Artificial neural networks analysis of the abdominal aortic aneurysm

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Abstract. Background: Objective: Aneurysm denotes a localized increase in arterial diameter with loss of parallelism of the artery wall. Apart from the use of existing predictive models, it is difficult to precisely determine the boundaries between the aneurysmal segment and the aortic safe portions. Also, the factors favoring the development of the aneurysm are poorly defined. In this study, we propose an intelligent analysis of the individual variability of the diameter of the abdominal aorta associated with the risk factors involved.
Methods: Due to the complexity and uncertainty of individual variability, an intelligent technique analysis of the abdominal variation of the diameter of the abdominal aorta is performed. In a population of 100 patients, their ages are matched to the diameter of the abdominal aorta. An artificial neural network analysis system is proposed. This is done under the MATLAB compiler. Results: After learning the network, an input-output transfer function is created and adjusted. It then becomes possible to predict the degree of the aneurysm from a random value at the input of the system. Conclusions: a subject at a certain age is likely to have an aneurysm which it is necessary to diagnose in order to foresee his risk of rupture. The majority of cases are diagnosed accidentally in the absence of a screening program.

Keywords: Aneurysm, Age, Risk factors, ANN

1. Introduction

The abdominal aortic aneurysm usually causes few symptoms [1]. When it is not taken care of in time, it can even be fatal to burst. Eight in ten people with a burst AAA will have no chance of being cured. From there, appears the need to detect it in time. This allows it to be followed when it is in its initial phase. The screening is fast and reliable [2].

The problem with abdominal aortic aneurysms is to be able to act before they rupture by identifying them and defining when to treat them during their course [14], [15].

A screening program should be implemented so as to intervene as early as possible in relation to the development of abdominal aortic aneurysms.

Given the specificity of the absence of symptoms and in order to establish a screening plan for a large population, it becomes necessary to make a selection on the basis of risk factors. As these factors are characterized by their complexity, we found it useful to analyze them using an artificial neural network system. A database is established, linking diagnosed patients to related risk factors.

After the network learning phase, it becomes possible to predict the population at risk and therefore to include them in a screening program.

2. Risk Factors

The main risk factors for developing AAAs are smoking, hypertension, advanced age, male sex, atherosclerosis, dyslipidemia, positive family history and hereditary predisposition [3].
In our study, we limit ourselves to age variable.
Even considering only this factor which has a direct consequence on the aneurysm, the system remains very complex to analyze. Anyone can never accurately predict the weight of each factor without talking about the others in view of the uncertainty of the physiological system.

2.1 Age

The "age" factor is directly related to the diameter of the abdominal aorta although this is also a function of the "race" factor [4]. This is explained by the fact that with age the factors favoring the aneurysm such as diabetes, blood pressure or hyperlipidemia increase [5]. By analyzing the "Age" factor, we indirectly took into account other related factors.

The aneurysm manifests itself much more at an advanced age [6]; the Society for Vascular Surgery (SVS) has established recommendations for systematic screening for men over 65, regardless of smoking. While for men with a family history, this age drops to 55 years. For women, it is recommended to proceed to this screening from the age of 65 for those with a family history [7].

As the system is much more complex to be simplified in this way, an artificial neural network analysis is proposed.

3. Methods

Our study sample includes 100 diagnosed patients. For each, the 'Age' factor is taken as a function of the diameter of the aorta diagnosed by CT which makes it possible to measure its diameter. A system is established linking specific risk factors to diagnosed patients. The risk factors considered in this study is age which is the input variable to the system. The diameter of the corresponding aorta is considered the outlet of the system. The system makes the connection between the two spaces (input-output). This way of proceeding has proven its effectiveness in various fields [8]. And have the ability to solve data in complex systems.

The proposed neural network is multi-layered. Input layer-hidden layer and output layer. In our case, the complexity of the system and data relating to the risk factors to be adequate. The system is constructed and the link between the two spaces is performed. The internal activity of a single neuron computes the weighted sum of inputs and passes this sum through a non linear function. The function W_b used as a sigmoid.

3.1. Neural Analysis

Apart from fundamental research in artificial intelligence and the attempt to model the brain, artificial neural networks are concretely used in many different cases, of which we will see the case of our application [9]; [10].

