Health Monitoring System Based on Diet Evaluation

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Abstract- **Today every second person is detected with some disease. This disease ranges from Asthma to Obesity. Diseases (in terms of severity and chronicity) are directly proportional to medical cost. As a result, diet and physical activities are considered as the most important lifestyle factor for self-managing and preventing many chronic diseases. An effective solution for nutrition assessment is necessary. In this paper we have discussed the implementation of a health monitoring system based on diet evaluation. Firstly, a mobile application is built through which daily diet intake in the form of voice is recorded using natural language processing along with few processing techniques such as preferred food survey, speech recognition and mobile computing. Based on the food intake, a healthy weekly diet is suggested depending on the target calories consumed. It has an excellent performance in machine learning problem.**

Index terms- **Speech Recognition, Natural Language Processing, KNN, Mobile computing.**

I.INTRODUCTION

Obesity is a very common problem in today's world as many people spend most of their time sitting, with little or no exercise at all on a daily basis. Consumption of heavy calories based diet with minimal or no physical exercise to compensate it with, is found to be scientifically converted into an additional layer of fats on the body. It is therefore essential to have a healthy diet with the right proportion of calories to be consumed by an individual, as per the target calories set for the individual based on their Body Mass Index (BMI). Diet self-monitoring which involves meal recall and food frequency questionnaires is one of the earliest nutrition assessment technique based on pen and paper approach.

Although these approaches are somewhat successful in getting the approximate results, the detailed self-monitoring can be cumbersome, time consuming and erroneous. Hence we adopt a more objective method of using technology such as smartphone application that allows user to enter the diet data. The application has an underlying platform which provides natural language processing for speech to text conversion of data, which is then identified and matched with the data present in the nutritional dataset. Subsequently the calorie intake is calculated and the diet evaluation procedure takes place for the aforesaid time for the target calories consumption. This technology addresses the limitations of previous nutrition monitoring systems and enhances scalability and utility of mobile nutrition monitoring along with diet evaluation.

In addition to natural language processing, the different techniques like tokenization, lemmitization, sentence segmentation, POS tagging, and named entity recognition have been used for the extraction of food item from the text, to be matched later on with food items present in the food dataset. The daily target calorie for individual is set based on the Basal Metabolic Rate.

II. LITARATURE SURVEY

According to Niloofar Hezarjaribi, Sepideh Mazrouee, and Hassan Ghasemzadeh [1]. Their proposed system is based on voice which provides speech processing, natural language processing, and text mining technique to facilitate nutrition monitoring. After converting the spoken data to text, nutrition-specic data are recognize within the text using an NLP-based approach that combines standard NLP with the pattern mapping technique. A excellent matching algorithm is developed to search the food item name in the nutrient database and accurately compute calorie intake values. String matching algorithm is used as a class of algorithm with aim of finding location of a given pattern within a larger string or text.Speech2Health is evaluated using real data collected with 30 participants. The experimental results show that this system achieves an accuracy of 92.2 in computing calories intake

According to Ayushi Tivedi, Naya Pant, Simran Sonik and Supriya Agrawal[2].This paper includes various techniques for speech to text and text to speech and their application and usage. It specifies which system works as a better speech to Text. It also deals with grammatically correct sentences. It observes various techniques and determines best machine translation technique for speech to text. Under speech recognition, the method i.e. pre-emphasis of signals, feature extraction and recognition of the signals which helps in the training and testing mechanism. The conversion of speech to text uses two, models such as DTW and HMM models, along with various models since they work well with phoneme classification.

Niloofar Hezarjaribi, Cody A Reynolds, and Naomi Chaytor elaborates framework for voice based nutrition monitoring, and builds a data processing modules which have been developed using text analysis and Natural Language Processing. Speech-to-nutrient-information (S2NI) is comprehensive nutrition monitoring system that combines speech processing, NLP, and text mining in a unied platform to extract nutrient information such as calories intake from spoken data. Then it develops a matching algorithm to search the food name in the database and to accurately compute calorie intake. S2NI allows users to update their diet routine frequently and at any time through their smart devices such as smartphone [3].

