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e-Health Monitoring System with Diet and Fitness Recommendation using Machine Learning

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***Abstract*—Nowadays, more individuals are being diagnosed with diseases that are becoming chronic due to not following the proper diet, not doing proper exercise regularly, or not giving proper attention to the diseases because of busy schedules. Hence, we propose a system that aims at improving the health of the patients suffering from various diseases by recommending them healthier diet and exercise plans by analyzing and monitoring health parameters and the values from their latest reports related to the disease. We considered patients suffering from either Diabetes or Blood pressure or Thyroid. Our System can be essentially useful for the doctors to recommend diet and exercise based on their latest reports and personal health details. For this, we have broadly classified our system into 2 modules: 1. Health Monitoring, 2. Diet & Exercise Recommendation. In the Health Monitoring module, the system would suggest follow-up sessions until the reports come normal. For the Diet and Exercise Recommendation module, the algorithm that is used is a Decision tree for classification. To be precise, C4.5 is used to give recommendations of diet and exercise. A C4.5 Decision tree will help recommend and determine if a particular food item and exercise should be given to a particular individual or not with respect to our customized datasets.**

***Keywords*—Health Monitoring, Diet and Exercise Recommendation, Machine learning, C4.5**

I. INTRODUCTION

The health is also an important factor in human life. Due to busy schedules, workload, people are not paying attention to their health and fitness. Physical inactivity is the most important problem in today's generation. Maintaining their daily routine of diet and exercise is what people need to be fit. So people need some amount of nutrition to be healthy and maintain their health. Diet and exercise, if consider in general, varies from users having different lifestyles, height, weight, sex, age, and activity level. Diet and exercise are both correlated. To maintain sugar level, it is required to balance the intake of calories. So, the proposed system would help doctors to recommend diet and exercise to their patients suffering from Diabetes, Blood pressure, or Thyroid along with the medication they provide on every follow-up on the click of their mouse.

In this paper, we have modeled a Health Monitoring system with Diet and Fitness recommendation. We are specific to 3 diseases in this model i.e. Diabetes, Blood pressure, and Thyroid. These diseases are most widely spread across the people which require proper health monitoring and treatment. The recommendation system will provide information based on user requirements and constraints. We divided our system into 2 modules 1. Health Monitoring System 2. Diet & Exercise Recommendation. For Diet and Exercise Recommendation module, the C4.5 classifier is used. It has additional features like pre pruning, handling continuous attributes and missing values, and rule induction which helps in the accuracy of the model than a normal decision tree classifier. Multiple comparisons are done for finding ideal algorithm for the recommendation system. ID3 and C4.5 is perform and with respect to the properties of the algorithms and C4.5 fulfills ideal conditions with the following properties.

Following **TABLE I** shows the difference between ID3 and C4.5 concerning Type of Data Handled, their Speed, whether Pruning happens or no, their Splitting Criteria, and accuracy.

TABLE I
DIFFERENCE BETWEEN ID3 AND C4.5

	ID3	C4.5
Data type handled	Categorical	Categorical, Continuous, Numerical, Missing
Speed	low	faster than ID3
Pruning	Not Supported	Pre-pruning
Splitting criteria used	Information Gain	Information Gain Ratio
Accuracy	low	higher than ID3

II. LITERATURE REVIEW

A. With respect to Health Monitoring System

In [1] Health care recommendation system was built using ontology framework for food and exercise recommendation. Decision tree algorithm was used for getting user's information from the data-set. In [2] Four different algorithms (k-nearest neighbors, Support vector machine, Random forest, AdaBoost) were used and among this Random forest gave more accuracy and score than other three, i.e. 60 to 70 % for health monitoring that checked the patient's ECGs suffering from LQTS genetic disorder and identified patients with a high risk of cardiac

events. In [3] Three different algorithms (random forest, gradient boosting, logistic regression) were used, and among this logistic algorithm gave more accuracy and score than others, i.e 87%. which monitored and authenticated the Fitbit credential of a user. In [6] Data analysis was done using different machine learning models like Random Forest, Support Vector Machine, and Deep Learning for remote health monitoring for Elderly People. In [7] The system extracts the features from **UCI Chronic kidney** data set which was responsible for Chronic kidney Disease, After that, ML automated the classification of different stages in the CKD with respect to its severity.