The first phase is learning the network. During this phase the function is adjusted via the modification of the weights which are mathematical coefficients.

Input variables
Each variable is numerically coded depending on the degree of severity.

- Age: the age is represented by its numeric values in years which range from 40 to 100 years.

Output variable
People diagnosed positive according to their aorta diameter are represented by numeric values from 2.5 to 5.5 cm.

4. Model

Out of a sample of 100 people, 50 are used for learning about the network, i.e. 50% while 50 other tests are used for testing. A priori, the relationship between these two spaces is complex (in particular non-linear) which justifies the use of the multilayer network.

LEARNING THE NEURAL NETWORK

In our case, this involves entering recorded analysis data. The diameter of the abdominal aorta measured is considered output variable.

To achieve this, the method is in a way an imitation of the brain: if the answer is correct, it is good, but if there is an error, the network must be modified so as not to repeat the error. Our analysis mainly concerns them. The objective is to train the network to arrive at the minimum error value of the reading error observed at the output. Each factor is mapped to the output variable. The operation is repeated several hundred times, until the network has the smallest possible error value, in our case 1000 repetitions (Figure 1).

5. Discussion

INPUT VARIABLE 'AGE'

The constructed network is multi-layered (figure 1). With a transfer function, adjustment loop of 1000 by modifying the weights to achieve minimum error. We see that just at 789 iterations we manage to minimize the error to 10^{-7} (Figure 2).

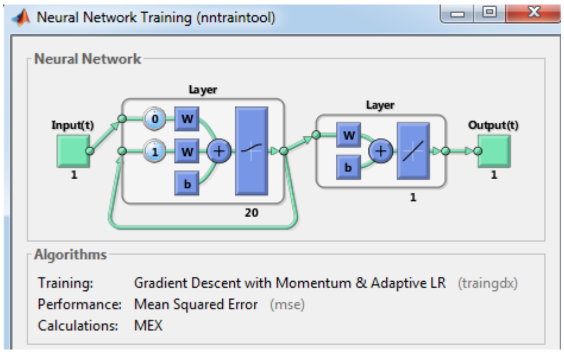


FIG. 1. SYSTEM BLOC DIAGRAM

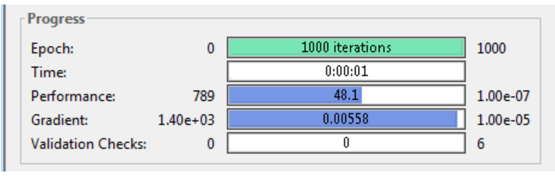


FIG. 1. SCHEMATIC OF THE ERROR CORRECTION SYSTEM WHEN LEARNING THE "AGE" NETWORK

Figure 3 represents the variation curve of the diameter of the abdominal aorta. When learning the network with 50 cases, the established transfer function was tested with the other 50 cases.

It should be noted that the learning values are taken intermittently as well as the test values

It can be seen that the test values merge perfectly with the learning values. This validates the function created.

