

## Use of General Regression Artificial Neural Network to Identify the Natural Growth of Head Circumference of the Baby

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### ABSTRACT

Recently, many cases of deformities and health problems that affect the newborn were recorded, because of the known pollutants and radiation. One of these problems is the growth of the child, both in terms of height and weight or in terms of the natural growth of head circumference. Any increase or decrease in the measurement of head circumference a sign of a problem

This research addresses the issue of natural growth of the baby's head circumference from the first month until he/she reaches a year and half old. Artificial neural networks were used to train the normal values for the growth of head circumference based on the medical chart for the growth of head circumference and adopted internationally. Results showed the efficiency and accuracy of the work of these networks in the diagnosis of natural cases from the others.

**Keywords:** Regression Artificial Neural Network, natural growth.

استخدام شبكة الانحدار العصبية الاصطناعية المعممة لتحديد النمو الطبيعي لمحيط الرأس للطفل

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### المخلص

في الآونة الأخيرة، تم تسجيل العديد من حالات التشوهات والمشاكل الصحية التي تؤثر على الأطفال حديثي الولادة، وذلك بسبب الملوثات المعروفة والإشعاعات. واحدة من هذه المشاكل هو نمو الطفل، سواء من حيث الطول والوزن أو من حيث النمو الطبيعي لمحيط الرأس. أي زيادة أو نقصان في قياس محيط الرأس دلالة على وجود مشكلة. هذا البحث يتناول مسألة النمو الطبيعي لمحيط رأس الطفل من الشهر الأول حتى يبلغ من العمر سنة ونصف السنة. تم استخدام الشبكات العصبية الاصطناعية لتدريب القيم الطبيعية لنمو محيط الرأس على أساس المخطط البياني الطبي لنمو محيط الرأس والمعتمد دولياً. وأظهرت النتائج كفاءة ودقة عمل هذه الشبكات في تشخيص الحالات الطبيعية من غيرها.

**الكلمات المفتاحية:** شبكة الانحدار العصبية الاصطناعية المعممة، لتحديد النمو الطبيعي.

## 1- Introduction:

Growth means change and includes all kinds of physical and physiological terms of height, weight, size, and the changes that occur in various organs of the body and changes of mental cognitive and behavioral changes, social, emotional experienced by the individual in different stages of growth. The most important elements of growth are the progressive members change and their functions. This change can be represented by a change in the type (as the change of the sperm and egg to embryo), or a change in number (as in changing the number of teeth from childhood to adolescence to old age), there is a change in the size (as in the change of height and weight), or the change in shape (as the proportions of the body change during successive stages of growth). The growth stages are treated in the sequence of a certain pattern [3].

Head circumference of the child is the index of the skull size, as well as it refers to the size and growth of a child's brain in the first years of his/her life. As shown in Figure (1), measuring of the head circumference is one of the tests performed by a pediatrician at every check of the child. The abnormal increase in the size of the head may indicate the occurrence of specific illnesses related to the central nervous system or a lack of vitamin D or other diseases [16].



**Figure (1).** The Measuring of the Head Circumference of Children [17].

There is a relationship between increased head circumference and autism spectrum disorders (ASD). The increase in the head circumference was more marked than that in the body growth. The values of physical measurements, in the first year, may be useful, minimally invasive parameters for the early detection of autism in combination with observing the timing of certain behaviors. [2]

Hydrocephalus is the most common disease of the central nervous system in children and requires neurosurgical treatment. Although, this condition may appear in a patient at any age, most often, it affects newborns and infants in the first year of life [14]. Primary microcephaly is a disorder of brain development characterized by a congenitally small, but normally formed brain, and non-progressive mild-to-moderate mental retardation. Most cases are inherited in an autosomal recessive [6] and [12].

Manual assessment of pathological changes is always subjective and time-consuming. There is also a risk that such assessment can be cursory and incorrect. Therefore, development of tools for an automatic detection and analysis of pathological changes is one of the most challenging tasks of the present. [14]

One of the major problems in medical life is giving a diagnosis. A lot of applications have been tried to help experts in offering a solution. This paper describes how artificial intelligence, for example, artificial neural networks can improve this area of diagnosis. [7]

## 2- Neural Networks and GRNN:

ANNs are inspired from the information-processing pattern of the biological nervous system. Input, hidden and output layers are the main components of most neural networks. The input layer takes information directly from input files, and the output layer sends information directly to the outside world through computer or any other mechanical control system. There may be many hidden layers between input and output layers. The advantage of ANN is the inclusion of non-linear relations in the model [11].

