

An ANN-Based Predictive Model for Diagnosis and Forecasting of Hypertension

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Abstract—The effects of hypertension are often lethal thus its early detection and prevention is very important for everybody. In this paper, a neural network (NN) model was developed and trained based on a dataset of hypertension causative parameters in order to forecast the likelihood of occurrence of hypertension in patients. Our research goal was to analyze the potential of the presented NN to predict, for a period of time, the risk of hypertension or the risk of developing this disease for patients that are or not currently hypertensive. The results of the analysis for a given patient can support doctors in taking pro-active measures for averting the occurrence of hypertension such as recommendations regarding the patient behavior in order to lower his hypertension risk. Moreover, the paper envisages a set of three example scenarios in order to determine the age when the patient becomes hypertensive, i.e. determine the threshold for hypertensive age, to analyze what happens if the threshold hypertensive age is set to a certain age and the weight of the patient if being varied, and, to set the ideal weight for the patient and analyze what happens with the threshold of hypertensive age.

Keywords—Neural Network, hypertension, data set, training set, supervised learning.

I. INTRODUCTION

HYPERTENSION occurs when a person's mean arterial pressure is greater than the upper range of the accepted normal pressure. A mean arterial pressure of 110mmHg is considered hypertensive [1]. This level of mean pressure occurs when the diastolic blood pressure is greater than 80mmHg (120/80mmHg) and the systolic pressure is greater than 120mmHg. Many cardiologists consider systolic pressure of 160mmHg and diastolic pressure 100mmHg (160/100mmHg) to be Hypertensive [2].

Causes of hypertension range from renal, endocrine, primary aldosteronism, neurogenic causes and, in many cases, is unknown. An unknown cause of hypertension is called essential hypertension. Hypertension caused by the secretion of large quantities of aldosterone is called aldosterone Hypertension. The aldosterone increases the rate of re-absorption of salt and water by the tubules in the kidneys, thereby reducing the loss of these substances in the urine while causing an increase in extra cellular fluid volume. Neurogenic Hypertension can be caused by the strong stimulation of the sympathetic nervous system. For instance, when a person becomes excited for any reason or at times

during states of anxiety, the sympathetic system becomes excessively stimulated. Vasoconstriction occurs everywhere in the body, and an acute hypertension ensues. The effects of Hypertension are often lethal; these are caused in the following ways:

- Excess workload on the heart leads to early heart failure and coronary heart disease, often causing death as a result of heart attack.
- The high pressure frequently ruptures a major blood vessel in the brain followed by death of a major portion of the brain, this is called cerebral infarct, and clinically this is called 'stroke depending on which part of the brain is involved.
- High-pressure almost always cause multiple hemorrhages in the kidneys, producing many areas of renal destruction and, eventually kidney failure, uremia and death.

When systolic and diastolic fall into different categories, the higher category should be selected to classify the patient's blood pressure as being high, normal or low. Routine blood pressure measurement is of value in detecting hypertension and also provides a useful record of baseline blood pressure in normotensive patients. As hypertension occurs commonly and is often asymptomatic, a proactive strategy is required to ensure its detection at a community level. There is a lack of data regarding the process of detection of hypertension in older people, but in younger patients this has been achieved using different practice-based strategies [2].

Reference [2] discovered that hypertension affects approximately 20% of the adult population worldwide (or approximately 700 million people). The prevalence of this condition significantly increases with age and it is estimated that up to 40% of people over the age of 60 have hypertension. Hypertension is associated with significant morbidity and mortality mainly from cardiovascular diseases and especially strokes.

Besides the current trend in technology and computer automation, the bioengineering interdisciplinary developments of the last years allowed the implementation of digital CAD (Computer Aided Diagnosis) aid tools to assist novice doctors in making diagnostic and recommended treatments and preventive decisions, herewith providing a second opinion on the decision and playing the role of the second pairs of eyes in the analysis, certifying or not the quality and/or the choice. Although the computational CAD techniques used in determining a medical prognostic do not always provide the desired quality, their implementation using intelligent techniques (like neural networks, support vector machines, fuzzy techniques, genetic algorithms, self organizing maps and

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their hybrid variants) that are based on human experience and provide learning and adaptation abilities, demonstrates high performance in these kinds of tasks.

In this paper, a neural network (NN) model was developed and trained based on a dataset of hypertension causative parameters in order to forecast the likelihood of occurrence of hypertension in patients. Our research goal was to analyze the potential of the presented NN to predict, for a period of time, the risk of hypertension or the risk of developing this disease for patients that are or not currently hypertensive. The results of the analysis for a given patient can support doctors in taking pro-active measures for averting the occurrence of hypertension such as recommendations regarding the patient behavior in order to lower his hypertension risk.

Moreover, the paper envisages a set of scenarios to determine measures that help the doctor assert the future development of the patient in certain conditions like: what is the age when the patient becomes hypertensive (i.e. determine the hypertensive age) if the patient condition maintains; analyze what happens if the threshold hypertensive age is set to a certain age and the weight of the patient if being varied; and, set the ideal weight for the patient and analyze what happens with the threshold of hypertensive age.

