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Prevention of obesity using Hopfield networks in patients with obese ancestry

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Abstract. This paper proposes a risk study to suffer from obesity based on genetics and caloric intake. Using the calculation of the amount of glucose ingested and Hopfield networks to detect patterns of kinship between a control group and their relatives with obesity or bad eating habits. Of the volunteers who are at risk of triggering obesity, 43% have good nutrition and obese parents, another 43% have a poor diet with obese parents, those volunteers who have poor nutrition and do not have overweight parents, have a 10% risk of obesity, those who do not have obese parents and have poor nutrition, their risk percentage is 4%. It was possible to detect the predominance of genetics in obesity and the advantages of the use of computer techniques in the support for the timely detection of obesity.
Keywords: Obesity; Cardiovascular diseases; Genetics; Fat.

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1 Introduction

The feeding of an obese person is composed mainly of an excessive amount of carbohydrates and saturated fats being these more calories than those that are spent in daily activities, that when not eliminated is transformed into fat that is reserved in the viscera and the body of agreement with Muñoz and Arango (2017). Because of bad eating habits, genetics, and a sedentary lifestyle, the number of people with obesity worldwide has increased, making this disease an epidemic, said González, Rio, and Adelantado (2018). Factors such as proper nutrition and exercise help to prevent, control, and cure this disease, unfortunately, due to a hurried lifestyle, the number of sedentary people who consume compound fast food increases every day.

Obesity is a chronic disease of multifactorial origin, which is characterized by excessive accumulation of fat or general hypertrophy of adipose tissue in the body, which indicates that when the natural energy reserve of humans stored in body fat increases, put health or life at risk. According to its symptoms and level of severity, obesity is divided into exogenous obesity and endogenous obesity, the differences between these is that an inadequate diet causes exogenous obesity in conjunction with low physical activity. In the other hand, obesity endogenous is caused by metabolic alterations such as the thyroid and deficiency of sex hormones according to Cabrera, Romero, Carballosa, Hermida, Sabina, and Coba (2009).

Obesity is related to other diseases, although metabolically healthy obese patients have been detected, since they do not present any metabolic problems or cardiovascular disease, this may be mainly because they are genetically favored. It is important to point out that in the future if their obesity increases can begin to develop health problems regardless of their genetic makeup, as mentioned by Acebo (2017). That is why it is essential to prevent and control obesity because it is a cause of premature deaths. This disease can cause cardiovascular diseases, diabetes mellitus type 2, sleep apnea, and osteoarthritis. Obesity is a predictable and treatable disease, as indicated by OMS (2016).

There is no age at which it can be determined that there is a risk of obesity since it is a disease that attacks people of different ages, among them and mainly at present to minors. Although various measures have been taken, obesity has increased, for example, childhood and juvenile obesity from 4.2% in 1990 to 6.7% in 2010 and if it continues that way, it is expected that in the future the population with problems of overweight increase according to Sanz (2018).

It is essential to consider various factors such as genetics, stress, insomnia, sedentary lifestyle, and bad eating habits. Also, the amount of fat provided in the intakes has vital importance in the control of obesity, a balanced diet low in fat and sugars helps to have a healthy level of weight.

Due to the effectiveness of artificial intelligence techniques, they have been used in various investigations; for example, in the field of medicine, diffuse logic has been used for a self-regulating oxygen control system, for supplying oxygen FIO_2 in a suitable dose.

The results obtained were positive since the fuzzy controller achieved an adequate level of FIO_2, as Ospino, Robles, and Duran (2014) say.

In the case of diseases such as migraine, Martins (2017) has implemented an expert decision system to predict migraine using algorithms such as c4.5 to build an expert decision-maker using devices monitored by doctors. As a result of this research, it was possible to detect the migraine in the average of 1.38 minutes, thus making the system a very suitable instrument for medical use.

Some research, such as that of Villegas (2016), has proposed the combination of artificial intelligence techniques such as fuzzy logic, neural networks and genetic algorithms in the case of the development of applications for the analysis of cardiac problems. These techniques were used to detect arrhythmia signals in advance using a mobile device, converting the system into an alternative to monitor people with heart problems.

Based on previous research in this article, a technique has been proposed so that from the number of fats ingested in combination with Hopfield networks, and based on family behavior patterns of obese relatives, information on the number of intakes and amount of food for intake of 20 people, determine the probability that they will be overweight in the future.

2 Application of the Hopfield Networks

The Hopfield network is a self-associative neural network, which means that it recovers and stores information by association. Each layer of the Hopfield network is connected, in this way they are fed back to each other so that using the perceptron, the neurons of a layer achieve to transmit the activation pattern, which is a vector formed by 1's and -1's.

This network allows a set of information to be stored in its learning phase, subsequently providing a binary output. The functioning of the Hopfield network can be explained in the following way: first, a data is introduced and communicated with the input layer, this transmits it to the middle layers which update their status, randomly choosing each neuron that is updated, at the end of this process a state of equilibrium is reached, and finally the activation pattern is transmitted to the output layer.

