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Food Recognition and Calorie Extraction using Bag-of- SURF and Spatial Pyramid Matching Methods

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Abstract— In this work we present methods to identify food and estimate calorie using Computer Vision algorithms. Specifically, we propose SURF based bag-of-features and spatial pyramid approaches to recognize the food items. We also experimented with larger PFID dataset containing around 111 food item categories and obtained best classification rate. Emerging food classification methods play an important role in nowadays food recognition applications. For this purpose, a new recognition algorithm for food is presented, considering its shape, color, size, and texture characteristics. Using various combinations of these features, a better classification will be achieved.

Keywords— SURF, PFID, Food recognition, Shape, color, size and texture detection, Calorie estimation.

1. INTRODUCTION

Food recognition is a challenging task. First, there are large number of food categories. Building a dataset of all categories of food by itself is a challenging task. Second, there can be a large number of intra-class variations in the food items that we observe. Same found food can have multiple visual appearance. Finally, presence of occlusions around food items adds extra complexity for its recognition, same food might be served on a bowl or wrapped within a paper cover. In this, we propose methods to automatically detect food item and estimate calorie from a given image of food item. Such model can then be ported to mobile devices, therefore it can serve as a way to automatically record calorie intake. Also, such system can be used in health-care industry to monitor the patients diet habits. Integrating such system in wearable devices such as Google Glass would further ease recognition and recoding of food items.

2. *Related Work*

Several papers have been presented to solve the problem of food recognition. Chen et al[4] introduced the PFID dataset for food recognition along with benchmarks using two baseline algorithms: color histogram and bag-of-SIFT. Yang et al[5] proposed food recognition using statistics of pairwise local feature matching approach. Kawano[6] proposed real-time food recognition system using bag-of-SURF method. Matsuda[7] proposed method for recognition multiple-food images, in which food regions are detected using several detectors and recognition is carried out using multiple kernel learning(MKL) by extracting multiple features such as color, texture, gradient, and SIFT. Shroff[8] proposed a wearable computing system to recognize food for calorie monitoring. Our goal was to provide benchmark for computer vision researchers who are working on this area rather than to propose such system as state of the art. Food recognition method using statistics of pair wise local feature matching[5] achieves best classification accuracy, so far the best on PFID dataset.

3. *System Architecture*

The objective of the design is to transform the detailed, defined requirements into complete, detailed specification for the system to guide the work of the development phase. The decision made in this phase addresses, in detail how the system will meet the defined functional, physical interface and requirements.

1.Bag-of-SURF model:

The following steps are taken place while using this Bag-of-Surf method for image recognition. They are as follows

- Consider the query images as an input.
- By using SURF method extract the descriptors.
- We build the histogram of codewords.
- Then classify these histogram by using linear kernel.
- Finally we get the results.