B. With respect to Diet and Exercise Recommendation System

In [8] Using **USDA Food Composition** Database they propose a diet recommendation that recommends Mauritian diet to patients that are hypertensive, with WEKA as a classification model. In [11] A web-based diet recommendation system using **Health Calabria Food** Database claims to improve the health of people affected due to chronic disease. In [12] Recommendation system was built for amateur as well as professional runner, which gives recommendations to the users by suggesting their diet and workout that will suit them, based on the inputs they provide on the system using Social Semantic Web.

C. With respect to Algorithms

In [4] They introduced a simplified and improved version of the ID3 algorithm. They observe as the number of data records increases accuracy also increases. With 1232 number of records, the accuracy of their improved ID3 Algorithm came out to be 92.6% which was more than the normal ID3 Algorithm which is 88.9%. In [5]Three different algorithms (ID3 decision tree algorithm,k-means, and naive Bayes algorithm) were used. It was observed that the ID3 algorithm was 6 to 7 % more accurate than the other two for the classification of data. In [9] The J48 Decision Tree Algorithm was applied on **ARFF** Dataset to build a classifier model for Test Data prediction of groupings of learner after using the K-means clustering algorithm to achieve class labels. In [10] They created a dataset based on the deaths of the celebrity using the public and open access databases from the year 2006 to 2016 which consists of 11,200 reported deaths over the globe reported over the decade.Lazy and decision tree classifier model were used for the analysis of the dataset prepared. The accuracy achieved using decision tree model with the dataset created is 75.07 %. In [13] Using the Data set of **Soil Nutrient**, they established a model for soil quality prediction and combined the composition of soil by using the C4.5 decision tree algorithm which gave the accuracy of 92.71%.

The papers cited above gave us the solution for the Health Monitoring system and Diet & Exercise Recommendation system separately. According to the review, only one i.e. [10] prepared their own data set, rest used the existing data set. None were specific to the disease like diabetes, Thyroid, and Blood Pressure collectively. As C4.5 is used as a prediction model and not a recommendation [13]. The advantage of our system is we combine all the above research gaps to make a combined Health Monitoring with Diet and Exercise Recommendation along with customized Separate Data sets for diet and exercise specifically for patients suffering from Diabetes, Blood Pressure, and Thyroid and used C4.5 for recommendation of diet and exercise.

III. C4.5 DECISION TREE ALGORITHM

A. Algorithm:

TABLE II
C4.5 DECISION TREE ALGORITHM

Steps	Steps to generate C4.5 Decision Tree
1	Finding Global Entropy - probability of occurrence of a value in the output $Entropy(output) = \sum -p(I).log_2 p(I)$ $where,\ p(I) = \lvert Xj/X \rvert$ where, Xj is the number of occurrence of true value in that particular attribute and X is the total no of value in that attribute
2	Again we will use the same formula to find entropy of each attribute with respect to output in step 1.
3	Now finding the information gain of every attribute with every possible values in the attribute with respect to output. **InfoGain (attribute)=** $Entropy(output) - \sum (p(output\|attribute).Entropy(output\|attribute))$
4	**SplittingInfogain(attribute)=** $-\sum p(I) * log_2 p(I)$
5	**InfoGainRatio (attribute)=** $Infottain(attribute)/SplittingInfogain(attribute)$
6	To find out the attribute that have highest information gain ratio
7	The root of the decision tree is the attribute that have highest information gain ratio.
8	Splitting the dataset based on the newly created root in step 7.
9	For all the sub-dataset in step 7, calling function C4.5 recursively (i.e .all steps from step 1 to 8).
10	Attaching the tree found in step 9.i.e. the subtree to the root found in step 7.
11	Return Tree.

