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Artificial Neural Network and Mobile Applications in Medical diagnosis

Gillian Pearce
School of Engineering and Applied Science
Aston University
Aston, UK
gpearce2011@gmail.com

Julian Wong
Department of Cardiac, Thoracic & Vascular Surgery
National University Heart Centre
Singapore
Julian_wong@nuhs.edu.sg

Lela Mirtskhulava
Department of Computer Science
Iv. Javakhishvili Tbilisi State University
Tbilisi, Georgia
lela.mirtskhulava@tsu.ge

Salah Al-Majeed
Systems Engineering Department
Military Technological College
Muscat, Oman
Salah.Almajeed@mtc.edu.om

Koba Bakuria
Department of Information Technologies
Georgian technical University
Tbilisi, Georgia
kobabak@yandex.ru

Nana Gulua
Faculty of Mathematics and Computer Science
Sokhumi State University
Tbilisi, Georgia
ngulua77@mail.ru

***Abstract* — The aim of this paper is to present a model of ANN and to use it in diagnostic approaches for strokes that occur at night during sleep. Our system makes use of a (i) a neural network that can be trained to recognize normal limb movements for individual people, which is then coupled to (ii) a physical grid mattress that can be used in the individual's home. Any changes that could potentially indicate that stroke has occurred are transmitted to a mobile phone app, that in turn alerts a relative or ambulance to render rapid assistance to the individual. When stroke has occurred it is essential to transfer the patient to hospital very quickly in order that treatment can be given promptly. In the case of strokes that have arisen due to a blood clot in the cerebral circulation of the brain, a drug called Alteplase (an anti-thrombolytic) must be given within 4.5 hours of the stroke occurring to be maximally effective. Our system would record this information together with recording abnormal changes in the individual's limb movements. Feed forward neural network was simulated in the testing set. Maximum error is 0.0002.**

Keywords - artificial network model; stroke; smart mattress; sensors; mobile telemedicine systems.

I. INTRODUCTION

Neural networks have found many uses in medicine. Neural networks are particularly useful in recognition, aiding in medical diagnosis. Specific examples of neural networks within the health industry follow.

The major task of medical science is to prevent and diagnose the diseases. Here our focus is the second task, which is not a direct and simple task at all. In 2001, Brause highlighted that almost all the physicians are confronted during their formation by the task of learning to diagnose. Here, they have to solve the problem of deducing certain diseases or formulating a treatment based on more or less specified observations and knowledge. Below some certain difficulties of medical diagnosis that have to be taken into account are listed: the basis for a valid diagnosis, a sufficient number of experienced cases, is reached only in the middle of a physician's career and is therefore not yet present at the end of the academic formation [1].

1) This is especially true for rare or new diseases where also experienced physicians are in the same situation as newcomers.
2) Principally, humans do not resemble statistic computers but pattern recognition systems. Humans can recognize patterns or objects very easily but fail when probabilities have to be assigned to observations.
3) The quality of diagnosis is totally depends on the physician talent as well as his/her experiences.
4) Emotional problems and fatigue degrade the doctor's performance.
5) The training procedure of doctors, in particular specialists, is a lengthily and expensive one. So even in developed countries we may feel the lack of MDs.
6) Medical science is one of the most rapidly growing and changing fields of science. New results disqualify the older treats, new cures and new drugs are introduced day by day. Even unknown diseases turn up every now and then. So a physician should always try hard to keep his/ herself up to date [2].

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Question would be how computers can help in medical diagnosis. Since decades ago, computers have been employed widely in the medical sector. From local and global patient and medicine databases to emergency networks, or as digital archives, computers have served well in the medical sector. Meanwhile, in the case of medical diagnosis, regarding the complexity of the task, it has not been realistic yet to expect a fully automatic, computer-based, medical diagnosis system. However, recent advances in the field of intelligent systems are going to materialize a wider usage of computers, armed with AI techniques, in that application. A computer system never gets tired or bored, can be updated easily in a matter of seconds, and is rather cheap and can be easily distributed. Again, a good percentage of visitors of a clinic are not sick or at least their problem is not serious, if an intelligent diagnosis system can refine that percentage, it will set the doctors free to focus on nuclear and more serious cases [3-5].

