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Comparison of Various Classifiers over Type I and Type II Diabetic Food Recognition System

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Abstract

The inability to control the infection of diabetic people, computer-aided automatic food detection system has wedged more attention now days. The food image processing is the most gifted tool is used for food identification. The key point extraction's Scale Invariant Feature Transform (SIFT) algorithm is used to extract the key points from food image, which is used for building visual dictionary of visual words based on color using k-means clustering algorithm. Features can be grouped into separate classes, namely class I and class II using multi-label Support Vector Machine (SVM) classifiers such as SVMlinear, SVMrbf, SVMexp, PARZEN WINDOW and K-Nearest Neighbor (KNN) to identify the input image belongs to which class. Class I have diabetic patient's eatable food images and Class II have diabetic patient's not eatable food images. GLCM use contrast, correlation, energy and homogeneity parameters to measure various calories from food image for diabetic patients. Finally measure and compare the recognition accuracy for various classifiers. The recognition accuracy for various classifiers is used to prove the feasibility of the approach in a very huge food image dataset. This project is about consciousness on food particularly for diabetic patients.
Keywords- GLCM; SIFT; visual dictionary; SVM; PARZEN WINDOW, ANN

I. INTRODUCTION

Diabetic is one of the issues in health board. Diabetic is one of the intricate issues for varies diseases like cardiovascular, neuropathy [1]. The worldwide series physical condition problem of diabetic is fatness. The proper go on a diet of carbohydrate restriction in people is used to improve their health and manage fatness problems. The proper prescription of diet does not contain any side effects. Diabetic metabolism caused by the inadequacy of functional beta-cell mass in two ways such as TYPE-I and TYPE II [2]. Child as well as adults are suffered because of diabetic. TYPE I is a hereditary and unrelieved disease. Because of insulin confrontation and cardiovascular barrier cause TYPE I diabetic in child the diagnosis age for infants was 5 to 6 months earlier and he sugar sweetened beverages are taken for up to 1 year of their life.32% of infant leads to hard risk [3]. TYPE II is a non-talkative disease [4]. Because of inferior BMI, C-peptide and cardio vascular complication cause TYPE II diabetic in adults [5]. "There is no way to cure for diabetic. But you can manage or delay diabetes through exercise, weight control, diet and if necessary, medication" [6]. For eliminating the vagueness caused in low carbohydrate go on a diet is represented in Table 1.

Table 1: Carbohydrate diet for eliminating vagueness

Very near to the view carbohydrate diet	*near to the view carbohydrate diet*	*reasonable carbohydrate diet*	*far above the view carbohydrate diet*	
			>45%	
			man	*Women*
2000 kcal/d of diet	*< 26% total energy*	*26%–45% of total energy*	*2450 kcal/d*	*1550 kcal/d*

II. RELATED WORK

The fast food dataset contains snacks associated food items introduced as PFID have its own benchmarks [18]. Color is the fundamental character of the natural images, which plays a vital role in visual perception. For many years' color component is used for identifying objects and also which concern the spectral properties of the object [8].

In the computer vision based feature extraction, SIFT is performed at the maximum level while testing various images. SIFT is slow, but it has high performance. SIFT's matching based on features to be robust to localization errors. By using small number of dimension image provide the significant benefits for both storage space and matching speed [9]. SIFT strongly depends on local features of the image. If the background has some other objects, the recognition accuracy is best for SIFT with the error rate is less than 1% [12]. The average matching speed of SIFT is about nearly 4 seconds [20].

K-means clustering technique is the widely used clustering technique. There are k initial cluster centres. They are one away from another. It calculates Euclidean distance with their neighbours [13-15].

Bayesian classifier is a supervised parametric classifier. It takes more quantity of parameters. Large number of training sample improves the recognition accuracy performance [24].

SVM assign a label to its object based on threshold values, which act as a classification device. It is based on machine learning. Supervised learning provides more accurate result to stored data [16]. SVM non-linear mapping is transform the original training image into higher dimension. The approximation of such mapping two classes are separated by using its hyper plane. Hyper plane is a decision boundary which separate two classes [17]. SVM's supervised learning method minimizes classification error and maximizes the geometric margin which achieves more generalization performance compared to other traditional methods [21].