According to Joel Rodrigues, Bruno M Silva, Isabel De la Torre Diez, Ivo M.C. Lopes [4]. SapoFit is a mobile system that takes from users, such as like weight, age, and height. System also takes food and exercise as an input. This data is updated on user profile through web service for easy and immediate access. The user profile makes use of the personal health record for showing the user’s health related status. This status includes their Body Mass Index, user daily calories intake, and energetic needs. The PHR is nothing but personal health record. Through the SapoFit mobile system they kept their user well motivated not only to use the application, but also to lose weight. All collected data is saved on a remote database through HTTP on SOAP and REST web services that furnish all the required information. SapoFit targets mobile devices running android and iPhone platform. They provide java programming solution for development.

According to Christopher C. Tsai, Gunny Lee, Fred Raab, Gregory J. Norman, Kevin Patrick, and Timothy Sohn [5] in recent days obesity is a major public health challenge. Their studies concluded that over 65 of U.S. adults are either overweight or obese. Estimated annual costs of obesity are around 78.5 billion and self-monitoring is a critical and difficult task for successful weight management. This problem is reported with help of Patient-Centered Assessment and Counseling Mobile Energy Balance (PmEB) cell phone application that allows users to self-monitor caloric balance in real time. The PmEB client application runs on the user’s phone while a server side application runs on the web application, and a web interface which allows users to register and personalize the mobile client. The client application is built using Java 2 Mobile Edition (J2ME) and the server application using Tomcat.

According to M. Nestle [6] the diet and physical activities has been critical lifestyle interventions for self-management and prevention of many chronic diseases. It uses the political system and marketing to influence the people's food choices, and the government's policies to sell its product. Thus, this influence affects people's health.

G. Ciocca, P. Napoletano and R. Schettini in Proc. Workshops New Trends [7] proposed system for automatic dietary monitoring of canteen customers that is based on robust computer vision techniques for automatic food recognition and leftover estimation in a canteen scenario. The problem of food recognition is still a challenging problem because of variation in the tray and plate composition. The system is able to identify and recognize the food category and estimate the amount of food in each plate. They designed system to evaluate both leftovers and allowing estimation of the truly consumed food. They stated food consumption is associated to the user identify through the use of visual marker on their mobile phone.

According to J. Cheng, B. Zhou, S. Wille, N. Wehn, J. Weppner and P.Lukowic [8]. They determine an enriched version that supports long-term monitoring of particular behaviors with a neckband connected to the smart phone using a low power Bluetooth module. They proposed statistical distribution of consume frequency and head motion can be detected definitive enough to be a indication of definite activities. In an initial experiment with a data set of 138 hours from 3 subjects they were able to detect meals, sleeping and spot three activities levels: 1.Fully quiet (e.g. watching TV), 2.normal (e.g. working on a computer) and 3.highly physically active (e.g. walking). The system comprises of a textile neckband with 4 sensors which operates at a sampling rate of 25Hz.

M. Korpusik, C. Huang, M. Price, and J. R. Glass [9] demonstrate a signicant improvement in semantic tagging performance by adding word embedding features to a classier. It inspects features for both the raw vector values and similarity to illustration words from each category. In addition, improving semantic tagging performance benets the subsequent task of associating foods with properties. The paper also builds a nutrition speech recognizer for assess the language understanding models on spoken data. It also estimates the system based on the user study of Amazon Mechanical Turk.

According to Philip R. Cohen and Sharon L. Oviatt [10] there are a number of situations had been specified in which spoken communication with machine may be advantageous like when the user's hand or eye are busy, when only limited resources are available, when the user is disabled, when a pronunciation is the subject matter of computer use, when natural language interaction is preferred. Their survey briefly examines the present and future roles of spoken interaction with computers for various environments. Since spoken natural language interaction is one of the difficult tasks to implement.

