

## Border Image Generation Based on Residual Map Vote

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**Abstracts.** In this paper, a new algorithm is proposed to automatically generate border image for paint color game. First of all, region grow algorithm is applied. And then morphological closing operation is used to smooth every separated region. All regions are then labeled and the un-labeled regions form residual map. We then use vote strategy to decide the label of residual pixels. The final border image will be generated until no residual pixel exists. The experiments show that the proposed algorithm is robust and effective to produce border image for paint color game.

**Keywords:** Image segmentation, Paint by number, paint color game

### 1. Background

Paint color is a kind game which is popular for killing time. Users are required to color image which contains only region borders. Generally, these games take time and are considered good for pressure release. The paper proposed a residual map based algorithm to generate such region borders image for paint color games.

In general, region border image can be treated as segmentation result, which involves image segmentation algorithms. Currently, there are literally tremendous research articles of image segmentations. All existing researches can be separated two categories: the traditional segmentation algorithms and CNN (Convolutional Neural Networks) based algorithms. Traditional algorithms always focus on low-level features. Reputable algorithms include ostu<sup>[1]</sup>, watershed<sup>[2]</sup>, meanshift<sup>[3]</sup>, jseg<sup>[4]</sup> and grabcut<sup>[5]</sup> et al. CNN based algorithms are emerging algorithms, which focus on object detection and classification, like FCN<sup>[6]</sup>, Mask R-CNN<sup>[7]</sup>. CNN based algorithms have showed great performance on object recognition and segmentation.

However, CNN based algorithms can only recognize limited objects and, more important, cannot produce inner segmentation of object. For paint color games, both between-object borders and inner-object borders are required. In addition, it shows only watershed algorithm can produce relatively acceptable border image after trying reputable traditional algorithms. But it's still not enough for paint color game. Therefore, this paper proposed an algorithm based on residual map vote. Experiments show the proposed algorithm can efficiently extract between-object and inner-object borders from image. The generated border image can be used for paint color games.

### 2. Algorithm Framework

In this section, we firstly introduce the algorithm flowchart in fig. 1.

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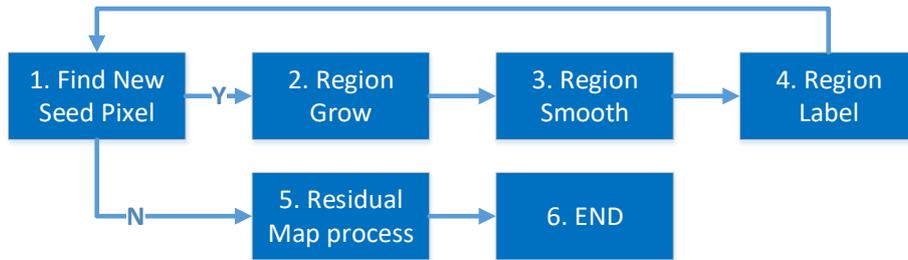


Fig 1: The main flowchart of proposed algorithm.

To ensure every regions in image is closed, the proposed algorithm starts with region grow based on seed pixel.

- 1) Select any unvisited pixel as seed pixel to grow and use a stack to store neighbor pixels with close color.
- 2) Execute region grow algorithm according to stack push and popup operation.
- 3) Region grow algorithm can lead to rough border since image edge regions are usually uneven. Special algorithm is required to keep region border smooth.
- 4) Region labeling operation is then followed and meanwhile, region related information like average color, pixels location will be gathered.
- 5) The first stage of algorithm is come to end when every pixel has been visited by repeating above operations from 1) to 4).
- 6) All pixels with no label compose of residual map. We call pixel in this map as residual pixel. In this step, vote strategy is applied to assign label to every residual pixel.
- 7) The final border image is generated after every residual pixel is assigned a label.

