Analyzing Nutritional Deficiencies through Hair

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ABSTRACT

Nutritional deficiencies are highly prevalent in many developing countries. They exist when human body doesn't absorb the adequate amount of a nutrient. These deficiencies can lead to a variety of health problems, such as problems of skin, digestion problems, defective bone growth, and even dementia. These deficiencies rarely occur in isolation; if someone is lacking of one deficiency then likely to have some other as well. Iron deficiency has strong relationship with hair loss, similarly many other deficiencies are also associated with hair texture, hair quality and hair loss. In this paper hair features has been used to diagnose several deficiencies in human body. The diagnosis is established by using Case based reasoning CBR. This automated nutritional deficient system reuse the existing cases and adapt if some new case arrives by using similarity measures.

KEYWORDS: Case-Based Reasoning (CBR), Medical knowledge-base system, Nutritional deficiencies.

1 INTRODUCTION

"CBR is an analogical reasoning method providing both a methodology for problem solving and a cognitive model of people" [1]. Case-based Reasoning is an advanced instance based machine learning approach in artificial intelligence for problem solving. It is a methodology for solving problems by referring to the old cases, past experiences and prior knowledge. Case-Based Reasoning uses existing case and matches it to a similar old case in order to solve a particular problem. Over the past years this area of AI has gained a lot of attention and has become an area of interest for researchers. Implementation of CBR can be conducted using a number of techniques to record old cases and then search for the nearest case to solve the problem. Furthermore some techniques are used to modify prior cases to map effectively with new cases and other techniques to integrate new cases when they are required. People are comfortable with the idea of using CBR for making decisions and solving their problems in situations where they are uncertain about everything or in dynamically changing situations as this technique is quite similar to the human behavior.

We propose an approach to develop an automated knowledge-based decision support system based on CBR methodology. Our system exhibits nutritional deficiency in human body on the basis of hair analysis. Deficiency or surplus of any mineral or toxic substances first affects the hair and later these effects are visible in human body as to prolong optimum blood level in human body these heavy metals are transformed to hair therefore we use hair to identify these deficiencies. We extended the idea from hair mineral analysis tests (HTMA)

The working of the system is described in figure 1 as follows: A new case (the problem) comes in for analyzing the nutritional deficiency; this test case is then matched with the Case Base which acquires prior knowledge, old cases and adaptation rules. If the test case match with the old case we reuse it otherwise we need to adapt using the adaptation rule. Hence we are either reusing or revising in this predicament. Subsequently we have a recommended result in form of the nutritional deficiencies. If in future facts urge that the recommendations made previously are not in accordance with the future factors or scenarios then the learning phase initiates in which we retain the case as a new case in the case base.

