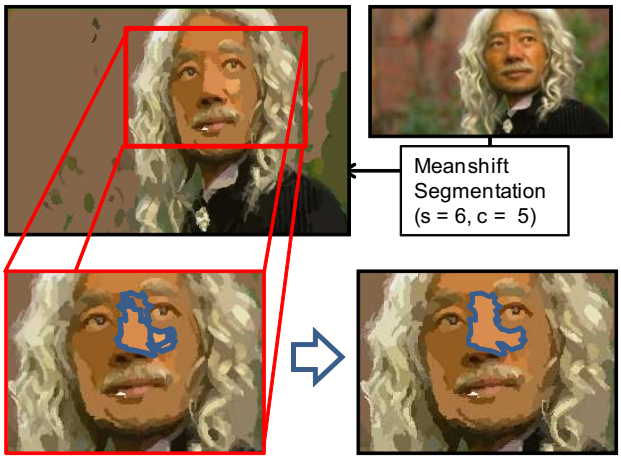


Figure 6. The process of proposed region extension(w_h = 0.5, w_s =0.1, w_v = 0.4)

3.2. Proposed Binarization Method

Binarization procedure is to decide whether each pixel $p(x, y)$ is on(white) or off(black). Therefore, it is very crucial work to determine threshold value, $T(p)$, for binarization. Assuming that the constant threshold value is considered as $T(p)$, there are lots of problem in case the pixel values of each region on the image are too high or low. To overcome this problem, we define $T(p)$ as threshold value for binarization using by the local representative value, $L(p, m, d)$, and the pixel effect on image in HSV color model, $H(p)$ like as Equation 2 where m is the mask size and d is given by user to control darkness of the binarized image. The local representative value $L(p, m, d)$ is to discriminate the particular pixels among the part of region which has similar color. $L(p, m, d)$ is computed by Equation 3 where $N(p)$ is the neighboring pixels of p and G_i is the i-th gray image. User can control the mood of binarized image by considering darkness d and mask size m. The darkness d is higher, the whole image is darker. The mask size m is bigger, the stippling effect on the image is more disappeared. Algorithm 3 explains the binarization procedure we proposed.

In typical black/white comics, there are many styles to draw comics according to the artists. Therefore binarization method should considere the artist style. For this, we prepared hue mapping table, $HSVTable(S_i, p)$ like Table 1, to consider hue value on the i-th segmented image S_i in Equation 4. Therefore the threshold is completely dependent on the neighboring pixels and hue value of the pixel. Figure 8 shows the result of cartooning obtained by our procedure.

$$T(p) = L(p, m, d) \cdot H(p) \tag{2}$$

$$L(p, m, d) = \frac{d}{m} \sum_{q \in N(p)} G_i(q) \tag{3}$$

$$H(p) = HSVTable(S_i, x, y) \tag{4}$$

In order to show stroke features of the black/white comics, we need to extract some edges from the bilateral filtered image by using Canny edge detection[1]. User can also control the amount of extracted edges by using double threshold parameters of Canny's method.

Algorithm 3 The binarization algorithm for black/white comics

procedure BINARIZATION(S_i, m, d)
→ S_i is the segmented image.
→ m is the size of mask.
→ d is the darkness of result image.
  while each pixel $p \subseteq S_i$ **do**
    v = ExtractValueImage(S_i,p)
    M =AdjPixel(p,m)
    $L(p, m, d)$ = LocalRepresentativeValue(p,M,d)
→ Consider pixels in the mask M
    h = HSVTable(S_i,p)
    $T(p) = h * l * d$
    if $v \leq T(p)$ **then**
      p is off [black]
    else
      p is on [white]
    end if
  end while
end procedure