ANN has been developed as generalization of mathematical models; it is mainly used in solving problems with extremely difficult or unknown analytical solution. ANNs' property of learning from examples makes them powerful programming tools especially when domain rules are not completely certain or when certain amount of inaccuracy or conflicting data exist. A neural network consists of a large number of simple processing elements called neurons. The network architecture is the arrangement of neurons into layers and the connection patterns within and between layers. Each neuron is connected to other neurons by means of directed communication links, each with an associated weight. The weights represent information being used by the net to solve a problem. Each neuron has an internal state, called its activation level, which is a function of the inputs it has received. An activation function is used to map any real input into a usually bounded range, often 0 to 1 or - 1 to 1 [1].

Neural networks have been programmed to perform pattern recognition, identification, classification, speech, vision, and control systems. Today, neural networks can be programmed to solve problems that are difficult for conventional computers or human beings. A neural network is superior at fitting functions and recognizing patterns. In fact, there is proof that a fairly simple neural network can fit any practical function [8].

The general regression neural network (GRNN) is a powerful regression tool that has a dynamic network structure. It is based on the established statistical principles, and asymptotically converges with an increasing number of samples to the optimal regression surface. GRNN has been observed to yield better results than the back-propagation network or RBF network in terms of prediction performance [13] [9] and [5].

The GRNN was introduced by Nadaraya and Watson and rediscovered by Specht (Specht, 1991) to perform general (Linear or non-linear) regressions. Unlike the RBF neural network, the training patterns are propagated through the network only once and consequently the training is achieved very quickly. The topology of a GRNN is described in Figure (2) and it consists of four layers [4]:

The input layer that is fully connected to the pattern layer and the pattern layer that has one neuron is assigned for each training pattern. These neurons have radial basis activation functions (Gaussian functions) of the form:

$$\phi_i = \exp\left(\frac{-D_i^2}{2\sigma^2}\right) \quad \dots(1)$$

The summation layer has two units  $N$  and  $S$ . The first unit computes the weighted sum of the hidden layer outputs and the second unit has weights equal to 1, consequently is the summation of exponential terms  $\phi_i$  alone.

The output unit divides  $N$  and  $S$  to provide the prediction result [4].

$$\hat{y} = \frac{\sum_{i=0}^n \phi_i \cdot Y_i}{\sum_{i=0}^n \phi_i} \dots(2)$$

**Input layer:** For each predictor variable, one neuron is in the input layer. In the case of categorical variables, “n-1” neurons use where, “n” is the number of categories. The input neurons standardizes the field of the values by subtracting the median and dividing by the inter quartile range. The input neurons, then send the values to each of neurons in the hidden layer [10].

**Hidden layer:** There is one neuron for each case in the training information collection. The neuron supplies the values of the predictor variables for the case along with the object value. The resulting value will shift to the neurons in the pattern layer [10].

**Pattern layer/summation layer:** There are two neurons in the pattern layer. One neuron is the numerator summation section, and another is the denominator summation section. The denominator summation section inserts the weight values coming from each of neurons in the hidden layer. The numerator summation section applies the weight values multiplied by the real target value for each neuron in the hidden layer. **Decision layer:** The decision layer separates the value accumulated in the numerator summation section by the value in the denominator summation section and uses the result as the predicted target value. The learning method is similar to finding a table in a multidimensional space that provides a perfect fit to the training data. The generalization corresponds to the use of this multidimensional way to include the test data. [10] and [11].

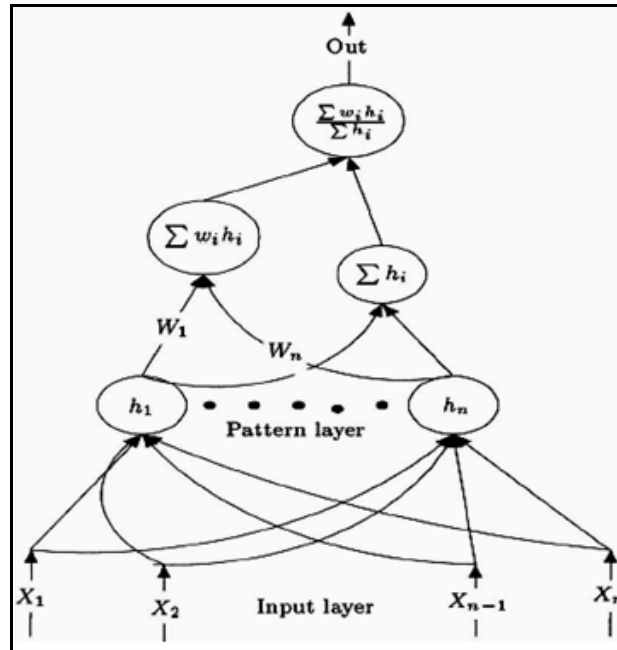


Figure (2). The GRNN Architecture. [4]