II. METHODS

The neural networks (NNs) models are simplified structural and functional nervous systems, formed by a number of processing elements, the neurons, which are bound by weighted connections, similar to the neural synapses [3].

The neural network architecture used usually in the medical field is known as the multi-layer perceptron (MLP), [4]. Fig. 1 shows such a MLP which usually consists of neurons organized in three feed-forward interconnected layers (i.e. all neurons in one layer are fully connected to all neurons in the next layer, but there are no feedbacks to previous layers).

A perceptron has the ability to learn, to self-organize and to generalize (i.e. it can have same output for similar sets of inputs). The most commonly used algorithm for training the neural network is the back-propagation algorithm, which calculates the error gradient of the network and adjusts each connection weight by minimizing the mean square difference and achieving convergence to a local minimum [5]. Fig. 1 shows a graphical representation of such a network, where, in the case of a medical system, the input layer neurons often corresponds to the clinical symptoms, the hidden layer simulates the medical inference process done by the doctor and the neurons from the output layer correspond to the medical diagnosis.

In this paper, a MLP neural network (NN) is first being trained with training dataset from medical record of 500 patients that suffer or not from hypertension. Different set of test dataset were used to draw inference from the trained NN model. For training and testing purposes, the inputs and the outputs for the trained NN can be seen in Table I.

Our research goal was to analyze the potential of the presented NN to predict, for a period of time, the risk of hypertension or the risk of developing this disease for patients

that are or not currently hypertensive. The results of the analysis for a given patient can support doctors in taking pro-active measures for averting the occurrence of hypertension such as recommendations regarding the patient behavior in order to lower his hypertension risk.

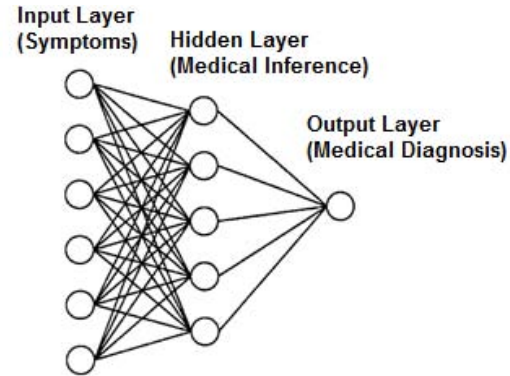


Fig. 1 Graphical representation of a MLP neural network with one hidden layer

TABLE I
INPUTS AND OUTPUTS FOR THE TRAINED NN

Inputs of NN	Value Variation (Min-Max)	Outputs of NN	Value Variation (Min-Max)
Age (Years)	15-90 years	Hypertensive	No/Yes
Height (M)	1,3-1,95 M		
Weight (KG)	48,5-110 Kg		
Body Mass Index (KG/M2)	23,97-52,66 KG/M2		
Family History	No/Yes		
Co-morbidity	No/Yes		
Smoking	No/Yes		
Cholesterol Level: high if contents > 260mg/dL or 6,7mmol/L	Low/High		

III. RESULTS

The above stated research goals were concluded in tree steps that are described in the following paragraphs.

TABLE II
PATIENT DATA

Clinical Features	Patient 1	Patient 2
Age (Years)	47	54
Height (M)	1.62	1.77
Weight (KG)	96	106
Body Mass Index (KG/M2)	36.58	33.83
Family History	Yes	Yes
Co-morbidity	Yes	Yes
Smoking	No	Yes
Cholesterol Level: high if contents > 260mg/dL or 6,7mmol/L	Low	High
Hypertensive	No	No

After training the NN the three analytical steps consist in analyzing a non-hypertensive, non-smoking, patient (Patient 1), clinically described by the data presented in Table II, for a period of time, by using the prediction capabilities of the

trained NN in order to:

- determine the age when the patient becomes hypertensive, i.e. the threshold for hypertensive age.
- analyze what happens if the threshold hypertensive age is set to 63 and the weight of the patient if being varied.
- set the ideal weight for the patient at 72 kg and analyze what happens with the threshold of hypertensive age.

The results for each analytical step are further detailed:

i. Determine the age when the patient becomes hypertensive, i.e. the threshold hypertensive age

This analysis was performed by varying the age between the patient age of 47 and 100 years in order to find out, by using the NN prediction model, what is the age when the patient becomes hypertensive. Fig. 2 shows the variation of the hypertensive risk, and the determination of the threshold hypertensive age of 63 years old.

ii. Analyse what happens if the threshold hypertensive age is set to 63 and vary the weight of the patient

This analysis was performed by varying the weight of the patient between 50 and 119 kg in order to find out, by using the NN prediction model, what is the influence of the weight on the HR when age is constant at 63. Fig. 3 shows the variation of the hypertensive risk, and the determination of the ideal weight of 72 kg which minimizes the hypertensive risk.