Table 1. The weight table for HSV color models using by our procedure

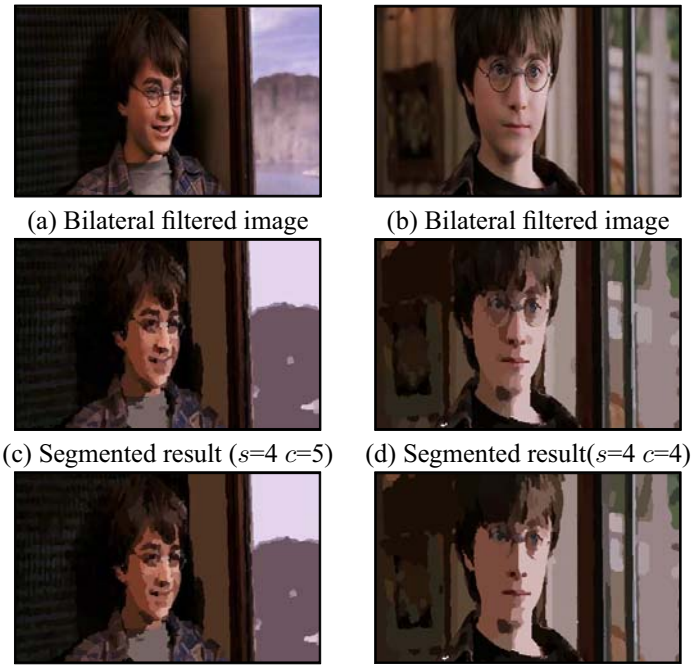
The weight value according to hue		
Hue	Color	Weight
(345 $\sim$ 360][0 $\sim$15]	Red	0.4
(15 $\sim$ 45]	Red	0.2
(45 $\sim$ 75]	Yellow	0.1
(75 $\sim$ 105]	Yellow	0.2
(105 $\sim$ 135]	Green	0.5
(135 $\sim$ 165]	Green	0.6
(165 $\sim$ 195]	Light Blue	0.4
(195 $\sim$ 215]	Blue	0.3
(215 $\sim$ 245]	Blue	0.3
(245 $\sim$ 275]	Magenta	0.35
(275 $\sim$ 305]	Magenta	0.4
(305 $\sim$ 345]	Red	0.5
The threshold value according to saturation		
Saturation	Color	Weight
[0.0 $\sim$ 0.2]	White	On (1.0,white)
The threshold value according to value		
Value	Color	Weight
[0.0 $\sim$ 0.1]	Black	Off (0.0,black)
[0.9 $\sim$ 1.0]	White	On (1.0,white)

3.3. Result of Binarization

Figure 7 and Figure 8 show the region extension and the binarization results obtained from the test images in Figure 7 (a) and (b). Our proposed procedure was so successful to render comic cuts from a well-known cinema in a resonable time and manual intervention. The simple binarization method not considered by color model can not make the black/white comic cuts from the video frame image with complicate color information. In the case of Figure 8, we can not render the face's skin as uniform color but also take account into pixel's darkness on original image. This is an improved effect by our region extension since their adjacent regions on the original image were more merged by their geometric information.

4. Conclusions and Future work

Recently comics has been more popular media since they have emotional expressiveness which can be hard to describe by other media such as textual novel, cinema and



(a) Bilateral filtered image (b) Bilateral filtered image

(c) Segmented result (s=4 c=5) (d) Segmented result(s=4 c=4)

(e) Region extended(e = 0.1) (f) Region extended (e = 0.3)

Figure 7. The result of region extension.

paper. But drawing comics is very burdensome work for the general people. In order to take account into this view, we propose a simple and straightforward binarization procedure which can generate black/white comics from video frame images in this paper. The most important part of binarization is how cluster their color information, since it is very difficult for computer to make simplified comic cut like Figure 1 (a) automatically. The main contribution of this paper is as follows:

1. We employ the region extention based on the mean shift segmentation to consider topology information of each region

2. Our procedure can reflect the style of artists by editing the HSV Table.

But there are lots of improvements for quality of comic cuts. First, we should improve geometric errors for segmented regions, since we use CRGN data structure provided by GDIPlus to compute vectorized regions. Second, the quality of our stroke on the binarized comic cut is very poor, because we just added edges extracted by canny method. We need to implement vectorization and stylization method considered black/white comic cut. Therefore we propose our future work as follows:

1. We need the stylized method to prune strokes.

2. We needs to implement the weight tables for HSV color model as presets according to artist's style through more experiment.