Parzen window gives theoretical guarantee for large datasets also give optimum performance. It has minimum error rate. It maximizes classifier performance [24].

KNN gives high-quality performance for most favourable value of k. It is sensitive to distance function. It calculates Euclidian distance [24].

III. PROPOSED FOOD RECOGNITION SYSTEM

A Food recognition process [2] begins when the user enters food image to the system. The images are input, which refer the user's information needs. Normally the information's in the food image database are organized, according to the diabetic system. The given user input food image is matched with nutritional information, perhaps with the degree of relevance. Based on relevant the images are classified whether the food is eatable by diabetic patients or not eatable by diabetic patients. If the food image is diabetic patient's eatable it told whether the food is Type I diabetic eatable or Type II diabetic eatable after measuring the calories from food image by using Gray Level Co-occurrence Matrix (GLCM) [7] such as contrast, correlation, energy, homogeneity. The overall architectural design of food recognition system with two phases including blocks is given in Figure 1.

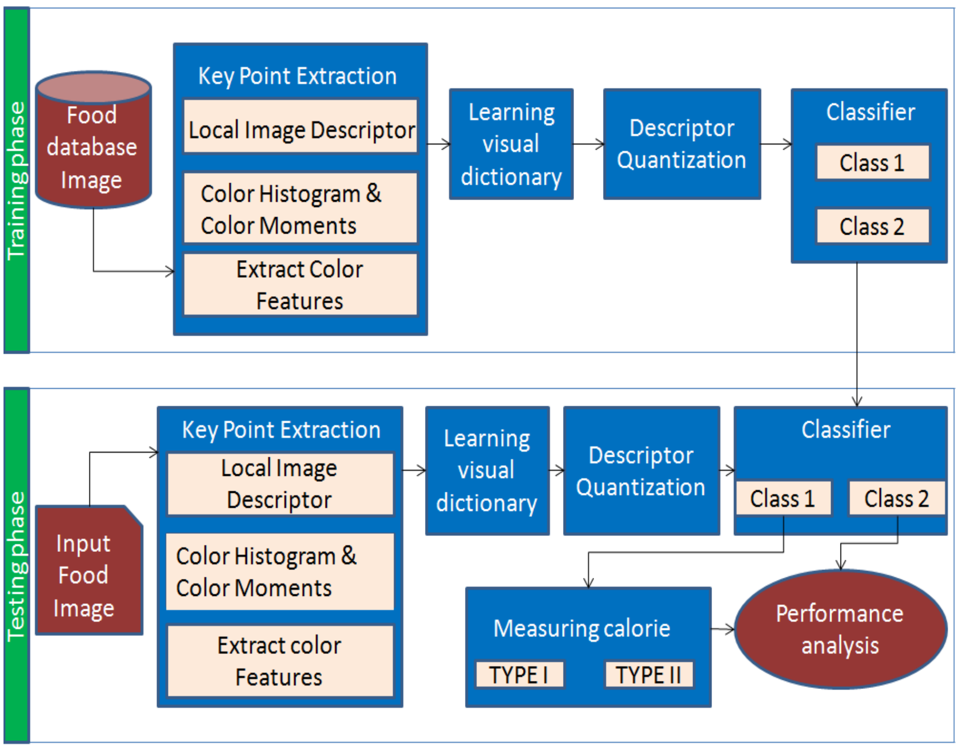

Fig. 1: Block Diagram for diabetic food recognition system

The food image dataset has collection of variety of food images eatable and not eatable by diabetic patients like fruits, fast foods etc…. The visual content of the image is extracted and quantified, which represents the set of food images. It provides input to the next stage, where the classifiers assign food images to two different set of classes Class I and Class II. The design and development of the entire system have two phases. They are named as,

– Training phase
– Testing phase

A. Training Phase

During this phase, the automatic food recognition system learns the acquired knowledge from food image. The BOF model, which proven ability to deal with high visual diversity and the absence of spatial arrangement within each class. BOF consists of four steps [7],

1) Key point extraction
2) Local feature description

3) Learning the visual dictionary
4) Descriptor quantization.
5) Food image classification