This algorithm **TABLE II** is used for classification in machine learning, which uses a structure of trees where the internal node represents values on a feature/attribute and leaf nodes represent decisions of that feature/attribute. C4.5 makes use of entropy for classification of data. The C4.5 is a continuation of the ID3 [16] In ID3, information gain is used as a splitting criteria where as in C4.5 information gain ratio is used as a splitting criteria which makes C4.5 faster and more accurate than ID3 as shown in **TABLE I**. Information Gain tells us how much information is associated with an

attribute value which is linked to the probability of occurrence of the values with respect to the output. Once the attributes have been selected, the probability of an event is calculated, known as entropy. Entropy is used to measure the amount of uncertainty, surprise, or randomness in a data set. This algorithm can handle categorical as well as numerical values data. It can also handle missing values. Also these missing values are not utilized in gain calculations by C4.5.The drawbacks of ID3 algorithm i.e. over fitting, time latency and complex to handle continuous attributes are resolved in C4.5 algorithm. [16]**TABLE I**.

IV. System Design

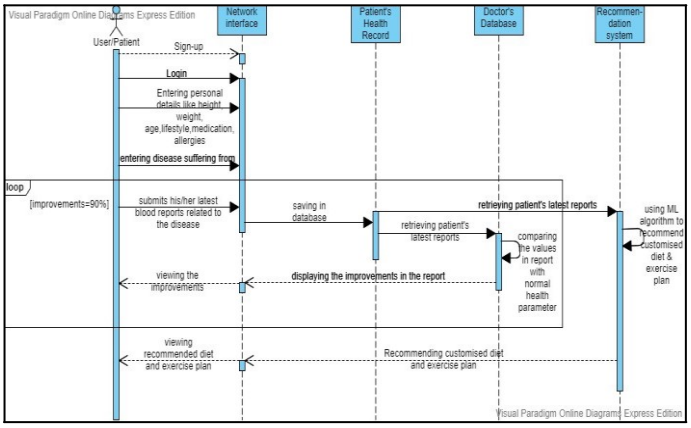


Fig. 1. Sequence Diagram

FIGURE 1 is the systemdesign/Sequence diagram for our model.

1) A patient/doctor here is the actor or user who will use this system.

2) **User Interface** - A user interacts with the system by adding body details like height, weight, age, gender, lifestyle, activity level, disease (Diabetes, Blood Pressure or Thyroid), and current reports related to that specific disease

3) **Patient's Health Record** - All the details mentioned in **POINT 2** will be stored here.

4) **Doctor's Database** - The fixed Parameter to detect category of disease i.e if the person is Normal or is suffering from Prediabetes or Diabetes from the reports of the specific disease is stored here.

The following are the Parameter that will be stored in the database.

a) The fixed parameters to detect category of disease which is used for monitoring purpose which is verified by a doctor and researched through different websites. [20] [21] [22]:

i) Diabetes

Blood Sugar Classification	Blood Sugar level		
	HB A1C (%)	Fasting (mg/dl)	2 hours Post-prandial (mg/dl)
Normal	<5.7	70-99	100-139
Prediabetes	5.7-6.4	100-125	140-199
Diabetes	>=6.5	>125	>200

Fig. 2. Diabetes Parameters used

ii) Blood Pressure

Blood Pressure Category	SYSTOLIC (mmHg)		DIASTOLIC(mmHg)
Low Blood Pressure - Hypotension	<80	or	<60
Normal	80-120	and	60-80
Prehypertension	121-139	or	81-89
Stage 1 high blood pressure Hypertension	140-159	or	90-99
Stage 1 high blood pressure Hypertension	160-179	or	100-109
Hypertensive crisis (where emergency care is required)	180=<	or	110=<

Fig. 3. Blood pressure Parameters used

iii) Thyroid

Gender	Age	Normal	Hypothyroidism	Hyperthyroidism
Male	18-30	0.45-4.15	<0.45	>4.15
Male	31-50	0.45-4.15	<0.45	>4.15
Male	51-70	0.45-4.5	<0.45	>4.5
Male	71-90	0.4-4	<0.4	>4
Female	18-30	0.4-4.68	<0.4	>4.68
Female	31-50	0.4-4	<0.4	>4
Female	51-80	0.46-2.38	<0.46	>2.38

Fig. 4. Thyroid Parameters used

FIGURE 2,3,4 are the disease parameters store in Doctor's Database **POINT 4**.