References

[1] J. Canny. A computational approach to edge detection. *IEEE Trans. Pattern Anal. Mach. Intell.*, 8(6):679–698, 1986.

[2] B.-K. Chun, D.-S. Ryu, W.-I. Hwang, and H.-G. Cho. An automated procedure for word balloon placement in cinema comics. In *ISVC06*, pages 576–585, 2006.

[3] D. Comaniciu and P. Meer. Mean shift: A robust approach toward feature space analysis. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 24(5):603–619, 2002.

[4] B. Gooch, E. Reinhard, and A. Gooch. Human facial illustrations: Creation and psychophysical evaluation. *ACM Trans. Graph.*, 23(1):27–44, 2004.

[5] M. Haller, C. Hanl, and J. Diephuis. Non-photorealistic rendering techniques for motion in computer games. *Comput. Entertain.*, 2(4):11–11, 2004.

[6] W.-I. Hwang, P.-J. Lee, B.-K. Chun, D.-S. Ryu, and H.-G. Cho. Cinema comics: Cartoon generation from video stream. In *GRAPP*, pages 299–304, 2006.

[7] H. Kang, S. Lee, and C. K. Chui. Coherent line drawing. In *NPAR '07: Proceedings of the 5th international symposium on Non-photorealistic animation and rendering*, pages 43–50, New York, NY, USA, 2007. ACM.

[8] J.-W. Lee. A stylized font rendering mothod for black/white comics generation. *Pusan National University Master Thesis*, 2008.

[9] S. McCloud. *Understanding Comics: The Invisible Art*. Kitchen Sink Press, 1999.

[10] A. Mitsuru. *H2*. SHOGAKUKAN, 2000.

[11] J. Preu and J. Loviscach. From movie to comic, informed by the screenplay. In *SIGGRAPH '07: ACM SIGGRAPH 2007 posters*, page 99, New York, NY, USA, 2007. ACM.

[12] A. Shamir, M. Rubinstein, and T. Levinboim. Generating comics from 3d interactive computer graphics. *IEEE Computer Graphics and Applications*, 26(3):53–61, 2006.

[13] D. Sýkora, J. Buriánek, and J. Žára. Unsupervised colorization of black-and-white cartoons. In *NPAR '04: Proceedings of the 3rd international symposium on Non-photorealistic animation and rendering*, pages 121–127, New York, NY, USA, 2004. ACM.

[14] C. Tomasi and R. Manduchi. Bilateral filtering for gray and color images. In *ICCV*, pages 839–846, 1998.

[15] J. Wang, Y. Xu, H.-Y. Shum, and M. F. Cohen. Video tooning. In *SIGGRAPH '04: ACM SIGGRAPH 2004 Papers*, pages 574–583, New York, NY, USA, 2004. ACM.

[16] H. Winnemöller and S. Bangay. Rendering optimisations for stylised sketching. In *AFRIGRAPH '03: Proceedings of the 2nd international conference on Computer graphics, virtual Reality, visualisation and interaction in Africa*, pages 117–122, New York, NY, USA, 2003. ACM.

(a) The pale comic cut with word balloon(d= 0.4, m = 10)

(b) The dark comic cut with word balloon(d= 0.7 m = 10)

(c) The pale comic cut with background effect(d = 0.4 m = 8)

(d) The dark comic cut with background effect(d = 0.6 m = 15)

Figure 8. Binarization results by our proposed procedure. Input images are Figure 7.