

Hair Loss Diagnosis Using Artificial Neural Networks

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Abstract

Hair is an appendage of the skin that plays an important role in the beauty of people's face. Daily averages of 50 to 80 hairs are shed naturally. Various factors are effective in hair loss. In this paper using the eight influence attributes of gender, age, genetic factors, surgery, pregnancy, Zinc deficiency, iron deficiency, anemia and the use of cosmetics, the amount of hair loss is predicted. This work has been performed using artificial neural networks. 60 percent of the collected data was used for train, 20 percent for validation and the remaining 20 percent is used for testing the neural networks. For this, various training algorithms has been used. The result of the implementation of these algorithms has been compared. It seems that neural networks can be successful to predict hair loss.

Keywords: *Hair Loss, Artificial Neural Network, Genetic Factor, Iron deficiency.*

1. Introduction

Hair is an appendage of the skin that comes out it as thin filaments. This member for lack of nerve is any sense. Each hair is made up of sections and layers. Natural hair color is considered as one of the main characteristics of hair and this is a direct function of race. The hairs have different diameters. According to hair appearance, three categories of straight hair, wavy and frizzy can be divided. The speed of hair growth, not only in different parts of the body, but also in different parts of the head is different. Different hair colors and forms have a direct impact on people's faces beauty. Daily averages of 50 to 80 hairs are shed naturally. In some cases, hair loss is over this determined range [1, 2]. If the hair loss reaches a significant level sooner or later, the scalp will be visible from amidst the hair. Hair loss in men and women follow of a certain pattern [3-5]. Thus, in men started from the temples and crown and then advances more. But hair loss in women is dispersed. Borders of the hair usually do not disappear. Meanwhile the onset of the hair loss in women is delayed for about ten years. Hair loss in women has more periodic changes than men. Women's hair volume is usually little with increasing age and some people genetically has thin and sparse hair and since the child were less hair, this is normal and does not need special treatment. Factors such as disease, hormone changes and consumption of drugs and environmental factors and

genetic cause complete hair loss [6, 7]. These cases require medical treatment or surgery. Many people think only men are bald and women do not lose their hair but the truth is something else. Millions of women in the world suffer from baldness and every year their number is increasing. Another powerful factor in the baldness is inheritance. Hair loss has several types and each has different reasons. Reasons like genetic factors, diseases, poor nutrition, vitamin deficiencies, anemia, iron deficiency, stress, using cosmetics and so are effective on hair loss [7]. These factors are mentioned more fully in the next section.

To recognize the amount of hair loss, artificial neural networks are used. Some effective factors in hair loss are used in neural networks as input parameters that the physicians and hair experts consider as effective. The actual data have been collected from several physicians who worked at clinics.

2. Hair

Hair is very effective in the face beauty. This member for lack of nerve has no sense so when it is cut with scissors, there is no pain. Each hair is composed of two main parts, Stem, the part of the hair that is located off the skin and root of the hair that is located under the skin surface. Hair is composed of three layers of the brain, shell and cover. The brain of hair is the innermost layer that does not have any specific performance. Shell form the strength and ability for the hair elasticity. External surface of the hair is composed of a protective layer called the cuticle. This layer with such squamate structure like a fish covers the hair surface and is responsible for protecting hair against damaging environmental factors [8].

- Natural hair color

Natural color is an iconic feature of hair that is a direct function of the race. This feature is due to the natural hair pigment called melanin. There are two types of melanin in the hair: Eumelanin or black pigment that is responsible for brown and black colors in hair and pheomelanin or red pigments which is responsible for red and yellow colors in hair. The ratio and size of the two pigments will determine

the final color of hair. In table 1, the ratio and size of the pigment and the influence of these two parameters in the final hair color can be seen [9].

Table 1: The ratio and size of the pigments and their effect on hair color

Eumelanin	Pheomelanin	Natural Hair Color
High number & large size	Almost no	Black
High number & mediocrity	Very little	Brown
Low number & small size	More or less	Blond
Almost no	High number & large size	Red
Almost no	Almost no	Gray

- Diameter of hair

Thickness or diameter of the hair depends on the race, sex and gender. The thickness of the hair is divided into three categories: thin hair (less than 60 microns), medium hair (between 60 to 80 microns) and thick hair (more than 80 microns) [9]. You can see two samples with diameters of thin and thick hair in Figure 1.