1) Key Point Extraction

The key point extractions are used to identify the information about their position and also the coverage area in the image. It assigns a numerical value to the image area [25]. The importance of the key point descriptors are,

- It should be independent of key point position
- It should be robust against image transformations
- It should be scale independent

The key points are selected points in an image. It defines the centre of local patches of an image. Interest point detector, SIFT is the key point extraction algorithm, which is the best choice for image matching problem. It provides stability under local and global image perturbations [27]. It applies Difference of Gaussian (DOG) to different scales of image. It uses two methods for extracting key points from food image in HSV color space such as random sampling and dense sampling.

Random sampling is the method of extracting key points coordinates randomly from food image. It follows uniform distribution. Dense sampling produces a grid on image and extracts features in grid shape [7].

Random sampling SIFT extract local features from image. It creates 16x16 descriptors. It runs over the image and extract color features from food image. SIFT involve following steps [26],

- Scale space extrema detection
- Key point localization
- Orientation assignment
- Key point descriptor
- Matching key points

2) Scale Space Extrema Detection

SIFT uses DOG, which is the rough calculation of LOG. LOG is found out from image with different scale. DOG blur an image with different scales, which is done for different octaves.

3) Key Point Localization

It eliminates low contrast points and edge points from food image. Because DOG have higher response for edges of images.

4) Orientation Assignment

To achieve invariants to rotation, orientation is assigned to each image. It keeps stability of matching.

5) Key Point Descriptor

After creating the key point descriptor, a 16X16 neighbourhood is produced around the key point, which divides the image into 16 sub blocks of size 4X4.The smaller neighbourhood selection does not provide sufficient information.

6) Matching Key Points

It is done by identifying their neighbours. The match between the dataset image and input image may vary by its distance taken by image. It can be corrected during orientation assignment [28].

B. Local Feature Description

To produce a feature, vector a local image descriptor is applied to the rectangular area around the key point after extracting key points from image. Color constitutes one of the valuable sources for image descriptor.

1) Color Histogram

The color histogram represents the color distribution of image. The color histogram representations are,

- Histogram RGB (histRGB)
- Opponent color space (histOP)
- RG normalized channel (histRG$_{norm}$)
- Hue channel (histHUE)
- Transformed RGB color space (RGB$_{trans}$)

C. Learning Visual Dictionary

After training image patch computation, the most representative patches are identified, which will constitute system's visual words. It uses k-means clustering algorithm to create the visual dictionary [108,111].

1) K-Means Clustering Algorithm

To cluster x objects into k partition, where k<x. Euclidean distance is used as a metric to measure the cluster scatter [109,110].

k-means clustering stepladder
Step 1: Begin with conveying value to k. k represent the image is structured into how many clusters. *Step 2: Assigning training samples arbitrarily or methodically.* *Step 3: Compute distance from centroid of each of the clusters.* *Step 4: Repeat the step 3 in anticipation of achieving convergence or in anticipation of pass through the training sample forming no new assignment.*

D. Descriptor Quantization
Assign a feature vector to the closest visual word of a predefined visual vocabulary. If already the visual dictionary is learnt the descriptor of the image is quantized. The histogram values are scaled to [0 1]. Complexity of descriptor depends on the dimension of the descriptor and number of visual words in the dictionary [7].

E. Food Image Classification
The automatic food classification method can be used to increase classification accuracy. The food image classification involves both training and testing phase.

1) SVM
The Support Vector Machine (SVM) is used for classifying the food image weather it is diabetic patients eatable or not. SVM is a multi-label classifier. It is a supervised classification method. The BOF features have SVM with linear and nonlinear kernels.

A support vector machine is a design of classification of both linear and nonlinear data. The pseudocode of working procedure SVM classifier is given below as [33],

2) SVM Linear
Linear SVM is the newest extremely fast machine learning algorithm for solving multiclass classification problems from ultra large data sets that implements an original proprietary version of a cutting plane algorithm for designing a linear support vector machine. The SVM_{linear} can be measured by using the formulae given in equation (1) represented as below,

$$SVM_{linear}\ (A_1, A_2) = A_1 * A_2 \quad (1)$$

Where A1and A2 are feature vectors.

