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Food image Classification using Sphere Shaped-Support Vector Machine

S. Jasmine Minija
Research Scholar, Dept. of Computer Science
Nesamony Memorial Christian College, affiliated to
Manonmaniam Sundaranar University,
Tirunelveli, India
minijakenson@gmail.com

W.R. Sam Emmanuel
Associate Professor, Dept. of Computer Science
Nesamony Memorial Christian College affiliated to
Manonmaniam Sundaranar University,
Tirunelveli, India
sam_emmanuel@nmcc.ac.in

***Abstract*— Nowadays peoples have shown their keen interest on reducing their weight by calculating the calorie values of their food intake. Calorie and Nutrition measurement are used to monitor the body fat. In this dietary management system the calorie values are calculated by means of segmentation, features extraction and classification. Then the calorie value is computed with the aid of food area volume and nutrition measure based on the mass value. By calculating the calorie value of every food item, the dietary assessment gives the efficient way for person's food intake. FCM algorithm is used here for segmentation and Sphere Shaped SVM classifier is used to classify the segmented food items. This method automatically identifies the food items and then calculates their calorie value. The proposed method shows 95% of accuracy value which attains better classification.**

***IndexTerms*— Segmentation, Feature extraction, Classification, Calorie Calculation.**

I. INTRODUCTION

Dietary management is the process of determining what someone eats as food for their health, which provides valuable close for mounting invention programs for the prevention of many chronic diseases [3],[4]. To avoid the health disorder problem, the food data is obtained accurately from each human being and the clinical research equipment is developed by researcher for effective treatment of patients. Nowadays, obesity and cancer are considered as major worry of chronic diseases [5]. Dietary management in the field that related to healthcare, it attain rapid growth in the field of research and development of innovative tools for supporting dietary based system [6]. The food intake of every human is measured in terms of calorie which caters the energy of food [7]. Recently, the dietary assessment becomes a challenging problem, which is majorly based on reported data of patients. In general, the dietary assessment consists of four steps: i) Segmentation, ii) Feature extraction, iii) Classification and iv) Calorie calculation [8]. But the food segmentation and classification are troublesome for the dietary assessment, since the food items in the input image can be varied in their size, shape and texture. Also the another problem is that the classification phase requires both the global and local features like texture, shape and Colour, which are also contain dissimilar properties [9]. The colour, texture and shape feature of the image plays the essential role for the feature extraction process. Thus, the food features are extracted by global and local feature extraction method. Average colour features and Gabor features are of images are used in [11] while in [12], the food items are described by a bag of SIFT features. Thus, the food features are retrieved by statistical feature of food images, then the texture feature is achieved through the LBP, LVP etc, and finally the shape features of the images also obtained [13]. Subsequently, the food recognition is the major phase in the dietary assessment system. Once the features are attained, the food items are classified by the proficient classifiers. Such classifiers are named as Support Vector Machine (SVM) [1], Extreme Learning Machine (ELM) [2], etc. Moreover, peoples are unconscious about evaluating or controlling their daily calorie of food intake due to their nutritional knowledge, irregular eating patterns of their meals or lack of self-control in front of foods [15]. There is much information that recapitulates the suitable daily amount of calories. However, it is difficult to do it practically. The users, who need of knowledge about nutrition, might be not capable to know the quantity of calories in each feast [14]. Thus, the foodstuff calorie of every food item is measured, which increase the performance of the dietary assessment system. Then, the volume evaluation and nutritional analysis are defined as the major requirement for the dietary assessment. Figure 1 shows, some of the foods that related to the nutrition value on Dietary chart. Due to above mentioned challenges, the proposed method classifies each food item with a relevance to dietary assessment.

In this paper the Fuzzy C-Means method is used to segment the image which is given as input. The significant feature of food items is taken out by the global and local feature extraction method. The global feature is based on the color and texture descriptor where the local features are extracted by its local neighborhood pixel. After that the classification phase is performed by the Sphere – Shaped SVM classifier, which is engaged to classify the food items of every segmented input image. The main objective is to design a system which automatically evaluates the food item based on the measurement of food intake and energy consumption. This paper mainly focused on better dietary assessment of food segmentation and classification.

This paper ordered as follows. Section 2 explains the related work for the dietary assessment. Section 3 describes the proposed system methods for automatic portion estimation and visual refinement. Section 4 presents experimental results. It concludes with the conversation of proposed system in Section 5.

