# Spectroscopy Based Food Recognition

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## ABSTRACT

In brief, our project deals with calorie count detection of diverse food items and the objective is achieved by applying Machine Learning on Android.

Recognizing food items consumed by user is the first step in diet monitoring which is the most important method to prevent and treat obesity. The project aims at developing an intelligent android application capable of recognizing food items and can be effectively used in showing the oil, salt, protein contents of the consumed meal based on infrared spectroscopy.

## Keywords

User Experience, Obesity, Diet Monitoring, spectroscopy sensor, Feature Extraction, Machine Learning, Food Diary

## 1. INTRODUCTION

Obesity has always played a major role in the wellbeing of a human body as it increases the risk of diseases like Diabetes, Chronic kidney disease, metabolic disease, cardiovascular disease, etc. In United States alone, nearly 35% of Americans are suffering with it. It is not just a problem of "girth control" anymore but is now considered a chronic disease. To prevent and cure the obesity, a productive method would be to notify people about the food they eat. In this project, we are building the spectroscopy sensor-based food recognition Android application which can be used for diet monitoring as it is capable of recognize food items and the contents it carries within.

Near-Infrared (NIR) Spectroscopy helps explore the chemical composition of the food directly via wavelengths absorbed when light is transmitted through it. It uses the near infrared region of the electromagnetic spectrum. 99% of food is made of proteins, carbohydrates, fats and water. NIR provides a means for measuring these components in food [C-H bonds (as in fats and oils, hydrocarbons), O-H bonds (as in water and alcohol) and N-H bonds (as in Proteins)]. By measuring the absorption of these chemical bonds which are due to overtones of molecule vibration, one can quantify the amount of the ingredients. To measure the spectral fingerprints (unique molecular fingerprints) of each food item, we use a SCIO spectrometer which scans the food items and get us the information about its chemical makeup.

In this project, some of the feature extraction and machine learning Algorithms are used to train the model, they are explained below:

**Feature Extraction Techniques**

**PCA:**

Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components.

**Fast Fourier Transform:**

A fast Fourier transform (FFT) is an algorithm that samples a signal over a period (or space) and divides it into its frequency components. [1] These components are single sinusoidal oscillations at distinct frequencies each with their own amplitude and phase.

**Independent Component Analysis:**

Independent Component Analysis (ICA) is a computational method for separating a multivariate signal into additive subcomponents. This is done by assuming that the subcomponents are non-Gaussian signals and that they are statistically independent from each other.

**Latent Dirichlet Allocation:**

Latent Dirichlet Allocation (LDA) is a generative statistical model that allows sets of observations to be explained by unobserved groups that explain why some parts of the data are similar.

**Matrix Factorization:**

Matrix Factorization are a foundation of linear algebra in computers, even for basic operations such as solving systems of linear equations, calculating the inverse, and calculating the determinant of a matrix.

### Machine Learning Algorithms

**Naive Bayes:**

Naive Bayes classifiers are a family of simple "probabilistic classifiers "based on applying Bayes' theorem with strong (naive) independence assumptions between the features.

**Logistic Regression:**

Logistic regression is a statistical method for analyzing a dataset in which there are one or more independent variables that determine an outcome. The outcome is measured with a dichotomous variable (in which there are only two possible outcomes).

**SVM:**

Support Vector Machines are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis.

**K Nearest Neighbor (with k=5):**

K nearest neighbors is a simple algorithm that stores all available cases and classifies new cases based on a similarity measure (e.g., distance functions)

**Random Forest:**

Random forest (or random forests) is a trademark term for an ensemble classifier that consists of many decision trees and outputs the class that is the mode of the classes output by individual trees. Random forests are collections of trees, all slightly different. It randomizes the algorithm