### 3- Data Collection:

The newborn head circumference is about 34cm, which becomes 36cm at the age of the fifth week. It increases to one and a half centimeter at the age of two months, then grows to about 40 cms at the age of four months. After six months, the head circumference is about 41.5 cms, and then reach to about 42.5 cms. at ninth month. [16].

Head circumference measured in a wider area of the head, a region which includes the distance from above the eyes to the back of the head. Often, the head

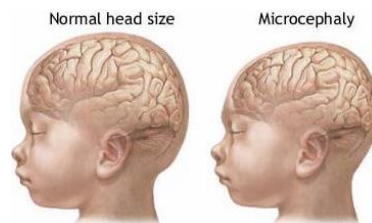
circumference of the child increases in proportion with the growth of his/her brain by age and sex, so there are charts separately for males and females by age where they are monitoring this growth which is within normal limits according to drawings, as well as the increase or decrease in the growth of the follow-up by the doctor and the medical intervention early if necessary. There are two types of abnormal growth of the baby's head circumference, which may indicate a defect in the growth and development of the brain:

- 1- Large head circumference, head circumference or a large increase in head circumference (Hydrocephalus) is when measuring head circumference above the normal limits and being accepted on the child's development charts and often indicates the presence of disease of the nervous system as shown in Figure (3).



**Figure (3).** Hydrocephalus disease in infants and children [8]

- 2- Lack of head circumference Microcephalus and often indicates that the slow growth of the brain and the concomitant failure of brain [15], as shown in Figure (4).



**Figure (4).** Microcephalus Disease in Infants and Children [19]

In this research, the measurement of the head circumference depended on the medical charts for male and female that is shown in Figures (5) and (6) respectively. For high efficiency and accuracy of diagnosis were taken measure for each month individually for males and the same process for females and until the child reaches the year and a half year of age for example, were taken 32 cms for females since the early hours of birth and until the completion of them by a month them month, with up area around his/her head to 38 cms on average for normal growth and thus its outlook for the rest of the months and even month (18) years of age. The whole process is repeated and details for the male with a simple note the difference in measurements. Figure (7) shows the steps of this work

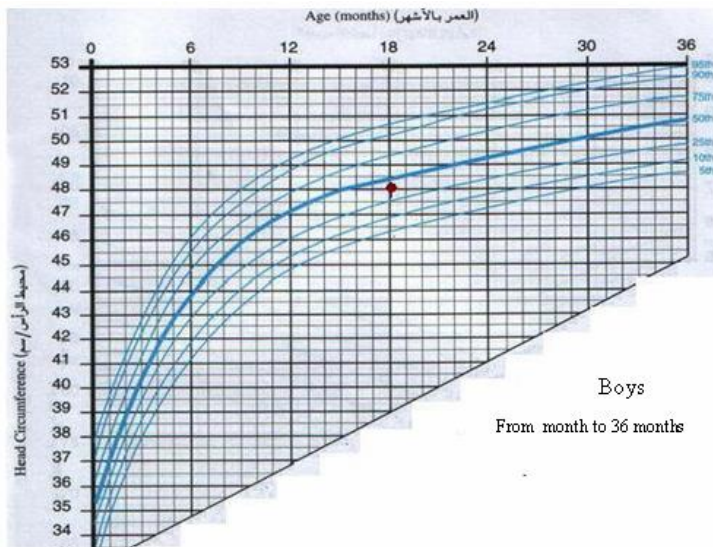


Figure (5). The Medical Chart to Measure the Growth of Head Circumference for Males.

