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Indian Food Image Classification Using K-Nearest-Neighbour and Support-Vector-Machines

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Abstract- Food being the vital part of everyone's lives, food detection and recognition becomes an interesting and challenging problem in computer vision and image processing. In this paper we mainly propose an automatic food detection system that detects and recognizes varieties of Indian food. This paper uses a combined colour and shape features. The K-Nearest-Neighbour (KNN) and Support-Vector -Machine (SVM) classification models are used to classify the features. A comparative study on the performance of both the classification models is performed. The experimental result shows the higher efficiency of SVM classifier over KNN classifier.
Index Terms- Food Classification, KNN (k-nearest-neighbour), SVM (Support Vector Machine), Template Matching

I. Introduction

Dietary food nutrients are the essential source for sustain life. Food being the most important source of energy it is consumed in a variety of style with diverse presentation. Earlier food was consumed mainly as whole vegetables, fruits, grain, dairy product and honey. Preparation of any food with the best nutrient values is of major concern both in domestic and industrial setting. There is a plethora of food delicacies available globally, due to which food industry is a major key player in economic growth of a country. Extensive and diverse platters offer a nutritional pallet so elaborate and attractive that the consumer inculcates both good and bad food habits. People face difficulty in choosing the best food with high nutrient value to stay healthy, thus we are proposing an openCV based food identification system to detect, localize and recognise Indian food items.

The proposed food recognition system is developed in such a way that it can classify the Indian food items based on two different classification models i.e. SVM and KNN. Food images are captured using high resolution portable cameras or cameras attached to a wearable glass, cap or hat. Eventually this system can also aide the visually impaired recognise the food on the platter with its features like colour, texture and shape.

The paper mainly classifies Indian food items. The main reason for opting Indian food is the diversified eating habits present in India. As an example the simple staple food: rice is prepared with different styles patterns. It is often difficult and challenging to classify rice as rice considering few features. Hence more complex algorithms based on colour texture and shape feature training and learning is required.

The other intricacies are, the colour of food items may resemble another dish itself example colour of idly resembling rice. In this paper we use the combine feature present in food images and classify with KNN and SVM classifiers. Fig 1 shows the sample image used in the proposed system as in put images.

Fig. 1: Indian Food Images

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The paper is organised as follows: in section II, a brief coverage of related literature is given. We discuss few challenges faced during the detection and recognition process. In section III, we have discussed the how processing is done using Indian food images. The Pre-processing in Indian Food Images are discussed. This gives the detailed insight about the proposed system. In section IV the observational results are discussed. In section V we conclude the paper.

II. Literature Survey

There are several on-going research works based on food detection and recognition. Several android applications based on dietary nutrients management also exist. Brief appraisals on the available literatures are illustrated in this section. Most of the literatures used methods that include naïve Bayes classifier, support vector machines, K-nearest neighbors, Gaussian mixture model, decision tree and radial basis function (RBF) classifiers [3,4].These classifiers are used in algorithms that involve food recognition.An alternative technique proposed in [6] is visual life logging that consists of using a wearable camera that automatically captures pictures from the user point of view (egocentric point of view) with the aim to analyse different patterns of his/her daily life and extract highly relevant information like nutritional habits [6]. Marios M. Anthimopoulos, Lauro Gianola, Luca Scarnato, Peter Diem, and Stavroula G. Mougiakakou, in [15], proposed the Computer vision-based food recognition could be used to estimate a meal's carbohydrate content for diabetic patients. This study proposes a methodology for automatic food recognition, based on the bag-of-features (BoF) model. Marc Bola˜nos and Petia Radeva in [1], proposed a food activation map on the input image for generating bounding boxes proposals and recognize each of the food types.

Hokuto Kagaya, Kiyoharu Aizawa and Makoto Ogawa in [16], proposed the tasks of food detection and recognition through parameter optimization and how to construct a dataset of the most frequent food items in a publicly available food-logging system, and used it to evaluate recognition performance. Niki Martinel, Gian Luca Foresti, and Christian Michelon in [17] this paper introduces a new deep scheme that is designed to handle the food structure and also explains about the recent success of residual deep network, introduce a slice convolution block to capture the vertical food layers. Outputs of the deep residual blocks are combined with the sliced convolution to produce the classification score for specific food categories.