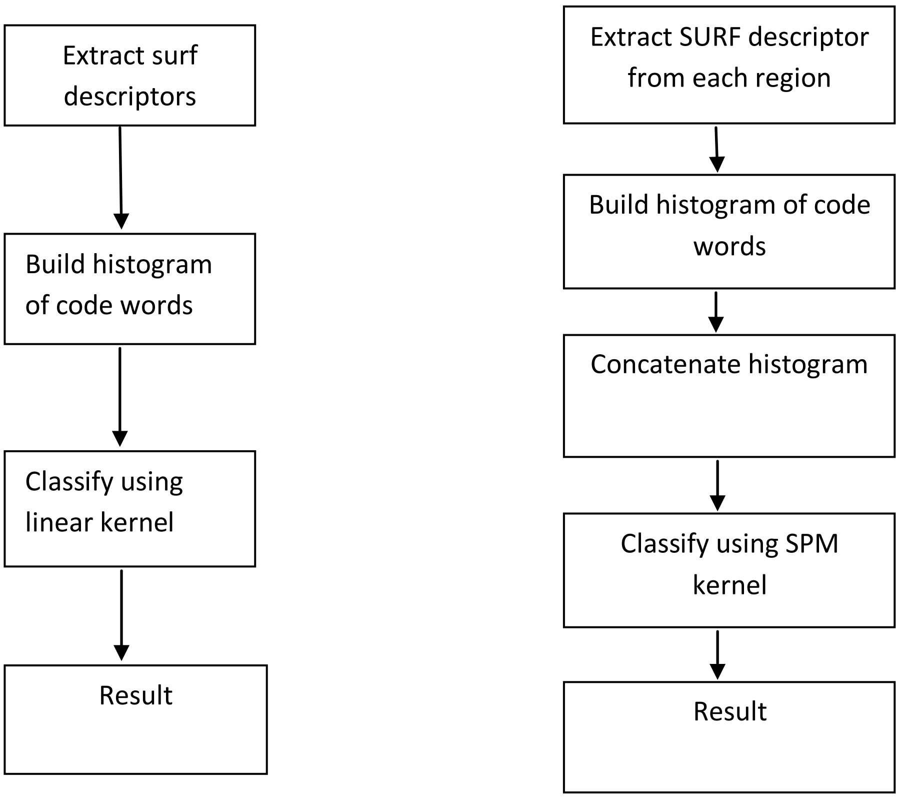
2.Spatial Pyramid Matching(SPM) Method

The following steps are taken place while using this spatial pyramid matching method for image recognition. They are as follows:

- Consider the query images as an input.
- Divide the input image into 21 regions in total.
- By using SURF method extract the descriptors of each and every region.
- We build the histogram of code words for every region of the input.
- Then concatenate the histograms.
- Classify the histograms using SPM method.
- Finally we get the result.

We propose methods to recognize food items: Speeded Up Robust Features [1] (SURF) descriptor based Bag of features model and Spatial Pyramid Matching(SPM) based method. In bag-of-SURF method, we first build a dictionary of code words, then generate a histogram of code words for all training images and use linear kernel classification scheme.

Spatial pyramid matching method tries to account for the spatial information by dividing and subdividing the given food image and constructing the histogram of code words of individual regions. We then train a classifier with spatial pyramid kernel using libsvm[3] package. Recognition using proposed system is shown in **figure1.**



Fig(a) **Fig(b)**

Figure 1: Recognition using (a) Bag-of-SURF model and (b)Spatial Pyramid Matching method

The **figure1(a)** represents the bag of surf model which represents the extraction of surf descriptors at the first step and then in the second step soon after the extraction it builds the histogram of code words by using bag of surf method then it classifies the code words using linear kernel and at last we get the result.

The **figure1(b)** represents the spatial pyramid matching method where first the surf descriptor is extracted from each region then the histogram of code words is built in the next step the concatenation of the histogram takes places after the concatenation the code words are classified using SPM kernel then the result is obtained.

4. Methodology

This section provides the technical details of the proposed methods that we use in our methods and then propose two methods to classify food items: bag-of-SURF and spatial pyramid matching approach.

1. Bag-of-SURF method

First step in bag-of-SURF method is to build a dictionary of code words. We use a subset of training images to prepare the codeword dictionary. For each of the image of this subset, we extract 64 dimension SURF descriptors. Descriptors from all images belonging to this subset are then plotted on a high dimensional space and clustered using k-means algorithm into 200 clusters, which is the size of our dictionary. We also experimented using dictionary of size 100 and 300, dictionary size of 200 performs the best in our experiment. Next, we train a classifier on a set of training images. For this, we extract 64 dimensional SURF descriptors from each of the training images. By means of Euclidean distance metric, we then compute the nearest neighbour of each of the feature vector in diction.ary of code words and build a histogram of code words of length 200. This histogram is normalized so that it is probability density. Finally, we train a classifier using lib svm package using linear kernel. Testing procedure is also very similar. For all the test images, we get the SURF descriptors, build a histogram of code words, normalize the histogram and predict the output using the model learned during training section. This approach is shown in **figure2** below.

Figure2 : Food recognition using Bag-of-SURF method

2.Spatial Pyramid Matching

Initially we report the pyramid matching original formulation and later establish our application of having this structure to generate a spatial pyramid image representation. Spatial Pyramid Matching (SPM) technique works by partitioning the image into increasingly smaller sub regions and computing histogra.ms of local features found inside each sub region. By doing this, we embed the spatial information of scene in our histogram. Spatial pyramid matching method is depicted .Similar to bag-of-SURF method, we begin by building dictionary of code-words by extracting the SURF feature vectors from a subset of training images, then we plot the descriptors in 64 dimensional space and cluster them into 200 clusters using k-means algorithm.

In our work, we employed 3 level SPM: level 0, level 1 and level 2. Level 0 represents the whole image, we get level 1 by dividing each image into 4 sub-regions and finally level 2 is constructed by partitioning into 16 sub regions. In total we will have 21 regions. We then extract SURF descriptors for each of the regions and then a histogram of code words. Histograms of all sub-regions are concatenated together to form a long feature vector of dimension 21*200 = 4200. Finally this histogram is normalized so that it is probability density. We use Spatial Pyramid Matching Kernel[2] to train a classifier using lib svm package. SPM kernel is defined as follows. Let X and Y be the two histogram of code words.