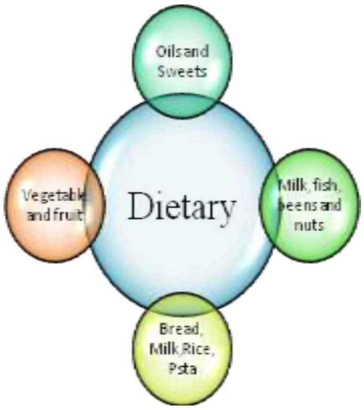

Fig.1. Various types of foods related to nutrients value

II. RELATED WORKS

Fengqing Zhu *et al.* [1], proposed a dietary assessment system which automatically identifies the food items from the input image. The food images are segmented using the multiple hypothesis method. Then the food features like global and local features of input images are extracted using the extraction method. Therefore, the extracted features of every food items be classified using the KNN and SVM classifier which efficiently measure the calorie value of each input food images. Then, the food detection system based on a committee classification was established in [2].

The structural SVM was used to filter out the unrelated features of food items for the final grade of possible matches of food types. The automatic food recognition system was explained by Marios M. Anthimopoulos *et al.* [16] using Bag-of-Features. The SIFT descriptor for the HSV colour space obtain and exploited the local features of every food items. After the feature vector was obtained from the food images, the SVM classify the food items drastically and attained the higher accuracy.

In biomedical and health care related areas, food intake assessment has been open research topic over a period of years. The diary and paper records are the traditional method used to store the intake of human's foods plane [17], [18], where people need to record food types and estimate food volumes manually. It is applicable to most people who take care of their diet. The inaccuracy and the personal issues in human estimations are the limitations in this method [19].

In [20] the authors proposed a system where the food images are captured and store from the publically available resources called FoodLog. Then, a dataset of 6512 images is created together with the calorie estimation. Such images in the developed dataset are used in dietary assessment approach. The accuracy from such approach for measuring calories is near to the ground. In [21], proposed methodology the sphere shaped SVM classifier is used for efficient way to classify the items.

III. PROPOSED METHODOLOGY

The proposed methodology comprises of 4 stages: i) Segmentation, ii) Feature extraction, iii) Classification and iv) Calorie measurement. The block diagram of the proposed methodology shown in Figure 2. The food or meal image is segmented using the FCM segmentation algorithm. After the food items of every input image is segmented. The food features are extracted. Then the classifier exploits these feature space for the classification performance. To achieve this, the SVM classifier is utilized which extensively classifies the food items.

A. Food Segmentation

Initially, the segmentation process holds the food image as input image and segmented the image significantly. Image processing techniques uses a more flexible model that is made to order the structure of fundamental data can attain improved result. For that, Fuzzy C-Means algorithm is used for segmentation. Fuzzy c-means is a data clustering method where in each data point belongs to a cluster to same degree that is specified by an association grade. FCM starts with an initial guesses for the cluster center point, which is indented to mark the mean location of every cluster. Initial guesses of centroid values is mostly inaccurate. By changing the cluster centers of each data point, FCM iteratively moves the cluster center to the right position within a dataset. This iteration is based on minimizing an objective function that represents the distance from any given data point to cluster center weighted by the data point's membership.

The every iteration of the Fuzzy c – means segmentation algorithm, the objective function, J_k is minimized by (1),

$$J_k = \sum_{i=1}^{D}\sum_{j=1}^{C}\delta_{ij}^{m}\left\|x_i - y_j\right\|^2 \tag{1}$$

Where D is the number of data points, C is the number of clusters required, y_j is the center vector for cluster j, δ_{ij} is the degree of membership for the i^{th} data point x_i in cluster j and m is the weighting exponent on each fuzzy membership. The norm, $\|x_i-y_j\|$ measures the closeness of the data point x_i to the center vector y_j of cluster j. In all iteration, the algorithm maintains a center vector for each of the clusters.

The solution to the objective function J is obtained by the following iterations

1. Set the value for c, m, and Ɛ.
2. Initialize fuzzy partition as matrix $U^{(0)}$.
3. Set loop counter to b=0.
4. Calculate c cluster centers to $C_j^{(b)}$ with $U^{(b)}$

$$C_j^{(b)} = \frac{\sum_{i=1}^{N}\left(\delta_{ij}^{(b)}\right)^m .x_i}{\sum_{i=1}^{N}\left(\delta_{ij}^{(b)}\right)^m} \tag{2}$$

5. Calculate the membership matrix $U^{(b+1)}$

$$\delta_{ij}^{(b+1)} = \frac{1}{\sum_{k=1}^{y}\left(D_{jk}\right)^{2/m-1}} \tag{3}$$

$$\text{Where } \delta_{jk} = \frac{\left\|x_{j-}c_j\right\|}{\left\|x_k - c_i\right\|} \tag{4}$$

6. If max $\{U^{(b)} – U^{(b+1)}\}$ < Ɛ then stop,
 Otherwise, set b = b+1 and go to step 4.

B. Feature Extraction of segmented food items

After the foods are segmented the features are extracted from the image. The features of every food hold the significant demonstration of the image. Here, the global and local feature extraction technique is employed to extract the food features from the segmented image.