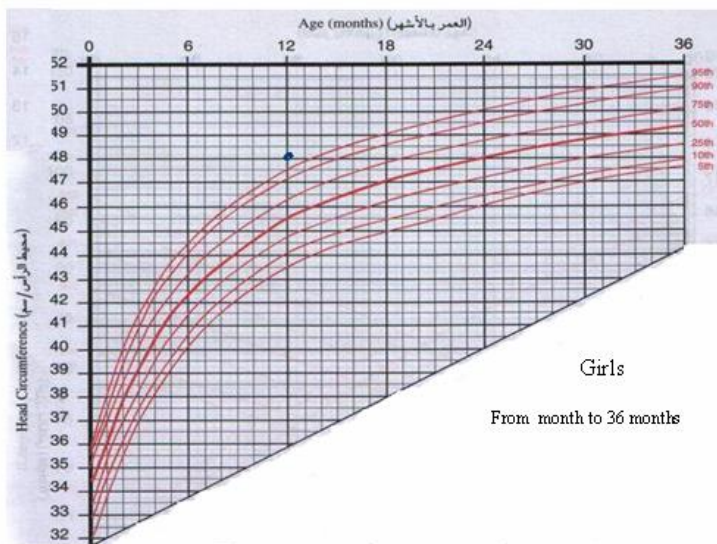


Figure (6). The Medical Chart to Measure the Growth of Head Circumference for Females

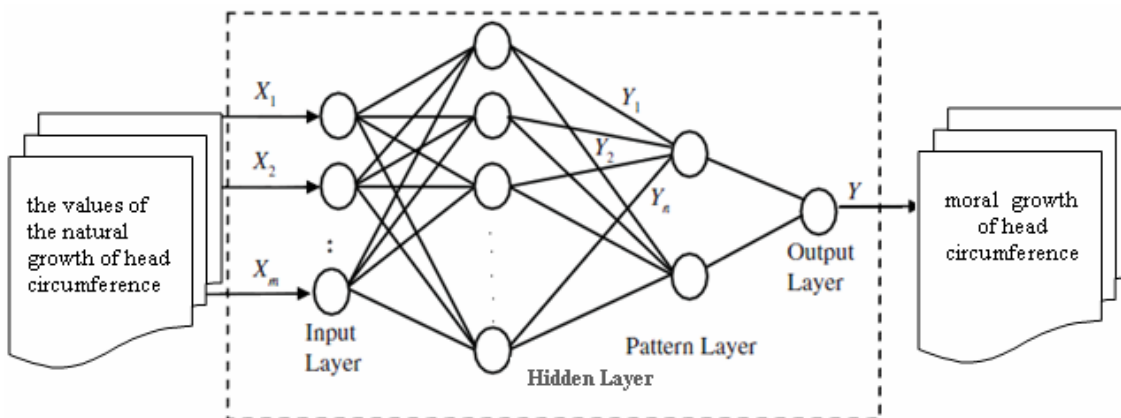


Figure (7). Work Steps

**4- Practical application:**

In this research, based on the medical chart for the growth of the baby's head circumference and with using Matlab (R2012a) program, (36) general regression neural



networks were built, (18) for males and (18) for females. Each network represents the age group (GRM1), for example; artificial neural network represents the training and the testing the specific measurement male child aged one month. And the network (GRF2) represents the training and the testing specific measurement for female child aged two months, and so on down to the network's for the last child age year and a half .

Since, the (GR) name of the neural network is used, and (M) to denote that the baby's sex a male and number (1) means that the network dedicated to the child in the first month of age. Search did not continue in the establishment of networks to the age of two or three years because of the situation in these ages is very clear and accompanying symptoms of diseases have emerged clearly and the disease may worsen without the treatment in a timely manner.

Each network contains input layer, hidden layer, pattern layer and output layer with different in the input values only. Each aged has values of the normal growth sequence and start with value for females and other values for males, for example, matrix input to the network (GRM1) any child mentioned in the first month values beginning with (33 cms) and ending (40 cms) and an increase rate of (1.0) and as follows:  $P = [33: 0.1:40]$  and this increase is constant for males and females to get to a better and more accurate diagnosis to address the potential problem in a timely manner without waste of effort, time and risk to the health and safety and protection of children from serious diseases or disabilities sustained left behind by the negligence of these symptoms.

Hidden layer in these networks contains the same number of neurons as in the input layer to order treatment .The output layer contains one neuron, of number (1) refers to the success of the training process of the network after inserting the values of the natural growth of head circumference. Tables (1) and (2) clarify the structures and the applications with all results of the neural networks in this research for male and female respectively.