According to Marios M. Anthimopoulos, Lauro Gianola Luca Scarnato, Peter Diem, and Stavroula G. Mougiakakou [11] there are two stages of food recognition 1. Food image description and 2.Image classification. Food image description and image classifier provides input to second stage and an image is assigned to one class by the classifier from a predefined set of foods classes. It has two phases i.e training and testing phase. In the training phase, the system learns from the knowledge acquired, while in the testing phase the system recognizes the type of food from unknow food image. The design and development involves two stages: training and testing.

III. PROPOSED METHODOLOGY

The proposed system deals with speech-to-text and diet chart module. Health monitoring system based on diet evaluation is an android application developed using Android studio for the excellent user interface, and it provides a client-server architectural paradigm as a backbone of the application. The system implements machine learning model i.e. KNN model which is used for the prediction of diet based on his/her calories consumption. The diet charts are prepared based on standard diet charts and recommended by a doctor as well as in accordance with the medical conditions stated by the user.

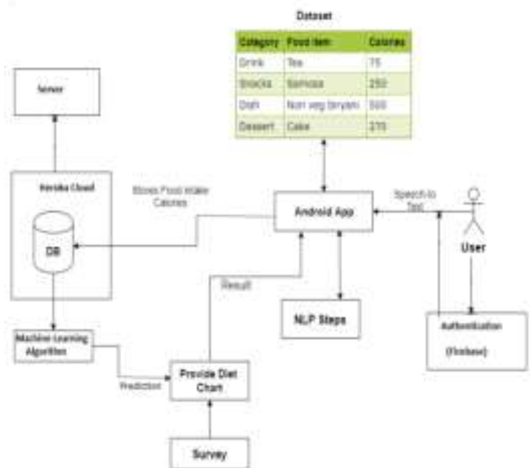

Fig 1: Proposed System Architecture

The application is built to be scalable and feasible from anywhere. Due to this, instead of a localhost server, we propose the usage of a cloud services technology heroku which allows even remote access to the server by a client from anywhere to use the application and gain significant knowledge about his/her diet. The information stored on the heroku cloud can be accessed by the server in terms of requests and responses. We are using Flask-Api as an intermediate connectivity between Android studio and python. The information exchange take place in terms of JSON objects and GET and POST methods are used for obtaining information or storing information respectively in a database present at the server. The proposed health monitoring system uses a firebase for user authentication. Firebase Authentication is a service that can authenticate users using client side code. It includes a user management system where developers can permits user authentication with email and password login stored with Firebase.

A Insert Food Item subsystem

The users can insert food item using with help of speaker. The natural language processing platform for speech-to-text conversion of data, then matches the food item with the nutritional dataset. The module uses different techniques like removing stopwords, tokenization, and POS tagging for the extraction of food item from the entire sentence. Total food item consumption of user will be stored in user's individual table in database. For exact string matching, the proposed system uses boyer moore string search algorithm.

Algorithm 1: Insert food item(Speech-to-text)
Input: Audio Waveform
Output: CalorieIntake
Step 1: Sentence set S = {s1, s2,…, $_{Sn}$}
Speech-to-Text ('Audio Waveform')
Step 2: for each $_{Si}$ in S do
Nutrient_Info ← NLPModule ($_{Si}$)
Food_item← Nutrient_Info [0]
Quantity←Nutrient_Info [1]
Timestamp←Nutrient_Info [2]
Step 3: Caloriesperfooditem ←
StringMatchingModule (Food_item)
Step4: CalorieIntake (Caloriesperfooditem, Quantity)
Step 5: End for