1.1 CBR Process
The figure 1 below explains the process pictorially:

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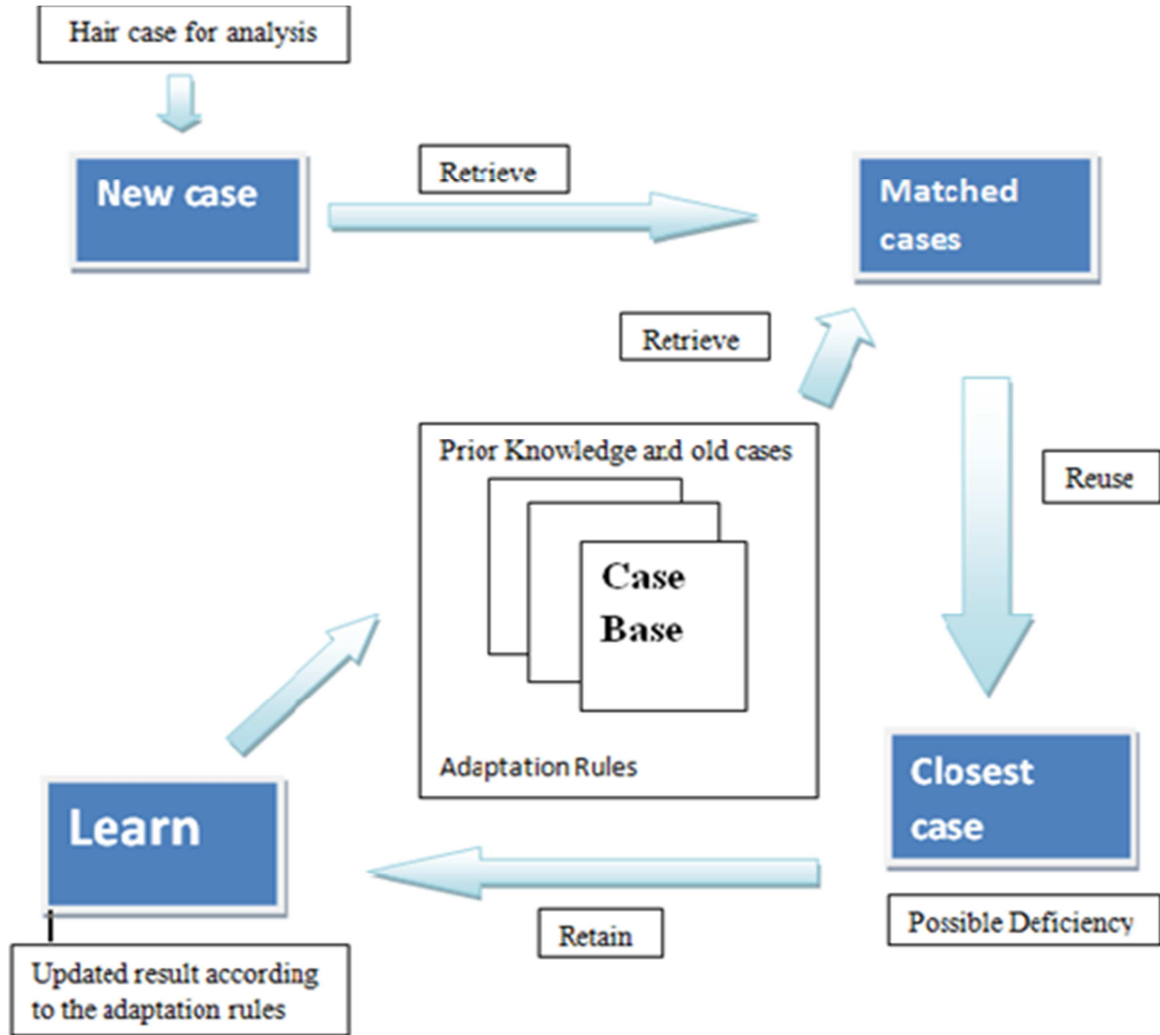
Figure 1. CBR process diagram for proposed system

This paper proposes a methodology to diagnose and analyze the nutritional deficiencies of different people belonging to different regions, different age groups and gender on the basis of hair factors. The foundation of making the indices are: Hair texture, Region, Age, Balanced Diet, Stress, and Amount of Hair loss. The deficiencies can be of Iron, Iodine, Copper, Manganese, Zinc, Cobalt, Molybdenum, Selenium, Chromium, Tin, Vanadium, Fluorine, Silicon, and Nickel.

This remaining paper is organized as follows: Section 2 narrates the related work in this particular field, Section 3 delineates the algorithm being used, Section 4 demarcates all the experimentation and analysis, Section 5 recounts the limitations and future recommendations and lastly the conclusion is given

2 BACKGROUND AND RELATED WORK

Hair has strong relationship with most of the nutritional deficiencies in human body; Bertazzo A et al [2] showed in their paper that human hair color has an immense effect on Cu concentration in both males and females. Afridi et al [3] did research to analyze the presence of heavy metals (cadmium, copper, iron, nickel, chromium, lead, and zinc) in the scalp; certified reference material (CRM 397) hair was adopted to check the validity of this approach. Moeinvaziri et al. [4] found strong relationship between iron deficiency and hair loss in women of child bearing age. Bhat et al. [5] showed association of premature graying of hair due to few immune disorders in human body. Naieni et al. [6] presented a paper to show that premature canities of hair is strongly caused by different abnormal levels of serum iron, copper and zinc in human body.