It is said that the Hopfield neural network is one of the networks with simple operation and has been used for various functions in the field of physics, as used in a study at the UNAM by Mora, (2011). In this study, a binary optimization was carried out for a dynamic system with a tendency to equilibrium, using the advantages of the Hopfield network to reduce the computation time and a decrease in energy due to the constant updating of the middle layers.

Also, in Celoria and Pulenta (2017) used a Hopfield network for segmentation of biomedical images for magnetic resonances. The way it was handled was together with the winner-takes-all learning mechanism, the brain classes were segmented to obtain the number of grey levels, According to the bits of the image as results, a more precise identification of tissues was obtained, being useful for the identification of hepatologies, facilitating the doctor's monitoring, surveillance or diagnosis.

On the other hand, when working with artificial intelligence to contribute to gender equality studies applied to gender equality in García (2017), a Hopfield network was used taking into account the 18 laws of 100 countries to determine if a country is sexist or feminist. The sample was taken from 1960 to 2010, a pattern line file was obtained per year, and the laws of the countries were given values 1 or -1 thus forming the entry patterns, as a conclusion received information according to the laws of the countries, determining which gender favors each country and the evolution that these have had over the years.

3 Material and methods

Since genetics and poor diet are factors that have a high impact on the development of obesity, the number of fats ingested per week in the intakes for which the following technique was proposed was taken as an experiment in this study:

$$\sum_{m=1}^{M}\sum_{a=1}^{A} caloricCounter_{m,a} \tag{1}$$

where:

$caloricCounter_{m,a}$: number of calories ingested in the intake a, of the day m,
M: number of days of the week,
A: number of intakes per day.

The Hopfield neuronal network, to obtain information on the relationship between the genetics of volunteers and their parents for the detection of obesity, is expressed as follows:

$$W_{ij} = \sum_{k=1}^{M} e_i{}^{(k)}\, e_{ij}{}^{(k)} \tag{2}$$

where:

M: number of patterns to learn, of which the sum of all those that will be memorized in the network,
i: neuron i with connection to the ith of the pattern that contains the information that must be stored,
j: neuron j with link to the jth of the pattern that includes the information that must be stored,
W_{ij} : weight associated with the connection between the neuron j and the neuron i,
$e_i{}^{(k)}$: value of the ith component of the vector corresponding to the kth information that the network must learn,
N: Number of neurons in the network (size of the learning vectors).

A survey was carried out on 20 people aged between 15 and 25 years old, and some factors that contribute to the detection of obesity were compared with those of their parents to detect similarities. These volunteers were questioned about their feeding along seven days, this to analyze the data and identify the relationship between habits in food intake and genetic similarity, which can influence a person to be more prone to obesity.

For the scope of this research work and to obtain an approach in the search for the prediction of obesity, five attributes were used: stress, sedentary lifestyle, insomnia, the existence of obese relatives and suffering from cardiovascular diseases. The presence of any of these attributes in each volunteer is expressed by number 1; otherwise, if the volunteer does not suffer from the problem, the way to represent it is through a -1. These attributes were programmed in a Hopfield network in java language, in a machine with an Intel core i3-6100U processor, with 4 GB of memory RAM and a Windows 10 x64 operating system.

4 Results

The summary of the data obtained from the volunteers can be seen in Table 1, and the information on the habits of their relatives in Table 2.

Table 1. Factors that influence the detection of obesity.

No. of volunteers	Stress	Sedentary	Insomnia	Obese relatives	CD[1]	FWW[2]	Ingested fats/week
1	1	1	1	1	1	910	1982
2	1	-1	-1	1	-1	630	672
3	1	-1	-1	-1	-1	672	600
4	-1	-1	-1	-1	-1	952	960
5	1	-1	1	-1	-1	840	1879.2
6	1	1	-1	-1	1	952	954
7	-1	1	-1	-1	1	602	549
8	-1	-1	-1	1	-1	560	705.6
9	-1	1	1	1	-1	546	644
10	1	1	1	-1	1	980	2112
11	-1	-1	1	1	-1	1050	2282.4
12	1	-1	-1	1	1	1078	958
13	1	-1	-1	-1	1	854	2304
14	1	1	1	1	-1	826	2080
15	1	-1	-1	1	-1	882	803
16	-1	-1	-1	1	-1	1120	2365.6
17	-1	1	-1	-1	-1	700	616
18	-1	-1	1	1	1	644	632
19	1	1	-1	1	1	924	1248
20	-1	1	1	1	1	686	644

[1]CD = Cardiovascular diseases,
[2]FWW = Fats per week that you should consume according to your weight expressed in grams.

Table 2. Information from relatives of volunteers.