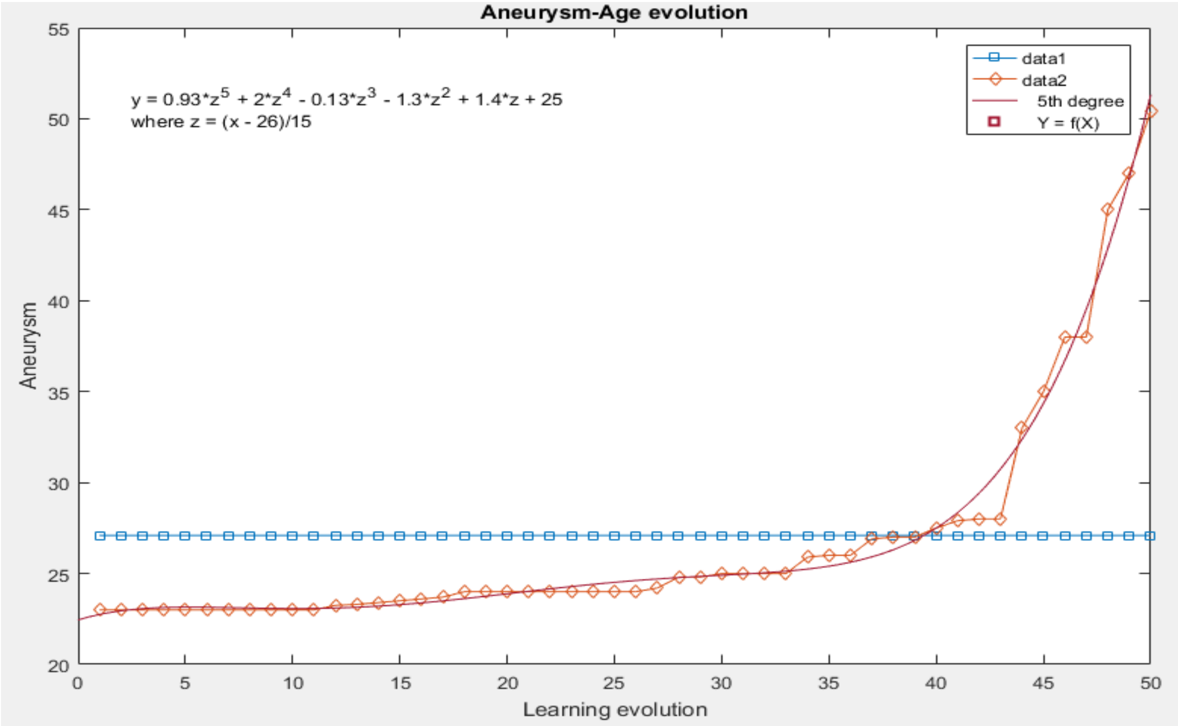


FIG. 3. VARIATION OF THE ANEURYSM AS A FUNCTION OF THE VARIABLE "AGE"

After calculating the summary of the, we can predict the diameter of the corresponding abdominal aorta. Example at 86.6 years old, the diameter of the aorta will be probably 55 cm.

Note: in order to modify the network, it suffices to intervene on the weights [W] which are in the form of real numbers linking the neurons. As these weights are involved in the sum performed by each neuron (the sum is weighted), it is possible to modify the network by changing their values without changing the network itself. However, it is not clear how much to change these weights. The goal is to converge to a minimum error.

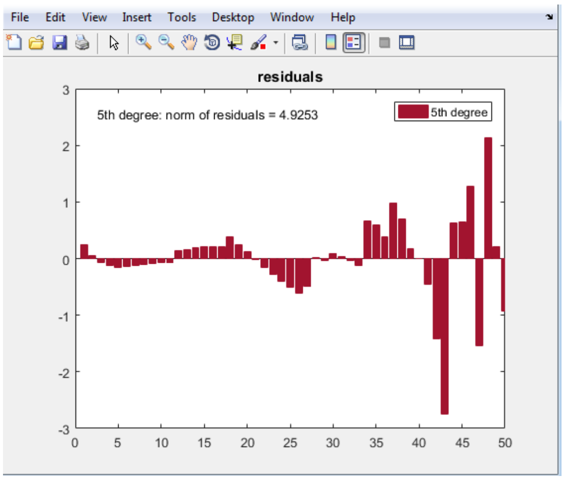
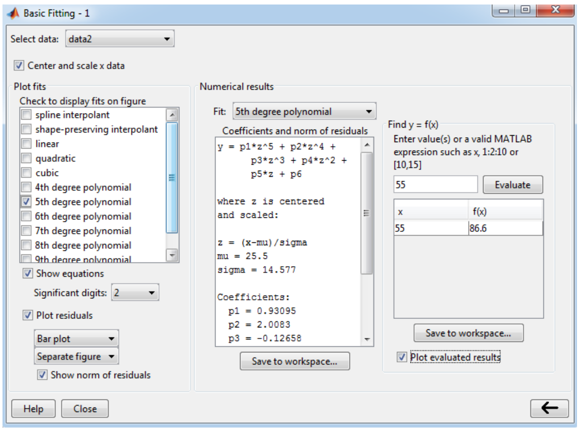


FIG.4. FUNCTION OF RESIDUALS "ANEURYSM-AGE"

These residues are shown in Figure 4.
The approximate displayed trend line equation shows residuals. From the function created and adjusted to the minimum error, the predicted aortic diameter is calculated.