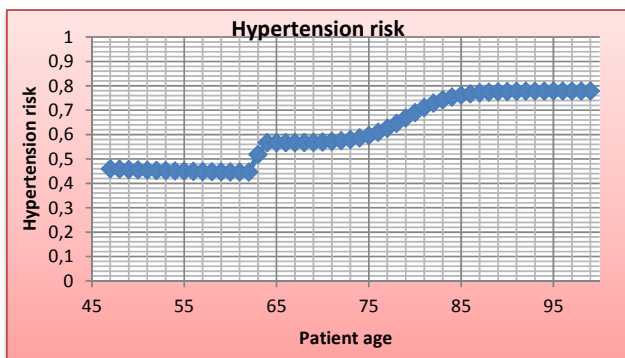


Fig. 2 HR prediction by varying patient age

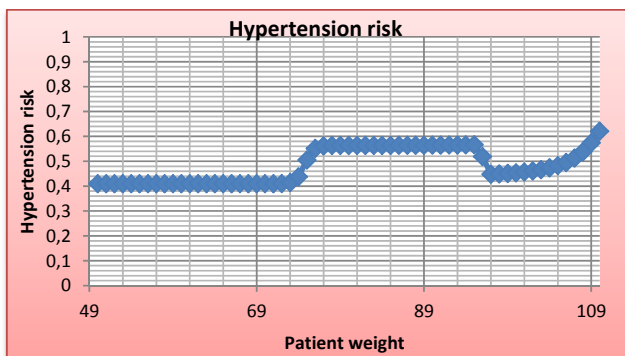


Fig. 3 HR prediction by varying patient weight and age=63

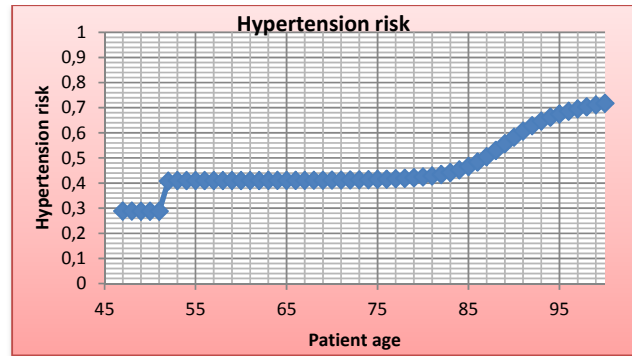


Fig. 4 HR prediction by varying patient age with patient age = 72 kg

iii. Set the ideal weight for the patient at 72 kg and analyse what happens with the threshold hypertensive age

This analysis was performed by setting the weight for the patient at 72 kg and varying the age between the patient age of 47 and 100 years in order to find out, by using the NN prediction model, what is the age when the patient becomes hypertensive. Fig. 4 shows the variation of the hypertensive risk when the patient age is 72kg, and the determination of the threshold hypertensive age of 87 years old.

IV. DISCUSSION

The above presented sensibility analysis demonstrates that a decrease of the weight of the patient induces a reduction of the hypertension risk, i.e. an increase of the threshold hypertensive age of the patient.

Another test that analyses, for a period of time (by using the prediction capabilities of the trained NN), a non-hypertensive, but smoking, patient (Patient 2), clinically described by the data presented in Table II, demonstrates that the hypertensive risk initially evaluated by the NN at 0,73 can be reduced to 0,54 if the patient loses around 30 kg or can get to values below 0.50 if the patient quits smoking and loses only 7 kg.

Such sensibility analysis can be made rapidly and personalized for anybody that needs it. Its availability on a large scale can be useful for the human kind in order to increase consciousness about hypertension and the ways it can be prevented.

V. CONCLUSION

The paper presents the developments of a neural network (NN) model trained on a dataset of hypertension causative parameters and used for the prediction of the occurrence likelihood of hypertension in patients. The specific research purpose was to analyze the potential of the neural networks to predict, for a period of time, the risk of hypertension or the risk of developing this disease for patients that are or not currently hypertensive. Expressed in form of a sensibility analysis, the results demonstrate that a decrease of the weight of the patient induces a reduction of the hypertension risk, i.e. an increase of the threshold hypertensive age of the patient.

This CAD system can be really helpful in assisting doctors for establishing recommendations and correcting measures in

a personalized manner for patients and offering certified indications of how to lower the hypertension risk and keep a more healthy body for a longer period of time.

The efficiency and the prediction power of the intelligent systems, either simple or hybrid, is extremely high, being currently limited only by the existence of a small number of data in the database. Thus, the versatility of analyzed data may be particularly wide. Additionally, the acquisition of more specific data from different sources related to clinico-pathological results and also patient information can lead to the identification of different correlations helpful for the medical process and for improvement of the people way of living.

The future developments of this application consists of the integration of better learning algorithms for the neural network, the utilization of its intelligent hybrid variants or also subsequently the employment of other intelligent technique that might offer an increase in the prediction performance of the hypertension diagnosis. Simultaneously, the intelligent analysis and prediction of optimized treatment protocols for reliable and controlled therapy in hypertension is a further goal to attain in the long run. Thus, in the context of a high number of CAD tools, the development of an expert system that takes into account the available analysis data and also the expertise of the doctors in order to select the most reliable hybrid technique to assist the diagnosis and treatment of hypertension is the envisaged goal.

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