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DEVELOPING A NEW FEATURES APPROACH FOR COLOR FOOD IMAGE SEGMENTATION

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ABSTRACT

Image segmentation technique was widely used in pattern recognition to estimate calories. However, the process of segmentation multi-food images is more difficult. In this paper, segmentation of color food images for segmenting food images is proposed. The segmentation technique segments food image into two regions: foreground and background. In addition, it can separate between food items in the plate. In this article, a new features based on *k*-means algorithm are developed for food image segmentation. The results show that the proposed segmentation technique based on A, B and neighbors features has been achieved successfully segmented food images with preserving significant features and removing the background.

Keywords: image segmentation, *k*-means, food image, color spaces, pattern recognition.

INTRODUCTION

Nowadays, food images are now growing in popularity in the latest nutritional control (Aizawa, Maruyama, Li, & de Silva, 2013). A user receives numerous assistances if there is an option to choose images of food during nutritional assessment; First of all, this gives better knowledge of the types of food taken previously as well as food to be taken at the time ahead. Moreover, unlike writing or tabular description of the meal, images of foods contain full information about the meals. Therefore, images can be considered as rich media of information. Furthermore, images are highly prospective candidates for the quick and easy recording of dietary information. The recognition of the items of food based on colour model is one of the most challenging tasks in image computer vision.

Image segmentation is the process of dividing the given image into regions homogenous with respect to certain features, and which hopefully correspond to real objects in the actual scene. In fact, image segmentation is used to provide easy and simple data for following phases of a typical pattern recognition system (Awad, 2010; Krishan & Singh, 2014). From a multi-media perspective, image segmentation can be applied to one image or to sequence of images representing a video (Zhang, Fritts, & Goldman, 2008). The importance of image segmentation cannot be ignored due to it is used nearly in all sciences' fields (Pham, Xu& Prince, 2000), satellite imaging, machine vision, computer vision, biometrics, military, image retrieval (Khan, 2014), extracting features and recognizing the objects (Matsuda, Hoashi, & Yanai, 2012). The segmentation of colour images which requiring more information about the scene has made it received less attention in developing the algorithms.

Image segmentation is an essential process for most subsequent image analysis tasks, which covers general segmentation problem, involves the partitioning of a given image into a number of homogeneous segments, such that the union of any two neighbouring segments yields a heterogeneous segment (Luccheseyz & Mitray, 2001; Vartak & Mankar, 2013). Generally, image segmentation is defined as the subdivides of digital image $f(x, y)$ into its continuous, disconnect and non-empty subset $f_1, f_2, f_3, \ldots f_n$, which provides convenience to the extraction of the attribute (Thakur & Madaan, 2014). Segmentation process has become more challenging because of similarity between neighbouring food items in many food plates and lacking agreed standardization of food shapes, colour, or placement. In Kumar, Verma and Singh (2006) stated that colour images are a very rich source of information because it provides a better description of a scene as compared with grayscale images. Bansal and Aggarwal (2011) have been used L A B colour space and Ant Colony-based clustering for colour images segmenting, the results show the feasibility and successful of the approach in segmentation. The color is a powerful feature that can be used for image segmentation. The authors concluded that colour images are more reliable and useful in image segmentation than grayscale images (Delon, Desolneux, Lisani, & Petro, 2005).

The colour space representation is defined as a computerized representation of colours, which allow for reproduction of the represented colour with the aid of both digital and analogue devices (Drimbarean & Whelan, 2001). There are many colour spaces using in computer vision. However, this study focuses only two components of L A B models with and without neighbour's features.

METHODOLOGY

Our aim at this research is developing features based *k*-means algorithmto make more appropriate for image segmentation. The most common problem in the food item segmentation is the typical way of arranging the food items in order to put them in a way that connected to each other. This can leads the *k*-means algorithm trap into local minima or wrong clustering results because of the pixel are classified under other clusters (pixel might be classified to a segment in a nearby object).In order to avoid this problem, it is important to represent each pixel with enough features.

In the first, the Region of Interest (ROI)is determined. Then, In order to segment regions, each region is dealt separately. Classical *k*-means is called on each region separately, and then a homogeneity test is applied. Each applyingof the *k*-means has to pass to the set of features. The selected features are depicted in Table-1.