1) Global feature extraction

Due to large variation in shape of the food items, the global characteristics like colour and texture feature are extracted to improve the classification performance. Also, this feature is mainly used to represent the shape characteristics of the image. The global feature space comprises of colour and texture descriptors.

a) Colour descriptor

The colour characteristic is the major concern which is used to differentiate the food items of the input image. Based on the colour, the food feature is extracted from each food segments. The global colour information is obtained by the colour component where the moments of the colour space is employed. Thus, the feature can be obtained from every component of the colour spaces which are RGB and HSV colour spaces. Thus, the feature is achieved using (5) with the aid of frequently representative colour in the RGB space. The predominant colour feature for each segmented region is obtained, which is expressed as:

$$F = \{(C_1 P_1 V_1), \ldots\ldots\ldots\ldots, (C_p P_p V_p)\} \quad (5)$$

Where, C_p is the 3D Colour vector representation of the segmented image, P_p defines the percentage value and V_p is the variance measure of the region.

b) Texture descriptor

The texture descriptor is one of the significant feature descriptors which represent the shape of the food items where the feature has been extracted. Thus, the texture descriptor is achieved by i) Gradient Orientation Spatial Dependence Matrix (GOSDM), ii) Entropy categorization and Fractal Dimension (EFD) and iii) Gabor based image decomposition and Fractal Dimension estimation (GFD).

In (6), the feature vector of the gradient orientation comprises several statistics like angular second moment (A), entropy (E), contrast (Ct) correlation (Cr) and homogeneity (H). It is represented by,

$$F = \left[f_{d_1}, f_{d_4}, f_{d_{16}}, \ldots\ldots., f_{d_{\min}\left(H/2, V/2\right)} \right] \quad (6)$$

where, the feature vector f_d defined as:

$$f_d = [Cr_0, A_0, E_0, Ct_0, H_0, Cr_{45}, A_{45}, E_{45}, Ct_{45}, H_{45}, Cr_{90}, A_{90}, E_{90}, Ct_{90}, H_{90}, Cr_{135}, A_{135}, E_{135}, Ct_{135}, H_{135}]$$

2) Local feature extraction

The local feature of an image is extract with the local neighbour pixels located around the regions of the points in the image. This is also termed as point of interest. Because the local feature exhibits the image pattern of the immediate neighbour pixel which can be point, edges and also the image patches. The main advantage of local feature is robust against the occlusion and clutter of the image. Here, the SIFT (Scale - Invariant Feature Transform) and SURF (Speeded Up Robust Feature) feature descriptors are utilized to detect the local feature information. This filter is used to extract the feature from the first and second moment pointers using the local neighbourhood pixel. Then, the SIFT descriptor is applied on the colour component of the RGB image.

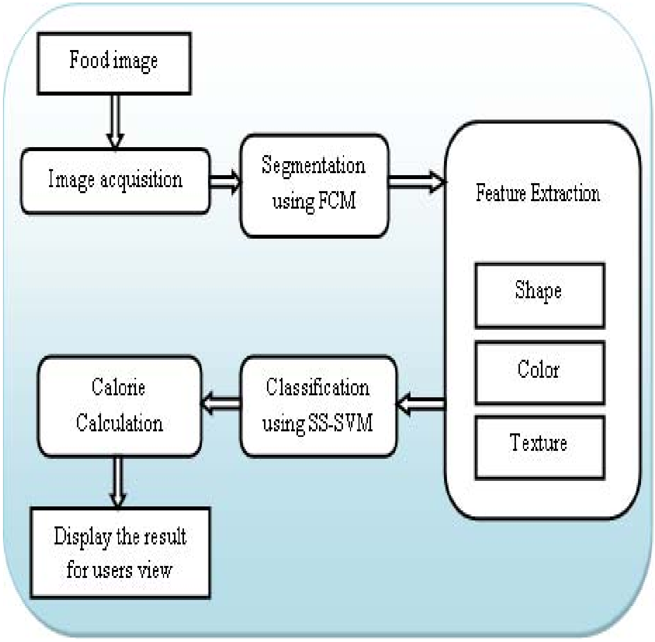

Fig.2. Block diagram representation of proposed methodology

C. Sphere - Shaped SVM classifier for identifying the food segments

After the segmentation and feature extraction the food items are classified using the Sphere – Shaped SVM technique, which is one of the popular technique used for classification. SS – SVM classifier differ from normal algorithm, this Sphere Shaped SVM is easily expandable and interesting to use due to its high efficiency. Classification phase usually involves training and testing. Each instance in the training set contains one class label and numerous features. The goal of SS - SVM is to produce a representation, where the data instance in the testing test easily expands the target value. Based on the food items detected, the SS - SVM classifier will be executed. For each food portion the features like the Colour, texture, and shape of each food items are send to the SS - SVM Model. The SS – SVM classifier compared the features with the features of entries produced in the training step to the increase accuracy, after the SS - SVM module has determine the each food portion type, the system displays the name of detected food portion to the user.