II. Artificial Neural Network

Artificial neural networks provide a powerful tool to help doctors to analyze, model and make sense of complex clinical data across a broad range of medical applications.

Fig.1.Overview of the main applications of artificial neural network in medicine

Computer scientists have long been inspired by the human brain. In 1943, Warren S. McCulloch, a neuroscientist, and Walter Pitts, a logician, developed the first conceptual model of an artificial neural network. In their paper, "A logical calculus of the ideas imminent in nervous activity," they describe the concept of a neuron, a single cell living in a network of cells that receives inputs, processes those inputs, and generates an output. [6]

The most common application of neural networks in computing today is to perform one of these "easy-for-a-human, difficult-for-a-machine" tasks, often referred to as pattern recognition. Applications range from optical character recognition (turning printed or handwritten scans into digital text) to facial recognition [7].

One of the key elements of a neural network is its ability to *learn*. A neural network is not just a complex system, but a complex adaptive system, meaning it can change its internal structure based on the information flowing through it. Typically, this is achieved through the adjusting of *weights*.

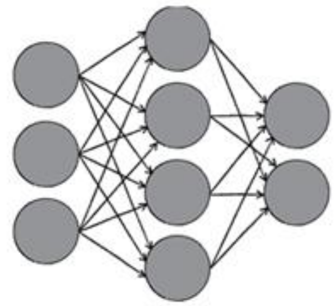

Fig.2. Artificial neural network diagram

In the diagram above (Fig.1.), each line represents a connection between two neurons and indicates the pathway for the flow of information. Each connection has a weight, a number that controls the signal between the two neurons. If the network generates a "good" output (which we'll define later), there is no need to adjust the weights. However, if the network generates a "poor" output—an error, so to speak—then the system adapts, altering the weights in order to improve subsequent results.

III. How to Use ANN in Medicine

Artificial neural networks could be used in every situation in which exists a relationship between some variables that can be considered inputs and other variables that can be predicted (outputs). The most important advantages using artificial neural networks are that this kind of system solves problems that are too complex for conventional technologies, do not have an algorithmic solution or the solution is too complex to be used. These characteristics have often appeared in medicine. Artificial neural networks have been successfully applied on various areas of medicine, such as: diagnostic systems, biomedical analysis, image analysis, drug development. Using artificial neural networks, it can be monitored a lot of health indices (respiration rate, blood pressure, glucose level) or can be predicted the patient response to a therapy. Artificial neural networks have a very important role in image analysis, too, being used together with processing of digital image in recognition and classification. They are used in pattern recognition because of their capacity to learn and to store knowledge. The medical image field is very important because it offers a lot of useful information for diagnosis and therapy. There are also a lot of applications that use neural networks connected with Bayesian statistics (which can estimate the probability density of model parameters given the available data) [8].

IV. RISK OF STROKE

Strokes can occur at any time during the day or night. In the. UK alone there are 150,000 strokes (http://www.stroke.org.uk).