After finding strong relationship between different hair factors like graying of hair, baldness, and gradual hair loss, we focused on finding some artificial intelligence algorithm to diagnose human nutritional deficiencies using hair. CBR has been widely used in different medical diagnosis. CBR yielded a very efficient cancer diagnostic system, initially diagnostic processes were carried out by firing of rules in the Rule-Based inference, Salem et al.[7] used nearest neighbor to map similar cases and frame is used for case indexing, retrieval and the storage in cancer diagnosis. Ahmed et al.[8] proposed a multi-model and multipurpose-oriented clinical decision support system for stress management, by introducing a fuzzy rule-based classification scheme along with CBR technique performance of the system has been improved. A case base diabetes management web system was designed by Nguyen et al [9]; they presented the implementation of a Case-Based Diabetes Management Web System (CWDM), which is a website that integrates the DM lifecycle, CBR, and web technology.

Shahina Begum et al.[10] conducted research by using artificial Intelligence techniques for diagnosing stress. Due to the large variations Case-Based Reasoning technique is applied coupled with fuzzy logic to incorporate uncertainties. Shahina Begum et al [11] .presented a Cased-Bases Reasoning (CBR) system that classifies people into two categories healthy and stressed person based on sensor fusion. Sensor Signal Fusion is the technique which is used in this paper to combine different sensory data so the resulting information obtained from them is better than when these sources used individually. Multivariate Multi scale Entropy Analysis (MMSE) algorithm is used to combine these sensory signals and to extract features from these signals. Euclidean distance and Fuzzy Logic are used to match the nearest case.

3 ALGORITHMS

3.1. Case Base Reasoning Algorithm

CBR is a problem solving technique that learns from its past experience of related problems to solve and give the most accurate result for new problems. CBR solves a particular problem by predicting the future, based on the training examples also called the cases of the CBR. Cases are foundation of CBR. CBR algorithm maps the incoming problem on the cases it is trained on, in order to solve that problem. When cases are complex, such as complicated legal ruling and planning the method of classification or regression is used to find solution. However, for simpler cases, K-nearest neighbor is employed along with the CBR algorithm to find the distance between the cases and map the incoming problem with its nearest trained case efficiently and effectively. K-nearest algorithm is further explained in detail below.

For obtaining k-nearest neighbors, a distance metric is required to estimate the closeness of two cases. In our system the initial values of attributes are converted to a numerical scale that can be used to collate values as done in Figure 4. The distance between these attributes is calculated by using the formula below. The metric Euclidean distance - the square root of the total of the squares of the attribute differences-is used to differentiate the two cases. Given as:

$$d(p,q) = d(q,p) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \cdots + (q_1 - p_1)^2} = \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$$

3.2 Cases

CBR case is representation of an experience. A case consists of three vital parts:

Problem: issue that needs to be solved (determine nutritional deficiencies in humans).

Solution: appropriate reaction for the problem (select among different cases if matched occurs otherwise adapt for new one).

Outcome: impact of that solution (proposed solution should be retained for future use or not).

A good representation of these three parts of problem makes it feasible to reuse, revise and retain cases.
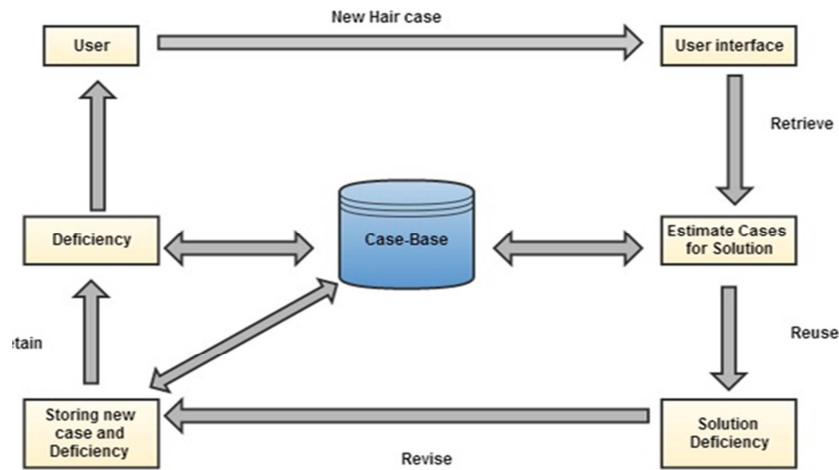

Figure 2 : Illustration of Hair Deficiency Test System

3.3 Retrieve

For retrieval of a case user is required to enter their information. Including user's region, stress level, hair problem user is having, user's diet is it balanced or not, hair type, texture and user's age. As shown in Figure 2.