Algorithm 2: Boyer Moore string search algorithm for searching all food items related to the given food item.
Input: A csv file containing all the food items name.
Output: A list of food item which matches completely or partially to the food item spoken.
Step 1: a. Using NLP, Extract the food item name into string variable "pattern" from the spoken data.
b. Fetch all food items from server and store in a list.
Step 2: For each items in list, assign the item to a String "text".
Step 3: Boyer Moore Algorithm works as follow,
a. A[i] denotes the character at index i of string "text".
b. A[i..j] denotes the substring of string "text" starting at index i and ending at j.
c. Prefix of "text" is a substring A[1..i] for i in range [1, n], where n is the length of string 'A'.
d. Suffix of "text" is a substring A[i..n] for i in range [1, n], where n is the length of string 'A'.
e. The string to be searched for is called the "pattern" and is denoted by "pat". The length of string pattern is n.
f. The string being searched in is called the "text" and is denoted by "txt". The length of string text is m.
g. An alignment of "pat" to "txt" is an index k in "txt" such that the last character of "pat" is aligned with index k of "txt".
h. A match or occurrence of "pat" occurs at an alignment if "pat" is equivalent to txt[(k-n+1)..k].

B Diet predication subsystem

The proposed system shows diet chart of user using total consumption calories of food item. This model works based on machine learning algorithm. Here we are using K-Nearest neighbor algorithm to generate the diet chart of particular user.

Algorithm 3: A custom KNN based Main Course food items combo prediction algorithm.
Input: A csv file containing all the main course food combos along with their calorific details, category (veg or non-veg) and labels (suggestible (1) or non-suggestible (0)), which are prescribed as per standards and diet charts of dieticians. A user target calorie value, based on the user's basal metabolic rate(BMR) as calculated by the app.
Output: A main course food combo which is suggestible and is having the same or if not same, then the nearest calorific value to the required target calorific value, generated daily using the basal metabolic rate (BMR).
Step 1: a. Read the target calories value for the user and store it in variable.
b. Read the main course food combos' csv file and store it in a pandas variable.
c. Read the aforementioned choice of user regarding the choice of food, i.e. veg or non-veg (1 for veg and 0 for non-veg).
Step 2: Bring precision and an optimum time complexity, by minimizing the area of search for the food combos on the basis of calories.

All food combos having calories in the range of (target calories - 200) and (target calories + 50) is first separated from the rest of the dataset.
Step 3: Calculate Euclidean Distance

a. Create a sep_arr array which contains calorific values of all the combos in the dataset.
b. for i in range(len(sep_arr)):

```
euclidean_distance=np.linalg.norm(targ - sep_arr[i])
distances.append(euclidean_distance)
```

Step 4: The euclidean_distances of all the combos is stored in a list called distances.

A dataframe is then generated which contains the list of combos along with their euclidean distance from target calories, their category (veg or non-veg) and their label(Suggestible or Non-Suggestible).

Step 5: The dataframe is sorted in an ascending order of their euclidean distances and the nearest food combo with label as 1(i.e suggestible) is suggested.

```
lq = pq.sort_values('Distances')
    for i in range(len(lq)):
     if (lq.iloc[i, 2] == [1]):
     pred.append(lq.iloc[i, 0])
return (pred)
```

Step 6: Return nearest food combo.

Algorithm 4: A custom KNN based Breakfast food items prediction algorithm.

Input: A csv file containing all the breakfast food items along with their calorific details, category(veg or non-veg) and labels(suggestible or non-suggestible), which are prescribed as per standards and diet charts of dieticians.

Output: A breakfast food item which is suggestible and is having the same or if not same, then the nearest calorific value to the required target calorific value, generated daily using the basal metabolic rate (BMR).

Step 1: a. Read the target calorie value for the user and store it in a variable.

b. Read the breakfast food items csv file and store it in a pandas variable.

c. Read the aforementioned choice of user regarding the choice of food, i.e veg or non-veg (1 for veg and 0 for non -veg).

Step 2: Bring precision and an optimum time complexity, by minimizing the area of search for the food items on the basis of calories.

All food items having calories in the range of (target calories - 200) and (target calories + 50) is first separated from the rest of the dataset.