No. of volunteers	Stress	Sedentary	Insomnia	Obese relatives	CD*	Relationship
1	1	1	1	1	1	Obese mother
	1	1	-1	1	-1	Obese father
2	1	1	-1	1	-1	Obese mother
	-1	-1	-1	1	-1	Healthy father
3	1	-1	-1	-1	-1	Healthy mother
	-1	-1	-1	-1	-1	Healthy father
4	-1	-1	-1	-1	-1	Healthy mother
	-1	-1	-1	-1	-1	Healthy father
5	1	-1	-1	-1	-1	Healthy mother
	-1	1	-1	-1	-1	Healthy father
6	-1	1	1	-1	1	Healthy mother
	1	-1	-1	1	1	Healthy father
7	1	-1	1	1	-1	Healthy mother
	1	-1	1	1	1	Healthy father
8	-1	-1	-1	-1	-1	Healthy mother
	1	1	1	1	1	Obese father
9	1	1	1	1	1	Obese mother
	1	1	1	1	1	Obese father
10	-1	-1	1	-1	-1	Healthy mother
	-1	1	1	-1	-1	Healthy father
11	-1	-1	-1	-1	-1	Healthy mother

	1	1	1	1	1	Obese father
12	1	1	1	1	1	Obese mother
	-1	-1	-1	-1	-1	Healthy father
13	-1	-1	-1	-1	-1	Healthy mother
	-1	-1	-1	-1	-1	Healthy father
14	1	-1	-1	-1	1	Healthy mother
	-1	1	1	-1	1	Obese father
15	1	1	-1	-1	1	Obese mother
	-1	1	1	-1	-1	Obese father
16	1	1	1	1	-1	Obese mother
	-1	-1	1	1	-1	Healthy father
17	-1	1	-1	-1	-1	Healthy mother
	1	-1	1	-1	-1	Healthy father
18	1	-1	1	1	-1	Obese mother
	-1	-1	-1	-1	1	Obese father
19	1	-1	1	1	1	Obese mother
	1	1	1	1	1	Obese father
20	-1	-1	-1	1	-1	Healthy mother
	1	1	-1	-1	1	Obese father

*CD = Cardiovascular diseases.

In this study, the Hopfield neuronal network was used by means of the 5 factors used to determine the probability of contracting obesity in each volunteer, learning patterns extracted from the information of close relatives were obtained, which are observed in Table 2 and which were associated with the entry patterns derived from the 20 volunteers in Table 1.

After various iterations, when finding a similar pattern of the volunteer with one of their parents, the network shows this pattern as output. In this way, it will be known if the volunteer runs the risk of being obese since the similarity of the volunteer's pattern with the pattern of one of the parents obtains genetic influence on the risk of obesity.

The Hopfield network, considering the genetic factors and eating habits for the prevention of obesity, showed that 14 volunteers are at risk of obesity, as shown in Figure 1, 43% are volunteers with proper nutrition and obese parents, while another 43% are volunteers with poor diet and obese parents.

With this, it is possible to observe that even though food is an essential factor, some habits or patterns of behavior performed genetically have a higher incidence, since in those volunteers who, despite their bad eating habits, but do not have obese parents, their percentage of risk is 10% because the rest of their habits and their genetics favors them. In the case of those who do not have obese parents and have a poor diet, their risk percentage is 4%.

The habits that a person is accustomed to choose from childhood can affect in adult life because as seen in Figure 2, those volunteers with obese parents tend to have intakes with more glucose than those who they do not have obese parents; this may be due to the habits that have been had in the upbringing or the family environment.

5 Discussion

At the beginning of this work, the objective was to predict by taking some habits, genetic and nutritional factors, the probability of obesity modelling the proposed technique for calculating fats ingested by intakes and the Hopfield network algorithm. Finally, gathering the valuable information of the amount of fats by intakes as well as the habits of the volunteers and their genetic information, putting into practice the algorithm of Hopfield networks, we obtained the information that was needed to predict the risk of obesity and to prevent the disease in people with characteristics similar to those used in the experimental parameters described in the results section.

Because the amount of information with which the technique and the Hopfield network algorithm was tested is limited, these results may vary when tested with more volunteers. As the network is trained and when consulting with an expert, as not all people metabolize food in the same way because they can influence various factors of which only five were used to avoid working with a large amount of information in the first tests.

With the results obtained, both volunteers and their doctors can get information to focus on what habits to change to prevent obesity.
This study can be useful to develop a telemedicine or m-Health service, which could be very useful for doctors and nutritionists to remotely monitor the most important variables of patients to prevent obesity.

To improve results, we can add more variables that cause fats to rise and implement some other networks or artificial intelligence techniques and compare results to make use of optimal techniques.

From the preliminary results can be observed that there are preponderant attributes when predicting which person could suffer from obesity. Therefore, it would be useful to implement a technique of selective ordering by induction methods called ID3, which would outline a scenario that would make it easier for health experts to perform medical diagnoses based on data obtained from medical evolution patterns of patients with a high degree of the feasibility of getting sick.

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