### 3. Algorithm Details

#### 3.1. Region Grow

8 connected neighborhood is considered when region grow algorithm is applied. Seed pixel is denoted as  $S$  and neighborhood pixel is  $N_i$  ( $i=R, G, B$ ). Euclid distance in color space, showed in Eq.1, is used to determine whether the neighborhood pixel belongs to same region with seed pixel. Here  $T$  is a distance threshold. Our experiments suggest that RGB color space shows better result than HSV and Lab color space. Fig. 2 shows some results of region grow.

$$\left| \sum_{i=R,G,B} S_i - N_i \right| \leq T \quad (1)$$

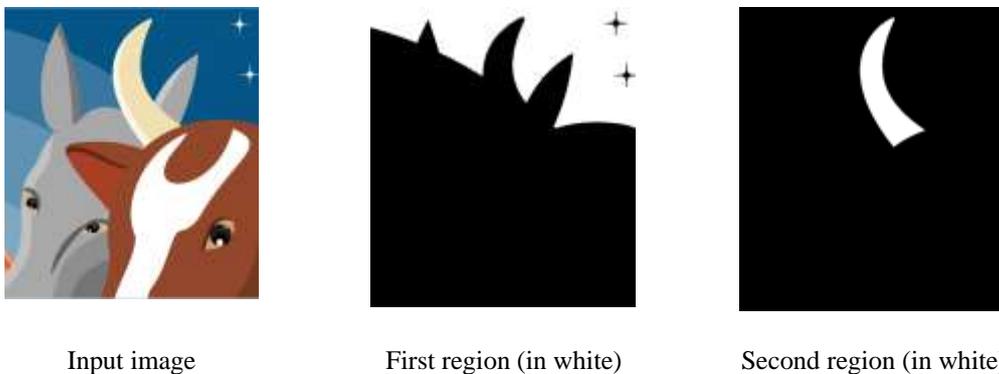


Fig. 2: Results of region grow.

#### 3.2. Region Smooth

Edge regions of image generally appear blur according to image compression and low resolution, as shown in Fig.3. Therefore, the pixels in edge region are uneven, which leads to bumps and holes of every regions after grow. The middle and right images of figure 2 show the problems.

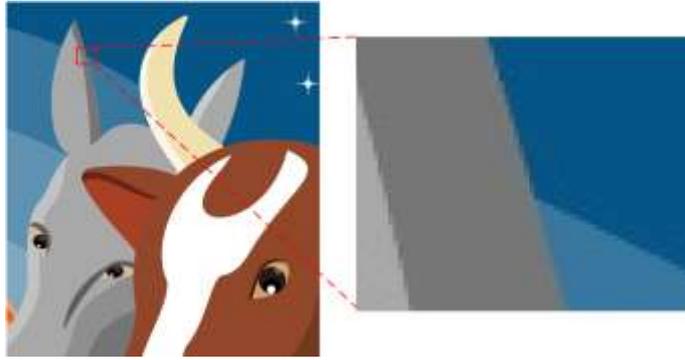


Fig. 3: The blur edge regions in image.

To make the region border smoother, morphological algorithm is applied. Specifically, closing operation is chosen to eliminate bumps and fill holes in region border. Fig.4 shows resultant region border image after smooth operation.

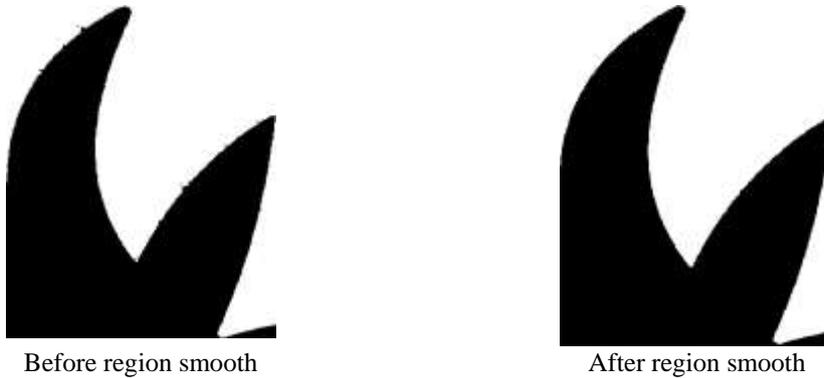


Fig. 4: Region smooth operation.

