Food Recognition for Diabetic Patients using Bag-of-features Model based System

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Abstract— In this research, food recognition system based on the bag-of-features (BoF) model for diabetic patients is proposed to design. The extensive investigation is carried out based on the aforesaid dataset for components and parameters inside the BoF architecture to be optimal. The testing and comparative assessment of three extraction techniques based on key point, fourteen local image descriptors, two clustering techniques for visual dictionary creation and six classifiers is carried out. Also testing of fusion of descriptors and selection of feature is carried out. Furthermore, the effects of parameters such as number of key points extracted, size of descriptor and number of visual words are demonstrated.

IndexTerms - Food recognition, Diabetic patients, BoF model, SVM, ANN, RF classifier

I. INTRODUCTION

Food is the cornerstone for life of people's. These days an ever increasing number of individuals think about the dietary admission since unfortunate eating routine prompts various maladies, similar to heftiness and diabetes. Precisely naming food things is altogether fundamental to enable us to stay in shape and carry on with a sound life. Be that as it may, as of now alluding to sustenance specialists or Amazon mechanical Turk is the best way to perceive the food class. Diabetes is a ceaseless illness that happens when the human pancreas does not deliver enough insulin[1], or when the body can't viably utilize the insulin it produces, which prompts an expansion in blood glucose levels. Regularly, after a feast, the body separates the nourishment (food) into glucose, which is conveyed by the blood to cells all through the body. The cells utilize insulin, a hormone made in the pancreas, to change over the blood glucose into vitality. Individuals with diabetes have issues in doing such a transformation prompting weariness and numerous different genuine confusions[2].

Late finding as well as dishonorable control of diabetes can prompt numerous genuine complexities: harm to the eye (prompting visual impairment), kidney (prompting renal disappointment), and nerves (prompting weakness and foot issue with conceivable removal). Too, it builds the danger of coronary illness, stroke, and decreases future. Diabetes has as of late turned out to be a standout amongst the most widely recognized maladies around the globe, where in year 2000, 171 million individuals overall experienced diabetes. This number is relied upon to increment to 366 million by the year 2030. There are three sorts of diabetes, specifically:

i. Type 1 diabetes mellitus (T1DM) or some of the time called adolescent diabetes, is the kind of diabetes that outcomes from halting the insulin age by the pancreas beta cells. It is the most extreme sort of diabetes among the greater part of alternate ones. It is predominant among youngsters and requires a few insulin infusions every day to bring the patient's glucose levels under control[3].

ii. Type 2 diabetes mellitus (T2DM), or the purported grown-up beginning diabetes, is the most widely recognized sort of diabetes, where it bargains 90% of diabetic populace around the world. Individuals can create T2DM at any age. This type of diabetes normally begins with insulin protection, which in the end prompts the loss of the pancreas capacity to create enough insulin in light of nourishment admission.

ii. Gestational diabetes is the kind of diabetes influencing a few ladies amid pregnancy as it were.

A versatile application for monitoring eating regimen is ending up more imperative for individuals to keep solid. Applications, for example, MyFitnessPal2 and LoseIt3 for this reason for existing are very famous. These applications ask clients to physically type watchwords in the hunt enclose and select the sustenance the returned list. Typically it finds a way to record only one sustenance thing which demoralizes consistent employments of those applications. With the pervasiveness of cell phone cameras, taking a photograph of the food is a perfect strategy to advantageously log abstains, from food information. There has been existing work [4, 5, 6] utilizing image based sustenance acknowledgment procedures to break down the food images and help record the sustenance certainties. In any case, most existing methodologies are either requiring client input or are still in crude stage with low precision rate. Besides, despite the fact that a couple of existing methodologies [7, 8, 9] tended to the issue of perceiving various sustenance things, they accepted the accessibility of a great deal of preparing information with ground truth bouncing boxes. Most existing work accepted that one food images contained just a single food thing, along these lines couldn't deal with images which contained at least two food things. In this manner, a strategy that can consequently arrange different sustenance things in a camera picture taken under genuine conditions is fundamental for the achievement of a food recording framework[10]-[13].