3) SVM RBF
The radial basis function kernel, or RBF kernel, is a popular kernel function used in various kernelized learning algorithms.
The SVM_{rbf} can be measured by using the formulae given in equation (2) represented as below,

$$SVM_{rbf}\ (A_1, A_2) = \exp(-\gamma * \|A_1 - A_2\|^2) \quad (2)$$

Where A1and A2 is feature vectors and γ is the scaling parameter.

4) SVM exp
It is a nonlinear SVM classifier. The SVM_{χ^2} can be measured by using the formulae given in equation (3) represented as below,

$$SVM_{\chi^2}\ (A_1, A_2) = \exp(-\frac{\gamma}{2} * \sum_i \frac{(A_{1i} - A_{2i})^2}{(A_{1i} + A_{2i})}) \quad (3)$$

Where A1 and A2 are the feature vectors and γ is the scaling parameter

5) Parsen Window
In this classification model, a d-dimensional window is created and all the training samples will depend upon the number of patterns that belongs to that window [24]. The probability of those windows can be estimated as

$$K_m(y) = \frac{1}{m} \sum_{j=0}^{m} \frac{1}{w_m} \varphi(\frac{y - y_j}{b_m}) \quad (5)$$

Where w_m is a d-dimensional hypercube in the feature space. φ is a general probability distribution function. $K_m(y)$ is the probability that the pattern belongs to the given class.

6) KNN
It is a machine learning algorithm. It classifies the images based on neighbouring training values stored in feature matrix. The k value is always positive and it calculates Manhattan distance [29, 32]. The formula is represented in equation (6).

$$a(m, n) = \|m - n\| = (\sum_{j=1}^{k} (m_j - n_j)^2)^{\frac{1}{2}} \quad (6)$$

7) Testing Phase
During this phase, the automatic food recognition system recognizes diabetic food or not and also identifies Type 1 diabetic patient's eatable food or Type 2 diabetic patient's eatable food from unknown images after extracting contrast, correlation, energy, homogeneity.

IV. PERFORMANCE MEASUREMENT AND RESULT ANALYSIS

A. Calorie Measurement

The GLCM values are measured by finding out the parameters such as contrast, correlation, homogeneity, energy for measuring the calories from food image [23].

1) Contrast

The contrast is determined by finding out the difference between luminance or color and brightness, which makes the object distinguishable. The contrast of the image can be measured by using the equation (7) as represented below,

$$\text{Contrast}=\frac{\text{Difference in luminance}}{\text{Average luminance value}} \quad (7)$$

2) Correlation

To measure the correlation between pixel values and its neighborhood by using the formulae given in equation (8) as represented below,

$$\text{Correlation}= \sum_{a,b=0}^{Z-1} P_{a\,b}\,\frac{(a-\mu)(b-\mu)}{\sigma^2} \quad (8)$$

Where $P_{a\,b}$ is the probability value of the pixel, (a, b) is the pixel coordinate value, μ is the mean, σ is the standard deviation?

3) Energy

It is used to measure the uniformity. The energy of the image can be measured by using the formulae given in equation (9) as represented below,

$$\text{Energy}=\sum_{a,b=0}^{Z-1}(P_{a\,b})^2 \quad (9)$$

Where $P_{a\,b}$ is the probability value of the pixel, (a, b) is the pixel coordinate value, μ is the mean, σ is the standard deviation?

4) Homogeneity

It is used to measure the degree of variance. The homogeneity of the image can be measured by using the formulae given in equation (10) as represented below,

$$\text{Homogeneity}=\sum_{a,b=0}^{Z-1}\frac{P_{a\,b}}{1-(a-b)^2} \quad (10)$$

Where $P_{a\,b}$ is the probability value of the pixel, (a, b) is the pixel coordinate value, μ is the mean, σ is the standard deviation?

B. System Performance

1) Recognition Accuracy

The performance of the automatic food recognition system is evaluated by using the formulae given in equation (11) as represented below [7],

$$\text{Recognition accuracy}=\frac{\sum_a^Z CM_{aa}}{\sum_a^Z \sum_b^Z CM_{ab}} \quad (11)$$

Where, CM_{aa} is the number of images that belongs to class a and classified in class b. CM_{ab} is the number of images that belongs to class a and classified in class b and Z is the number of classes.