We used Matlab 2016a for data processing.

6. Results

By introducing values to the input variables in correspondence with the output variable and processing several combinations, the transfer function is constructed.

At each input-output, the function is adjusted via weights (mathematical coefficients). This phase is the phase of learning the network. This continues up to the optimum of the desired function.

After the learning phase of the network, it becomes possible to predict the rate of risk disease according to these variables.

The optimum of the learning is reached with a performance of 10^{-7} from at 1000 epoc for (Age) variable. A performance is achieved with a gradient of 0.45 starting from 550 for 'Age' variable

7. Conclusions

After the learning phase of the network, it becomes possible to predict the result at the output of the system from the input of the variables at the input.

As the effect of each parameter is supported as weight (mathematical coefficient) when adjusting the function, the result will be as accurate as possible [11]. This will make it possible to establish a screening plan. Thus, the number of cases to be detected will be reduced and targeted. This will make it possible to predict the population at risk.

References

[1]. Sourabh A., Arman Q., Vishal S., and Alka S. (2011). Abdominal aortic aneurysm: A comprehensive review. Exp Clin Cardiol. Spring; 16(1): 11–15.

[2]. NHS public health functions agreement 2016-17 Service specification No.23 NHS Abdominal Aortic Aneurysm Screening Programme.

[3]. Becker F, Baud JMM. Dépistage des anévrysmes de l'aorte abdominale et surveillance des petits anévrysmes de l'aorte abdominale : Argumentaire et recommendations de la Société française de médecine vasculaire. J Mal Vasc 2006; 31(5) : 260–76.

[4]. Greenhalgh RM. Screening men for aortic aneurysm : a national population screening service will be cost-effective. BMJ 2002 ; 325 : 1123–4

[5]. Erbel R, Aboyans V, Boileau C, Bossone E, Bartolomeo R, Eggebrecht H, Evangelista A, Falk V, Frank H, Gaemperli O, Grabenwöger M, Haverich A, Iung B, Manolis AJ, Meijboom F, Nienaber CA, Roffi M, Rousseau H, Sechtem U, Sirnes PA, von Allmen RS, Vrints CJM (2014). ESC Committee for Practice Guidelines. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC). Eur Heart J.; 35:2873-926.

[6]. Jin Hyun Joh, Hyung-Joon Ahn, and Ho-Chul Park. (2013). Reference Diameters of the Abdominal Aorta and Iliac Arteries in the Korean Population.Yonsei Med J 54(1):48-54,

[7]. http://dx.doi.org/10.3349/ymj.2013.54.1.48

[8]. Kim J, Meade T, Haines A. (2006). Skinfold thickness, body mass index, and fatal coronary heart disease: 30 year follow up of the Northwick Park Heart Study. J Epidemiol Community Health;60:275–9.

[9]. Chaikof EL, Brewster DC, Dalman RL, et al. (2009) SVS practice. guidelines for the care of patients with an abdominal aortic aneurysm:executive summary. J Vasc Surg 50:880–896

[10]. Brant W. Ullery, Richard L. Hallett, Dominik Fleischmann. Epidemiology and contemporary management of abdominal aortic aneurysms. Abdom Radiol (2018). Springer Nature 2018.

[11]. https://doi.org/10.1007/s00261-017-1450-7

[12]. Tao Shuai, Yuanqing Kan, Yi Si, Weiguo Fu. (2020). High-risk factors related to the occurrence and development of abdominal aortic aneurysm. Journal of Interventional Medicine 3 80–82

[13]. 7. Khaoula B., Mustapha B., Saddek B., Mokhtar HC. (2017). Leishmaniasis transmission vectors analysis using artificial neural networks. Averooes European Medical Journal. Volume 5, Number 1.

[14]. Khenchouche A., Bouharati K., Bouharati S., Mahnane A., Hamdi-Cherif M. (2017). Post Mortem Interval: Necrobiome Analysis Using Artificial Neural Networks. Computational Biology and Bioinformatics. 5(6): 90-96.