



Color Image Segmentation using IMOWT with 2D Histogram Grouping

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Abstract— *In this paper, a novel algorithm based on 2D histogram Grouping for color Image Segmentation is proposed. The proposed method uses intermediate features of maximum overlap wavelet transform (IMOWT) as a pre-processing step. The coefficients derived from IMOWT are subjected to 2D histogram Grouping. This method is simple, fast and unsupervised. 2D histograms are used to obtain Grouping of color image. This Grouping output gives three segmentation maps which are fused together to get the final segmented output. This method produces good segmentation results when compared to the direct application of 2D Histogram Grouping. IMOWT is the efficient transform in which a set of wavelet features of the same size of various levels of resolutions and different local window sizes for different levels are used. IMOWT is efficient because of its time effectiveness, flexibility and translation invariance which are useful for good segmentation results.*

Keywords— *Color image segmentation; intermediate features of maximum overlap wavelet transform; 2D Histogram Grouping*

I. INTRODUCTION

Image Segmentation methods are divided into two types 1) Region based methods 2) Edge based methods. Region based methods segment the regions according to their anatomical or functional roles. Edge detection techniques segment the image based upon the discontinuities or variations in the pixel values. Three types of discontinuities i.e. Points, Lines and Edges are present in the images. However these methods suffer from the problem of failing to segmenting all the regions. Also there is a problem of usage of number of clusters. The proposed algorithm consists of three steps: IMOWT, 2D Histogram Grouping, Label Matching algorithm. An overview of the paper is as follows. In Section II, Grouping of an

image with 2D histogram Grouping is detailed and Label Matching algorithm is presented. In section III, the performance and the resultant images are illustrated. The conclusion is given in section IV.

II. MATERIALS AND METHODS

A. 2D Histogram Grouping

Here the band subsets are chosen as RG, RB, and GB pairs. 2D histogram is constructed by summing up all the intensities occurring in the plane. The main peaks of the histogram give the cluster centroids. Due to sparseness of the colors in the image, the histogram is noisy. An exponential filter is applied, to remove the noise and smoothen the histogram. The following figure shows the first stage of 2D Histogram Grouping Algorithm.

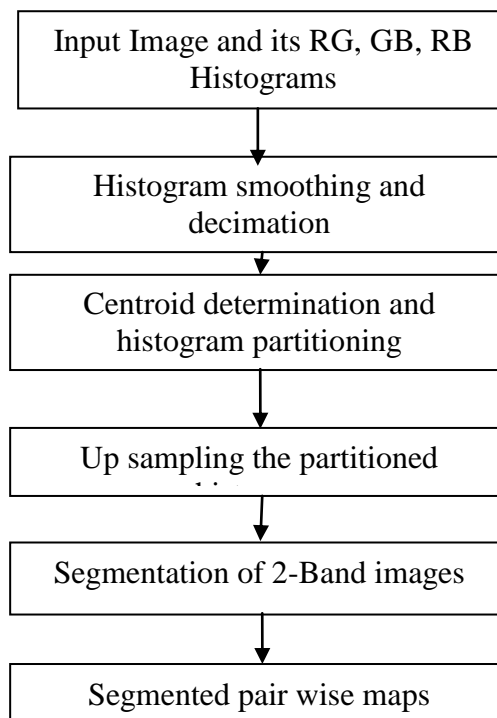


Fig.1. 2D histogram Grouping algorithm

As shown in Fig.1, First, the input image is taken and its RG,GB and RB histograms are found. Histogram Smoothing is done to remove noise. Color Cluster Centroids are determined and extracted and histogram partitioning is carried over to group the histogram. Next, Segmentation of 2 Band Images to yield segmented pair wise maps.