The recognition accuracy values for various SVM classifiers with various food items are given in Table 2.

Table 2: Recognition accuracy for various classifiers

FOODS	SVM_{linear}	SVM_{rbf}	SVM_{exp}	PARZEN WINDOW	KNN
FRUITS	52.5 %	60 %	67.5 %	52.5%	72.5 %
VEGITABLES	55 %	70 %	70 %	60%	72.5 %
JUICES	52.5 %	57.5 %	60 %	55%	67.5 %
SNACKS	47.5 %	80 %	87.5 %	52.5%	90 %
NON-VEG	42.5 %	42.5 %	87.5 %	55%	47.5 %
MISCELLAEOUS FOOD	55 %	42.5 %	27.5 %	47.5%	72.5 %

2) True Positive

A true positive test result is one that detects the condition when the condition is present [113].

3) *True Negative*
A true negative test result is one that does not detect the condition when the condition is absent [113].

4) *False Positive*
A false positive test result is one that detects the condition when the condition is absent.

5) *False Negative*
A false negative test result is one that does not detect the condition when the condition is present.

6) *Sensitivity*
Sensitivity is also called the true positive rate, or the recall. It measures the proportion of positives that are correctly identified. High recall means that an algorithm returned most of the relevant results. It is based on an understanding and measure of relevance. The recall or true positive rate can be measured by using the following formulae given in equation (12) as represented below.

$$Recall = True\ positive\ rat = sensitivity = r = \frac{True\ positive}{true\ positive + false\ negative} \qquad (12)$$

e.g.: the percentage of sick people who are correctly identified as having the condition.
The sensitivity values for various SVM classifiers with various food items are given in Table 3.

Table 3: Sensitivity values for various classifiers

FOODS	SVM_{linear}	SVM_{rbf}	SVM_{exp}	PARZEN WINDOW	KNN
FRUITS	75	75	80	57.1429	90
VEGITABLES	65	80	80	75	85
JUICES	75	65	65	65	80
SNACKS	5	90	95	75	95
NON-VEG	50	50	45	55	50
MISCELLANEOUS FOOD	50	55	75	50	75

7) *Specificity*
Specificity is also called the true negative rate. It measures the proportion of negatives that are correctly identified. The sensitivity or the true negative rate or specificity can be measured by using the following formulae given in equation (10) as represented below,

$$True\ negative\ rate = Specificity = \frac{True\ Negative}{True\ Negative + False\ Positive} \qquad (10)$$

e.g.: the percentage of healthy people who are correctly identified as not having the condition
The specificity values for various SVM classifiers with various food items are given in Table 4.

Table 4: Specificity values for various classifiers

FOODS	SVM_{linear}	SVM_{rbf}	SVM_{exp}	PARZEN WINDOW	KNN
FRUITS	70	55	45	57.8947	45
VEGITABLES	55	40	40	55	40
JUICES	70	50	45	65	45
SNACKS	10	30	20	45	15
NON-VEG	65	65	90	55	55
MISCELLANEOUS FOOD	40	70	40	53.87	30

8) *Accuracy*
The accuracy can be measured by using the following formulae given in equation (11) as represented below [31],

$$Accuracy = \frac{True\ Positive + True\ Negative}{True\ Positive + True\ Negative + False\ Positive + False\ Negative} \quad .....(11)$$

The accuracy values for various SVM classifiers with various food items are given in Table 5.

Table 5: The accuracy values for various SVM classifiers with various food items

FOODS	SVM_{linear}	SVM_{rbf}	SVM_{exp}	PARZEN WINDOW	ANN
FRUITS	0.6500	0.6500	0.6250	0.5750	0.6207
VEGITABLES	0.6000	0.6000	0.6000	0.6500	0.5862
JUICES	0.5750	0.5750	0.5500	0.6000	0.5926
SNACKS	0.6000	0.6000	0.5750	0.6250	0.5278
NON-VEG	0.5750	0.5750	0.6750	0.5674	0.5263
MISCELLANEOUS FOOD	0.6250	0.6250	0.5750	0.6000	0.5172

9) Roc Curve

ROC means Receiver Operating Characteristics Curve. Relation between the sensitivity and specificity are represented by ROC curve. The ROC curve is represented in Figure 3.