II. PROPOSED SYSTEM

The proposed system for food recognition is design in two stages, the first stage is food image description and second stage is food image classification. The architecture for proposed BoF model based food recognition system is shown in Fig.1. In the food image description stage a set, of characteristic, representation of the visual content of image of food image is extracted and also quantified. The set of characteristic extracted and quantified in first stage is provided as input to the second stage i.e food image classification stage, where a classifier assigns to the image one class out of a predefined set of food classes.

The design of food image description and food image classification stages involves training and testing phases. In training phase, the food recognition system learns from the obtained knowledge and in testing phase food types are recognized by the system from new, unknown images. The proposed system is appropriate for dealing generic food description because of using BoF model and the BoF architecture contains parameters and components which are optimal. The BoF display has demonstrated capacity to manage high visual assorted variety, and the nonappearance of run of the mill spatial course of action inside each class. So BoF demonstrate is received to show the presence of the different food classes.

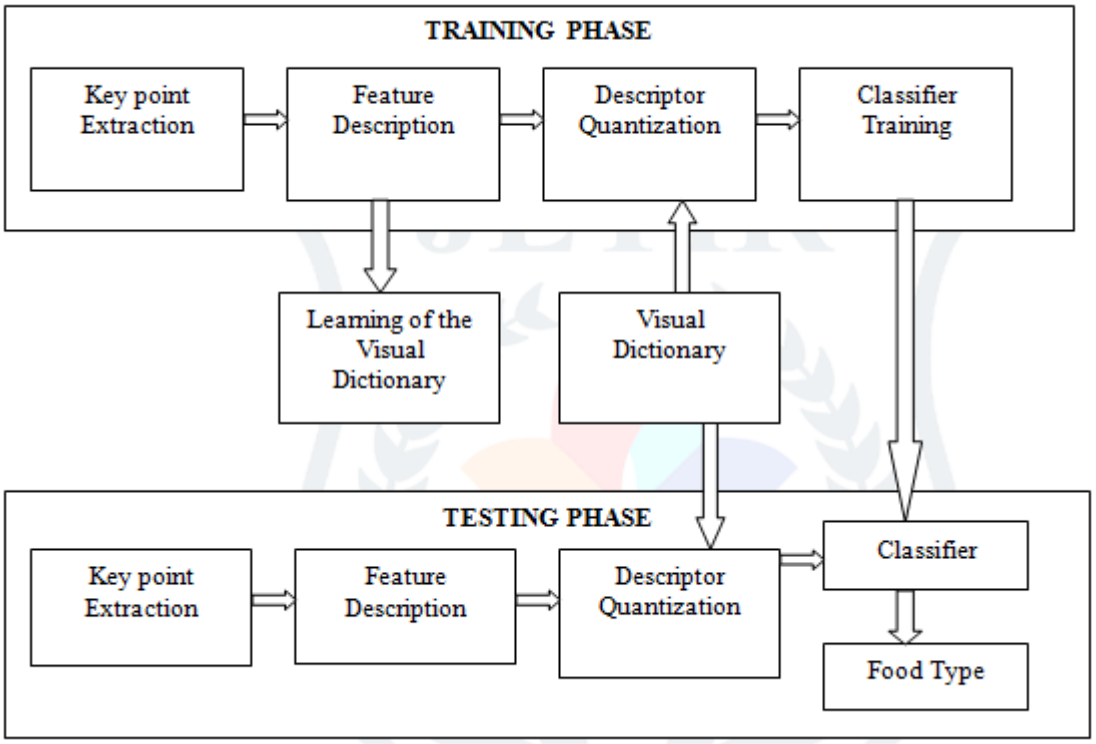

Fig.1 the Architecture of Proposed Food Recognition System Based on BoF Model.