Figure 3: Graphical under interface of the proposed system

System reads these cases and converts them to index numbers that are assigned to each case as given in Figure 3. These attribute indexes are stored in variable a1…a8 used in Algorithm 1. These attributes comprise a single case. This user case is compared to all cases in case-base and a set of nearest neighbors is retrieved from the
case-base. To perform the task of retrieval following algorithm is generated.

Algorithm 1
Input: Input attributes a1…a8
                File attributes b1…b8
Method:
1.   While   file has next line
a.   Read case from file and storing information;
b.   Store case deficiency;
// Euclidean Distance of user case from case read from file
c.   Difference=   Math.sqrt(1*(a1-b1)*(a1-b1)+1*(a2-b2)*(a2-b2)+1*(a3-b3)*(a3-b3)+1*(a4-b4)*(a4-b4)+1*(a5-b5)*(a5-b5)+1*(a6-b6)*(a6-b6)+1*(a7-b7)*(a7-b7)+1*(a8-b8)*(a8-b8));
2.   End while
This algorithm takes user related information, as input. Compares all the cases present in case-base with user case gradually, calculates their difference and deficiency specified with each case present in case-base. In line 'c' of algorithm the concrete work of retrieval, Euclidean Distance is calculated.
While loop in line '1' of the algorithm is executed until all the cases are read from case base file. Line 'a' is reads a single case and stores all details temporarily. Likewise line 'b' is stores deficiency of current case of file. In line 'c' Euclidean Distance is implemented. It calculates the difference of all cases with the current case and stores that difference.

3.4 Reuse
Reuse method in CBR is responsible for lodging solution for new case from solution of cases retrieved. As there is no remarkable difference between the cases therefore solution of retrieved case is used as solution of new problem as it is. Adapting to retrieved case.
For devising accurate solution to the given problem difference and deficiencies of all cases are sorted in ascending order using following algorithm

Algorithm 2
Input: Difference: case differences (calculated I above algorithm)
          cs: case deficiency
Method:
1.   For i=0 to end of file
a.   For j=0 to end of file
i.   If(difference[i]>difference[j])
            1.   temp=difference [i];
            2.   difference[i]=difference[j];
            3.   difference[j]=temp;
            4.   temp1=cs[i];
            5.   cs[i]=cs[j];
            6.   cs[j]=temp1;
b.   End For
2.   End For
3.   Return cs[0];
For sorting in ascending order this algorithm compares difference of each case- i with all other differences-j. In line 'i' the two differences are compared and swapped if condition is true. Swapping is done on both

differences and deficiencies. Lines '1' to '6' are repeated until all the differences and deficiencies are sorted in ascending order.
In line '3' the algorithm is returning the first deficiency in cs list which is the deficiency of case having least difference from the user case.

3.5 Revise

In situation where there is a significant variation between user case and retrieved case, the retrieved solution is adapted to account for those prime differences. Adaptation can be done through Substitution, Transformation, Genetic method or other methods depending on the complexity of case. However, in this system there is no noticeable contradiction between the two cases. Hence, solution of retrieved case is restated.

3.6 Retain

Retention is the final and key step of step of CBR cycle. The learning characteristic of CBR approach is what makes it more attractive in all other methods. There are certain issues when learning and recording new cases. When cases are complex or have a wide range of attributes additional information is stored with the case or solution. On contrary many system store solution of problem solved.
To retain this system all the attributes of user case and along with the proposed solution are stored in case base. Attributes are stored as indexes that were assigned by the system following to factors provided at time of retrieval.
Following algorithm is used which stores the present case along with the deficiency in case-base:

Algorithm 3
 Input: sorted difference list: difference
            Sorted deficiency list: cs
Method:
1.   If difference[0]!=0
a.   Store user details in file
b.   Store deficiency in file
In line '1' the system probes the first difference of list whether it is zero or not. If it is zero then it means that the new case exists in file and does not needs to be appended in case-base, thus lines 'a' and 'b' are not executed. These lines are executed when the cases do not match and the system has to store the new case for future use

