K-Means and Normalized Cut Clustering on Lipstick Decision

Tran-Yuan Chen and Yi Chou
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Abstract – The choice of lipstick color is one of the hardest decisions when doing online shopping. The purpose of this project is to allow online shopping customers visualizing the effect of different lipstick colors on their own face images. We perform k-means clustering in L*a*b* color space, and normalized cut clustering in HSV space, to cluster out the lips region for further color transformation. We demonstrate our proposed work by a comprehensive experiment, and a discussion about limitations of the proposed work.

I. INTRODUCTION

Nowadays, more population do their shopping online instead of in store. Cosmetic is one of the most popular types among the online shopping categories. Since customers cannot apply the cosmetic for trial purpose, which what they would do in store, one of the biggest challenges is the choice of color for cosmetic such as lipsticks. In this paper, we propose k-means clustering and normalized cut algorithm to help customers make better lipsticks decision during online shopping. Through the process, customers are able to visualize that whether the desired color of lipsticks will look good on them without trying in store. The result of our proposed work will be more natural and be closer to the reality, when compared to other painting programs.

II. PROPOSED METHODOLOGIES

In this section, we will discuss the steps and methodologies of achieving the proposed task.

Images preprocessing
For efficiency, we reduced eighty percent of the original face image size. We will select only bottom one-third of the image in RGB color space, scaled from 0 to 255 for each axis of base color (that is, red, green, and blue).

Image Segmentation by K-means clustering based on colors
For the selected region, we calculate Euclidean distance on a*b* plane from \(^1\)L*a*b* color space for k-means clustering process. We will obtain the clusters of image segmentations with similar color grouped together. Algorithm 1 presents the above steps in details.
Algorithm 1 K-means clustering in L*a*b* color space

**Input:** Training Data X (image sequence: \(m \times n \times 3\) unit8), number of clusters k

**Output:** Figures of k clusters

**Steps:**
1. Read the resized image (in RGB color space)
2. Select desired region of the image (in this paper, bottom \(\frac{1}{3}\) of the image is selected)
3. Transfer the data from RGB color space to L*a*b* color space
4. Use a* and b* space which contains color information, to calculate Euclidean distance for clustering
5. Repeat step 4 three times to avoid local minima
6. For clusters 1 to k, return the images with only the index clustering

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Image Segmentation by Normalized Cut for separation of different objects

After doing image segmentation by k-means clustering, we select the image of cluster that contains the target area (here, the lips). But since the previous step calculates distance only based on color, we have to do normalized cut algorithm that also calculates weights based on color difference and pixel distance. In this algorithm, we set several thresholds such as number of neighbors (\(r\)), sigma for distance of pixels (\(\sigma_B\)), sigma for distance of pixel color in \(^2\)HSV color space (\(\sigma_I\)), smallest N-cut value to keep partitioning (ncv), and smallest size of area to be accepted as a segment (area). We will obtain numbers of image segmentations with different objects separated. Algorithm 2 presents the above steps in details.

Algorithm 2 Normalized Cut in HSV color space

**Input:** Training Data X (the image sequence of the selected cluster from step 2), \(r\), \(\sigma_B\), \(\sigma_I\), ncv, area

**Output:** Figures of clusters (number of clusters are determined based on N-cut value and area)

**Steps:**
1. Construct the weight,

\[
W_{ij} = e^{-\frac{\|C(i) - C(j)\|^2}{\sigma_I^2}} \times e^{-\frac{\|B(i) - B(j)\|^2}{\sigma_B^2}} \times \begin{cases} 1 & \text{if } \|B(i) - B(j)\|_2 < r \\ 0 & \text{otherwise} \end{cases}
\]

\(C(i) = [v_i, u_i \cdot s_i \cdot \sin(h_i), v_i \cdot s_i \cdot \cos(h_i)]\) (for \(i\)th point), where h,s, and v are defined in the HSV color space section.

\(C(j)\) has same definition as \(C(i)\) for \(j\)th point.

\(B(i)\) and \(B(j)\) are the physical location of pixels.

2. Solve the equation for eigenvalue decomposition,

\[(D - W)y = \lambda Dy\]

where \(D\) is degree matrix, \(W\) is the weight matrix calculated in step 1, \(\lambda\) is the eigenvalue, and \(y\) is the eigenvector with second smallest eigenvalue.

3. Use the eigenvector obtained in step 2 to bipartition (that is, two partitions) the graph.

4. Repeat the bipartition in step 3 recursively. Stop if N-cut value is larger than the \(ncv\) we set. Or stop if the total number of nodes is in the partition is smaller than the \(area\) we set.
Transform the color of lips on RGB color space
We select the image segments of the target (here, the lips) obtained from Algorithm 2, then transform the data points of each pixel to the desired color in the RGB color space.

Return image with desired color of lips
We put the lips with transformed color with all other parts of image back together, then we obtain the image with the desired color of lips.

III. EXPERIMENT

Images preprocessing (part of Algorithm 1)

Image Segmentation by K-means clustering based on colors (Algorithm 1)

For the optimal results we experiment, for Figure 2a we set number of cluster k = 4; for Figure 2b we set number of cluster k = 6.
For people with lighter color (less obvious) lips, more clusters are required in this algorithm.
Image Segmentation by Normalized Cut for separation of different objects (Algorithm 2)

For the optimal results generated, Figure 3a is clustered in 5 segments and Figure 3b is clustered in 3 segments by the N-cut algorithm.

Transform the color of lips on RGB color space

We select desired segments (all the lips part) from the previous result, and transform the color. For both Figure 4a and 4b, we transform +80 for red, green, and blue, respectively.
Return image with desired color of lips

![Figure 5: Results of images with transformed lips color](image)

**IV. CONCLUSION**

Figure 5 indicates a decent result of our proposed work. Generally, 20% to 30% of the original image size are able to provide good clustering. For k-means clustering, the more similar color of target and nearby region will require more clusters in order to obtain better grouping. In normalized cut algorithm, we have to try several different values for both sigmas, based on speculation of size of lips area and the color of lips. For transforming the lips color, in order to avoid the effect of the mis-clustered region, we take the difference between the mode of the original lips color and the desired color. Then we add the difference back to every pixel of the original lips. The texture of the lips is well kept after transforming the color.

**V. LIMITATIONS AND DIFFICULTIES**

Although k-means clustering based on color does pretty good job on clustering parts with similar colors, the border of lips cannot be perfectly clustered due to the area has very similar color. Moreover, some mis-clustering occurred due to minor color difference on lips such as mouth peeling.

We take extra step of k-means clustering before normalized cut clustering, because the result of N-cut is not performing well as expected.
VI. FUTURE WORK
In our future work, we may search for better computations or formulas for tuning the parameters in N-cut algorithm, in order to obtain better clustering result. And, for better detection of target region, besides doing clustering based on color, we may use alternative clustering algorithms for the detection of texture, or the shape of the target region.

Note on Color Space

[1] \( L^*a^*b^* \) color space: A type of color space that present colors by \( L^* \) (Luminosity, range: \(-L^*\) is black and \(+L^*\) is white), \( a^* \) and \( b^* \) (Chromatic coordinates: \(+a^*\) is red direction; \(-a^*\) is green direction; \(+b^*\) is yellow direction; and \(-b^*\) is blue direction). Demonstrated as figure in the right.
[2] HSV color space: A type of cylindrical-coordinate color space. HSV stands for hue, saturation, and value. Demonstrated as figure in the right.

REFERENCE