Improvements in reports	Threshold
Yes	>90%
Less	65-89%
No	<65%

Fig. 5. Threshold Parameters used

b) The threshold values assumed for comparison of improvements in health monitoring is shown in **FIGURE 5**

5) **Recommendation System**-This system will help doctors to recommend diet and exercise plans for the patients with the help of a machine learning technique.

   Customized Diet and Exercise Data sets is prepared with the assistance of fitness trainer, doctor and various websites. [24] [25] [26] [27] [28] [29]

   a) **Exercise data-set [20]**- It comprises 107 exercises concerning what user prefers Gym or Yoga, age, activity level with a total of 1261 records.
   b) **Diet data-set [20]**- It comprises 102 food items with its calorie intakes and servings concerning what user prefers Veg or Non-veg with a total of 102 records.

6) **BMI (Body Mass Index) [18] and Calories Requirement Calculation [17]**

$$BMI = \frac{\text{body weight in kg}}{\text{Square of body height in m}} = kg/m^2$$

where, Underweight ≤ 18.5
Normal weight = 18.5 – 24.9
Overweight = 25 – 29.9
Obesity ≥ 30

Calories =

For Men : $66.5 + 13.8(W) + 5.0(H) - 6.8(A))$

For Women : $65.51 + 9.6(W) + 1.9(H) - 4.7(A)$

where,
W = Weight in lbs.
H = Height in inches.
A = Age in years

V. METHODOLOGY ADAPTED

The given below **FIGURE 6** is the block diagram of the complete system.

A personalized healthcare recommendation system consists of diet and exercise mainly considering user's profile and accordingly the food items are suggested. The food item varies for different diseases. But the purpose of our diet and fitness recommendation is to make sure that it is adaptable and practical to users. The system is broadly classified into two modules,

1) **Health Monitoring system** - Monitoring and keeping a track of the improvements in the latest reports of the patient related to the disease that they are suffering from i.e. either Diabetes, Blood Pressure, or Thyroid.

   a) Starting with entering patient's details such as height, weight, age, gender, activity level along with the disease he is suffering from (Diabetes or Blood Pressure or Thyroid)
   b) Submitting the values from his latest report related to the disease.