Step 3: Calculate Euclidean distance

a. Create a sep_arr array which contains calorific values of all the items in the dataset.
b. for i in range(len(sep_arr)):

```
euclidean_distance =np.linalg.norm(targ- sep_arr[i])
distances.append(euclidean_distance)
```

Step 4: The euclidean_distances of all the items is stored in a list called distances.

A dataframe is then generated which contains the list of items along with their euclidean distance from target calories, their category(veg or non-veg) and their label(Suggestible or Non-Suggestible).

Step 5: The dataframe is sorted in an ascending order of their euclidean distances and the nearest food item with label as 1(i.e suggestible), is suggested.

```
lq = pq.sort_values('Distances')
    for i in range(len(lq)):
    if (lq.iloc[i, 2] == [1]):
    pred.append(lq.iloc[i, 0])
return (pred)
```

Step 6: Return nearest food item.

C New food item classification subsystem

Algorithm 5: A KNN based new food item classification algorithm, which classifies the new item as suggestible or non-suggestible.

Input: A knn-based model to which the entire food dataset is fed, which is then passed through the inbuilt KNN classifier of sklearn library and is pickled. The nutritional values of the new food item such as the calories, proteins, fats and carbohydrates is given as input to the pickled model.

Output: Classification of new food item into suggestible (1) or non-suggestible (0).

Step 1: a. Read the food items csv file and stores it in a pandas variable.

b. Take a variable X having the list of features selected which is calories, proteins, fats and carbohydrates of all food items.

c. Take a variable y having the classes which are binary in nature, i.e Suggestible (1) or non-suggestible (0).

Step 2: Split the dataset into training (80%) and testing (20%) in a randomized fashion.

Step 3: The KNN algorithm is acted upon using the metrics as Euclidean distance and optimum values of 'k' for best accuracy.

Step 4: The KNN model is then pickled for serialization and stored into a file with .pkl extension.

Step 5: An array of calories, proteins, carbohydrates and fats of the new food item given by user is taken as input to the model and the classification is predicted.

example_measures = np.array([cal, proteins, carbs, fats])

example_measures = example_measures.reshape (1, -1)

prediction = model.predict(example_measures)

Step 6: Returns the class of the new food item.(i.e Suggestible or Non-Suggestible)