D. Calorie measurement for the identified food segments

After the food items are classified by the SS - SVM, the classified results from the image are used to estimate the calorie value. Thus, the calorie value is calculated by the i) food area volume computation and ii) calorie calculation.

In general, every food image consists of various food items and they are varying from their texture, colour and size. Thus, the volume of food item is estimated using the total area in (7) and depth of the food image. It is formulated as:

$$TA = \sum_{i=1}^{n} T_i \quad (7)$$

where, n represents the total number of square grids in the segmented image. Then the food area volume is calculated by (8),

$$V = TA \times d \tag{8}$$

where, TA is the total area of the food item and d represents the depth. Then the calorie value of food items is measured by its volume and mass. Equation (9), shows the mass value of food items which, is calculated from the volume and density of food.

$$M = \rho V \tag{9}$$

where, M is the mass, ρ is the density and V denotes the volume which is obtained by the area. Then, the calorie and nutrition measure of each foods are calculated using (10).

$$Calorie = \frac{calorie \quad in \quad table \times mass \quad in \quad image}{mass \quad from \quad table} \tag{10}$$

IV. Results and Discussion

The experimental results and performance evaluation is validated using evaluation metrics such as segmentation accuracy, true and false positive rate and classification rate.

A. Experimental Setup

i) Dataset description: Food images are collected from publicly available resources. Here, 100 food images are collected from the online sources for experimenting the proposed dietary assessment using SS – SVM. Figure 3 shows two sample input images.

Sample Images		
Seg 1		
Seg 2		

Fig.3. Sample Input images and its Segmentation result

ii) Evaluation metrics: The performance of image segmentation and classification for dietary assessment is analyzed by the evaluation parameters. The accuracy is an important assess for classification purpose, the better classification attains when the classifier gives higher accuracy rate. The true positive rate is the measure of positive proportion which is correctly identified by the classifier.

Classification rate: The classification rate is the most important concern for the dietary assessment system. Here, the features of every foods item are classified and recognized by the SS – SVM classifier. Therefore, the (11) evaluate the classification rate by.

$$CR = \frac{TP + TN}{TP + TN + FP + FN} \tag{11}$$

Table 1 and Table 2 shows the Segmentation and Classification Accuracy achieved by the Fuzzy C-Means and Sphere Shaped - Support Vector Machine.

Table 1. Performance evaluation for segmentation

	Image 1	**Image 2**
Segmentation	*Segmentation accuracy (%)*	*Segmentation accuracy (%)*
Multi hypothesis	84	87.5
K means	90.21	93
Fuzzy C- Means	94.32	95.4

Table 2. Comparative performance evaluation for classification

Classification (70:30)	**Sensitivity**	**False positive rate**	**True positive rate**	**Classification Rate (%)**
Marios Anthimopoulos et al [1]	79.5	20	70.5	85.9
SVM [22]	83	19.74	72.56	87.5
Map Reduced SVM [10]	85.2	19.2	73.4	91.1
Proposed Method- SS – SVM	86.1	18	72.3	92.9

Classification (80:20)	**Sensitivity**	**False positive rate**	**True positive rate**	**Classification Rate (%)**
Marios Anthimopoulos et al [1]	80.2	19.16	71.4	86.5
SVM [22]	82.9	18.2	72.7	89.4
Map Reduced SVM [10]	85	18	73.6	92.51
Proposed Method- SS – SVM	87.7	17.5	75	93.3

Classification (90:10)	**Sensitivity**	**False positive rate**	**True positive rate**	**Classification Rate (%)**
Marios Anthimopoulos et al [1]	81.87	19.5	72.8	87
SVM [22]	83.4	19	73.12	90.41
Map Reduced SVM [10]	87.1	18.3	74	94
Proposed Method- SS - SVM	89.2	17.1	75.2	95

V. Conclusion

In this paper, the fuzzy c-mean segmentation and classification using SS - SVM for dietary assessment was proposed. Here, the food or meal image was considered as the input image for the proposed system. SS - SVM classifier was utilized to perform the classification. After the Classification calorie value for each identified food was calculated. Then the outcome was validated by its segmentation and classification rate of the respective images. Thus, the proposed method achieved 95% of accuracy value which provided the better classification performance.

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