4 EXPERIMENTS AND ANALYSIS

4.1 Experiment

This section of the paper focuses on the experiment that we did to find the nutritional deficiencies in hair. In the experiment we include some major attributes, they are: 'Region, stress, problem factor (any problem related to hair person having), proper diet, amount of hair loss, type of hair, texture of hair and age. We have given discrete values to the attributes which are mentioned in following tables: Figure. 4

Table 1

Region	Index Assigned
African	0
European	1
Asian	2

Table 2

Hair Type	Index Assigned
Straight	0
Wavy	1
Curly	2
Kinky	3

Table 3

Balanced Diet	Index Assigned
No	0
Yes	1

Table 4

Stress	Index Assigned
No	0
Yes	1

Table 5

Hair Texture	Index Assigned
Thready	0
Wiry	1
Cottony	2
Spongy	3
Silky	4

Table 6

Hair Loss	Index Assigned
Very Low	0
Low	1
Normal	2
High	3
Very High	4

Table 7

Problem Factor	Index Assigned
None	0
Brittle or Dry Hair	1
Flaky scalp And Dull hair	2
Dandruff	3
Red Itchy scalp	4
Brittle top layers	5
Hair thinning	6
Split ends	7
Poor growth	8

Table 8

Age	Index Assigned
5-10	0
11-15	1
16-20	2
21-25	3
26-30	4
31-35	5
36-40	6
41-45	7
46-50	8
50-above	9

Figure 4: Deficiency Test Attributes

As our hair comprises proteins, iron and minerals like electrolytes, sodium, potassium and calcium. Elements such as copper, manganese, iron, zinc and toxic metals like lead, mercury, cadmium, arsenic, aluminium can be traced in our hair also. Required minerals and nutrients are carried from body to hair in order to maintain optimum nutrition level and hair structure. But lack of these essential nutrients and minerals in body causes undersupply to hair making it brittle and weak. Hair being one of the most intricate parts of human body delineates body deficiencies pertinently. This causes hair troubles. "21" mineral levels can be determined through hair mineral analysis test that assists in diagnosing body deficiencies.

In order to detect hair deficiencies we have conducted an experiment which takes health condition of the user as its attributes given in Figure 4. We conducted a survey over 400 people. Who were asked to fill a questionnaire entailing information about their region, stress, diet, other attributes in Figure d and deficiencies if they had or know about any. Out of these cases 300 were selected and studied. Deficiencies were identified properly following medical conditions. Data was entered in system's case base in the form of indexes specified in Figure d along with deficiencies for system training.

From cases given in figure 5, we perceive that how much hair issues help you in identifying your body deficiencies. If these deficiencies are recuperated hair conditions can also be improved. Apart from hair issues your region age and diet has a great impact on your health and hair conditions. Sometimes it is nothing but the climatic conditions of your region that causes your hair to enfeeble. However, in certain situations it may be an apprehension of a serious hidden health issue which can always be sorted with physician.

Following are a few examples that illustrate the process of discerning deficiencies:

| Region	Takes Stress	Problem Factor	Balanced Diet	Hair Loss	Hair Type	Hair Texture	Age	Deficiency
African	No	None	Yes	Normal	Kinky	Spongy	11-15	No Deficiency
African	Yes	Red Itchy Scalp	No	Very High	Kinky	Spongy	16-20	Stress
African	No	Flaky Scalp and Dull hair	No	High	Kinky	Spongy	16-20	Iron, Zinc and Vitamin C
European	Yes	Flaky Scalp and Dull hair	Yes	Normal	Kinky	Spongy	31-35	Protein and Iron
European	No	Brittle or Dry hair	Yes	Normal	Kinky	Spongy	31-35	No Deficiency
European	Yes	Brittle top layers	No	Low	Wavy	Cottony	5-10	Low Carbohydrates
Asian	No	Dandruff	No	Very Low	Straight	Thready	16-20	Zinc and Vitamins
Asian	Yes	None	No	Very Low	Straight	Thready	21-25	Low Thyroid
Asian	No	Brittle and Dry hair	No	Normal	Straight	Silky	16-20	Iron, Zinc and Vitamin C
Asian	Yes	Poor Growth	Yes	Normal	Straight	Silky	31-35	Vitamin B & C, Zinc

Figure 5: Few cases from the training set

4.2 Analysis.
Plotting collected data set we come to following interpretations:

Hair Loss due to Nutritional Deficiency
Hair is probably most important attribute of body. Thinning and loss of hair is the first signal of poor health, stress, hormonal imbalance and vitamin or mineral deficiency. Healthy and vibrant hair exhibits vibrant health. Graph below shows the rise in hair fall due to increased nutritional deficiency.