Nayan Kumar Konaje, in [18] proposed methods to recognize Food and estimate calorie using Computer Vision algorithms. Introduces to SURF based bag-of-features and spatial Pyramid approaches to recognize the food items and also mention how it can be deployed on mobile platform for real time recognition. Parisa Pouladzadeh, Shervin Shirmohammadi and Tariku Arici, in[19] explained about how to improve the accuracy of the current state of the art technologies, using colour k-mean clustering along with colour mean shift and texture segmentation schemes to get more accurate results in segmentation phase. Also, the proposed system is built on food image processing techniques and uses nutritional fact tables, via a special calibration technique. Yoshiyuki Kawano and Keiji Yanai in [20] this paper ,illustrated about how to recognize food more accurately, it make use of segmented food item region by Grub Cut, extract a colour histogram and also SURF based bag-of-features, and finally classify with linear SVM and fast $\chi 2$ kernel.

Niki Martinel, Claudio Piciarelli, Christian Micheloni and Gian Luca Foresti in [21] this paper proposes a committee based recognition system that chooses the optimal features out of the existing plethora of available ones. Each committee member classifies food plates on the basis of a single feature type. Then it applies classification method, structural Support Vector Machine.Simon Mezgec, Barbara Korouši´c Seljak in[22] this paper proposes, a novel approach to the problem of food and drink image detection and recognition that uses a newly- defined deep convolution neural network architecture, called NutriNet. The other solutions adopted recently that could ease the automatic construction of nutrition diaries is to ask individuals to take photos with their mobile phones [2].

As mentioned in the introduction section, Indian food recognition is challenging and a complex task due to the diversified varieties of food available with different names for the same dish. With these challenges it is also seen that few technical intricacies affect the accuracy in food recognition system. In this section we mention about the challenges that exist with mobile or egocentric images.

The images mainly suffer with poor quality such as low resolution, blurriness, occlusions illumination and lighting conditions. In this paper we have mainly considered a pre- processing stage that aids in building an enhanced noise free image.

III. Proposed Work

The Indian food image dataset is the foremost consideration for building and testing our system. We have considered the Indian food density tables, color and shape acknowledgment as a part of image processing, and classification with the SVM and KNN. As illustrated in the Literature survey, lot of research work has been based on-colour, shape, calories and nutrition values. The process of recognition from the captured images can be performed using edge based, region based approaches. Feature detection and

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extraction finds the region in the Indian food images. The recognition is done with the help of template matching and the bounding the detected Indian food.

The procedure of classification for the proposed system is as shown in the Fig-2. In this paper, we will be comparing two popular classification methods: Hypothetical evaluation is conducted on the traditional Indian food dataset [7] to see the variation between two classification methods. The proposed system is divided in to sub module for easy and better understating. The series of step required to go through the system to perform the classification are:

- Pre-processing
- Segmentation
- Feature detection
- Feature extraction
- Classification
- Matching
- Recognition

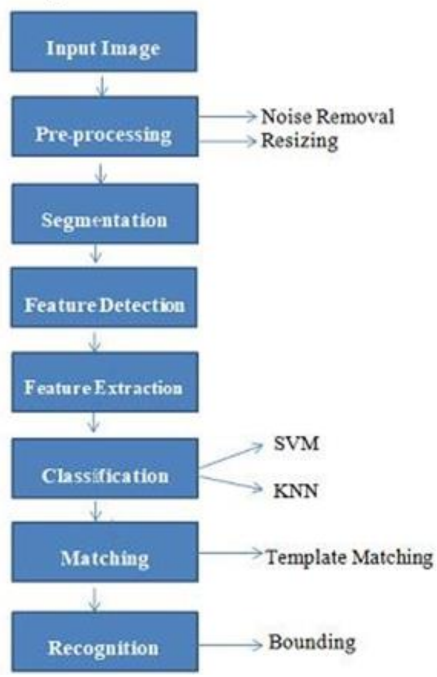

Fig. 2: The process of image Classification and Prediction

Dataset*:*

The steps discussed above are repeated for all the test images in the dataset and the features extracted in the feature dataset which is a CSV file. The data set contains the feature vector extracted from the sample images. The below Fig 3 show the data set generated by the image selected and also used in the proposed system to classify Indian food. We have considered around 200 image samples with cluttered food and individual food items. We have considered two combined features for these 200 samples we have considered 80% of the images as training set and 20% of them as the testing set.