Similarly, during testing we divide the test image into 21 sub regions, SURF feature vectors from each of the sub-region is extracted. Histogram for each of the sub-regions is computed, then concatenated and normalized. We then predict the output using learnt model.

3.Spatial Matching Scheme

Pyramid match kernel can work with an order less image representation. In a high dimensional appearance space, it permits for exact matching of two feature collections whereas discards complete spatial data. This project presents an "orthogonal" approach in which pyramid matching is performed in two-dimensional image space using traditional

5. Results and Discussion

1.Calorie estimation

The main aim of the project is calorie estimation. Calorie estimation plays an important role in food industry, health care sectors and also in day to day life to know what quantity of food and calorie is needed for an individual to stay fit , nowerdays food intake estimation and calorie estimation is playing an important part in the world, With the knowledge of food types and food scales, the calorie density is used to roughly estimate the energy a food item contains. With the volume v, mass density r, calorie density c, the number of calories is defined as Cal = v_r _c

2.Importance

The application potential of image processing techniques to the food industry has long been recognized. The food industry ranks among the top ten industries using image processing techniques, which have been proven successful for the objective and nondestructive evaluation of several food products. The core technique in computer vision is always related to image analysis and processing, which can lead to segmentation, quantification and classification of images and objects of interest within images. It is also playing an important role in health care centres for health management, diabetics, dietary management and also for day to day life for physical fitness**.**

Effective dietary guidelines are essential to combat various chronic diseases. Studies have shown that healthy diet can significantly reduce the risk of diseases. This motivates a need monitor and assess dietary intake of individuals in a systematic way. It is known that individuals do a poor job of reporting their true dietary intake. Even dieticians need to perform complex lab measurements for accurate assessment. To overcome these problems we developed a dietary management system which provides calorie of each cuisine image so it becomes very easy to manage our diet.

The screenshots below describes the surf feature extraction and the matching methods used in the food calorie estimation methods

Figure 3 : The above figure describes that the features of SURF are been extracted from the loaded image.

Here the feature of surf after the loading is extracted from the image datasets and further it proceeds for matching where it matches the features among it.

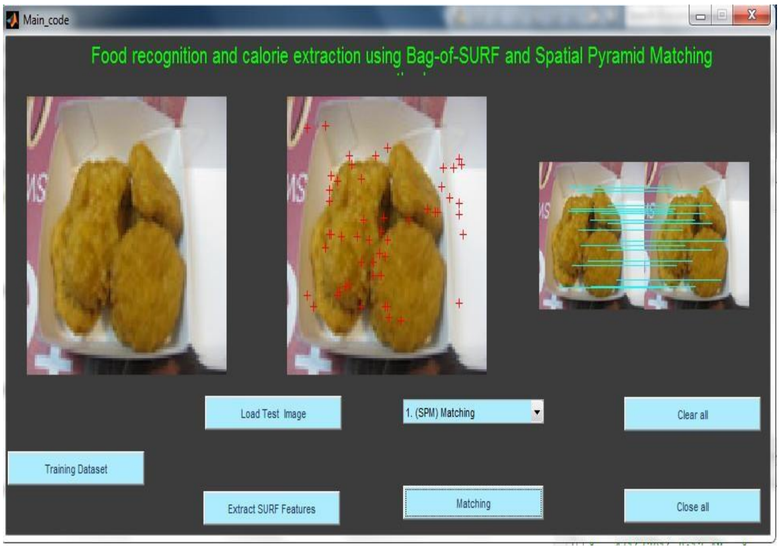


Figure 4 : The above figure determines spatial pyramid matching takes place.

Here the matching of image features takes places with the help of spatial pyramid matching method the matching of every single features is carried out here.

6. Conclusion and future work

Given the number of categories of food items and intra class variations within each class, food recognition is a challenging task. With the increase in popularity of fitness applications and advancements of wearable devices such as Google Glass, exploration of food recognition methods are growing. While we do not claim that the methods presented here are state of the art, we achieved significant improvement over the baseline methods. However, f.ood recognition using statistics of pairwise local features [5] . In future work, we plan to extend our work to: (1) use object bank approach for food item classification, (2) port the trained model to mobile devices for real-time recognition purpose.

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