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Neural Philosophy in Medical Applications

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ABSTRACT
Neural Network provides significant benefits in medical research. Neural network in medicine is subject to increase, as the number of experts is limited while interpretation work at clinical laboratories is subject to mounting. Neural Network (NN) in medicine has attracted many researchers. A simple search by Machado (1996) in Medline for articles about computer-based NN between 1982 and 1994 resulted with more than 600 citations. Another search by Dybowski (2000) in the same database yields 473 publications in 1998.
Keywords – ANN, BP, LOS, MLP

I. INTRODUCTION

NN has been shown as a powerful tool to enhance current medical diagnostic techniques. Several potentials of NN over conventional computation and manual analysis in medical application:

* Implementation using data instead of possibly ill defined rules.
* Noise and novel situations are handled automatically via data generalization.
* Predictability of future indicator values based on Past data and trend recognition.
* Automated real-time analysis and diagnosis. Enables rapid identification and classification of input data.
* Eliminates error associated with human fatigue and habituation.

The benefits of neural networks as follows:

* Ability to process a massive of input data
* Simulation of diffuse medical reasoning
* Higher performances when compared with Statistical approaches
* Self-organizing ability-learning capability
* Easy knowledge base updating

II. NEED FOR NEURAL NETWORKS

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. This expert can then be used to provide projections given new situations of interest and answer "what if”"questions. Other advantages include:

1.Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.

2.Self-Organisation: An ANN can create its own organization or representation of the information it receives during learning time.

3.Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.

4.Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.

III. ARCHITECTURE OF NEURAL NETWORKS

Feed-forward networks

Feed-forward ANNs (figure 1) allow signals to travel one way only; from input to output. There is no feedback (loops) i.e. the output of any layer does not affect that same layer. Feed-forward ANNs tend to be straightforward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organization is also referred to as bottom-up or top-down.

Feedback networks

Feedback networks (figure 1) can have signals traveling in both directions by introducing loops in the network. Feedback networks are very powerful and can get extremely complicated. Feedback networks are dynamic; their 'state' is changing continuously until they reach an equilibrium point. They remain at the equilibrium point until the input changes and a new equilibrium needs to be found. Feedback architectures are also referred to as interactive or recurrent, although the latter term is often used to denote feedback connections in single-layer organizations.

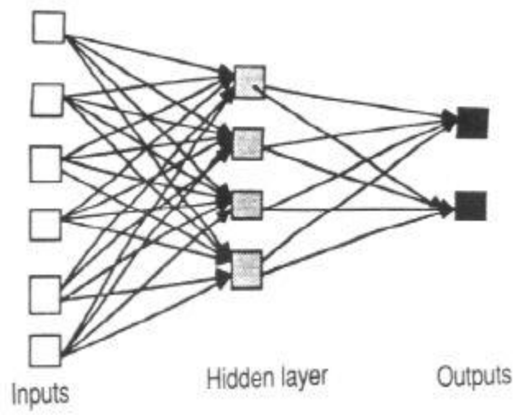


Fig1. Structure of Neural Networks

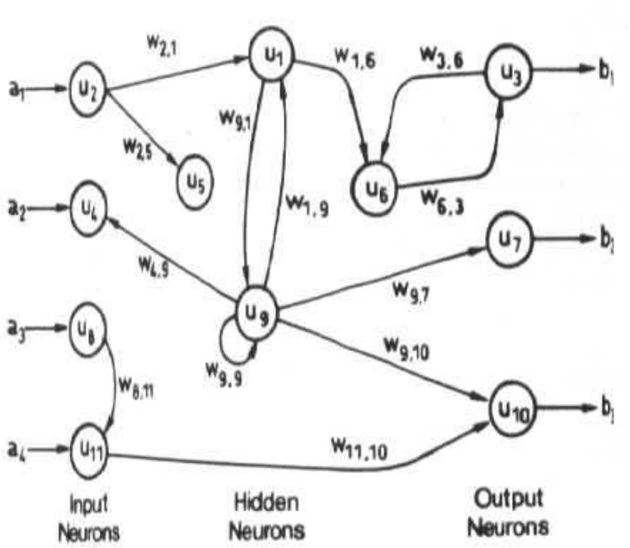


Fig2. Processing of Neural networks

Network layers

The commonest type of artificial neural network consists of three groups, or layers, of units: a layer of "**input**" units is connected to a layer of "**hidden**" units, which is connected to a layer of **"output**" units.