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1	11052	1707	1657	8805	8897 vada
2	11052	1707	1657	8805	8897 vada
3	11052	1707	1657	8805	8897 vada
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7	11052	1707	1657	8805	8897 vada
8	11052	1707	1657	8805	8897 vada
9	11052	1707	1657	8805	8897 vada
10	11052	1707	1657	8805	8897 vada
11	11052	1707	1657	8805	8897 vada
12	11052	1707	1657	8805	8897 vada
13	11052	1707	1657	8805	8897 vada
14	11052	1707	1657	8805	8897 vada
15	11052	1707	1657	8805	8897 vada
16	204042	58547	61089	31057	86517 vada
17	754106	171156	270102	305486	308558 food
18	172126	14908	64401	66737	113828 food
19	507140	301033	244732	180215	178030 rice
20	507140	301033	244732	180215	178030 rice
21	507140	301033	244732	180215	178030 rice
22	507140	301033	244732	180215	178030 rice

Fig. 3: Food Dataset in CSV format

Pre-Processing:

The input image goes through the pre-processing phase. In this phase the series of tasks for improving the quality of the image takes place so that, all the images will be under a common colour format and maintains the standard resolution. The pre-processing stage includes 3 stages: a. RGB to HSV Colour conversion, b. Noise removal, and c. image cropping and d. edge detection.

RGB to HSV Colour Conversion:

Initially in any image which as the RGB colour space will be converted to HSV colour space. RGB colour space is a colour enhancer in which certain percentage of red, blue green colour are added hence providing with a huge range of colours. HSV colour space is an addition of the terms Hue, Saturation, and Value. Where hue is the colour percentage in the colour model, which range from 0 to 360.Saturation is portion of grey in the colour, and value is the intensity of the colour. The HSV model is most commonly used, as it can be relate to colours.

The formula to calculate the HSV is given:

Hue Calculation

$$II = \begin{cases} 60^\circ * \left(\frac{G^1 - B^1}{\triangle} * \text{Mod } 6 \right), & Cmax = R^1 \\ 60^\circ * \left(\frac{B^1 - R^1}{\triangle} + 2 \right), & Cmax = G^1 \\ 60^\circ * \left(\frac{R^1 - G^1}{\triangle} + 4 \right), & Cmax = B^1 \end{cases}$$

Where, $R^1 = R/255$, $G1 = G/255$ and $B^1 = B/255$

$Cmax = Max(R^1, G^1, B^1)$,

$Cmin = Min(R^1, G^1, B^1)$

$\triangle = Cmax - Cmin$

Saturation Calculation:

$$S = \begin{cases} 0, & Cmax = 0 \\ \triangle / Cmax, & Cmax != 0 \end{cases}$$

Value Calculation:

$V = Cmax$

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Noise removal:

The aim of pre-processing is to improve the image quality by suppressing the unwanted distortion and enhance the input image for further processing. The major noise in the Indian food images is either from the camera sensor or the sensitivity of the camera sensor. To reduce median filter technique is often used to remove camera sensor noise, median filter preserve the edges in the food images while removing noise.

Image cropping:

Indian food image need to go through the cropping to remove the outer part of the image and improve the frame and the aspect ratio of the image. Hence the region is cropped around the images to get the clarity in the image which helps to detect the edge.

Edge Detection:

Once the noise is suppressed and cropping of the image is done. The proposed system utilise the canny edge detection for extracting the Food image region. This module makes use of few arguments to detect the edges. Our Indian food image is passed as an input image which is the first parameter. Next, we pass threshold value (minimum and maximum value). Then the intensity of gradient of edge greater than the maximum value are assured to be edges and those below minimum value are assured to be non-edges, those in-between the threshold is decided based on the connectivity of the sure edge.

