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Implementation of Discrete Wavelet Transform Technique for Food Recognition and Calorie Estimation

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Abstract:

Poor diet plays an important role in developing chronic diseases like obesity, diabetes, stroke and heart attacks in human beings. These are lifestyle diseases mainly caused due to fad diets and unhealthy lifestyle. So it is very important to know your food before consuming it. To identify food items using images, image processing techniques like segmentation, feature extraction and classification are used. In this paper, we propose a food recognition system that could estimate the calories. For feature extraction, we have mainly considered color and texture features of the image. For higher accuracy we have used color Discrete Wavelet Transform method and for classification kNN classifier is used. The calorie value is measured with the help of nutrition table.

Keywords — **KNN classifier, DWT, Image Segmentation, Food Recognition, Calorie and Nutrition Measurement.**

I. INTRODUCTION

Obesity is a major cause for concern these days. Obesity is a condition where a person has accumulated so much body fat that it might have a negative effect on their health. The major reason for this is an unhealthy lifestyle. Obesity can trigger many unwanted conditions like blood pressure abnormalities, diabetes, heart diseases, etc. It is also responsible for polycystic ovaries in women.

Automatic food recognition is an emerging research topic in machine learning due to the increasing demand for better dietary assessment tools to battle obesity. The major goal of such systems is to make the people aware of the nutritional contents in their food choices. These systems also help doctors investigate their patient's food habits because manual reports may not be accurate enough.

Food recognition is a demanding task. First, there is a huge number of food categories. Building a dataset of all these categories is itself a difficult task. Second, there can be a substantial number of intra-class varieties. Same food item can have many visual appearances. Finally, existence of occlusions around food items increases complexity for its recognition. That is, same food item might be served in different ways. For example, it can be served on a bowl or wrapped within a paper cover. In this, we propose methods to automatically identify the food item and estimate calories from a given image of the food item. Then such models can be ported to mobile devices, therefore serving as a way to automatically record the calorie intake. Likewise, such systems can be used in health-care industry to monitor the patient's diet habits. Integrating such systems in wearable devices such as Google Glass would further ease recognition and recording of food items.

II. LITERATURE SURVEY

Researches in the literature have often focused on different aspects of the food recognition problem. Many works address the challenges in the recognition of food by developing recognition strategies that differ in terms of features and classification methodologies.

Zhang et al. [1] are using convolutional neural network method and divide it into the following steps : preparing dataset, building networks,

training and testing the networks. It reduces the complexity of the network model and the amount of the weights, especially when the input is a multi-dimensional image. It is a multi-layer neural network. Each layer consists of several 2-D surface and each surface has plenty of single neural cells. The input of each cell connects with the retina below and extract the local feature.

ShotaSasano et al. [2] developed an auto food-log record system with automatically estimate the calories of food. The food recognition mainly consists of three steps: construction of food image database; extraction of effective visual features of food image such as color and texture features; image classification using machine learning methods such as Bayesian, Support Vector Machine and so on.

Chang Liu et al. [3] proposed to address these issues from the following two aspects: (1) to develop novel deep learning-based visual food recognition algorithms to achieve the best-in-class recognition accuracy; (2) to design a food recognition system employing edge computing-based service computing paradigm to overcome some inherent problems of traditional mobile cloud computing paradigm, such as unacceptable system latency and low battery life of mobile devices.

GianluigiCiocca et al. [4] describes w dataset for the evaluation of food recognition algorithms designed for dietary monitoring. Each image depicts a real canteen tray with dishes and foods arranged in different ways. Each tray contains multiple instances of food classes.

P. Velvizhy et al. [6] proposed to capture food and fed to Dense SIFT method, this method extract keypoint and visual vector from an image. Extracted visual vector are clustered using K-means clustering technique. Finally support vector machine classifier is used in this work, classifies the food image and measures the carbohydrate level from food image. Our proposed system is based on Bag of Feature (BoF) model.

ParisaPouladzadeh et.al, [14] proposed calorie measuring system that illustrates health related problems faced by human being and to reduce such problems they introduced a system that can measure calories and nutrition in every day meals and this system can help patients and dieticians to measure and manage daily food intake. Via a special calibration card technique, the algorithm gives accurate results.