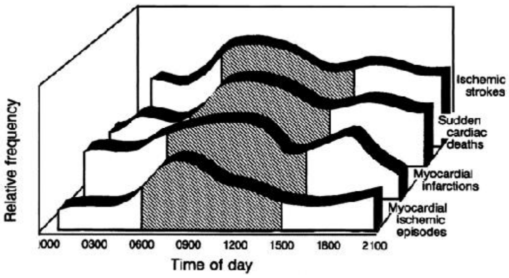

Fig.3. Circadian variation in ischemic stroke and cardiovascular events

Strokes that occur during the daytime are more likely to be witnessed by other people around the patient. Therefore the time of onset of the stroke is more likely to be known and recorded. At night however, a stroke can occur during sleep. Therefore the time at which the stroke occurred is less likely to be known. It is important to know the time of onset of the stroke, since many strokes (that arise due to a blood clot in a vessel in the cerebral circulation in the brain) are suitable for treatment with Alteplase (a clot busting agent that is given intravenously to stroke patient). However Alteplse has to be administered within 4.5 hours of the stroke occurring in order the really be effective. Clearly if a stroke arises while the patient is asleep, it is difficult to know the time of onset of that stroke. It is also known that if a stroke occurs the limbs (arms, legs) may be affected by the stroke causing loss of motor function. The affected arm or leg (of both) would not move independently as is the case for a normal person. Therefore if we had some way of monitoring the normal movement of an individual's limbs (while asleep) by recording any profound changes in normal movement e.g. loss of independent movement of a limb (arm, leg or both) like that which occurs in a stroke (affecting limb motor functions), we would have a system of knowing the time when the stroke occurred.

Additionally the system could alert a relative or ambulance to the occurrence of a potential stroke in that person. This would enable rapid transfer of the stroke patient to hospital and timely administration of Alteplase as appropriate. We are developing such a system based on neural network application coupled with a physical mattress grid (shown in Figure 4 below). The mattress is placed in the patient's bed (woven into the fabric of the bedding material). Furthermore the neural network itself can be trained to recognize an individual patient's normal movement and therefore to recognize lack of limb motion (as occurs in a stroke).

Sensor Data application provides direct access to data. All the data have been collected by using different types of the sensors[7]. Based on the symptoms these sensors can pass the data (offline or in real time) to the NN, where the latter will analyze it though a modelling system designed to distinguish limb's movement. The method based on magnetoelastic sensors has been used for the monitoring of movement of limbs. The ribbon-like magnetoelastic sensor oscillates at a fundamental frequency, which shifts linearly in response to applied mass loads or a fixed mass load of changing elasticity.

Actually, the mobile phone has been recognized as a possible tool for telemedicine since it became commercially available [5]. In fact, the mobile telephony has evolved a lot and offers new devices with some useful resources, such as serial ports and Internet connections. Therefore, the phones can interact with electromedic devices (EMDs) – like patient monitors, for example – and transmit vital signals through Internet protocols, such as TCP/IP and UDP.

V. THE PROPOSED MODEL

The mattress with the electronic grid - we are developing a mattress that elderly people lie on in bed. The mattress has an electronic grid (X,Y coordinates) that map where the limbs (arms, legs) of the patients are. The mattress transmits the X Y coordinates of arms and legs of the person to an app on a mobile smart phone. When the individual moves their legs and arms during sleep the X,Y coordinates will change- that is good because then they are moving their limbs normally and have not had a stroke. However, if the individual suffers a stroke, then their limbs (arm, leg of both) would not move normally, and the neural network would register any such changes from normality. The information would then be transmitted to an app on a mobile phone and the individual's relative or an ambulance could be sent to render assistance to the stroke patient as appropriate [4].

A neural network simulator is a program that creates a model of artificial neurons and the connections between them and then trains this model. Neural networks, just like people, learn by example and repetition. At a fundamental level, all neural networks learn associations. With a medical neural network, all you have to do is show it the related data for patients with the disease and data for those without the disease; the network will figure out the subtle relationships in your data. In that way a trained network can recognize e.g. abnormal movements (12). Once the network 'understands' what 'abnormal' means, it can either adjust movements by manipulating the created virtual environment or guide the patient directly through impedance-controlled resistance. A mattress is a typical input device to control a virtual environment. At the same time it measures movements of limbs (11). As such, it provides an important role for the evaluation and treatment of abnormal movements in patients.

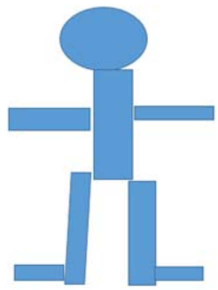

Fig.4. Patient's position on the
Electronic mattress

Mobile telemedicine systems can be utilized for emergency ambulance services, mobile hospitals, rehabilitation and paraplegic monitoring cases. Such systems are most effective when an ambulance is handling a patient on its way to the hospital. Ambulances carry paramedics but they only provide immediate medical care during the journey. Mobile telemedicine systems can send electrocardiograms (ECGs), still images, videos (including the aforementioned ultra-sound imagery), and other biomedical signals of the patient via a 4G network to the enable them to prepare the required medical resources to the hospital ward. The physicians in the ward will consequently obtain sufficient data about the status of the patient, even though the patient remains in the ambulance. This will consequently allow medical resources to be assembled, before the patient's arrival at the hospital, thereby, increasing the gold rescuing time [13].