Feature Detection and Extraction:

The next phase is to detect the items in the image using histogram and shapes. A rate of repetitions depicts the recurrences in which each different value in a set of data occurs. A histogram is the most commonly used way to display recurrence of the values in dataset. The regularity in data distributed in the representation in terms of shape, determines whether the output of a process is distributed normally. It used for evaluating process that can meet the requirement specification done at the early stages of the system and to measure the changes periodically. For this to accomplish usually histogram gathers at least 50 successive sample data points from a process. The sample histogram graph is show in the below Fig-4. The range in the Fig- 4 shows the left and right space of histogram. Left space shows the aggregate pixels which are darker in the image and right space shows the aggregate pixels which are brighter in the image.

In order to detect shape, the proposed system uses the contours. Contours is a way in which the points/edge detected by above module is been joined to form a continuous curve. It helps to draw any form of graph on condition that you have its boundary edge points having the same colour. Finally, thresholding it to reveal the shapes in the image.

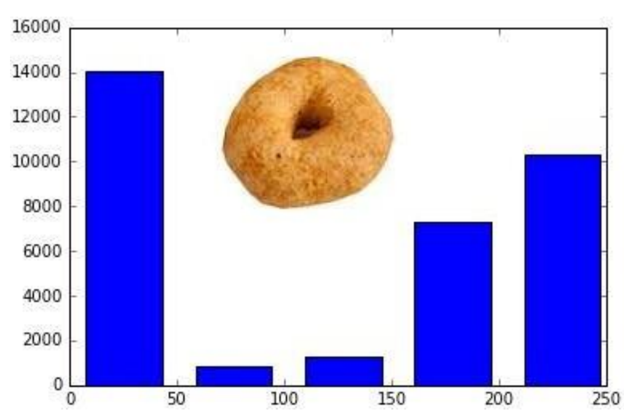

Fig. 4: The Histogram as a bar graph for the inset image

Classification:

Classifications are provided by the computer vision which helps the user to use the algorithm without any difficultly.

K-Nearest-Neighbor Classification

k-nearest neighbor algorithm (KNN) [12, 13] is a widely used classification methods. The closest class will be identified using the Euclidean distance. This algorithm uses the neighbour point's information to predict the target class. Training procedure for this algorithm entails of storing feature vectors and labelling of the training images. In the classification process, the unlabelled point is simply assigned to the label of its k-nearest neighbours.

Euclidean Distance

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1-p_1)^2 + (q_2-p_2)^2 + \cdots + (q_n-p_n)^2}$$
$$= \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}.$$

Normally, the food is categorized based on the labels of its k- nearest neighbors by the maximum number of votes. Classification is performed by comparing features from the image and the dataset. The working of KNN algorithm is showcased in the below pseudo code:

K-Nearest Neighbor

Step 1: For i=1 to M (no of elements in dataset), Calculate the Euclidean Distance

Step2: Calculate the set I containing index for, the K smallest distances (training data is 5,in the samples)

Step3: Return majority label for Y (considering 5 class/cluster)

Support Vector Machine Classification

SVM [14] is the next widely used classification method. The points in the data set are plot on a graph, and then the hyper plane is drawn such a way that the whole plane is divided in to separate classes. This is owing to the indication that the separating plane has the largest distance to the nearest training data points of any class, it sinks the generalization error of the overall classifier. These points are then plotted into that same space and predicted. The working of SVM algorithm is showcased in the below pseudo code:

Support Vector Machine Classify(X)

Step 1: For each i=n (Cluster) to M (no of elements in dataset),

Step2: Calculate the Score for points training data, in the samples

Step3: Remove the lowest score

Merge the other surviving points in to one pool

In proposed paper the feature extracted from the previous section are plotted on the graph. To plotted graph, the classification methods (KNN& SVM) are applied to predict the class based on the colour and shape feature. The hyper plane is drawn between points which differentiate the two classes.