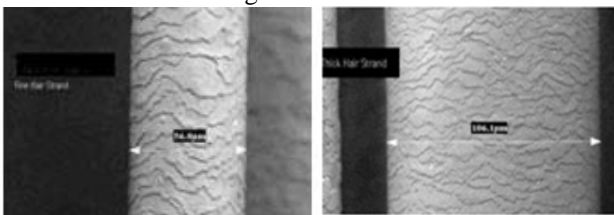


Fig. 1 Example of a thin hair (56 microns in diameter) and thick hair (106 microns in diameter)

- The form of hair cross section

Hair cross section can be circular, oval or rectangular. This factor is determined with the parameter named as hair diameter index. This index is the ratio of smaller diameter to a great diameter. As this parameter is nearer to one cross section of hair more like to circular and is nearer to zero, the cross section of hair more like to rectangular or flat. Hair is divided into three categories according to shape: smooth hair (Straight), wavy hair (wavy) and frizzy hair (Curly) [9]. Can you see these three types in Figure 2.

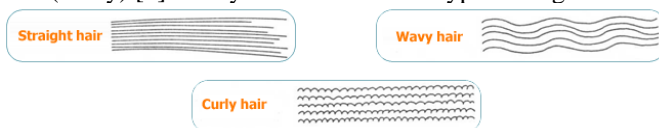


Fig.2 Three different types of hair appearance
 The number of hair

The average number of one hundred thousand hairs is on the head of a human. Also, the number of hair for those who have hair bushiness reaches to 150 thousand. This number varies in persons with age, race, gender, genetics and different hair color. Table 2 shows the average number of hair with different hair colors. In every square

centimeter of child head skin, there are 1100 follicles. While in the age of 25, this number reaches 600. From age 35 to 50 the hair density decreased, so that in these ages the average of 250 to 300 hairs per square centimeter has been reported.

Table 2: Average number of different hair colors

Natural hair color	Average number
Blond	140000
Brown	109000
Black	102000
Red	88000

- Growth rate of hair

The speed of hair growth, not only in different parts of the body but the head is also different. On average, hair grows per month at the rate of 1 to 1.5 cm. Unlike nails, hair growth is not continuous, this means that after a while it is stopped, and replaced with new growing hair. The process of hair growth, hair loss and regrowth is done in a cycle called hair growth cycle. This cycle is performed in three stages that can be seen in Figure 3.

- 1- Anagen (Growth phase): At this stage, the average for healthy hair takes 5 to 6 years, the hair grows. After passing this stage, the hair does not grow more.
- 2- Catagen (intermediate phase): The hair does not grow, but it is prepared for falling and giving place to another hair. This stage lasts from 2 to 3 weeks.
- 3- Telogen (resting or shedding phase): The stage is called the falling phase, the new growing hairs expel previous hair and will replace the previous hair. This stage lasts from 2 to 3 months [9].

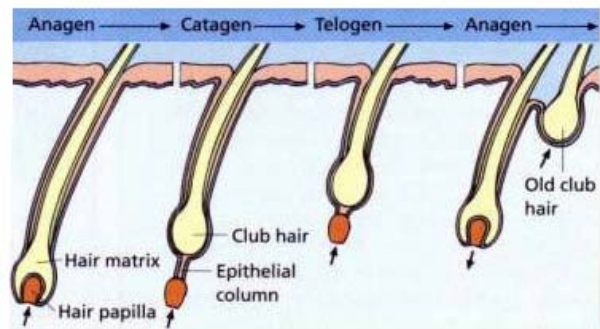


Fig. 3 hair growth cycle

3. Hair loss

Hair loss may occur for various reasons. Every hair has a lifetime. When a hair falls, it is replaced by another. So, naturally hair falling rate equals with their replacing rate. When hair loss is considered as an injury or illness, the disorder occurs in the growing new hair to replace the missing hair. Daily averages of 50 to 80 hairs are shed naturally. In some cases hair loss is determined over the range. If the hair loss reaches a significant level, sooner or later the scalp is visible from amidst the hair. This case is called alopecia or hair loss. The most common type of hair loss is baldness that men and women have been plagued over many years. At the age of 25, 25 percent and at age 50, 50 percent of men lose their hair more or less. Hair loss in men and women follow a certain pattern. In some cases, hair loss in women follows the male's pattern, unlike in some other, men hair loss follows that of female's pattern [3, 10, 11].