A. System Design & Implementation

The modules of proposed system are implemented using Microsoft Visual studio 2012 and SQL server 2012 is as follows:

1. Food Image Description: key point extraction, local feature description, learning the visual dictionary and descriptor quantization
2. Food Image Classification: Support Vector Machine (SVM), artificial neural network (ANN) and Random Forests (RF)

The food image classification step is involved in training and also in testing phases of food recognition system. In this proposed system several experiments has been conducted to recognize the suitable classifier for the specific problem using supervised classifications techniques such as SVM, ANN, and Random Forests.

i. Scale invariant feature transform (SIFT) algorithm :

In 2004, D.G Lowe [14], has proposed Scale invariant feature transform(SIFT) matching algorithm. SIFT is a feature detector and it is very efficient for food image recognition. SIFT detector is used for extraction of significant key points set in a food image. The key points (feature vectors) extracted are distinctive and invariant to scaling, rotation and translation of food image. Assignment of image orientation is carried out to achieve rotation invariance because representation of key point descriptor will be with respect to orientation and consequently achieves image rotation invariance. The food image feature locations are determined as the local extrema of Difference of Gaussians (DOG pyramid) as given by (3). To implement the DOG pyramid the input food image is convolved iteratively with a Gaussian kernel given by (2). This process is repeated as long as the down-sampling is possible. Each collection of food images of the same size is called an octave. All octaves build together the so-called Gaussian pyramid given by (1), which is represented by a 3D function $L(x, y, \sigma)$:

$$L(x,y,\sigma) = G(x,y,\sigma) * I(x,y), \tag{1}$$

$$G(x,y,\sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2} \tag{2}$$

$$D(x,y,\sigma) = (G(x,y,\sigma) - G(x,y,\sigma)) * I(x,y) = L(x,y,k\sigma) - L(x,y,\sigma). \tag{3}$$

ii. **Support vector machine (SVM) classifier algorithm:**

The SVM classifier uses linear kernels and it is most widely used classifier among the Bag-of-Features approaches[15]. In SVM classifier independent test dataset is classified by construction, training and testing of SVM model[16]. After this calculation of accuracy, true positives, and false positive rates is carried out and extraction of rules is done by using sequential covering approach for rule extraction SQRex-SVM(Sequential Covering Approach for Rule Extraction) and Eclectic Rule Extraction methods[17][18].

Step1: the SVM classifier is trained using a labeled dataset and acceptable accuracy is reached

Step2: support vectors are constructed using the predicted class of SVM classifier as the target class

Step3: C5 decision tree is used to extract rules from the newly constructed dataset.

$$\text{Linear: } k_{\text{linear}}(\mathbf{x}_1, \mathbf{x}_2) = \mathbf{x}_1^T * \mathbf{x}_2 \tag{4}$$

$$\text{RBF: } k_{\text{RBF}}(\mathbf{x}_1, \mathbf{x}_2) = \exp\left(-\gamma * \|\mathbf{x}_1 - \mathbf{x}_2\|^2\right) \tag{5}$$

$$\exp X^2: \quad k_{X^2}(x_1, x_2) = \exp\left(-\frac{\gamma}{2} * \sum_i \frac{(x_{1i} - x_{2i})^2}{x_{1i} + x_{2i}}\right) \tag{6}$$

where x_1 and x_2 are feature vectors, γ is a scaling parameter.

iii. Artificial neural network algorithm

ANN mode as shown in Fig.2 is an interconnection of nodes (neurons) that are arranged in input, hidden, and output layers[19]. In our proposed system a linear without hidden layers feed forward ANN model (ANNnh) and a nonlinear with hidden layer feed forward ANN model (ANNwh) are used. The training of feed forward ANN models is carried out using two algorithms.