Table-1. Features for segmentation.

Name of variable	Feature name
F1	A (L A B colour space)
F2	B (L A B colour space)
F3	X (position of pixel)
F4	Y (position of pixel)
F5	X-N1 (position of 1'st pixel neighbour)
F6	Y-N1 (position of 1'st pixel neighbour)
F7	X-N2 (position of 2'nd pixel neighbour)
F8	Y-N2 (position of 2'nd pixel neighbour)
F9	X-N3 (position of 3'rd pixel neighbour)
F10	Y-N3 (position of 3'rd pixel neighbour)
F11	X-N4 (position of 4'th pixel neighbour)
F12	Y-N4 (position of 4'th pixel neighbour)

The Table-1provided the features which chose in this study. A and B components from L A B colour space features, adding the position of pixels and pixel's 4 neighbours to region features were used because they are expected to be discriminative with respect to food items. Also, make the clustering more robust to outliers.

PERFORMANCE MEASURE

In this section, the following measures (Tan, Steinbach & Kumar, 2006;Tariq & Burney, 2014) are used to obtain an indication of the performance of the developed approach.

A. Accuracy is the proportion of the total number of predictions that were correct.

$$Accuracy(\%) = \left(\frac{TP + TN}{TP + TN + FP + FN}\right) * 100\% \quad (1)$$

B. Precision is a measure of how the classifier is capable of providing a true prediction of given sample of data.

$$Precision(\%) = \left(\frac{TP}{TP + FP}\right) * 100\% \quad (2)$$

C. Recallis a measure of how the classifier is true in detecting given a sample of data.

$$Recall(\%) = \left(\frac{TP}{TP + FN}\right) * 100\% \quad (3)$$

D. F-measure is a harmonic mean of precision and recall.

$$F - measure(\%) = 2\left(\frac{Recall * Precision}{Precision + Recall}\right) * 100\% (4)$$

Parameters:

TP (True Positive) indicates tocorrect pixel for food.
TN (True Negative) indicates to a number of correct predictions that a pixel does not belong to a particular type of food.
FN (False Negative) indicates to a number of incorrect predictions that a pixel does not belong to a type of food.
FP (False Positive) indicates to a number of incorrect predictions that a pixel belongs to the type of food.

E. Correlation: Correlation is the comparison of the segmented image with an actual image. The segmented image is superimposed on the actual image of an object to generate the correlation image to display match or disparity (Saini & Sethi, 2013).

$$F * I(x, y) = \sum_{j=-N}^{N} \sum_{i=-N}^{N} F(i.j)\, I(x - 1, y - 1) \quad (5)$$

Where F: original image and$I$: segmented image.

F. Mean Squared Error (MSE): it is used for measuring the average of the squares of the error or deviations(Bora & Gupta, 2015).

$$MSE = \sum_{i,j}^{N,M} (groundtruth(i, j) - segmented(i, j))^2 \quad (6)$$

Where: N, M are image dimensions and i, j denotes indexes.

G. Structural Similarity Index Measure (SSIM): is used to measure the similarity between two images, ground truth $i$and segmented$y$ of common size $N * N$ (Wang, Bovik, Sheikh, & Simoncelli, 2004).

$$SSIM(i, j) = \frac{\left(2\mu_i\mu_j + c_1\right)\left(2\sigma_{ij} + c_2\right)}{\left(\mu_i^2 + \mu_y^2 + c_1\right)\left(\mu_i^2 + \mu_y^2 + c_2\right)} \quad (7)$$

Whereμ_i the average of$i$; μ_i the average of j ;σ_{ij} covariance of$i$and$j$, $c_1 = (k_1\, \mathcal{L})^2$: $c_2 = (k_2\, \mathcal{L})^2$ are two variables to stabilize the division with weak denominator, $\mathcal{L}$: dynamic range of pixel values and$k_1 = 0.01$:$k_2 = 0.03$ default.