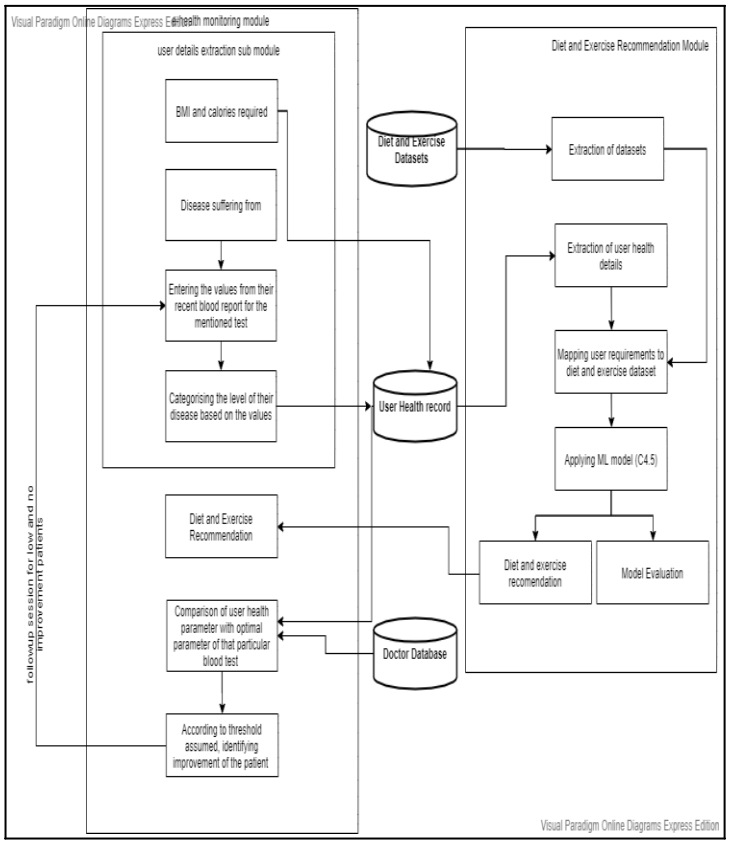


Fig. 6. System Block Diagram

   c) Calculating BMI and calories required with formula mentioned in the last section using his personal details that were inputted at the back end.
   d) All these user details as mentioned in **POINT a** are stored in User Health Record.
   e) Comparison with fixed parameters of that specific disease which is been stored in Doctor's Database takes place to categorise their disease.
   f) A customized Diet and Exercise Plan is been recommended to the user through the Diet & Exercise Recommendation Module.
   g) The process continues by checking improvements in the reports (i.e. how much similar is the reports with the normal parameter of that disease) based on threshold values **FIGURE 5** assumed i.e. if there is an improvement of about 90%, the system would recommend to follow the same diet/exercise plan and the process terminates, if there is an improvement of about 65-89%(LESS) and below 65%(NO), the patient will be suggested to come after a definite interval of time (follow-up session) and with his new reports related to the disease.
   h) Now for a follow-up session, again a comparison of values in reports with fixed parameters of that specific disease stored in Doctor's Database takes place, but this time comparison with previous ses-

sion reports with the current report will also take place and the procedure from *point (a)* will be continued.

i) The cycle of follow-up sessions continues till the improvement of the patient's report comes out to be 90%

2) **Diet & Exercise Recommendation** - Recommending healthier diets and exercises plan using a Machine Learning algorithm based on the monitoring as mentioned in **POINT 1** and other health parameters related to their disease.

a) Starting with loading the custom data set for diet and exercise from Diet and Exercise Database [20], extracting and mapping all the necessary details from User Health Record.

b) The data-set is split for training and testing with a 25% test size.

c) The C4.5 decision tree based classifier is used as it is to identify the important variables in one of the fastest ways and relation between them. New features/variables can be created that has a better power to predict target variables.

d) In the Training process, decision tree generation i.e. selecting best attributes among all using Attributes Selection Measures (ASM) such as information gain ratio and breaking the data-set in a small subset takes place.

e) The procedure of decision tree generation will continue every child node in the tree.

f) The output of this process gives recommendations of diet plan and exercise plan.

g) The output from the training process is combined with testing data for Model Evaluation.

h) Then the accuracy of the model is checked through various Performance Evaluation Measures like Confusion matrix, Precision, Recall, terminating the process.The accuracy of our model with C4.5 is compared with ID3 to find which one is more efficient.

VI. RESULTS

Fig. 7. Screenshot of User Record suffering from hyperthyroidism after putting all the details

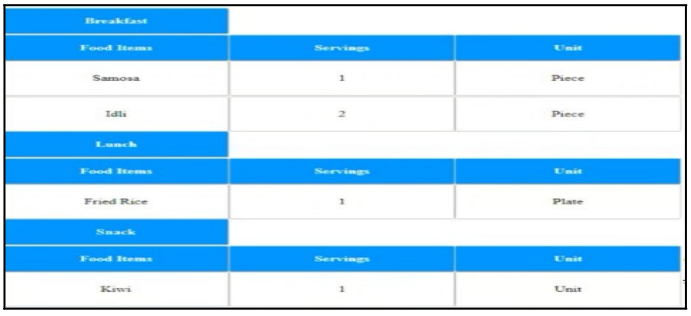


Fig. 8. Screenshot of Diet and exercise recommended to the patient whose details are mentioned in **FIGURE7**

Fig. 9. Screenshot of Diet and exercise recommended to the patient whose details are mentioned in **FIGURE7**

FIGURE 7 shows the user record inputted for the female suffering from thyroid. With the help of her height, weight, age and activity level, BMI and calories intake is been calculated at the backend.

The value from her TSH test was 0.2 which categorized her disease as Hyperthyroidism according to **FIGURE 4** and as the value was not normal, 'Assess again' button appears which indicates that improvements are needed and patients has to come back for a followup session. Her reports are also updated in the followup which will eventually change their diet and exercise plan.