## 2. PROJECT SETUP & PERMISSION

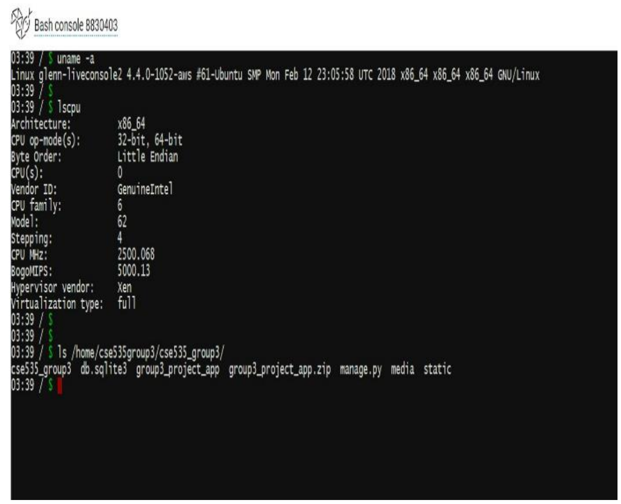
The architecture consists of 3 systems. The configurations and functions are described below:

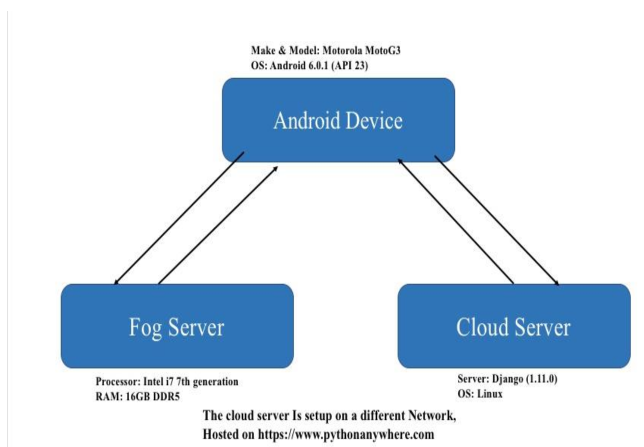
1. **Android device**
   Make & Model: Motorola MotoG3
   OS: Android 6.0.1 (API 23)

2. **Android Emulator Virtual Device**
   Make & Model: Nexus 5
   API Level: 21

3. **Fog Server (Local Server)**
   Setup on the same network as the Android phone.
   Server: Django (1.11.0)
   Make and Model: Dell Inspiron
   OS: Windows 10
   Processor: Intel i7 7th generation
   RAM: 16GB DDR5

4. **Cloud Server**
   Setup on a different Network, located on the cloud.
   Hosted on: https://www.pythonanywhere.com
   Server: Django (1.11.0)
   OS: Linux




## 3. SERVER-SIDE SETUP

- Both the server use Django server (version 1.11.0).
- The extracted features are stored in csv format.
- Preprocessing, feature extraction and machine learning algorithms are written in python.
- Processed Data can be downloaded.

## 4. IMPLEMENTATION

The implementation is performed based on the category of tasks, described as follows:

1. Development of an interactive user interface where the user can select if he wants the model to learn, see the recent accuracy, process the existing data or to see the food diary. The options are selected using buttons “Leaning”, “Recent Accuracy”, “Process Data” and “Food Diary” respectively.

This is illustrated in figure 1.

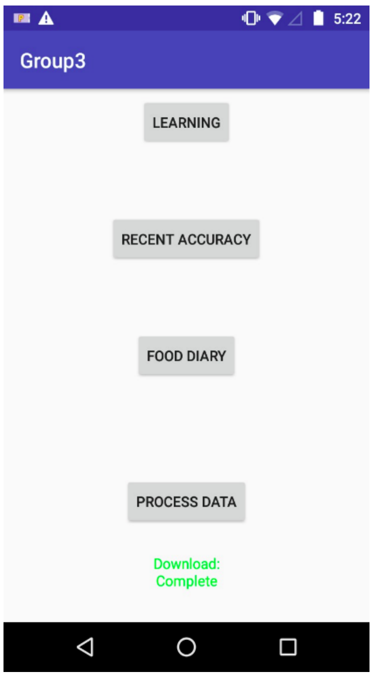



**Fig. 1**

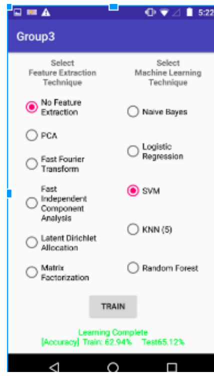
2. For performing learning methods, the data needs to be processed. This is done at server side upon clicking the “Process Data” button. The preprocessing uses raw data to create 2 different processed data file, and then download them from server, one file is used to partition foods based on date, another contains the food items features. which are used to display Food Diary chart and Training models.