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Matching and Recognition

Template matching is a method for identifying the small chunks of an image which matches an input image or as a way to detect edges in images. If the template input image has strong features, it is recommended to use feature-based approach. The feature we have considered is the colour based which is then represented using the histogram. Computer Vision provides many built in function for this purpose. It basically scans the template image over the Input image (as in 2D convolution) and contrasts the template and patch of input image under the template image [8]. If input image is of size (L*B) and template image is of size (l*b), output image will have a size of (L-l+1, B-b+1) as show in the Fig-5.

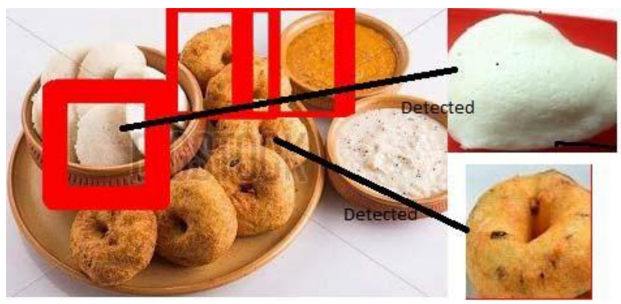

Fig. 5: Feature extracted using the match template function

IV. Results and discussion(if any)

The scattered matric of the dataset is plotted on to the bar graph as show in the Fig 6 for easy understanding and visualisation. The result of the classification is tabulated (Table-1) for better understanding and the same id depicted on the graph .the accuracy samples of both the algorithm is showed in the Fig-7.

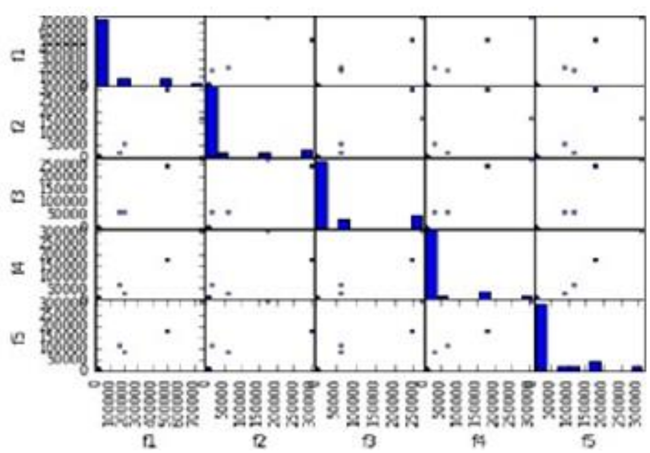

Fig 6: The bar graph of the whole data set in a scattered matric

Table 1: Table showing the accuracy of the algorithms

IMAGES	SVM%	KNN%
RICE	80.13	79.13
CHAPATHI	75.43	70.24
IDLY	75.16	70.03
VADA	50.06	59.56
DOSA	47.25	55
CLUSTERED FOOD	85	75

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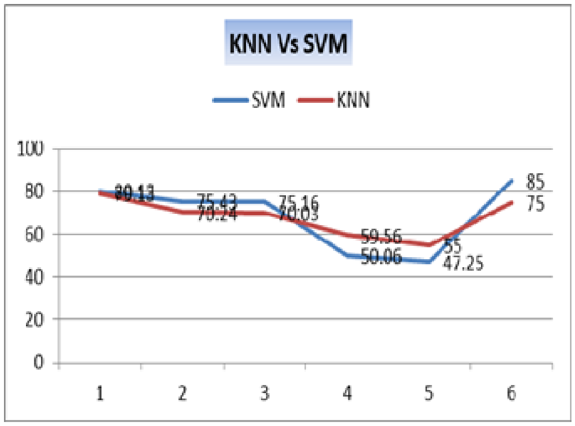

Fig. 7: Graph showing the comparisons of two classification algorithm

V. CONCLUSION

The proposed paper compares the two traditional classifiers KNN and SVM to classify, detect, and recognise food images. The proposed approach was compared based on the performance analysis of both the classifiers. It was evident from the experiments that SVM was performing better classification than KNN. For future work, the proposed system can be evaluated with other classification models and can be combined with data mining to recommend the food to the user

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