B. Label Matching Algorithm

Each image pair was segmented independently and labeled. Label Transformation is used to match the labels of segmentation map I to co-located segments in another map b on the basis of maximum mutual overlap is defined as follows.

$$T_{ab}(x) = y \quad (1)$$

Where 'x' denotes the source label in segmentation map 'a' and 'y' denotes the target label in segmentation map 'b' and T_{ab} is the label transformation. This equation shows that the region label x in map 'a' must be same as label y in map j on the basis of being co-located and

maximally overlapping. Thus six transformations are formed. $T_{RG,RB}$, $T_{RG,GB}$, $T_{RB,RG}$, $T_{RB,GB}$, $T_{GB,RG}$, $T_{GB,RB}$. Using these definitions of transformations, bilateral matching cases are checked to find out regions to be identically labeled. A match is defined as,

$$T_{ba}(T_{ab}(x))=x \quad (2)$$

This equation means that in map a and b, there are two segments that are each others maximally overlapping counterparts, so that the x-labeled segment in 'a' is mapped into y in b, while the y-segment in b mapped to x in a. Notice that in general if $T_{ab}(x)=y$, then $T_{ba}(y) \neq x$. The following matching scenarios can be encountered:

- RG-RB and RB-RB and RB-GB all match;
- (RG-RB and RG-GB match, RB-GB does match) or (RG-RB and RB-GB match, RG-GB does not match) or (RG-GB and RB-GB match, RG-RB does not match);
- (RG-RB matches only as change in only R band forms a region) or (R-GB matches only G-band forms a region) or (RB-GB matches only as change in B-band forms a region).

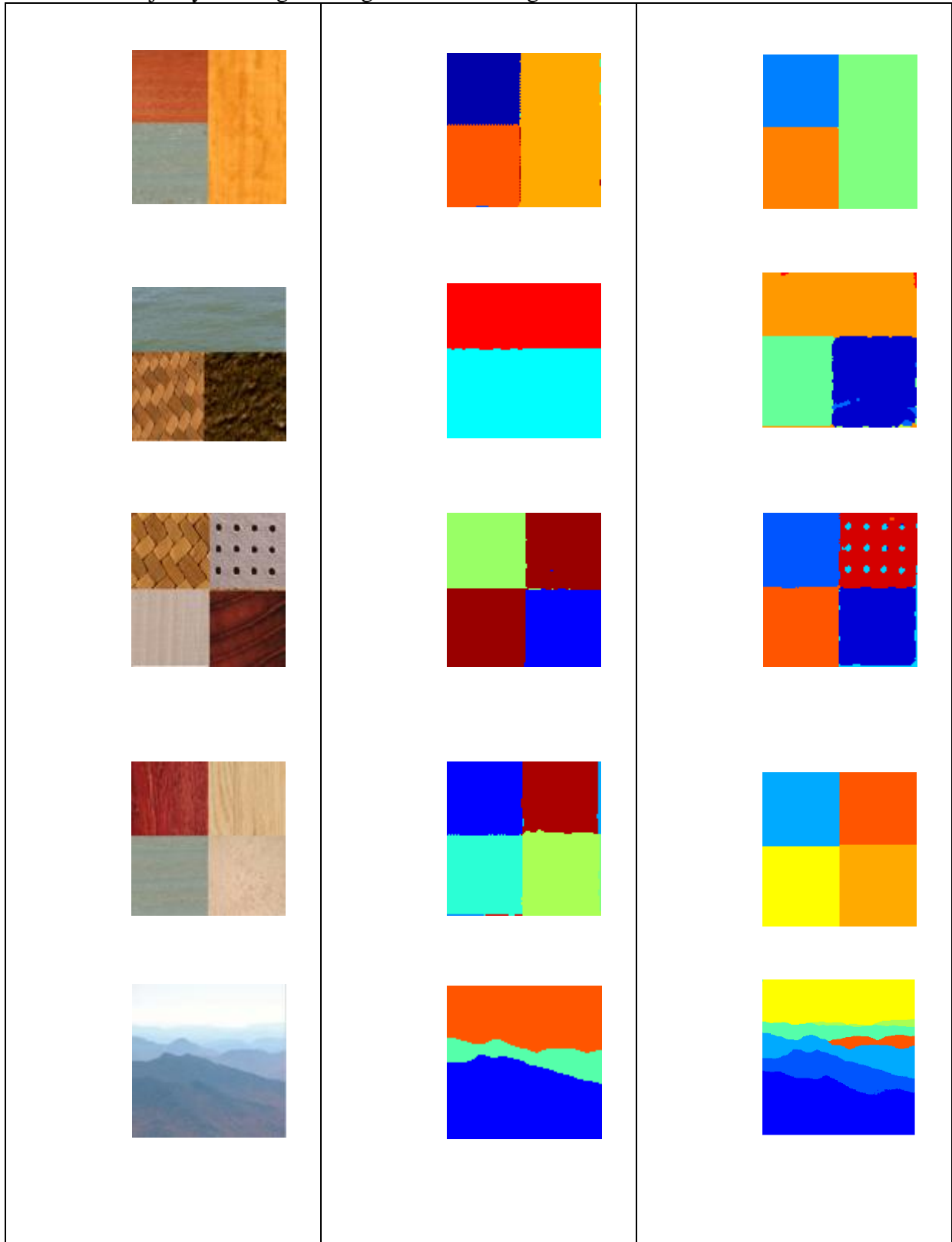
In the first scenario all the same segment exists in all the three maps. In the second scenario one of the three maps get fail. This case occurs due to partial deformation and noise. This match is, however, overruled since it is not physics-based and the labels are forced to be the same as matching ones in the other band-pairs. The third scenario arises when a strong variation in only one color band is responsible for the creation of a segment. In this case, the labels of only the matching maps are made to agree while the corresponding pixels of the conflicting band-pair are left without a label. Once the label concordance is achieved, the final segmentation is obtained by fusing the three band-pair maps. Towards this aim, majority filtering operation is applied on both spatial and chromatic dimensions. A 5X 5 neighborhood pixel in each band-pair is considered. The most frequently occurred pixel is declared as the label of the pixel.