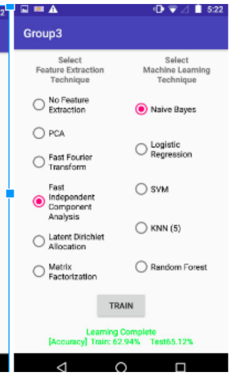
### Learning:

If the user clicks the learning button, he is now prompted to choose between Feature Extraction Method and Machine Learning method he would like to use for the data to be trained upon. This is for performing in server side and based on selected Feature Extraction Technique and Machine Learning Algorithm, the server will perform model training and return the train /test accuracy.

For feature extraction techniques - PCA, Fast Fourier Transform, fast independent component analysis, Latent dirichlet allocation and matrix factorization can be selected. The user is also given an option to not select any extraction technique.

The machine learning algorithms which can be used for training are - Naive Bayes, Logistic Regression, SVM, KNN (5) and Random Forest. This is depicted in fig x, y, z below.



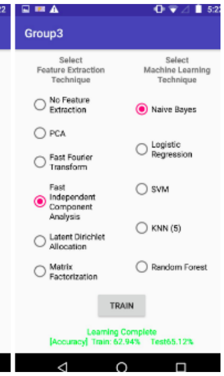




**Fig. x** **Fig. y** **Fig. z**

2.1. Upon clicking the train button, the training and testing accuracy for the data is observed.

3. Upon clicking the recent accuracy button, the user is navigated to the page where training and testing accuracy is shown for the recently processed data in which the user can steer between the different feature extraction and machine learning techniques, illustrated in figure p, q:



**Fig. p** **Fig. q**

4.The button food diary is used to shows two different types of view:

- **Quality:** Healthy (in color green) vs Unhealthy (in color red) food consumed in a particular day

- **Quantity:** Amount of Protein (in color green), Salt (in color Yellow) and Fat/Oil (in color red) consumed in a particular day.

**Anomalies:**

Exception handlings are also being taken care of:

A. The Error during Model Train is illustrated in fig a:

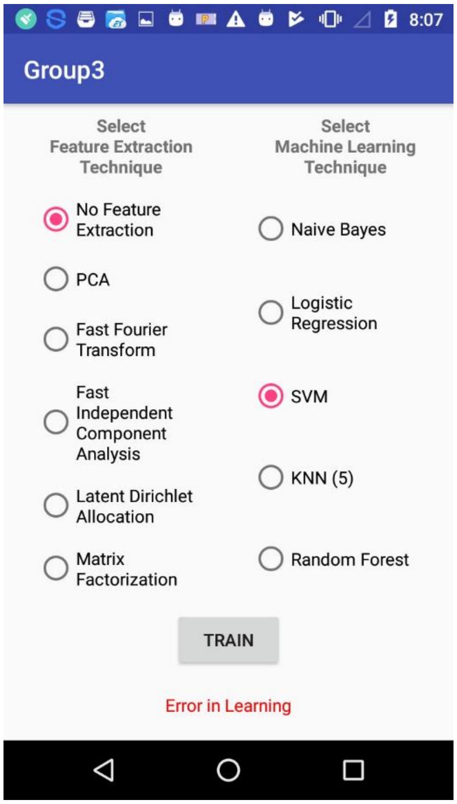
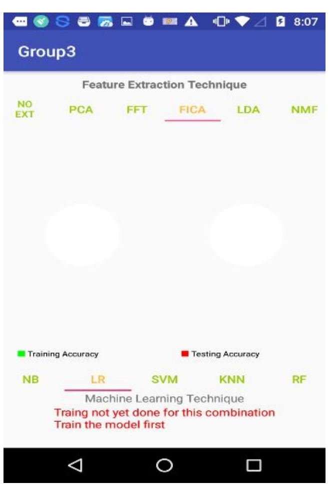