RESULTS AND DISCUSSIONS

In order to evaluate and validate the proposed approach, different type of food items with different food arrangements are used. 300 images captured by a smartphone with an 8-mega pixel camera are saved in Joint Photographic Experts Group (JPEG) format by default. No special arrangement for lighting is required more than the normal lighting in any indoor environment. The angle of acquiring the image is not restricted to a certain angle with respect to the food table in order to maintain capturing both vertical and horizontal information. This section compares the results of segmentation using two segmentation methods; A, B components from LAB with neighbour based *k*-means, and A, B components from LAB colour space without neighbours based *k*-means.

The comparison process is done based on visual and quantitative evaluations. The section is divided into two subsections according to the evaluation techniques. The first subsection focuses on visual interpretation where the performance is compared in term of the accuracy of segmented areas. The second subsection is allocated for quantitative evaluation where the results were compared based on recall, precision, F-measure, accuracy, similarities and difference between segmented images and ground truth. Ground truth is obtained manually using Photoshop 2015.

a) Performance of different segmentation methods based on visual evaluation

Segmentation results have been compared for two methods: A, B components from LAB colour space without neighbour's features based *k*-means and A, B components from LAB colour space with neighbour's features based *k*-means. The considered images have a different colour of the plate, colours of food items, and variation of illumination. Also, the tablecloth was different from one image to another. All of that adds to the testing more realistic aspect. Moreover, some images have combined items of small objects were segmented correctly like pasta in the image (6) and olives in the image (10). Moreover, another observed realistic aspect is the collection of colours in the image. Furthermore, some neighbouring items are similar to each other from colour perspectives such as the image (7).

The results are shown in Table-2. Apparently, the results with features of neighbours have outperformed method without neighbours. The powerful aspect of the neighbours based *k*-means is incorporating the region-based segmentation to remove the background with the plate and to maintain the only exterior boundary of the food items. As a result, this has led to more meaningful segmentation results for *k*-means with neighbours comparing with the much-degraded performance of other *k*-means approach.

Table-2. shows the results of the segmentation for two cases A and B based *k*-means without neighbour's features and *k*-means with neighbour's features. Clearly, *k*-means with neighbour's features has achieved better performance than *k*-means without neighbour's features as shown in the fifth column. In most images, it can be seen that the segmentation of the fifth column has yielded more clean results with avoidance of the false clustering in the areas inside the item, while in the fourth column the segmentation results suffer from outliers in the internal region of the item.

b) Performance of different segmentation methods based on quantitative evaluation

This section allocated for explaining the performance of A,B based *k*-means with and without neighbours was compared using quantitative evaluation based on recall, precision, accuracy, F-measure, correlation, SSIM and MSE values. For comprehensive evaluation purpose, quantitative results are discussed in two sections. The first section discusses the performance of A, B components from L A B colour space based *k*-means with and without neighbour's features for 10 images that mentioned in the visual section. The second section is allocated for discussing the performance of A, B components from L A B colour space based *k*-means with and without neighbour's features for all dataset.

A) Quantitative evaluation of A, Bcomponents based *k*-means with / without neighbour's features for 10 images

In order to show the impact of the neighbour's features, quantitative results have been generated for two approaches: A, B components with neighbour's features based *k*-means and A, B components without neighbour's features based *k*-means. Recall, precision, accuracy, F-measure, correlation, SSIM, and MSE have been generated. Refer to Figures 1, 2, 3, 4, 5, 6 and 7 respectively. In each Figure, X-axis indicates to the image number while the Y-axis refers to the measured value. In the Figures, ten data representing ten images are discussed in the visual evaluation section. It is clear that incorporating the neighbour's features is efficient in providing more segmentation quality. In all the mentioned measures, the neighbour's features have provided either superior or equivalent performance to the approach that does not include neighbour's features. Furthermore, for all images, the accuracy of the segmentation with neighbour's features is higher than the segmentation without incorporating these features. Looking at the results from the perspective of similarity reveals the same finding.