Baldness due to Nutritional Deficiency:
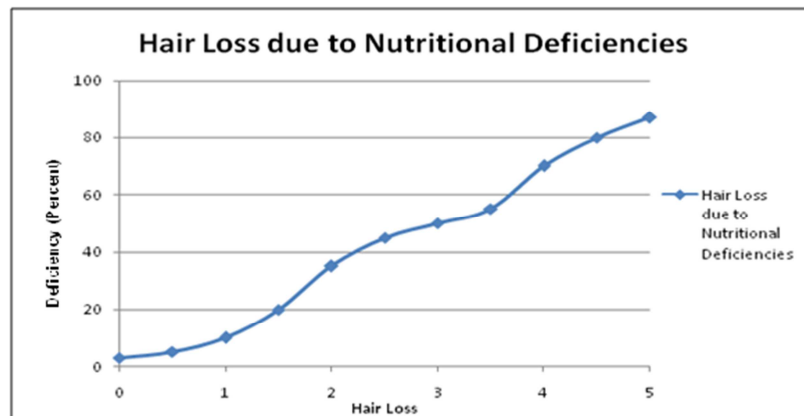
Baldness (alopecia) is partial or complete loss of hair from head and body. Hair cells are replenished more shortly than other cells in body. Hair acts like a barometer of your overall health. Imprudent or abrupt hair loss implies to hormonal imbalance, nutritional deficiency, stress or toxicity from environment. This excess of hair loss can result into complete baldness in men substantially. Following graph shows the tendency of baldness in men and women due to nutritional deficiency.
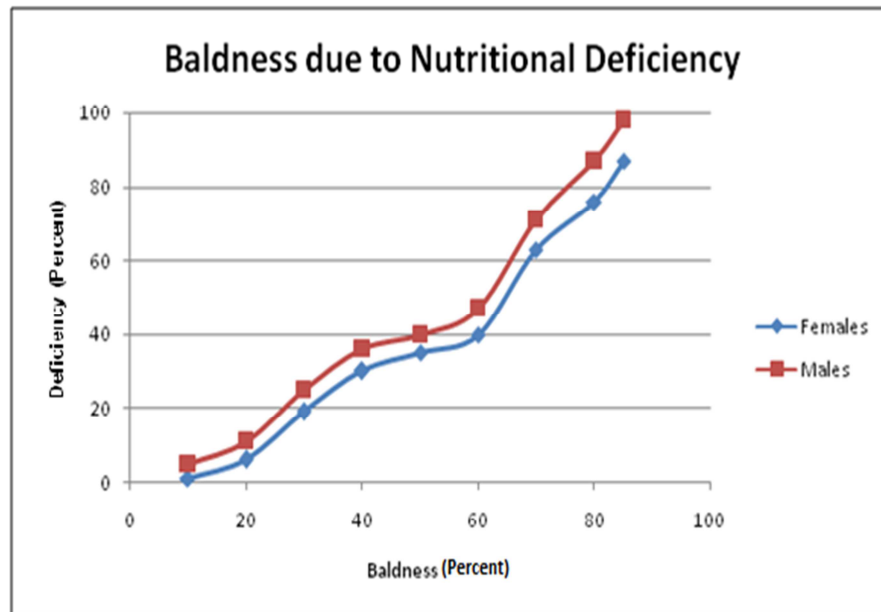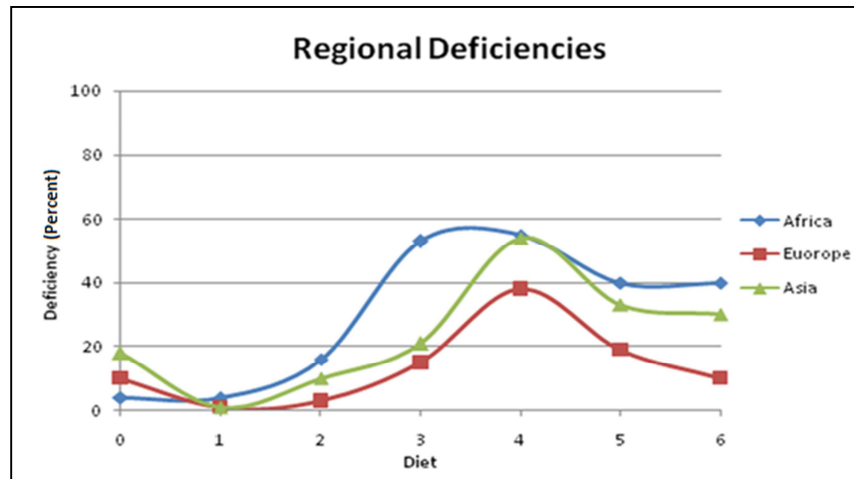