To confirm the abnormal hair loss and its severity, take out 50 to 100 hairs with fingers with a gentle pull. Normally 4 to 5 hair is pulled, if it is more than that, the hair loss is abnormal. An accurate method to evaluate the type of hair loss is checking the 50 to 100 hair strings under the microscope [4, 12].

If the hair loss is less than 10 strings in each comb, there is no loss and if this number is between 10 to 20, the hair loss is mild and if they are between 20 and 30, that is a medium hair loss and if it is more than 30 hairs, the loss is severe. In Figure 4, we can see the different patterns of hair loss.

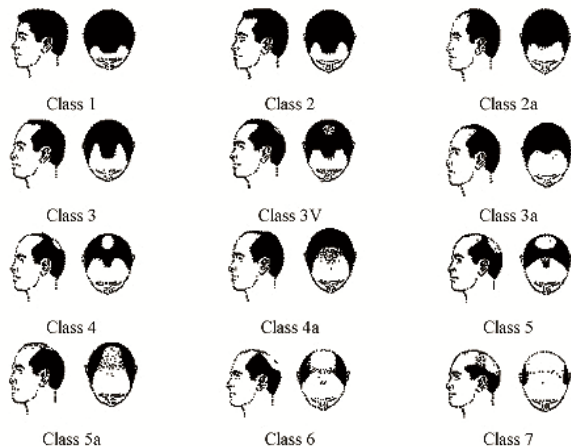


Fig. 4 Different patterns of hair loss

4. Effective factors in hair loss

Normally 90% of hairs are in growth phase and 10% are in the resting phase and on average, about 50 to 80 hairs during washing and combing are falling. So when a hair falls, a new hair takes its place. The problem begins when

the falling hair is further and faster than the growth of new hair or their growth cycle is short and fails to reach the maximum growth of anagen. In this case, after some time, the total number of hairs is reduced or hair is thinner and person may notice a decrease in the volume of hairs. This is the main cause of hair loss [11, 13].

Hair loss in men and women are different. 90% of men have some degree of alopecia. This factor is related to both genetic and hormonal reasons. Also, there are many different causes in women hair loss. One of the most common causes of female hair loss is iron deficiency. Because of monthly bleeding and difficulty impotence diet that some of them take, suffering from anemia or their bodies iron stores are reduced. Usually what is seen in the women is reduction of density of hair, not bald. Various factors are effective in hair loss, some of which are only effective in women and some in men [11, 14, 15]. Some of them are mentioned below.

- **Genetic factor**

This is considered as the most effective hair loss factor in men and women.

Androgenetic Alopecia or AGA is often used to describe a type of hair loss which is characterized by a pattern in men and women who are prone to genetic causes of hair loss. The word Andro is used to show the effect of androgens that are testosterone and Dihydro -testosterone (DHT), which are involved in men's hair loss. Genetic implies the fact that AGA is a genetic problem inherited from the parent genes. This kind of hair loss in men is called Male Patterned Hair Loss (MPHL) and in women Female Patterned Hair Loss (FPHL) [15-17].

- **Diseases**

Some diseases such as polycystic ovarian disease, thyroid, connective tissue diseases like lupus after menopause, different kinds of cancer, diabetes, cholesterol, etc. can cause hair loss [9, 18].

- **Iron deficiency**

This factor, especially in women who have heavy menstrual bleeding and who are at iron deficiency risk, can be considered as a powerful factor in the hair loss [19-21].

- **Drugs**

Medications such as drugs, blood diluting drugs such as Warfarin and Heparin, anti-convulsion medications like Dilantin, an anti-gout drugs such as Allopurinol and Colchicine, anti-pressure drug especially Beta-blockers, anti-inflammatory drugs such as Prednisolone, anti-depression drugs such as Lithium, contraceptives, high

intake of vitamin A, drugs related to atrophy are effective in hair loss [6, 9].

- **Cosmetics**

Hair dye, hair gel, non-standard softeners, hair ironer and using a hair dryer are effective in hair loss [9].

- **Stress and depression**

It has been known that there is a relationship between emotional and physical stress such as serious illness or surgery and hair loss. Depression resulting from separation, job loss, fever, infection, and so on has a remarkable effect on hair loss [9].

- **Gender**

Regarding the different patterns of hair loss in men and women, this is a very important factor in hair loss [2, 10].