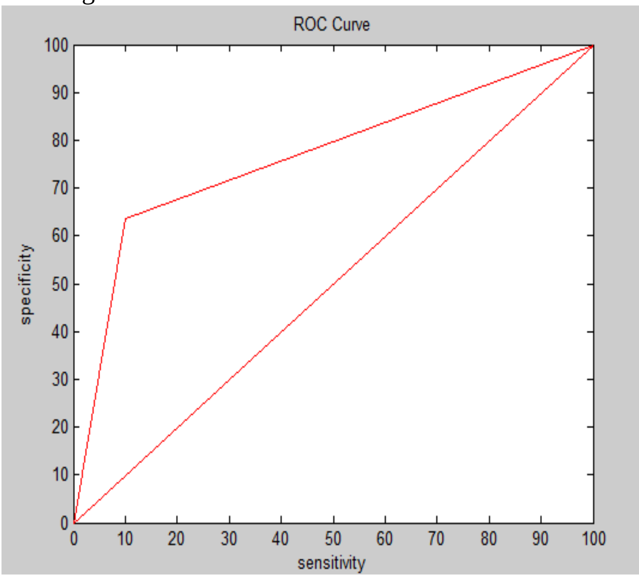

Fig. 3: ROC curve

10) Confusion Matrix

A confusion matrix is a table that is often used to describe the performance of a classification model on a set of test data for which the true values are known. The confusion matrix representation is represented in Figure 4.

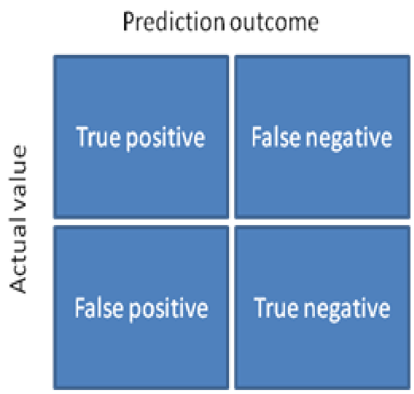

Fig. 4: Confusion matrix representations

The confusion matrix values for various SVM classifiers with various food items are given in Table 6.

Table 6: confusion matrix values for various classifiers

FOODS	SVM_{linear}	SVM_{rbf}	SVM_{exp}	PARZEN WINDOW	ANN
FRUITS	15 5 6 14	15 5 9 11	16 4 11 9	12 9 8 11	18 2 11 9
VEGITABLES	13 7 9 11	16 4 12 8	16 4 12 8	15 5 9 11	17 3 12 8
JUICES	15 5 6 14	13 7 10 10	13 7 9 11	15 5 6 14	16 4 11 9
SNACKS	1 19 2 18	18 2 14 6	19 1 16 4	1 19 2 18	19 1 17 3
NON-VEG	10 10 7 13	10 10 7 13	9 11 2 18	10 10 12 8	1010 9 11
MISCELLANEOUS FOOD	10 10 12 8	11 9 6 14	15 5 12 8	1 19 2 18	15 5 14 6

11) Precision

Precision takes all retrieved diabetic food image into account, but it can also be evaluated at a given cut-off rank, considering only the topmost results returned by the system. This measure is called precision at n. High precision means that an algorithm returned substantially more relevant results than irrelevant. The precision or positive predictive value can be measured by using the following formulae given in equation (12) as represented below.

$$Precision = Positive\ predictive\ value = p = \frac{True\ Positive}{True\ Positive + False\ Positive} \quad (12)$$

The Precision values for various SVM classifiers with various food items are given in Table 6.