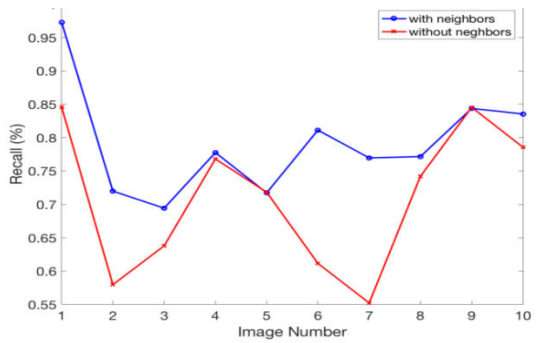


Figure-1. Result of recall measures for 10 images.

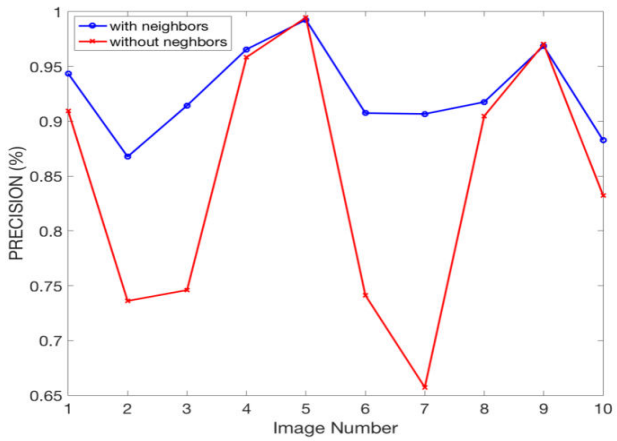
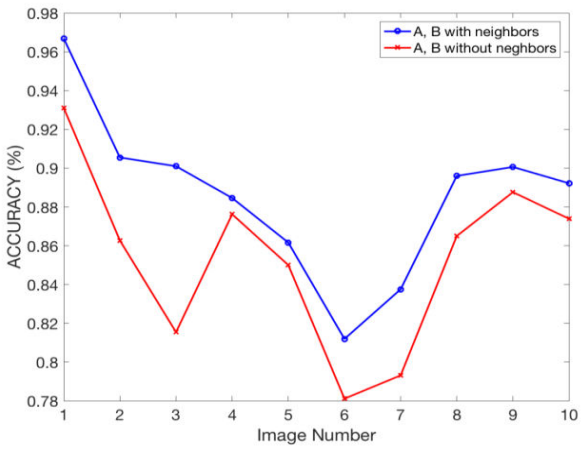


Figure-2. Result of precision measure for 10 images



Figur-3. Result of accuracy measure for 10 images.

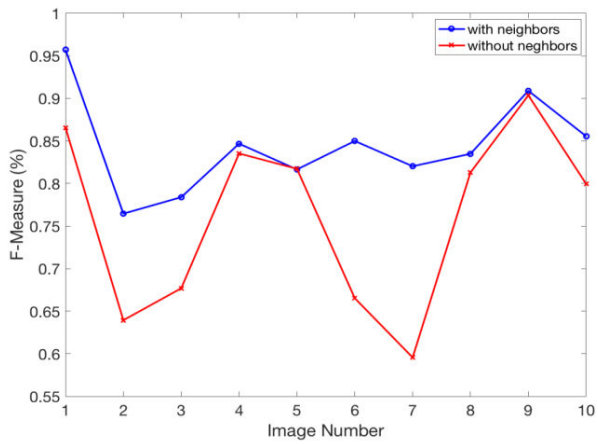


Figure-4. Result of F-measure for 10 images.

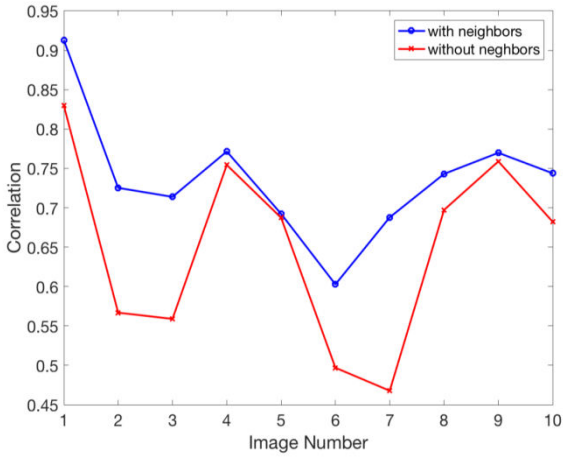


Figure-5. Result of correlation measure for 10 images.