VI. Evaluating performance

Feedforwarded Neural Network (FFNN) is a multilayered network with one layer of hidden units. Each unit is connected in the forward direction to every unit in the next layer. The input layer is connected to hidden layer and output layer is connected by means of interconnection weights. The bias is provided for both hidden and the output layer to act upon the net input. Network activation flow is in one direction only, from the input layer to output layer passing through the hidden layer. Back propagation algorithm resembles a multilayer feed forward network. The errors propagate backwards from output nodes to the input nodes. The FFNN is trained using Levenberg back propagation training algorithm because it finds a solution even if it starts very far off the final minimum. The training and testing samples are normalized between 0 and 1 using a binary normalization algorithm to fit the data within unity of 1. The network with on input was simulated in the testing set. The results were very good. Maximum error is 0.0002. Fig.4-5.

A neural network is formed by a series of "neurons" (or "nodes") that are organized in 3 layers: with 10 neurons on the first layer; 2 neurons on the second layer and 1 neuron on the third layer. There are Each neuron in a layer is connected with each neuron in the next layer through a weighted connection.

We are using clustering for training a neural network on patterns. This is useful for gaining insight into data and to simplify it before further processing. Where we are using four clusters values set as input data.

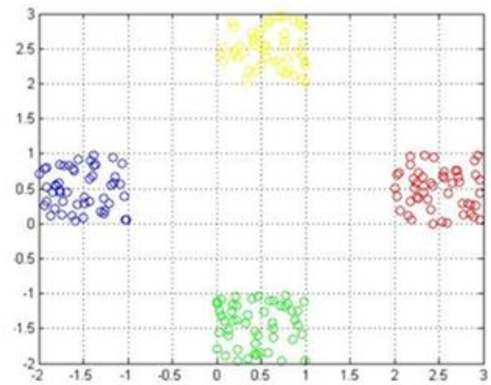

Fig.5.Trained FeedForward ANN

Optimal Neural Network design able of improving settling time and rise time of controllers based on genetic-fuzzy techniques were developed in [15]. Main task of the given paper was to design an algorithm for the optimization of fuzzy rules weights attempting to decrease the timing parameters values. To do this, it is necessary to find the best training sample for suitable Neural Networks [16]

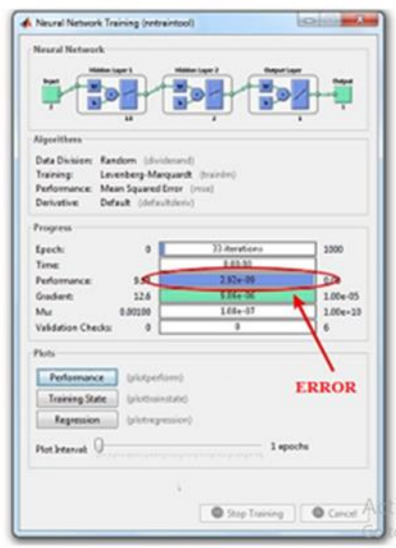

Fig.6. Maximum error is 0.002

VII. Conclusions

In this paper ANN model has been developed in diagnostic approaches for strokes that occur at night during sleep. The feed-forward neural network has been trained to recognize normal limb movements for individual people, which is then coupled to (ii) a physical grid mattress that can be used in the individual's home. Any changes that could potentially indicate that stroke has occurred are transmitted to a mobile phone app, that in turn alerts a relative or ambulance to render rapid assistance to the individual. This paper, investigated the possibility of recognizing limb movements using feed forward neural network. The network was simulated in the testing set. The results were very good. Maximum error is 0.0002.

Future work will concern for developing Optimal Artificial Neural Network app based on genetic-fuzzy techniques for detecting abnormal heart rhythms. The person could wear a watch type device on their wrist that detects the pulse.

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