D Implementation of proposed system

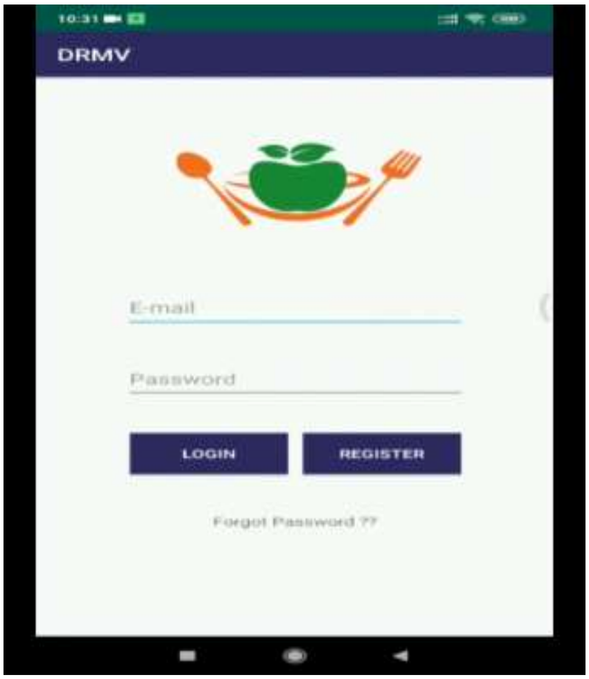

Fig 2: Login Page

Fig 3: New user registration page

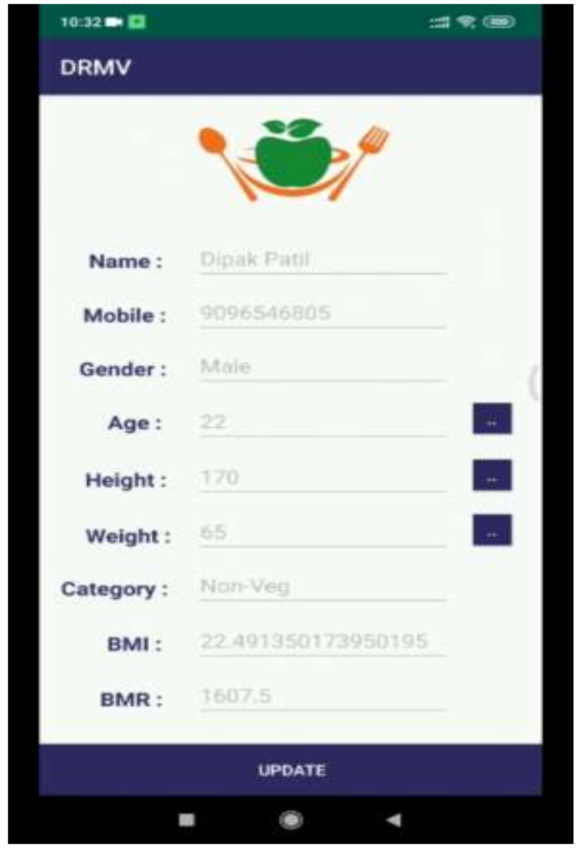

Fig 4: User profile details

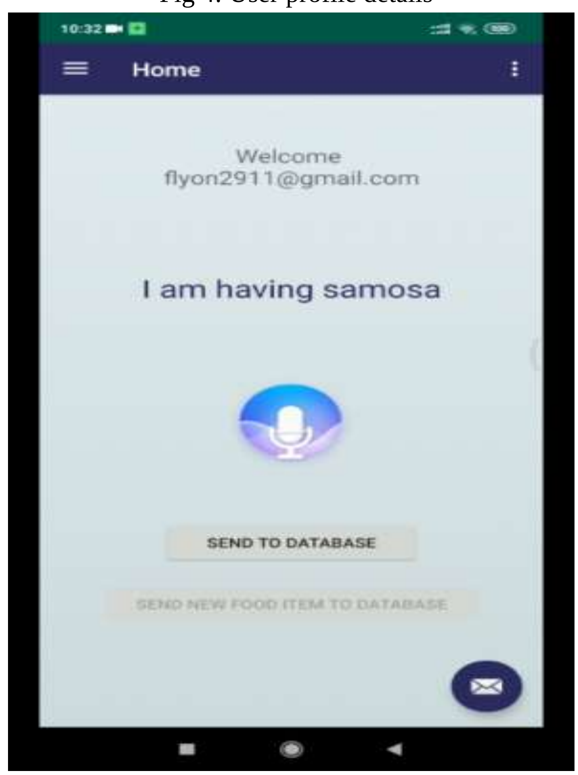

Fig 5: Insert food item

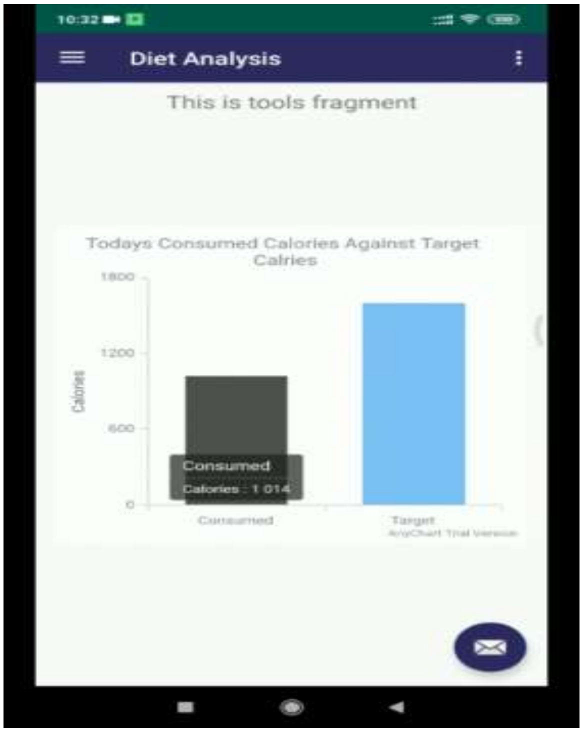

Fig 6: Daily Analysis

Fig 7: Food consumption history

Fig 8: Diet chart

IV. RESULTS

In our experimental setup we have done various experiments, the matrix has been calculated for each dataset according to label assign by testing algorithm. Our proposed system gives experimental results based on the following four various parameter.

1. Diet Prediction

The custom KNN algorithm used for the diet prediction algorithm has an accuracy of 99% and above. This accuracy is measured by considering how accurately the calories of the predicted diet match to the target calories calculated by the Basal Metabolic Rate (BMR). The proposed system has accuracy much more than the SapoFit app developed by to Joel Rodrigues, Bruno M Silva, Isabel De la Torre Diez, Ivo M.C. Lopes [3] which have an accuracy range from 70%.

2. Exact Matching

The proposed system uses effective boyer moore string matching algorithm which gives better performance result than the system proposed by Niloofar Hezarjaribi, Sepideh Mazrouee, and Hassan Ghasemzadeh [1]. The system gives 93% accuracy for noise-free environment.

3. Cloud based System

The proposed system has client-server architecture, with the server installed on a cloud service named Heroku. This allows the system to be running continuously 24*7 with real-time modifications being done to the system.

4. Classification of new food items