FOODS	SVM_{linear}	SVM_{rbf}	SVM_{exp}	PARZEN WINDOW	ANN
FRUITS	0.7143	0.6250	0.5926	0.6000	0.9000
VEGITABLES	0.5909	0.5714	0.5714	0.6250	0.8500
JUICES	0.7143	0.5652	0.5417	0.4545	0.8000
SNACKS	0.0526	0.5625	0.5429	0.7143	0.9500
NON-VEG	0.5882	0.5882	0.8182	0.0526	0.5000
MISCELLANEOUS FOOD	0.4545	0.6471	0.5556	0.5556	0.7500

12) F Measure

It is a final measurement used for measuring the mean between precision and recall value. It can be represented in the equation (13) as given below,

$$F_{measure} = \frac{2pr}{p+r} \quad (13)$$

Where p is the precision and r is the recall.

The F-measure values for various SVM classifiers with various food items are given in Table 8.

FOODS	SVM_{linear}	SVM_{rbf}	SVM_{exp}	PARZEN WINDOW	ANN
FRUITS	0.7317	0.6818	0.6809	0.5854	0.6750
VEGITABLES	0.6190	0.6667	0.6667	0.6818	0.6939
JUICES	0.7317	0.6047	0.5909	0.4762	0.6809
SNACKS	0.0513	0.6923	0.6909	0.7317	0.6786
NON-VEG	0.5405	0.5405	0.5806	0.0513	0.5128
MISCELLANEOUS FOOD	0.4762	0.5946	0.6383	0.638	0.6122

13) Analysis

Comparison of various classifiers with recognition accuracy chart is in Figure 5.

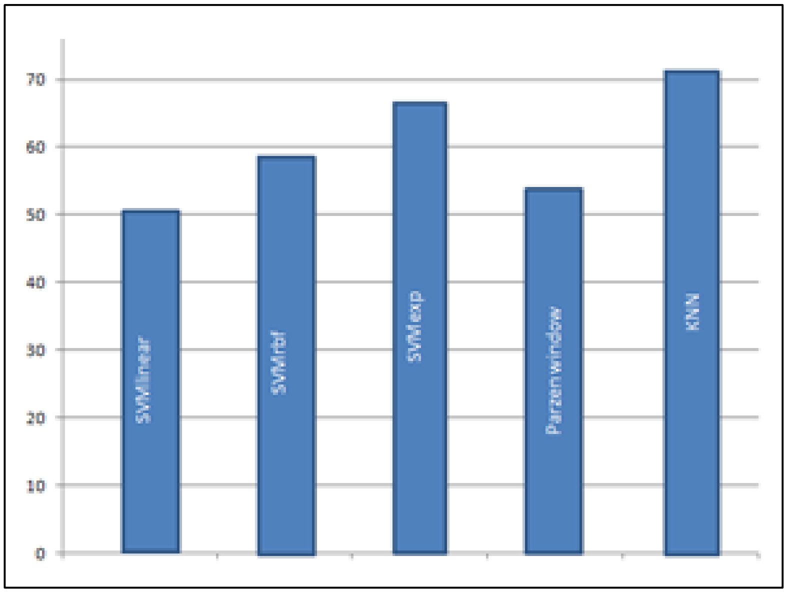

Fig. 5:

V. CONCLUSION AND FUTURE ENHANCEMENT

This paper proposed a computer vision based bag-of-feature model to improve the recognition accuracy for food image classification to diabetic patients. It provides dietary advice to people, who are suffered by diabetic disease and also it helps to prevent from diabetic disease. To reduce the misclassification rate of food images and to increase the dataset size in future it more helpful to disease control and prevention for people. SVM classifier such as $SVM_{linear}, SVM_{rbf}, SVM_{exp}$ and PARZEN WINDOW, ANN classifier results 50.83%, 58.75%, 66.67%, 53.75%, 71.44% are compared to the ANN classifiers result 71.44% give more accurate result compared to other classifiers result. For future work, a hierarchical approach will be investigated by merging visually similar classes for the first levels of the hierarchical model, which can then be distinguished in a latter level by exploiting appropriate discriminative features. The final system will additionally include a food segmentation stage before applying the proposed recognition module, so that images with multiple food types can also be addressed. As a final stage, food volume will be estimated on the basis of multi-view reconstruction of its 3D shape and CHO content will be calculated on the basis of previous results and corresponding nutritional tables.

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