III. RESULTS AND DISCUSSION

To assess the influence of the different representation of color (i.e color spaces) the obtained segmentation is compared with RGB, Lab, YCbCr, XYZ, Lch color spaces. Various color space results are displayed in Fig.2. From these results, it is very obvious that Lab color space gives better segmentation than the other color space. In Fig.2. Segmented result of Gallery image almost gives similar performance for Lab and YCbCr color spaces. As shown in Fig.3., Even though YCbCr gives somewhat similar performance as Lab color space, regions inside the water portion in that image is not clearly identified in YCbCr color space. Sky and cloud portions of the Gallery image is well discriminated in Lab color space. RGB, XYZ and Lch color spaces are failed to discriminate those regions in the image.

The proposed algorithm is applied to various natural color images and color spaces. The input color image is subjected to 2D histogram grouping to obtain the clustered image. Initially color image is splitted into three planes R, G, B and 2D histogram of RG, RB, GB planes are calculated. Then the histogram is smoothed by Gaussian filter with standard deviation 0.625 and down-sampled by a factor of 2. Smoothed 2D Histograms are then kept for reference. Morphological erosion is applied on the smoothed histogram which directly extracts the cluster centroids. Here, the dominant peaks in the 2D histogram are yielded whose centroids are labelled and watershed transform of the 2D histogram is performed which provides the clustered histogram. From the clustered histogram the segmentation map is obtained from simple mapping. Then the label Matching transformation is performed in

order to unify the segmentation maps. Unified segmentation maps are fused by using spatial-chromatic majority filtering which gives the final segmented result.