Huang Shiqi et.al, [15] a food calorie and nutrition measurement system that can help patients and dieticians to measure and manage daily food intake. Our system is built on food image processing and uses nutritional fact tables. Recently, there has been an increase in the usage of personal mobile technology such as Smartphone or tablets, which users carry with them practically all the time. Via a special calibration technique, our system uses the built-in camera of such mobile devices and records a photo of the food before and after eating it to measure the consumption of calorie and nutrient components. Our results show that the accuracy of our system is acceptable and it will greatly improve and facilitate current manual calorie measurement techniques.

III. PROPOSED SCHEME

A. Food Item Recognition

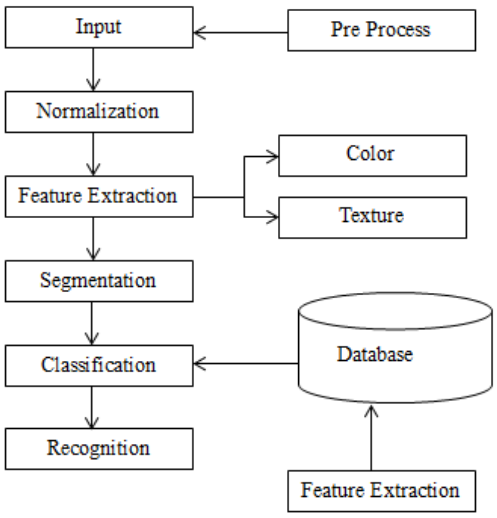


Fig. 1 Block Diagram of Food Recognition Phase

Pre-Processing:

Pre-processing basically is removing noise and normalizing the image, converting the image from one format to another as per the need, resizing the image to the specified size and removing unnecessary features from it. There are different

techniques for pre-processing like Histogram equalization, smoothening and RGB image to Grayscaleconversion, etc.

Segmentation:

In Segmentation, the image is partitioned into equal segments. After segmentation, the boundary detection of irregular food portions becomes easy and it gives better detection of food portion.

Feature Extraction:

It extracts the meaningful set of information which is called feature vector. Feature Vector represents the characteristics of food in the images. In this we consider the color and texture features of the image.

Color Feature Extraction:

A color image is a combination of some basic colors. Each individual pixel of a color image (termed 'true color') down into Red, Green and Blue values. As a result we get 3 matrices for the entire image, each representing a color feature.

Texture Feature Extraction:

Guiying Li (2012) defined texture as a repeated pattern of information or arrangement of the structure with regular intervals. In a general, texture refers to the surface characteristics and the appearance of an object given by the size, shape, density, arrangement, proportion of its elementary parts. A fundamental stage to collect such features through texture analysis process is called as texture feature extraction. Due to the signification of texture information, texture feature extraction is a key function in various image processing applications like remote sensing, medical imaging and content based image retrieval. There are several methods for extracting the texture features. In this paper, we use Discrete Wavelet Transform method.

Discrete Wavelet Transform (DWT):

Discrete Wavelet Transform is a well known transform that simultaneously gives information about the time and frequency of a signal. While low pass filtering yields rough approximations of the original image, high pass filtering yields the detailed features such as edges. There are two types of Discrete Wavelet Transforms: 1-dimensional (1D) DWT and 2-dimensional (2D) DWT. 2-Dimensional Discrete Wavelet Transform gives rise to four components, (i) approximation (cA), (ii) vertical (cV), (iii) horizontal (cH) and (iv) diagonal (cD) whereas, 1-Dimensional Discrete Wavelet Transform results in only two components, (i) approximation (cA) and (ii) detail (cD). We have used 2-Dimensional Discrete Wavelet Transform in this paper.

In 2-Dimensional Discrete Wavelet Transform, the original image is divided into four parts: (i) low frequency components in horizontal and vertical directions (cA), (ii) low frequency component in the horizontal and high frequency component in the vertical direction (cV), (iii) high frequency component in the horizontal and low frequency component in the vertical (cH), and (iv) high frequency components in horizontal and vertical directions (cD). In 1-Dimensional Discrete Wavelet Transform, the cA coefficients contain low frequency, while the cD coefficients contain high frequency information.

Classification:

Classification applies on the feature vector of training and testing image. It is used for result of outcome in recognition. In this paper, k-nearest neighbor classifier is used.

k-Nearest Neighbor is one of those algorithms that are very simple to understand but works incredibly well in practice. Also it is surprisingly flexible and its applications range from vision to proteins to computational geometry to graphs and so on.

Algorithm Steps:

(i) For each training example, add the example to the list of training_examples.