**Fig. a**

B. If the user tries to see accuracy for combination without training:




C. If an issue occurs in Network Connection:


## 5. COMPLETION OF TASK TABLE

| S.No | Task Name | Assignee |
|---|---|---|
| 1 | Data Collection | Moumita,Sam, Denim, Saumya |
| 2 | Feature Extraction: fast fourier transform | Denim |
| 3 | Feature Extraction: fast independent component analysis | Denim |
| 4 | Feature Extraction: Latent dirichlet allocation | Moumita |
| 5 | Feature Extraction: matrix factorization | Moumita |
| 6 | Machine Learning: Naive Bayes | Sam |
| 7 | Machine Learning: Logistic Regression | Sam |
| 8 | Machine Learning: SVM | Saumya |

| | | |
|---|---|---|
| 9 | Machine Learning: KNN | Saumya |
| 10 | Machine Learning: Random Forest | Saumya |
| 11 | Interface between Android and Server<br>Data Preprocessing | Denim |
| 12 | User Interface | Sam |
| 13 | Consumed Protein - Salt - Oil percentage Piechart | Denim |
| 14 | Food Diary Piechart | Moumita |
| 15 | Accuracy illustration based on Feature Extraction | Sam |
| 16 | Accuracy illustration based on Machine Learning | Moumita |
| 17 | Power Tutor | Saumya |

## 6. LIMITATIONS

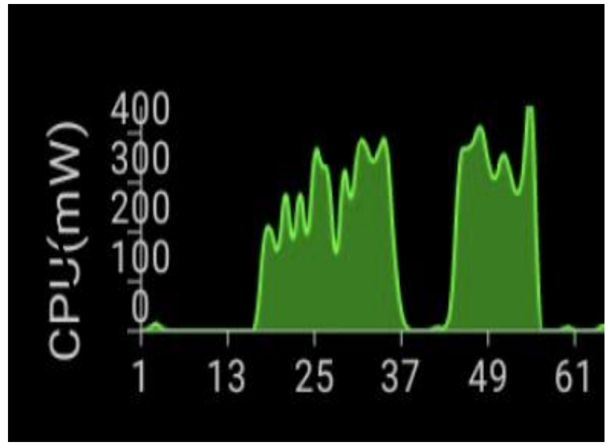
The scope of the application is limited since huge diversity of Food items exist in the real world and it is a complex task to sample all food items.

As we don't have the actual raw data from SCIO sensors, we are limited to use the axis data of the SCIO graphs, and thereby created raw data ourselves. Hence, the optimal sensor raw data is lost, and we have worked with dummy raw data to achieve our target.

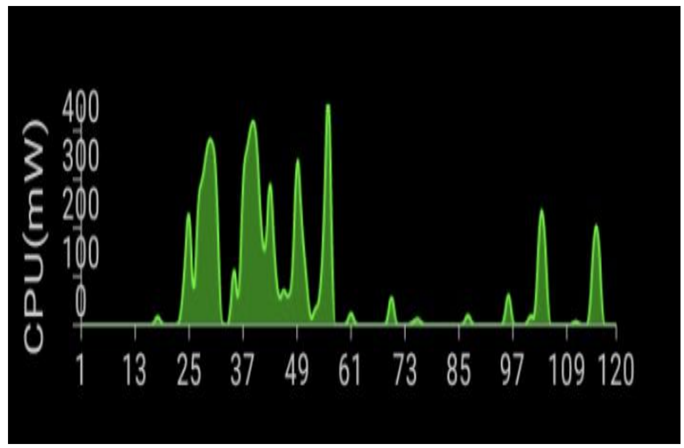
## 7. RESULTS

The above graphs depict the results of prominent Feature Extraction methods and Machine Learning Algorithms that have been implemented in our project.