A feature is present in the proposed system which is not at all present in any of the reference papers. If a food item fed to the system by the user is not already present in the food dataset, then this feature allows the user to explicitly insert the food item into the food dataset. An algorithm is then used to classify the user inputted food item into two classes- suggestible and non-suggestible.

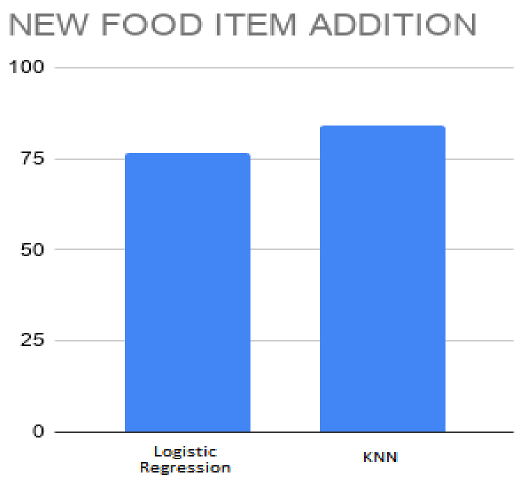

Fig 9: System accuracy while using KNN algorithm for classification

The above fig shows the comparison between the knn algorithm and logistic regression. On the initial tests over a food dataset it is found that among the two classification machine learning algorithms - Logistic Regression and KNN, Logistic Regression predicts the classification with about 76% accuracy while KNN gives a prediction of about 84%. The proposed system thus implements the KNN algorithm for classification.

V. CONCLUSION

Health monitoring system is a difficult task as many factors have to be considered which varies widely from user to user. The major contribution in this work is the introduction and validation of nutrition monitoring based on spoken data. This work also provides for a diet which is user specific and helps user from preventing unnecessary calorie intake and any type of diseases ultimately, both chronic and non-chronic. This research provides a pervasive approach for recording and understanding spoken language for diet assessment by integrating advances in speech recognition, NLP, text analysis and mobile health.

VI. FUTURE WORK

The proposed model can be enhanced to work with more accurate wearable sensor devices such as a wearable necklace sensor which uses piezoelectric sensor embedded in it to detect food type based on food intake, whether fluid or solid and chewing detection by capturing jaw movement.

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