(ii) Given a query instance xq(instances x and q to be classified).

(iii) Let x1,x2…xk denote the k instances from training_examples that are nearest to xq.

(iv) Return the class that represents the maximum of the k instances.

B. Calorie And Nutrition Measurement

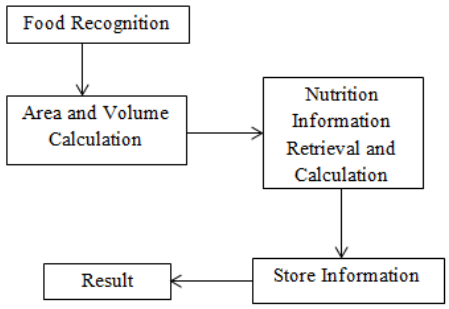


Fig. 2 Block Diagram of Calorie Estimation Phase

After food item recognition, the system then measures the volume of each food portion and converts it into mass, using available density tables, and finally uses the mass and nutritional tables to measure the overall calorie and nutrients in the food. These two latter components; i.e., food portion volume and calorie values, are calculated.

The total area (TA) of the food portion is calculated as the sum of the sub areas (Ti) for each square

$$TA = \sum_{i=1}^{n} Ti$$

where n is the total number of squares in the food portion's area.

The system will extract the depth of the food d, to calculate the food portion's volume V, using the following equation

$$V = TA \times d$$

The volume measurement method described above is really just an interim step in order to measure the mass of the food portion. Mass is what we really need since all nutritional tables are based on food mass. Once we have the mass, we can use these tables to calculate the amount of calories and other nutrition. We have the measurement for the volume of each food portion, and we can use the following general mathematical equation to calculate their mass:

$$M = \rho V$$

where M is the mass of the food portion and ρ is its density.

TABLE I
SAMPLE NUTRITIONAL FACTS TABLE

FOOD NAME	WEIGHT (grams)	ENERGY (Cal)
Chappathi	100	80
Bread white, commercial	100	116
Cake	100	250
Boiled Potato without skin	100	30
French toast	100	150

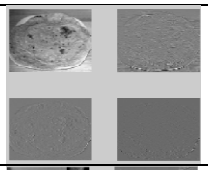
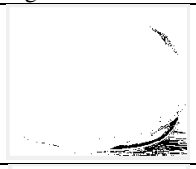
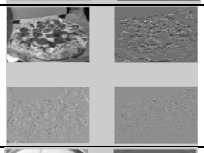
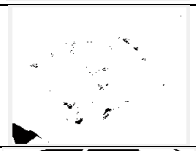
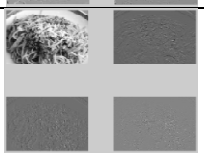
Now, the system can calculate the mass by having the type of food. Therefore, the amount of calorie and nutrition of each food portion can be derived using the nutritional tables, based on the following equation:

$$\text{Calorie in image} = \frac{\text{Calorie from table} \times \text{Mass in image}}{\text{Mass from table}}$$

IV. EXPERIMENTAL RESULT

C. Result of Feature Extraction of the given Food Items

TABLE III
FEATURE EXTRACTION AND SEGMENTATION RESULT

Food Images	Feature Extraction	Segmentation
		
		
		

D. Result for Recognition of the given Food Item

Fig. 3 The given image classified and Recognized as "Pizza"

E. Calorie Estimation Result

TABLE IIIII
CALORIE ESTIMATION RESULT FOR THE RESPECTIVE IMAGES

Food Images	Measurements
	density = 0.0747 area= 4.0921e+03 volume= 4014 Mass= 223.6516 Calorie= 911.8258
	density = 0.0062 area= 3.2988e+04 volume= 32487 Mass= 178.7008 Calorie= 297.3504
	density = 0.0517 area= 6.8626e+03 volume= 6770 Mass= 219.7570 Calorie= 598.9693

V. CONCLUSIONS

In the system, a method for recognizing food object and measurement of calorie and nutrition is carried out. The system helps people by closely controlling their daily food intake. We focused on identifying food items in an image using image processing and food classification is done for identifying healthy foods. The proposed system identifies the food individually according to which the classification is done using kNN classifier. This system also works towards improving the accuracy of identifying the mixed foods. Likewise, a method that estimates the amount of calories from a food's image by measuring the volume of the food portions from the image and using nutritional facts tables to measure the amount of calorie and nutrition in the food.

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