FIGURE 8, 9 shows the diet and exercise plan for the user suffering from Hyperthyroidism mentioned in **FIGURE 7**

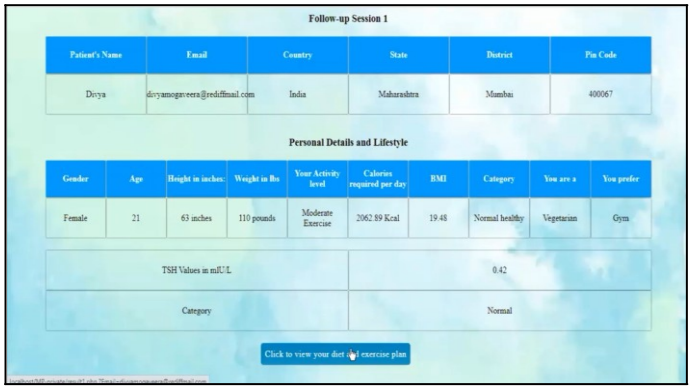
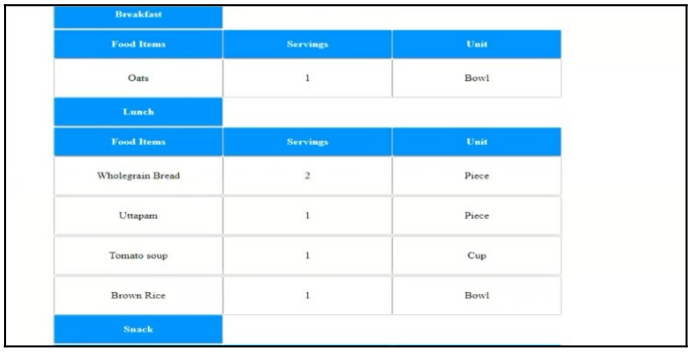
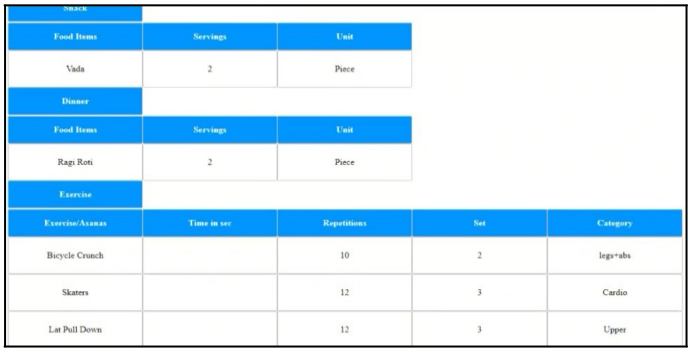


Fig. 10. Screenshot of followup session of the user suffering from hyperthyroidism mentioned in **FIGURE7**



Breakfast		
Food Items	**Servings**	**Unit**
Oats	1	Bowl
Lunch		
Food Items	**Servings**	**Unit**
Wholegrain Bread	2	Piece
Uttapam	1	Piece
Tomato soup	1	Cup
Brown Rice	1	Bowl
Snack		

Fig. 11. Screenshot of Diet and exercise recommended to the patient whose details are mentioned in **FIGURE 10**



Snack		
Food Items	**Servings**	**Unit**
Vada	2	Piece
Dinner		
Food Items	**Servings**	**Unit**
Ragi Roti	2	Piece
Exercise		

Exercise/Asanas	Time in sec	Repetitions	Set	Category
Bicycle Crunch		10	2	legs+abs
Skaters		12	3	Cardio
Lat Pull Down		12	3	Upper

Fig. 12. Screenshot of Diet and exercise recommended to the patient whose details are mentioned in **FIGURE 10**

FIGURE 10 shows the value in the followup session for the patient in **FIGURE 7**.

The values from the patient's new TSH report came out to be 0.42 which is normal according to **FIGURE 4**. As the category came out to be normal, therefore 'Assess again' button disappear which indicates that there is no followup session for the patient and the patient is normal.