(a) (b) (c)
Fig.2. Comparison of Direct applications of 2D Histogram Grouping Algorithm and Proposed Method
(a) Input images (b) Direct applications of 2D Histogram Grouping Algorithm (c) Proposed Method output

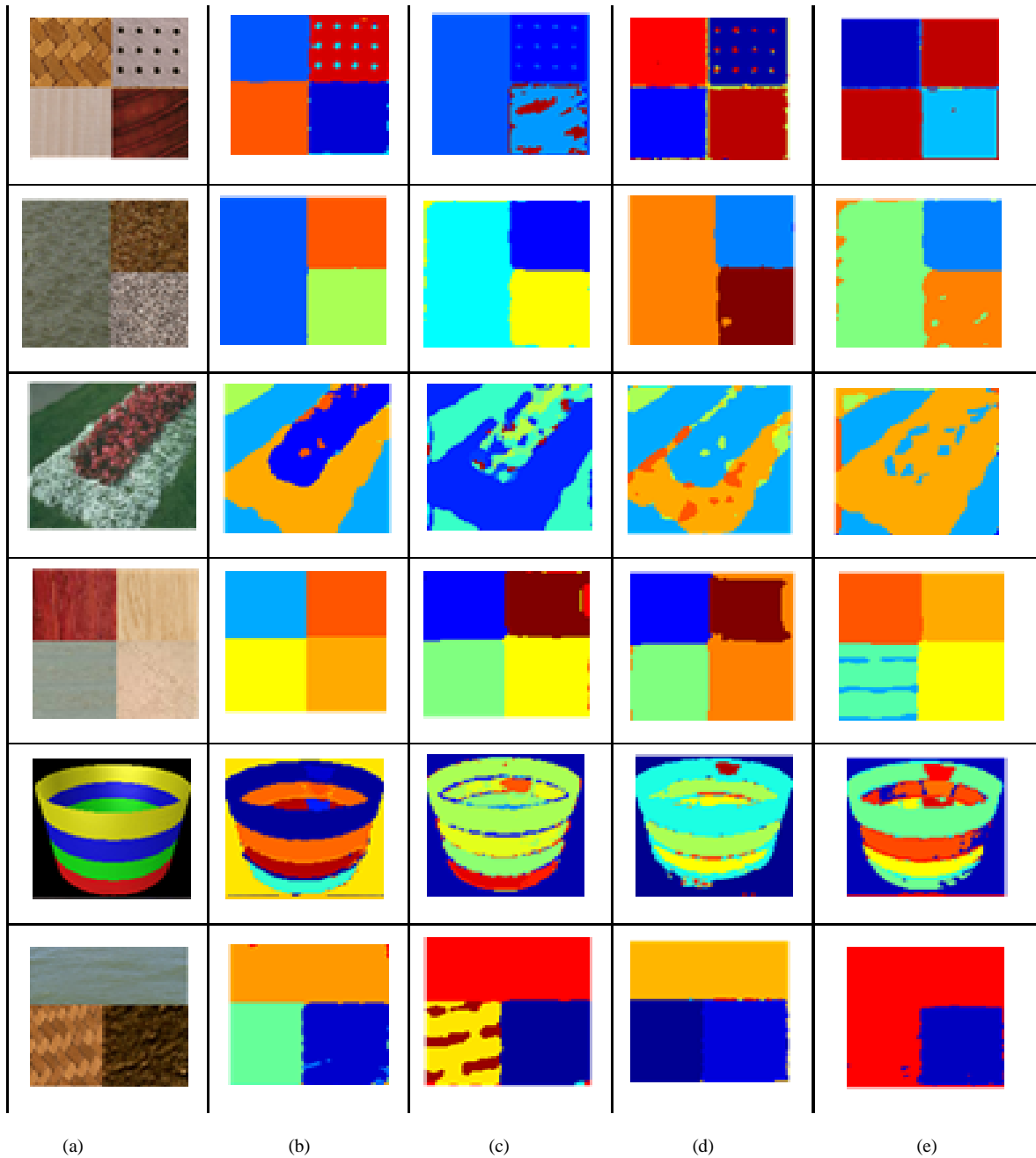


Fig.3. Segmentation results for various color spaces
 (a) Input Image (b) RGB (c) NTSC (d) YCbCr (e) HSV

Table I shows the comparison on Performance measures of the Proposed method (IMOWT with 2D Histogram Grouping) with the 2D Histogram Grouping method. The Performance of the proposed method has beaten the existing method in Color Error and Evaluation function for different images fed as input.

