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## Artificial Neural Network and Mobile Applications in Medical Diagnosis

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**Abstract** — The aim of this paper is to present a pilot study regarding the application of an ANN to stroke recognition and diagnosis. Our study makes use of a (i) a neural network that can be trained to recognize normal limb movements (for individual patients), which may then be coupled to (ii) a physical grid mattress that can be used in the patient's home. Any changes in the patient's movement that could potentially indicate that stroke has occurred are transmitted to a mobile phone app. The latter, in turn alerts a relative or ambulance to render rapid assistance to the patient. 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. Therefore it is important to know the exact time on stroke onset. Our system would record the time of onset of the stroke, by recognizing and recording abnormal changes in the patient's limb movements. A Feed forward neural network was used in our modelling.

**Keywords** - artificial network model; stroke; soft sensors; mobile telemedicine systems.

## I. INTRODUCTION

Neural networks have potential uses in medicine in many areas of medical diagnosis.

The major task of Doctors is to diagnose and prevent disease. Therefore any adjunct that could assist in this process is potentially valuable.

Doctors are often confronted with complicated problems involving a multitude of different clinical symptoms and often more than one medical problem involving a given patient. Doctors are also at various stages of their careers, some having more experience than others. Potentially neural networks could have the capacity to assist Doctors at all levels in their careers, but could perhaps help those especially in the early stages [1].

Neural network processing has been shown to be useful in several areas of medical analysis e.g. glucose monitoring [2], blood disorders e.g. the leukaemias and many other such areas. Such computer software systems have the advantage that they can run 24 hours a day, without mentally or physically fatiguing (unlike a human being) and the systems used are relatively low cost systems [3] [4] [5].

## II. ARTIFICIAL NEURAL NETWORK

Artificial neural networks (ANN's) are a useful tool to assist doctors in the analysis, and interpretation of complicated and involved clinical data in many fields of medicine and surgery.

As early on as 1943, neuroscientists such as McCulloch, and Pitts, considered and developed the concept of an artificial neural network. The idea broadly speaking was that an ANN would work along lines similar to the way in which a neuron works in the human brain, namely that input is received by a neuron, processed, and an output is generated. That output is then passed onto other neurons and even more neurons in several layers of the brain [6].

ANN's process information by using pattern recognition amongst other things. For this reason they may also be used in areas involving the recognition of features. They may also be used in areas such as the diagnosis of bowel cancer [7].

The key component and greatest asset of a neural network is its capability and capacity to learn. An ANN has the capacity to adapt in real-time as it processes information. This is achieved in part by a weight system. As the ANN processes information it assigns weights to particular functions in the processing. Each connection (unit in the system) is assigned a weight, in other words a numerical value that controls the signal between two given neurons. If the network generates a positive output, there is no requirement to change the weight factors. But, if the ANN produces a negative output, the system then adapts by changing the weights until a positive output is achieved.

## III. THE USE OF ANN IN MEDICINE

ANN's could potentially be used in any situation where variables and parameters are involved and where the parameters have a relationship with one another. However, ANN's come into their own when the parameters have an intricate and complex relationship with one another. 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) [12].

## 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>).

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 patients). However Alteplase has to be administered within 4.5 hours of the stroke occurring in order to really be effective [8]. 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 therefore 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 proposing such a system based on neural network application coupled with a physical mattress grid (shown in Figure 1 below). The mattress is placed in the patient's bed (perhaps woven into the fabric of the bedding material). The ANN 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). The output from sensors worn by the patients in e.g. wrist bands and ankle bands could then be transmitted wirelessly to the ANN, which processes the data to identify a potential stroke in a given patient. It is envisaged that this ANN may be developed and stored as an APP. Mobile phones may potentially be used to store and use such an APP. [9]. Such an ANN APP inside the mobile phone would be trained to recognize normal movement for any given individual.

## V. THE PROPOSED MODEL

The mattress, which would underlie the patient shown in figure 1, 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 the 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, thus indicating that the patient is 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/deviations from normality. The information would then be transmitted to the app on a mobile phone and the individual's relative or an ambulance could be alerted by the Smartphone to render assistance to the stroke patient as appropriate.

We believe that such a trained ANN, used in conjunction with smart sensors in e.g. wrist bands and ankle bands, coupled to a smartphone APP could potentially recognize stroke, and therefore save lives. Although such a system would potentially be useful anywhere, anytime, we believe that it would be especially useful and applicable to the diagnosis of stroke at night and for people who live alone. In respect of number of strokes that occur at night, Bassetti and Aldrich [10] reported that 23 of the 100 patients in their study reported a nocturnal onset of transient ischaemic attack or stroke.

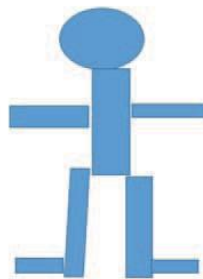


Figure 1. Patient's position on the Electronic mattress

## VI. EVALUATING PERFORMANCE

Feedforward Neural Network (FFNN) are classically comprised of a multilayered network consisting of one layer of hidden units. Each unit in the system is connected in a forward direction to each unit in the next layer of the system. The input layer is related to the hidden layer of the system, and the output layer is connected via a system of weightings and biasing. The biasing is applied to both the hidden and the output layers. The FFNN has only one rule and that is that activation flow is in one direction, i.e. from the input layer to the output layer passing via the hidden layer. The algorithm involving back propagation is similar in many

respects to a multilayer feed forward network. The errors propagate backwards from output nodes to input nodes. The FFNN may be trained using the Levenberg back propagation training algorithm [11]. This was chosen because this particular algorithm finds a solution even if it begins far off the final minimum. The samples involving training and testing are normalized between 0 and 1 via a binary normalization algorithm to fit the data. The results yielded a maximum error of 0.0002 (Figure 2).