* The activity of the input units represents the raw information that is fed into the network.
* The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units.

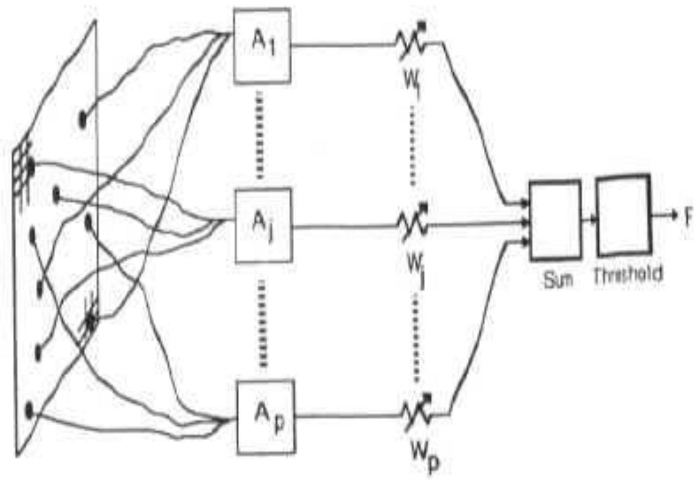
The behavior of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

This simple type of network is interesting because the hidden units are free to construct their own representations of the input. The weights between the input and hidden units determine when each hidden unit is active, and so by modifying these weights, a hidden unit can choose what it represents

We also distinguish single-layer and multi-layer architectures. The single-layer organization, in which all units are connected to one another, constitutes the most general case and is of more potential computational power than hierarchically structured multi-layer organizations. In multi-layer networks, units are often numbered by layer, instead of following a global numbering.

Perceptrons

The most influential work on neural nets in the 60's went under the heading of 'perceptrons' a term coined by Frank Rosenblatt. The perceptron (figure 4.4) turns out to be an MCP model (neuron with weighted inputs) with some additional, fixed, pre--processing. Units labeled A1, A2, Aj, Ap are called association units and their task is to extract specific, localized featured from the input images. Perceptrons mimic the basic idea behind the mammalian visual system. They were mainly used in pattern recognition even though their capabilities extended a lot more



IV. APPLICATIONS OF NEURAL NETWORKS

4.1. Applications in Basic sciences

In basic sciences, NN helps clinician to investigate the impact of parameter after certain conditions or treatments. It supplies clinicians with information about the risk or incoming circumstances regarding the domain. Learning the time course of blood glucose (Prank *et al.*, 1998) for example can help clinician to control the diabetes mellitus. Prank *et al.* uses feedforward NN for predicting the time course of blood glucose levels from the complex interaction of glucose counterregulatory hormones and insulin.

Multi-Layer Perceptron (MLP) with sigmoidal Feed-Forward and standard Back-Propagation (BP) learning algorithm was employed as a forecaster for bacteria-antibiotic interactions of infectious diseases (Abidi and Goh, 1998). They conclude that the 1-month forecaster produces output correct to within occurrences of sensitivity. However, predictions for the 2-month and 3-month are less accurate.

4.2.Applications in Clinical Medicine

Patient who hospitalize for having high-risk diseases required special monitoring as the disease might spread in no time. NN has been used as a tool for patient diagnosis and prognosis to determine patients' survival. Bottaci and Drew (1997) investigate fully connected feed forward MLP and BP learning rule, were able to predict patients with colorectal cancer more accurately than clinicopathological methods. They indicate that NN predict the patients' survival and death very well compared to the surgeons.