Diet and Deficiencies analysis

Nutritional diet is important imperative for health of body and hair. Balance diet maintains body's nutritional level and helps in suppressing deficiencies. Following graph shows influence of diet on deficiencies.
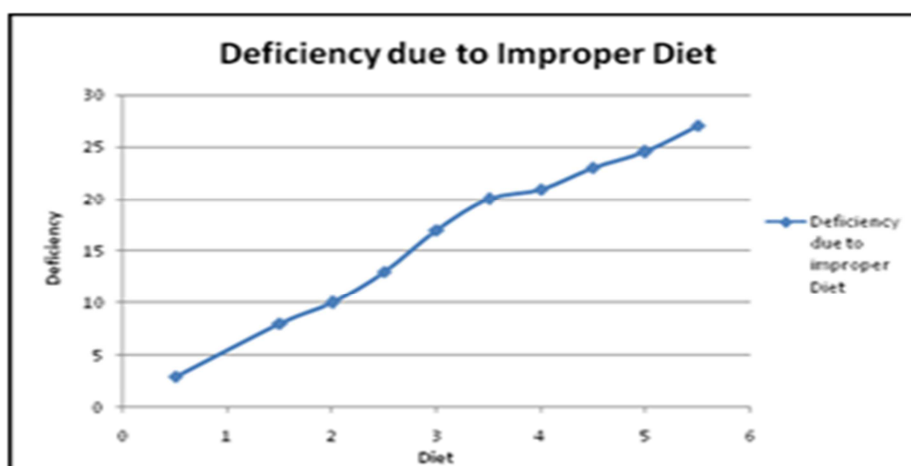

Regional Deficiencies

In past few years regional deficiencies have risen to substantial degree because of unhealthy and improper diet. The graph below shows the comparisons of deficiencies in Africa, Europe and Asia.


Analysis of Statistical and Deficiency Testing System Results
The graph below shows the trend of Nutritional Deficiency due to improper diet, stress and other health issues in Asia, generated by the results obtained from Deficiency Testing System.
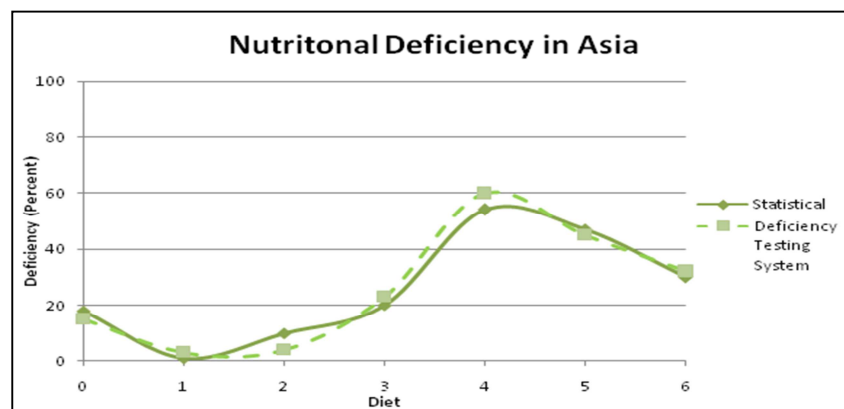
Mineral Deficiency in Human Body
Minerals are vital source of health in human body but their excess and scantiness both can harm health. Specific amount of Minerals should be taken daily to avoid health problems. The chart below shows deficiency of minerals required for hair, in body on average.
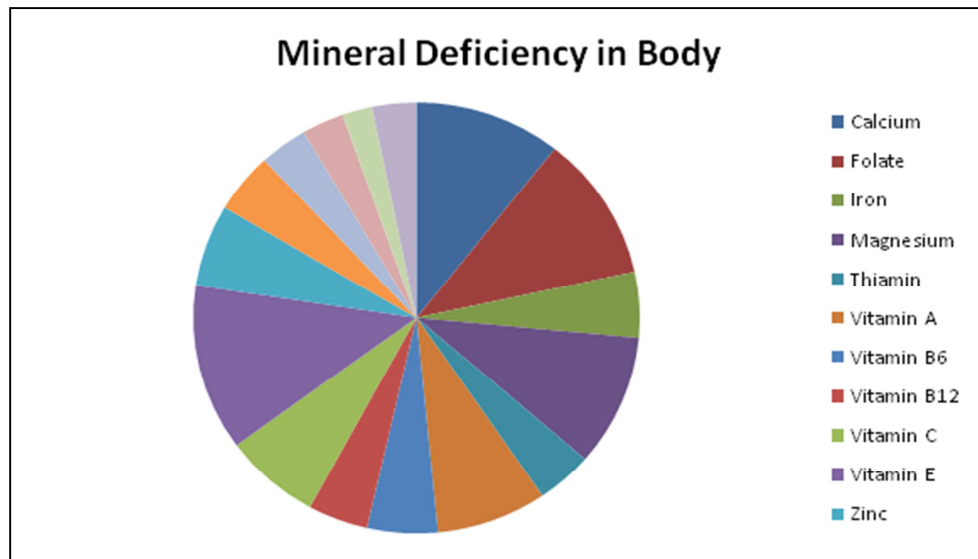
5 LIMITATIONS AND RECOMMENDATIONS