**Table (1).** The structures, applications and results of the neural networks (**for male**).

Name of the NNs	Age classes	Data inputs	Input neuron numbers	Hidden neuron numbers	Pattern neuron numbers	Output neuron numbers	Time elapsed for training(sec)
GRM1	1 <sup>st</sup>	[32:39.5]	66	66	2	1	0.333574
GRM2	2 <sup>nd</sup>	[35:41.5]	66	66	2	1	0.328492
GRM3	3 <sup>rd</sup>	[36.5:43]	66	66	2	1	0.253521
GRM4	4 <sup>th</sup>	[38:44]	61	61	2	1	0.267214
GRM5	5 <sup>th</sup>	[39:45]	61	61	2	1	0.323613
GRM6	6 <sup>th</sup>	[40:46]	61	61	2	1	0.347082
GRM7	7 <sup>th</sup>	[41:47]	61	61	2	1	0.307182
GRM8	8 <sup>th</sup>	[42:47.5]	56	56	2	1	0.247136
GRM9	9 <sup>th</sup>	[42.5:48]	56	56	2	1	0.302189
GRM10	10 <sup>th</sup>	[43.5:48.5]	51	51	2	1	0.392183
GRM11	11 <sup>th</sup>	[44:49]	51	51	2	1	0.343582
GRM12	12 <sup>th</sup>	[44.5:49.5]	51	51	2	1	0.308258
GRM13	13 <sup>th</sup>	[44.75:49.5]	48	48	2	1	0.277451
GRM14	14 <sup>th</sup>	[45.25:49.75]	46	46	2	1	0.269343
GRM15	15 <sup>th</sup>	[45.5:50]	46	46	2	1	0.284824
GRM16	16 <sup>th</sup>	[45.75:50.25]	46	46	2	1	0.342161
GRM17	17 <sup>th</sup>	[46:50.5]	46	46	2	1	0.242648
GRM18	18 <sup>th</sup>	[46.25:50.75]	46	46	2	1	0.278369

**Table (2).** The structures, applications and results of the neural networks (**for female**)

Name of the NNs	Age classes	Data inputs	Input neuron numbers	Hidden neuron numbers	Pattern neuron numbers	Output neuron numbers	Time elapsed for training(sec)
GRF1	1 <sup>st</sup>	[32:38]	61	61	2	1	0.750117
GRF2	2 <sup>nd</sup>	[34:40]	61	61	2	1	0.294545
GRF3	3 <sup>rd</sup>	[35.5:41.5]	61	61	2	1	0.280626
GRF4	4 <sup>th</sup>	[37:43]	61	61	2	1	0.312710
GRF5	5 <sup>th</sup>	[38:44]	61	61	2	1	0.323482
GRF6	6 <sup>th</sup>	[39:44.5]	61	61	2	1	0.243423
GRF7	7 <sup>th</sup>	[40:45.25]	53	53	2	1	0.318454
GRF8	8 <sup>th</sup>	[41:45.75]	48	48	2	1	0.342062
GRF9	9 <sup>th</sup>	[41.5:46.5]	51	51	2	1	0.266939
GRF10	10 <sup>th</sup>	[42.25:46:75]	46	46	2	1	0.307519
GRF11	11 <sup>th</sup>	[42.5:47]	46	46	2	1	0.273246
GRF12	12 <sup>th</sup>	[43:47.5]	46	46	2	1	0.272100
GRF13	13 <sup>th</sup>	[43.5:48]	46	46	2	1	0.357829
GRF14	14 <sup>th</sup>	[44:48.25]	43	43	2	1	0.325078
GRF15	15 <sup>th</sup>	[44.25:48.5]	41	41	2	1	0.290785
GRF16	16 <sup>th</sup>	[44.5:48.75]	43	43	2	1	0.294321
GRF17	17 <sup>th</sup>	[44.55:48:80]	43	43	2	1	0.301590
GRF18	18 <sup>th</sup>	[44.75:49]	43	43	2	1	0.367036

To training the neural networks, the input values, target values and the number of neurons in the hidden layer must be inserted. The input values were processed in the hidden layer, then treated in the pattern layer down to the decision layer and comparison of outcomes with target values. There are two possibilities either the growth of baby's head circumference is natural or is not. Networks were trained for all the natural growth possibilities and the ratio of success training was (98%). Testing process included all cases in addition to the most abnormal cases with success tasting ratio (95%). Results showed network's ability to diagnose all the cases.

### 5- Conclusion:

After practice and train network on the values of the natural growth of the baby's head circumference at different stages described for both genders and after the testing process on the natural and abnormal values, this research concludes that neural networks are able to distinguish between the two cases and can diagnose cases of abnormal accurately and efficiently.

### 6- Recommendations:

This research recommends additional work to build an expert system by using these networks devoted to diagnosing growth head circumference. Moreover, additional artificial neural networks may be used to customize both the normal weight and length based on the medical chart that adopted internationally in all medical centers, for the purpose of getting an integrated system that works as a medical consultant and be accessible to everyone.



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