FIGURE 11, 12 shows the updated diet and exercise plan for the user in the followup session mentioned in **FIGURE 10** .

VII. Performance Analysis

We evaluated our model based on the various disease categories.We also compared our model comprising of C4.5, with ID3 in order to find efficiency of C4.5 algorithm.

FIGURE 13, 14 represents the accuracy of Diet Data-set [20] with 102 data size concerning the diseases and accuracy of Exercise Data-set [20] with 1261 data size with respect to the diseases respectively.

In both the graphs **FIGURE 13, 14**, we can clearly infer that, C4.5 has higher accuracy than ID3, which makes C4.5 better than ID3 with respect to both the customised data-sets we used.

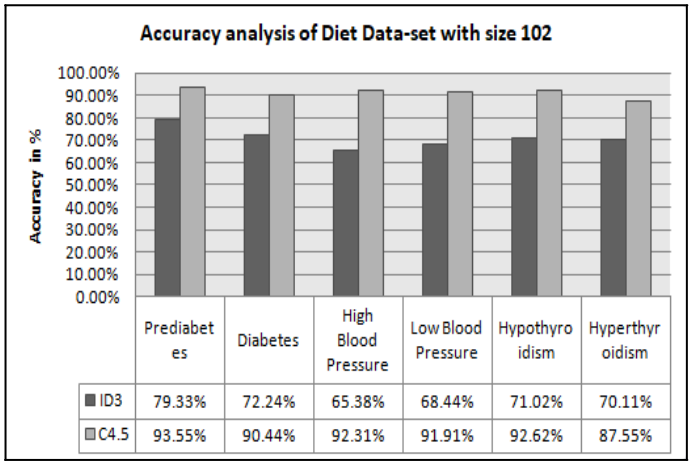


Fig. 13. Comparison of Accuracy for ID3 and C4.5 Decision tree Algorithm with Diet Data-set with 102 size

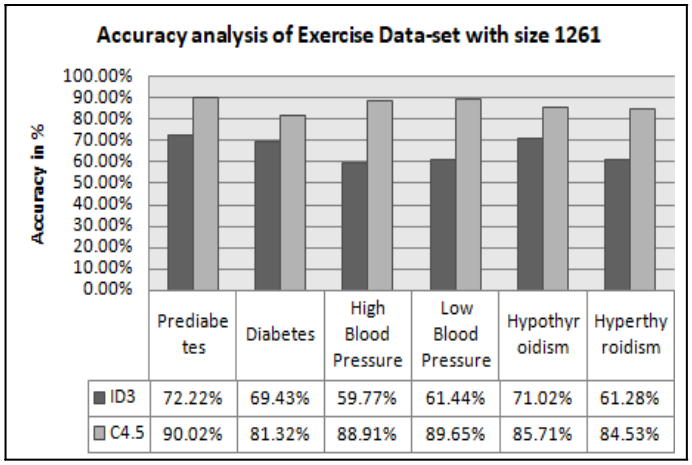


Fig. 14. Comparison of Accuracy for ID3 and C4.5 Decision tree Algorithm with Diet Data-set with 1261 size

VIII. Conclusion

The work presented lies in the field of Machine Learning in Health Care. We designed a system which can help doctors to recommend diet and exercise to the patients. It precisely deals with health monitoring of disease like Diabetes, Blood Pressure, and Thyroid based on the patient's latest report looking for improvements in every follow-up session and recommending suitable and updated diet and exercise plan in each follow-up session based on the reports and other credentials like height, weight, age, activity level, using the Machine Learning technique i.e. C4.5 decision tree algorithm. We can clearly infer that, C4.5 is better than ID3 algorithm with respect to both the data-sets we used.We conclude that although C4.5 being predictive model,C4.5 can be used for recommendation but it require some more improvements.

IX. FUTURE WORK

The future work would consist of a system for tracking of diet and exercise and in continuation would provide alternate options with respect to the user's ailments to a particular food item or exercise in case of change of user preferences and creating a regular and emergency alert system to remind the user before every follow-up session and in alert user in cases of extreme reports.

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