5.1 Limitations

Cased Based Reasoning has several probable virtues juxtapose to other conventional systems.

However it has some boundaries and limitations which are explained below:

The number of cases used in case base

Major foible of CBR is that the numbers of cases devised for hair analysis are restricted. Though the system is evaluated using different approaches, potential of our system can be aggrandized if the system is trained on colossal number of cases.

Difficulty in collection of data set

Clustering of real time data of hair is arduous as we are catering three regions in our paper namely; Africa, Europe and Asia. Every individual belonging to some region has different type of hair embodying different deficiencies. It is not possible to carter all the real time scenarios of all the regions. Hence there are inexhaustible real time cases which are hard to be incorporated in the data set.

Vague information from people

People are not explicit about the data. They are not aware of their hair type or texture. They don't tell us about their proper age, or they are having balanced-diet or not, do they take stress or not? How much amount of hair loss they have on daily basis? For proper analysis these questions should be answered carefully so we can have consistent information.

5.2 Future Recommendations

Cased Based Reasoning as compared to Artificial Neural Network is not close to human behavior hence our system's accuracy can be improved by using ANN approach instead of CBR.

Artificial Neural Networks (ANN) can also be used for implementation of nutritional deficiency using hair factor analysis system because this technique mimics natural selection and brain processing. Each neuron is linked to all neurons in next level and each level is assigned a weight. They travel through patterns and adjust imperfect data until they reach a state where they have no neurons to over fit data imperfections and converge to give a solution [9].

A major setback in our system is the sparse real time data. The accuracy level of the system rises if it is trained on every possible case of the hair deficiency. The regions taken into account to train our system are only three which are not adequate to maintain the data set. Hence if we further improve on our data set and incorporate other regions the accuracy of the system can possibly be elevated.

Moreover if we combine skin factors with hair for analyzing the nutritional deficiency the results would be more meticulous as the system would be trained on refined data than before hence the results would improve accordingly.

6 CONCLUSION

A machine learning technique which comes under the branch of instance based learning namely Cased-Based Reasoning is preferable for medical knowledge based systems. This paper ventures an idiosyncratic method to locate nutritional deficiency in human body with the help of analyzing different attributes of hair. Implementation is centered on Cased-Based reasoning technique. The cases are congregated from multiple surveys conducted on analysis of hair by different doctors and medical centers. Some cases lead to various diseases caused by deficiencies in body which had an immense effect on one's hair. The result provided by the system indicates the nutritional deficiencies in human body which assist the users determine the problem area so they can improve their diet and take preventive measures accordingly to avoid further damage.

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