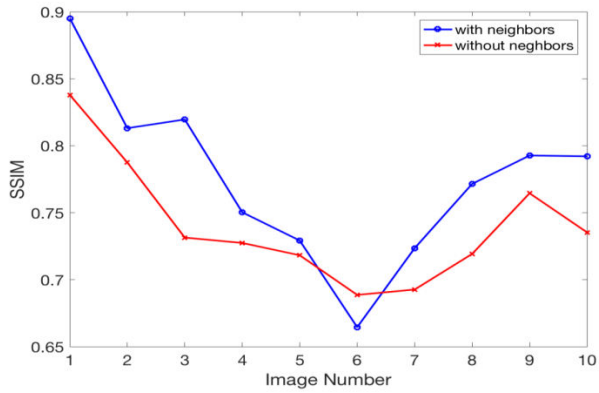


Figure-6. Result of SSIM for 10 images.

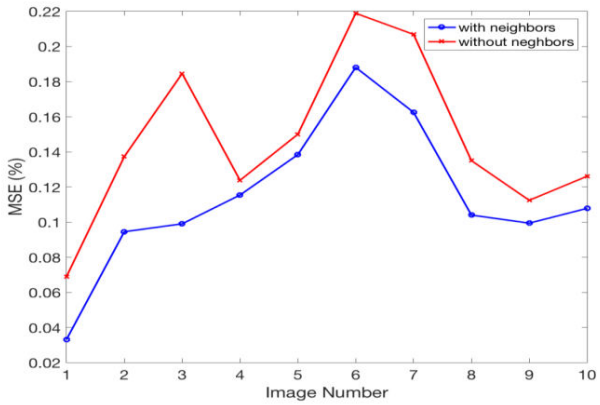


Figure-7. Result of MSE measure for 10 images.

B) Comparison between the methods for the whole dataset

A summary of the comparison results for the whole dataset has been generated as it is shown in Figures 8, 9 and 10. The results reveal the superiority of the incorporated neighbour's features approach which emphasizes on the fact that the developed features in our segmentation have assisted in providing good performance for connected food items images. Because from the

Figure-8 can see the values of accuracy for neighbours based *k*-means is higher than the other approach.

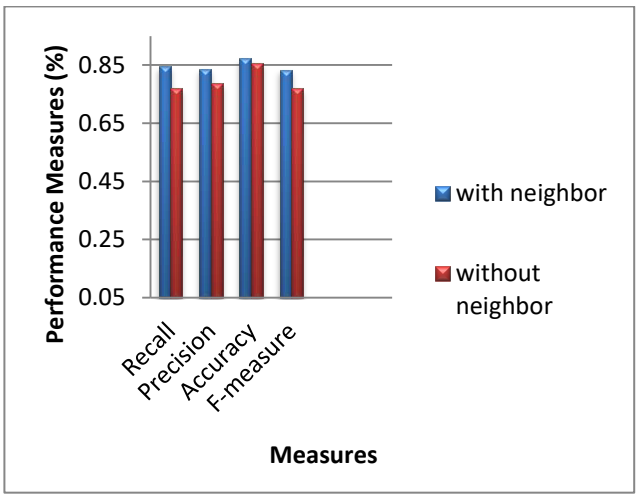


Figure-8. Result ofthe performance developed method for segmentation with and without neighbours.

Moreover, Figure-9 shows the performance of the segmentation approaches based on the degree of similarity using correlation and SSIM.The resultant value of correlation is valued between -1 and 1 where the value was nearest to 1; the degree of similarity was the higher and therefore it was found to produces better quality of segmented images. The values of SSIM ranging between 0 and 1where the nearer the value to 1, the better is the quality of segmented images, which is similar to what has been obtained in the results. From the Figure-10 can be seen the value of correlation for our approach is 0.6857 while the correlation value in other is 0.6468. Also, the value of SSIM for our approach is 0.7668 while the SSIM value in the other is 0.7423. These results indicate that our develop segmentation reveals the highest similarity of the segmented images.