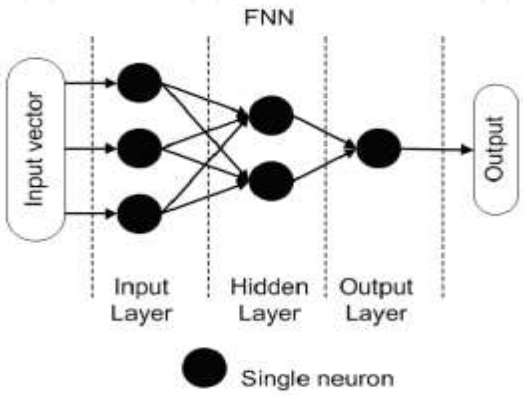

Fig.2. Feed Forward Artificial Neural Network[19].

The algorithm such as simple gradient descend algorithm is used to train the ANNnh and the scaled conjugate gradient back propagation algorithm is used to train the ANNwh.. The ANNnh and ANNwh are fully connected through randomly primary weights are chosen in the range (–1.0, 1.0). The trial and error process is employed to determine the topology of ANNwh and internal parameters. The saturated linear is used as activation function for the output layer and the activation function used for hidden layer is hyperbolic tangent sigmoid. The trial and error process is employed to determine the ANNwh topology and the internal parameters.

iv. Random Forests (RF) classifier

RF classifier as shown in Fig, 3 is a group of decision trees and every tree depends on values of random vector[20]. The random vector values are sampled independently in the forest to all trees. In this paper, one RF consist of 31 trees is used for the experiments. The advantages of Random Forests (RF) are extreme efficiency, training simplicity and able to provide estimates of variables importance

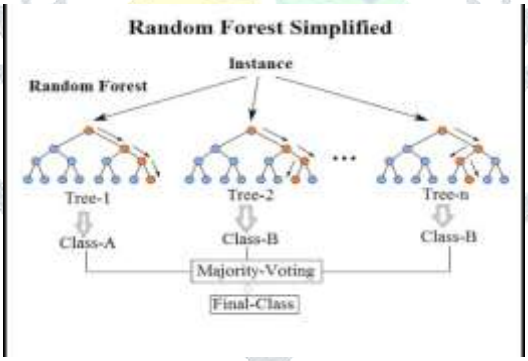

Fig.3. Diagram of Random Forest[20]

III. RESULTS AND DISCUSSION

The result varies from input to input. The snapshot makes the user understand easily the working operations in the proposed system. Fig.4 shows the details sensed data of diabetic patient such as Blood pressure, blood sugar, heart beat and body temperature. This report is sent to doctor and doctor will see this report and recommend the food.