This neural network model consisted of 3 layers with 10 neurons in the first layers, 2 neurons in the second layer and 1 neuron in the third layer. Each neuron is connected to the next layer through a weighted connection.

We used clustering for training the neural network with regard to patterns. This is useful for obtaining an insight into data and to its simplification prior to further processing. We used a four clusters value set as input data.

The work presented in this paper is a pilot study on regarding the application of ANN's to stroke recognition and diagnosis. We believe that our pilot study model could be further improved by using other adjuncts such as fuzzy logic. This could be the focus of further study.

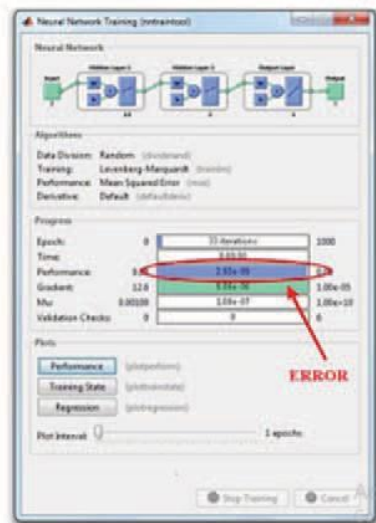


Figure 2. Maximum error is 0.002

## VII. CONCLUSIONS

In this paper we have presented a pilot study for the potential application of a ANN model to stroke recognition and diagnosis. We believe that the ANN (coupled with the output from smart sensors, worn by the patient and located in wrist and ankle bands or example) could be developed further and incorporated into a smartphone APP that could then be used to alert the emergency services or a carer (of the patient) if stroke arises.

We conclude that such a system could be potentially be particularly useful for strokes that occur at night, and/or for people (especially the elderly) that live alone or in remote areas.

Although we recognize that our study is a pilot study, we conclude that it is potentially worthy of further investigation and development.

## REFERENCES

- [1] Filippo Amato, Alberto Lopez, Eladia Maria, Pefia-Mendez, Petr Vanhara, Ales Hampl, Josef Havel. Artificial neural networks in medical diagnosis. *J Appl Biomed*. 11: 47-58, 2013. DOI 10.2478/v10136-012-0031-x. ISSN1214-0287.
- [2] Catalogna M, Cohen E, Fishman S, Halpern Z, Nevo U, Ben-Jacob E. Artificial neural networks based controller for glucose monitoring during clamp test. *PloS One*. 7: e44587, 2012.
- [3] Er O, Temurtas F, Tanrıkulu A. Tuberculosis Disease Diagnosis Using Artificial Neural Networks. *J Med Syst*. 34: 299-302, 2008.
- [4] Elveren E, Yumuşak N. Tuberculosis disease diagnosis using artificial neural network trained with genetic algorithm. *J Med Syst*. 35: 329-332, 2011.
- [5] Dey P, Lamba A, Kumari S, Marwaha N. Application of an artificial neural network in the prognosis of chronic myeloid leukemia. *Anal Quant Cytol Histol*. 33: 335-339, 2012.

- [6] Barwad A, Dey P, Susheilia S. Artificial neural network in diagnosis of metastatic carcinoma in effusion cytology. *Cytometry B Clin Cytom.* 82: 107-111, 2012.
- [7] Barbosa D, Roupar D, Ramos J, Tavares A and Lima C. Automatic small bowel tumor diagnosis by using multi-scale wavelet-based analysis in wireless capsule endoscopy images. *Biomed Eng Online.* 11: 3, 2012.
- [8] Werner Hacke, M.D., Markku Kaste, M.D., Erich Bluhmki, Ph.D., Miroslav Brozman, M.D., Antoni Davalos, M.D., Donata Guidetti, M.D., Vincent Larrue, M.D., Kennedy R. Lees, M.D., Zakaria Medeghri, M.D., Thomas Machnig, M.D., Dietmar Schneider, M.D., Rudiger von Kummer, M.D., Nils Wahlgren, M.D., and Danilo Toni, M.D. for the ECASS Investigators Thrombolysis with Alteplase 3 to 4.5 Hours after Acute Ischemic Stroke *N Engl J Med* 2008; 359:1317- 1329 September 25, 2008 DOI: 10.1056/NEJMoa0804656.
- [9] K. Hung, and Y.T. Zhang, "Implementation of a WAP-Based Telemedicine System for Patient Monitoring", *IEEE Transactions on Information Technology in Biomedicine*, vol. 7, n° 2, June, 2003.
- [10] Bassetti, C., and Aldrich, M. "Night time versus daytime transient ischaemic attack and ischaemic stroke: a prospective study of 110 patients" *J. Neurol Neurosurg Psychiatry* 1999; 67:463-467 doi:10.1136/jnnp.67.4.4 <http://jnnp.bmj.com/content/67/4/463.full>63.
- [11] <http://uk.mathworks.com/help/nnet/ref/trainlm.html>.
- [12] T. Zrimec and I. Kononenko, "Feasibility analysis of machine learning in medical diagnosis from aura images", University of Ljubljana, 2004.