### 3.3. Residual map

Repeating operations described in 3.1 and 3.2 until all pixels have been visited, then all regions in image will be produced. For every independent region, it is then numbered and saved basic information like average color, pixels location. All the pixels which are not labeled form residual map. As shown in Fig. 5, residual map includes pixels around edges between regions, in which pixels are relatively blur.

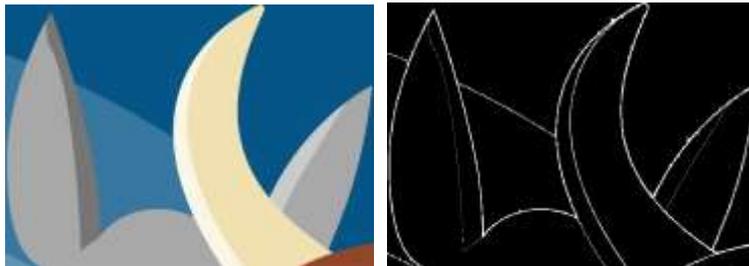


Fig. 5: Residual map. (Left)Original image, (Right) Residual pixels (in white).

### 3.4. Residual pixels vote

Vote strategy is taken into account to determine which region every pixel in residual map belongs to. To keep region's continuity, only neighbor space will be considered when vote operation takes place. 3X3 neighbor is initially good choice as fig.6 shown. Current pixel ('?' in fig. 6) will be assigned same label if there is only one label in neighbor region. However, vote operation will be involved when there are multiple labels in neighbor region as fig.6 (right) shown. We denote current residual pixel as  $P$ , neighbor region as  $R_j$  ( $0 < j \leq n$ ,  $n$  is the number of neighbor pixels) and distance between  $P$  and  $R_j$  as  $Dist$ , then the label of  $P$  is decided by following Eq.(2). Enlarges the neighbor window to 5X5 or bigger and repeats vote operation if there is still residual pixel after first round.

$$P \in j | Dist(P, R)_{min} = |P - R_j|_{j=0}^n \quad (2)$$

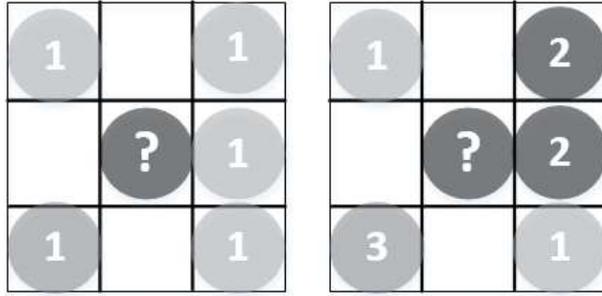


Fig. 6: Residual pixel vote strategy demonstration.

#### 4. Experiments

The color distance threshold  $T$  is 5 for simple images (first two rows in Fig.7) and 20 for complex images (third rows in Fig. 7) in our experiments. Fig. 7 shows comparisons between watershed algorithm and proposed algorithm. Obviously, more accurate and smooth border can be extracted based on proposed algorithm. Some local borders have been eliminated or merged. However, small region with sharp edges may be shrieked due to erosion operation in proposed algorithm, like first example in Fig.7. We will work for keeping small regions border in the near future.





Input image



Results of watershed algorithm



Results of our algorithm

Fig. 7: Experiment results.

## 5. Conclusions

In this paper, a new algorithm is proposed to generate region border image for paint color game. The algorithm starts from region grow. Then region smoothing and region labeling operation are followed. Finally, all un-labeled pixels are assigned label by applying distance vote strategy in neighbor space. Compared to existing algorithms, the new algorithm can produce both between-object borders and inner-object border. Experiments show the effectiveness and robustness of proposed algorithm.

## 6. Acknowledgements

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## 7. References

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