- **Nutrition**

Malnutrition and vitamin deficiencies especially iron and protein deficiency are other significant factors in hair loss. Fruits, vegetables, dairy, meat, cereal juice, bran, soy, etc. have a large impact on hair growth and loss [9].

- **Surgery record**

Stress and the use of anesthetics and bleeding which are associated with surgery are very effective in hair loss [7].

- **Pregnancy**

Some women experience hair loss after their child delivery which lasts for 1 to 6 months that can also occur after the abortion [7].

- **The obsession with hair loss**

- **Zinc deficiency**

- **Chemotherapy**

- **Radiotherapy**

- **Age**

These factors are all more or less effective in hair loss. However, other factors such as fungal infections, bacterial skin diseases, burns, etc. are also effective [7, 22].

5. Artificial neural networks

Today, Artificial Neural Networks (ANN) are widely being used to achieve a competence like humans especially for pattern recognition and system detection. These networks are made up of a number of nonlinear calculation elements which act in a parallel way. The main feature of neural networks is that they can learn the environment and improve their efficiency during learning [23-25]. There are different models of neural networks and

the most important of them is multilayer feed forward neural network. In this network each input connects to all nodes of the first hidden layer and each node in the middle hidden layers connects to the nodes of the next layer. Input signals propagate from one layer to the next layers. Multilayer feed forward neural network are trained using back propagation algorithm. These supervised networks require real and desirable responses. These networks learn how to convert input data to real responses. They can approximate each input-output mapping with one or two layers. Finally a collection of outputs is formed as the response of the network.

The following formula determines the activity of the interior surface of the neuron (net):

$$net_j = \sum_{i=1}^n W_{ji} X_i + W_{j0}, i = 1, 2, \dots, n; j = 1, 2, \dots, l \quad (1)$$

And the following output is formed:

$$y_j = f(net_j) \quad (2)$$

Where, W_{ij} is connection weight of input-output nodes, W_{j0} is bias weight, X_i is input vector, Y_i is neuron output and f is activation function.

Each processing unit has an activation function which is found in different types. If we use a sigmoid function, then:

$$f(net_j) = \frac{1}{1 + e^{-(net_j)}} \quad (3)$$

Error back-propagation learning method minimizes network errors using gradient descent. It is done using chair rule derivation and by updating weight parameters.

Performance measure E which indicates the final error network is shown:

$$E = \sum_{p=1}^n \left(\frac{1}{2} \sum_{k=1}^m (d_{pk} - y_{pk}) \right)^2 \quad (4)$$

Where, n is number of input data, m is number of neurons in output layer, d_{pk} is amount of desired output of k th neuron for p th input datum and y_{pk} is amount of network output with k th neuron for p th input data [25-28].

Weights are updated based on learning algorithm to minimize E . learning objective is to obtain the updated weights of all network layers by minimizing function E . This error as mean square calculates the differences between the output amounts of the network and the desirable output for all patterns.

Training is as an inseparable part of a neural network. Several algorithms have been introduced recently to train

neural networks. These algorithms are mainly based on the standard method of error back-propagation. They differ in their performance and convergence speed. For example, we can name the learning algorithms Levenberg-Marquardt, resilient back-propagation and different algorithms of conjugate gradient such as Fletcher reeves, Polak-Ribiere, Rowel-Beale and scaled conjugate.

6. Results and discussion

In this paper, we are trying to determine the amount of hair loss through the significant characteristics of age, sex, genetic factors, pregnancy, surgery record, zinc deficiency, iron deficiency and use of cosmetics. The data for this study were gathered through interviews with doctors and conducting exact medical tests. The data were collected from 384 individuals and by getting help from physicians and specialists in one year. These factors are the input parameters of neural networks.

We used the criteria Mean Square Error (MSE) and Mean Absolute Error (MAE) to evaluate the performance of the network.

$$MAE = \frac{1}{n} \left(\sum \left| \frac{t-a}{t} \right| * 100 \right) \quad (5)$$

$$MSE = \frac{1}{n} \sum (t-a)^2 \quad (6)$$

Where, n is number of input data, t is desired output and a is neural network output.

Figure 5 compares neural network outputs and different algorithms and desired output on test data. Table 3 shows the results concerning different learning algorithms in two-layer neural networks using MSE and MAE. The diagram of figure 6 also shows the linear regression between network output and desired output for training, validation, test and total data.