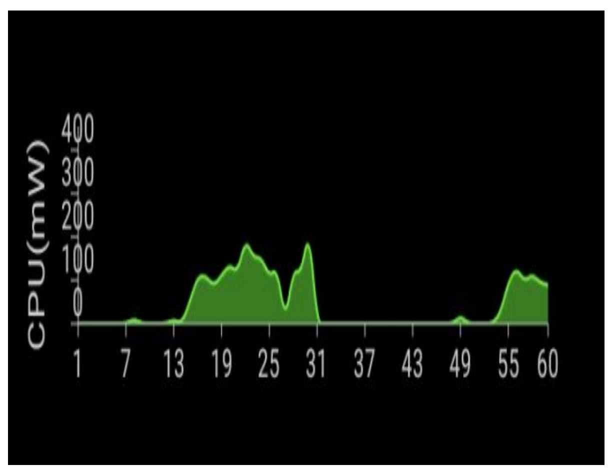
**Training Accuracy Results:**



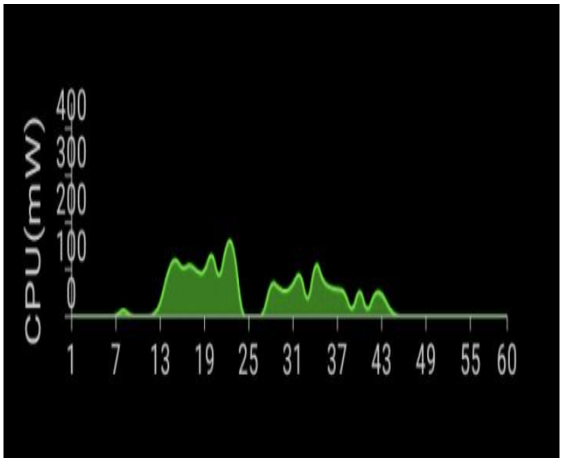

**Data Preparation/Food Diary:**



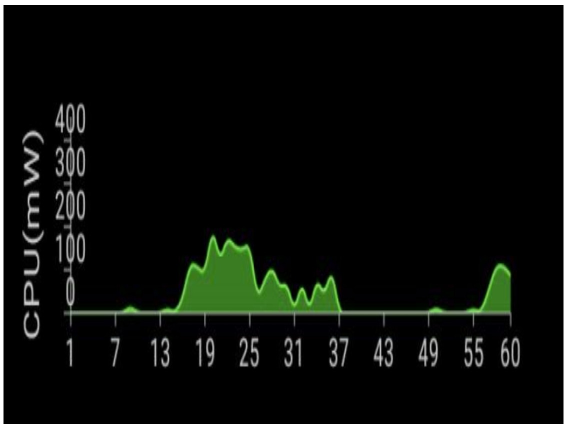

**PCA**



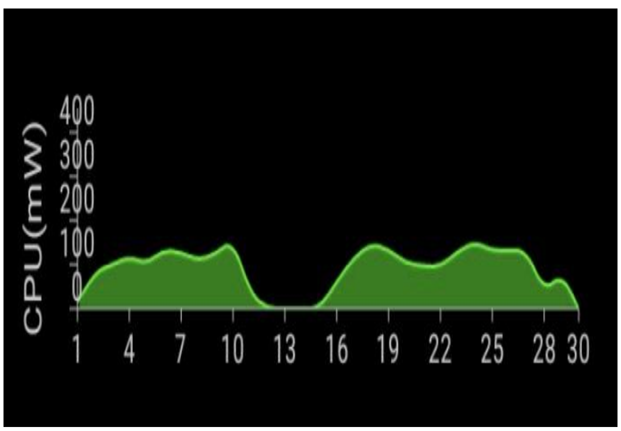
**FFT**




**ICA**




**LDA**




## 8. CONCLUSIONS

In this project, we have developed a Spectroscopy based food recognition application which can help us in diet monitoring. Using the data that was collected by Spectroscopy sensor, we were able to convert the raw data to csv files and applied Feature Extraction and Machine Learning Algorithms. Interfacing between sensor, device and server was successfully created and performance metrics are displayed. We were successfully able to implement an innovative application that has immense scope in diet monitoring. We brought an intuitive way in the detection of calorie count and incorporated Machine Learning to make it versatile.

## 9. ACKNOWLEDGEMENTS

We would like to thank professor Ayan Banerjee for his guidance and meticulous nature and the chance to work on a real world applicative project which helped us understand the very essence of Machine Learning on Android. This has been a challenging journey throughout our course-work during which we learnt the core concepts of Mobile Computing for which, we as a team are very thankful to the professor.

## 10. REFERENCES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