i. Patient Login

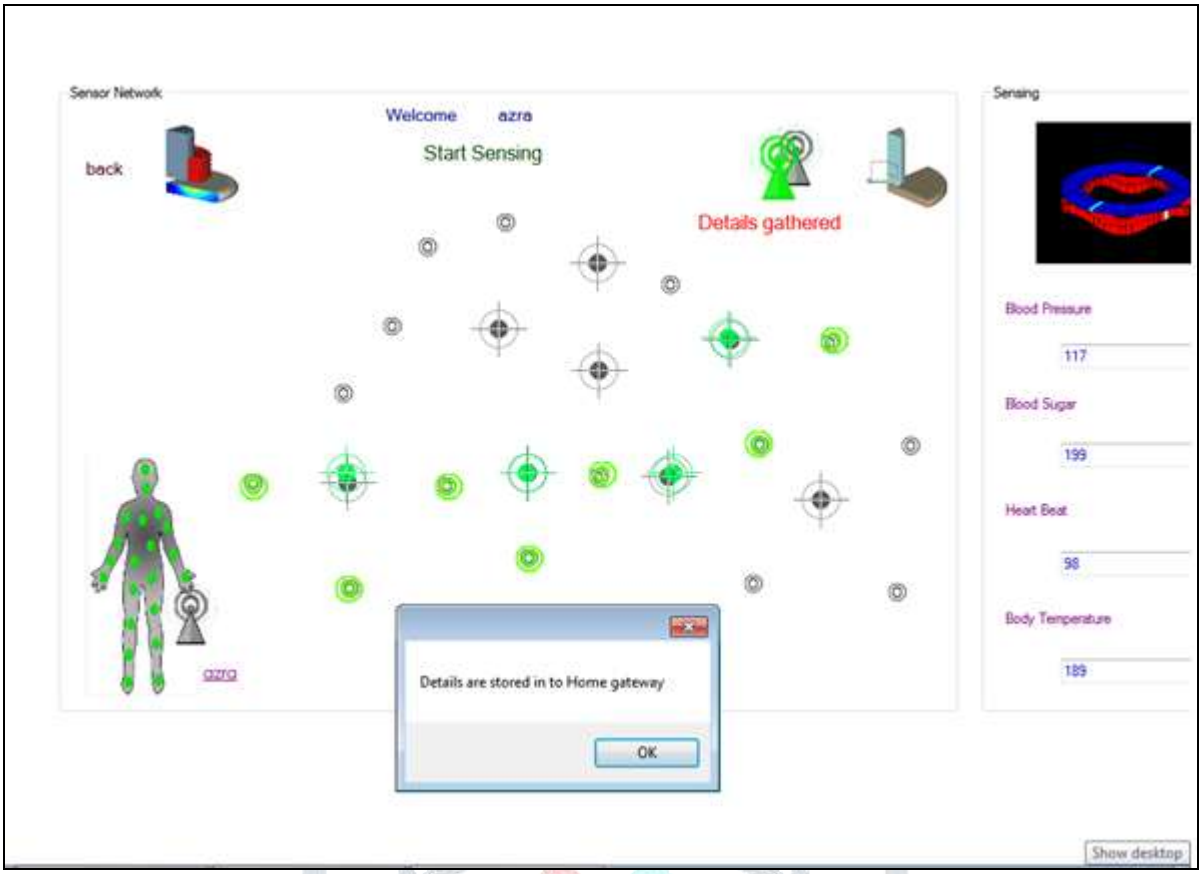

Fig.4 Patients Body Sensor Details

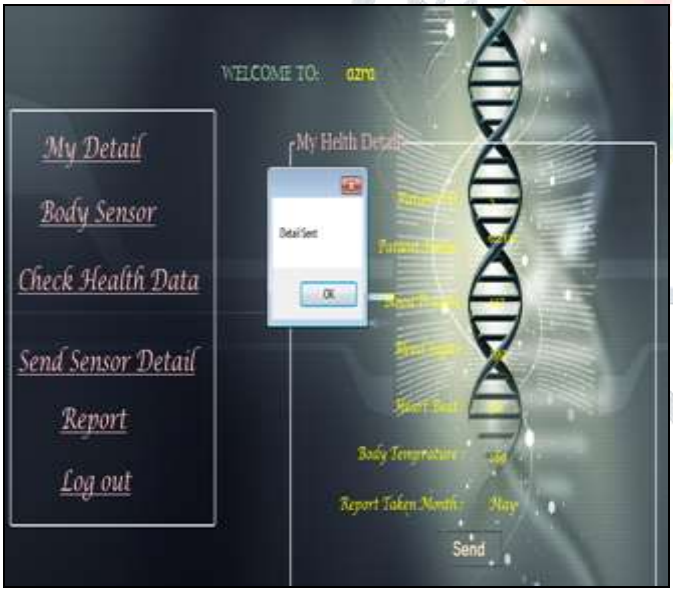

Fig.5 Patient's Body Sensor Details Sent

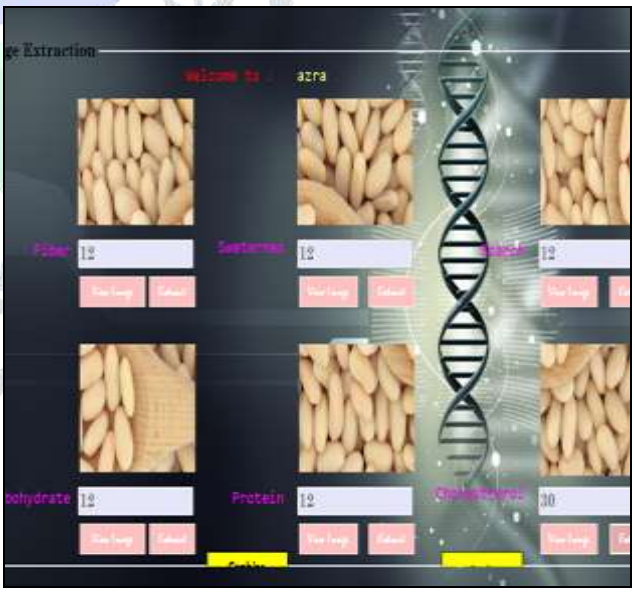

Fig.6 Patient's Food Recommendation

Fig.5 shows the patient's body sensor data sent to doctor verification and recommendation of food. Fig.6 and Fig.7 shows food recommended to diabetic patients by doctor after verification of sensor report sent by patient.

Fig.7 Patient's Food Recommendation (combined)

Fig.8 Doctor Login: Patient's Detail

Fig. 8 illustrates the doctor login: different patient's details such as ID, name, gender, age, email and city. From this doctor will select the patient name and gets the details report sent by the patient.

ii. Doctor login

Fig.9 Patient's Health Details

Fig.10 Different Food for Patient's Recommendation

The result of doctor login shows the diabetic's patient health details, and different food for patients recommended. In Fig 10 the doctor will select the food according the patients report received and recommend the food.