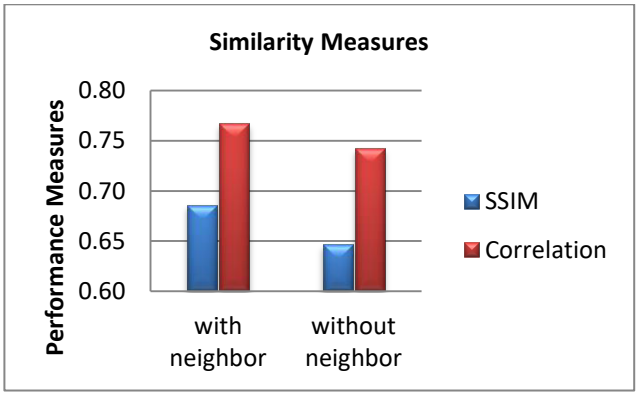


Figure-9. Performance of similarity measures forthe developed method for segmentation with and without neighbours.

But, the result of the degree of dissimilarity for the develop neighbours based *k*-means and without neighbours based *k*-means using MSE as shown in Figure-10.

The degree of dissimilarity is used tomeasure misclassification of pixels for segmented images. The misclassification can occur in two ways: under segmentation and over segmentation. Under segmentation refers to the rate of pixels in the ROI which are wrongly classified whileover-segmentation refers to the rate of pixels in the background which are wrongly classified as ROI. The value of MSE is non-negative, the lower values indicating less misclassification of pixels. The less misclassification o pixels, the better is the quality of the segmented images.

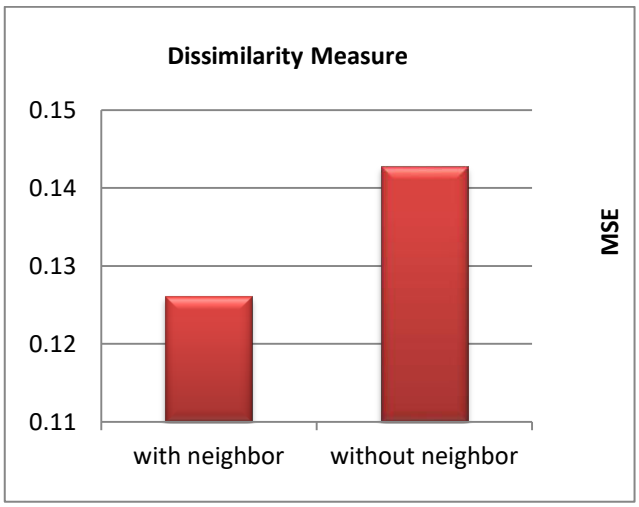


Figure-10. Dissimilarity measure.

From the results of the whole images in the dataset, it was observed that the value 0.12 for developing approach is lower than the value of another approach. The result indicates that the developed approach has successfully produced segmented images with a lower value of under- segmentation and over-segmentation.

5. CONCLUSIONS

This study has introduced the results of the segmentation approach for connected food items. The selection of the colour features for performing the segmentation is provided: A, B from LAB. Besides, newly developed features were incorporated under the name "neighbour's features". This approach has been evaluated and validated comparing to A, B without neighbours based *k*-means. The developed approach was evaluated based on both: qualitative and quantitative measures. The quantities measures are recall, precision, accuracy, F-measure, correlation, SSIM, and MSE. The developed approach has shown better in terms of both visual and quantitative perspectives.

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a multimedia food log. IEEE Transactions on Multimedia. 15(8): 2176-2185.

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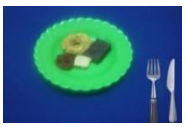
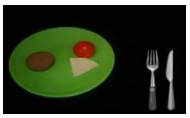
Table-2. Results of visual evaluation of different methods for segmentation food images.

No. of image	Raw image	Ground truth	A, B features based *k*-means	Developedneighbor's features based*k*-means
1				
2				

No. of image	Raw image	Ground truth	A, B features based *k*-means	Developedneighbor's features based*k*-means
3				
4				
5				
6				
7				
8				
9				
10