The results obtained from table 3 show that in two-layer neural network, Levenberg- Marquardt has fewer prediction errors in comparison with other algorithms. The MSE of this algorithm in 19 epochs is equal to 0.0348 and its MAE is equal to 0.1393.

Also, the MSE and MAE error of the Resilient back-propagation algorithm in 30 epochs are equal to 0.0419 and 0.1584, respectively.

Due to the fact that hair loss recognition rate is dependent on several factors and it is not easy to determine the exact cause, the results in this paper are satisfactory. The results from the algorithm were acceptable and among the different algorithms the Levenberg-Marquardt algorithm had minor errors in fewer epochs and resulted in better outcomes.

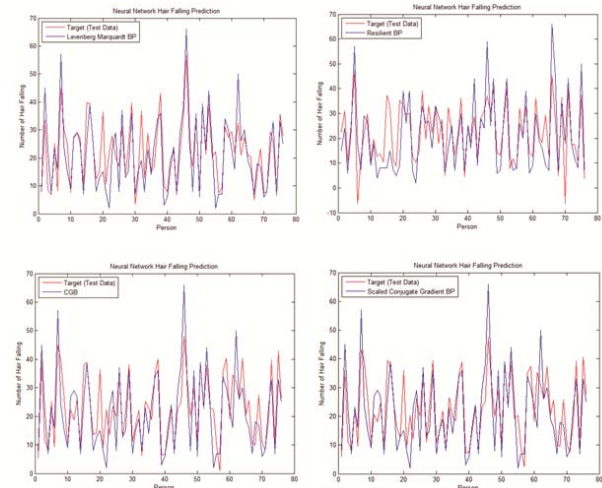


Fig. 5 The diagrams of comparing neural networks of different algorithms with the desired output on test data

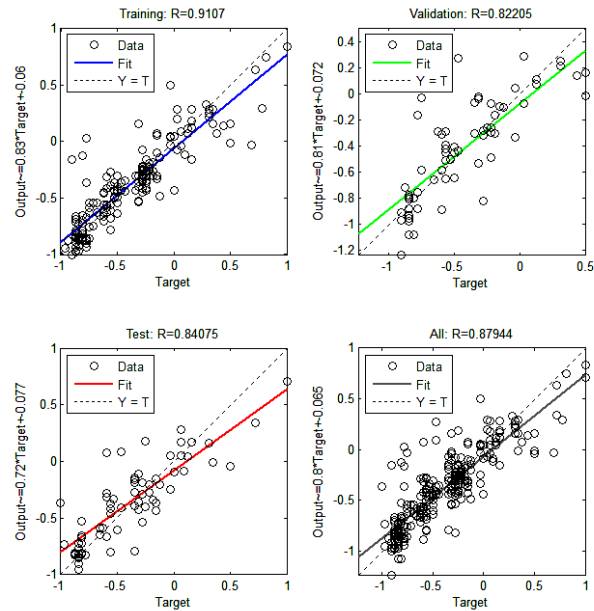


Fig. 6 Diagram of the network output and desired output for train, validation, test and all data

Table 3: Comparing the results of the algorithms of neural networks on the test date

Row	Algorithm	Epoc hs	MSE	MAE
1	Levenberg- Marquardt	19	0.0348	0.1393
2	Resilient Back Propagation	30	0.0419	0.1584
3	Powell-Beale Conjugate Gradient	36	0.0541	0.1617
4	Fletcher-Reeves Conjugate Gradient	43	0.0544	0.1625
5	Polak-Ribiere Conjugate Gradient	47	0.0514	0.1562
6	Scaled Conjugate Gradient	38	0.0447	0.1636

7. Conclusion

In this paper, hair falling has been predicted using an intelligent neural network method and has had good results.

Results revealed the fact that neural networks can be somewhat successful in detecting the amount of hair loss. Of course if more experimental samples are available to further improve these results.

Some learning algorithms like Levenberg-Marquardt have better results than others. Regarding the fact that hair loss is dependent on several factors and it is not easy to determine the exact basis, it can be useful to gather more samples and analyze them in order to reduce the error associated with the method.

We can also use other intelligent methods such as fuzzy neural networks to diagnose the diseases. Due to the use of linguistic variables, fuzzy neural networks seem to be more successful.

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