Fig.11 Food Details for Patient

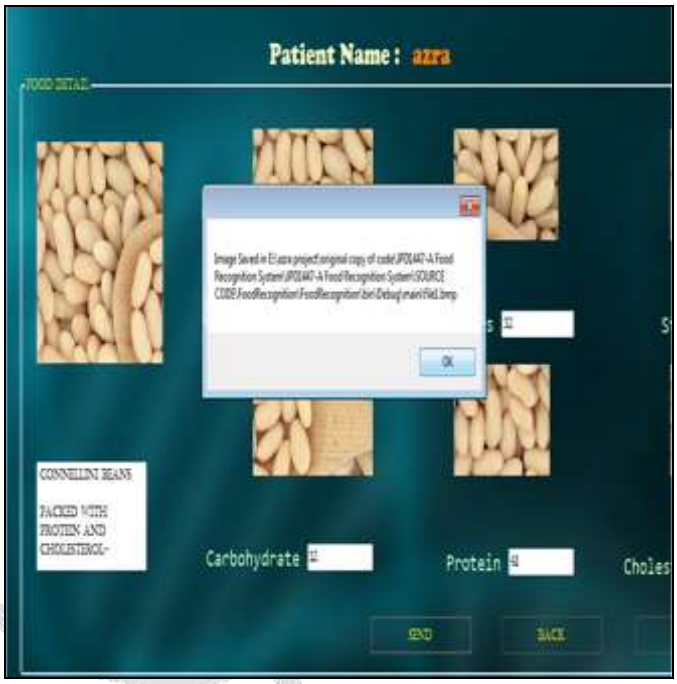

Fig.12 Patient Food Images Saved

Fig.11. illustrates the details of food, Fiber, protein, carbohydrates etc recommended by doctor to patient. Fig.12 describes the doctor recommendation details sent to patient and it is saved in patient database.

iii. CONCLUSION AND FUTURE WORK

We have designed and developed a food recognition system using BoF model for diabetic patients. The BoF architecture is suitable for dealing generic food description and different food classes. The BoF model has a capacity to manage high visual assorted variety. The proposed recognition system for food image dataset is successfully implemented and executed. The execution results illustrates that the designed food recognition system is efficient and optimal.

In future the food recognition system module can be rebuild using different sensors. Also, the hierarchical classification approach can be investigated and food segmentation stage is applied for addressing of multiple food types images.

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