TABLE I
COMPARISON OF PERFORMANCE MEASURES OF PROPOSED METHOD AND 2D HISTOGRAM GROUPING

Input Image	IMOWT with 2D Histogram Grouping			2D Histogram Grouping		
	No of Regions	Color Error	Evaluation Function	No of Regions	Color Error	Evaluation Function
3Tile (with sand and wood)	3	0.5295	1.2426	2	0.7268	1.4813
4Tile (with smooth mica)	4	0.4576	1.2861	4	0.4751	2.2844
4Tile (with mica and wood)	4	0.6557	1.0702	3	0.7420	1.9240
Garden	4	0.2686	1.0864	4	0.8337	1.5766
3Tile (with water)	3	0.2459	0.5840	2	0.7799	0.6700
Cylinder	5	0.1139	1.1347	9	0.5099	2.9223
Finger	6	0.0833	1.0984	6	0.9608	1.1826
Gallery	5	0.0704	1.4558	6	0.8888	2.4154
2Tile	2	0.1811	0.7948	2	0.9999	0.8919
Cup	5	0.4500	1.7880	5	0.4798	3.3954

TABLE III
PERFORMANCE METRICS OF VARIOUS COLOR SPACES

Input Image	No of Regions				Color Error				Evaluation Function			
	RGB	NTSC	YCbCr	HSV	RGB	NTSC	YCbCr	HSV	RGB	NTSC	YCbCr	HSV
3Tile (with sand and wood)	3	2	4	4	0.52	.9999	.6944	0.7269	0.681	3.3979	1.2426	0.8402
4Tile (with smooth mica)	4	8	8	7	0.45	0.5392	0.7219	0.4726	1.1721	3.0737	1.2861	1.4237
4Tile (with mica and wood)	4	11	6	8	0.65	0.7727	.7643	0.7577	0.8798	4.1113	1.0702	1.3494
Garden	4	7	2	10	0.26	.9534	0.8576	0.5513	0.3594	2.2528	1.0864	2.7347
3Tile (with water)	3	6	2	4	0.24	0.9999	0.9974	0.9980	0.3242	5.4323	0.5840	0.7614

Cylinder	5	14	11	9	0.11	0.1938	0.4318	0.1194	1.1347	4.9714	1.3673	2.7098
Finger	6	8	4	10	0.08	0.6384	0.9613	0.9560	1.0984	3.1584	1.2259	3.9072
Gallery	5	2	3	3	0.07	0.9542	0.9878	0.8092	1.2124	2.3195	1.4558	1.9490
2Tile	2	2	5	2	0.18	0.9999	0.5042	1.0002	0.4129	1.9535	0.7948	0.6983
Cup	5	8	6	10	0.45	0.9726	0.9900	0.9078	0.6011	4.5050	1.7880	3.0056

Table II shows the performance metrics of the proposed method of various color Spaces like RGB, Lab, YCbCr, XYZ and Lch color spaces. Best performance is achieved in Proposed method compared to all existing methods.

IV. CONCLUSION

In this paper, a novel algorithm based on 2D histogram grouping for color Image Segmentation is proposed. The proposed method uses intermediate features of maximum overlap wavelet transform (IMOWT) as a pre-processing step. The coefficients derived from IMOWT are subjected to 2D histogram Grouping. This method is simple, fast and unsupervised. 2D histograms are used to obtain Grouping of color image. This Grouping output gives three segmentation maps which are fused together to get the final segmented output. This method produces good segmentation results when compared to the direct application of 2D Histogram Grouping. IMOWT is the efficient transform in which a set of wavelet features of the same size of various levels of resolutions and different local window sizes for different levels are used. IMOWT is efficient because of its time effectiveness, flexibility and translation invariance which is useful for good segmentation results.

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