Pofahl *et al.* (1998) compare the performance of NN, Ranson criteria and Acute Physiology and Chronic Health Evaluation (APACHE II) scoring system for predicting length of stay (LOS) more than 7 days for acute pancreatitis patients'. Their study indicates that NN achieve the highest sensitivity (75%) for predicting LOS more than 7. Ohlsson *et al.* (1999) presents their study for the diagnosis of Acute Myocardial Infarction. In their study NN with 10 hidden nodes and one output neuron have been used as the classifier to classified whether the patient suffered from Acute Myocardial Infarction (1) or not (0). The results show that NN performance is 0.84 and 0.85 under *receiver-operating characteristics* (ROC).

4.3.Applications in Signal Processing and Interpretation

Signal processing and interpretation in medicine involve a complex analysis of signals, graphic representations, and pattern classification. Consequently, even experienced surgeon could misinterpret or overlooked the data (Janet, 1997; Dybowski, 2000). In *electrocardiographic* (ECG) analysis for example, the complexity of the ECG readings of *acute myocardial infarction* could be misjudged even by experienced cardiologist (Janet, 1997). Accordingly the difficulty faced in ECG patient monitoring is the variability in morphology and timing across patients and within patients, of normal and ventricular beats (Waltrous and Towell, 1995).

(Lagerholm *et al.,* 2000) employed Self-Organizing Neural Networks (Self-Organizing Maps or SOMs) in conjunction with Hermite Basis function for the purpose of beat clustering to identify and classify ECG complexes in *arrhythmia*. SOMs topological structure is a benefit in interpreting the data. The experimental results were claimed to outperform other supervised learning method that uses the same data.

Analysis of NN as ECG analyzer also proves that NN is capable to deal with ambiguous nature of ECG signal (Silipo and Marchesi, 1998). Silipo and Marchesi use static and recurrent neural network (RNN) architectures for the classification tasks in ECG analysis for *arrhythmia*, *myocardial ischemia* and chronic alterations. Feedforward network with 8-24-14-1 architecture was employed as a classifier for ECG patient monitoring (Waltrous and Towell, 1995). The analysis indicated that the performance of the patient-adapted network was improved due to the ability of the modulated classifier to adjust the boundaries between classes, even though the distributions of beats were different for different patients.

Multi layer RNN performance with 15-3-2 architecture had been studied and the performance of NN is compared with conventional algorithms for recognizing fetal heart rate abnormality (Lee *et al.,* 1999). The study reveals that the performance of NN is exceptional compared to conventional systems even with adjusted thresholds.

Applications in Medical Image Processing

Image processing is one of the important applications in medicine as most of decision-making is made by looking at the images. In general the segmentation of medical images is to find regions, which represent single anatomical structures (Poli and Valli, 1995). Poli and Valli employed Hopfield neural network for optimum segmentation of 2-D and 3-D medical images. The networks have been tested on synthetic images and on real tomographic and X-ray images.

Ahmed and Farag (1998) uses two self-organizing maps (SOM) in two stages, self-organizing principal components analysis (SOPCA) and self-organizing feature map (SOFM) for automatic volume segmentation of medical images. They performed a statistical comparison of the performance of the SOFM with Hopfield network and ISODATA algorithm. The results indicate that the accuracy of SOFM is superior compare to both networks. In addition, SOFM was claimed to have advantage of ease implementation and guaranteed convergence.

Locate Common Characteristics in Large amount of Data

Locating common characteristics in large amounts of data is a type of classification problem. Neural networks can be used to solve classification problems, typically through Multi-Layer Perceptron (MLP) and Support Vector Machines (SVM) type networks.

Examples of classification applications in medicine include dividing research populations or data into groups for further study. For example, data from studies of

Sample Study: Classification on Hand Movements

By recording EEGs during sequences of periodic left or right hand movements; patterns can be found, classified in real time, and used to move a cursor on a monitor left or right. EEG classification is necessary when the EEG is used as an input signal to a brain computer interface (BCI). Such a BCI can be helpful for handicapped people. In this study 4 out of 6 subjects showed a classification accuracy of 89-100%.

Better Forecast results based on existing data

Forecasting results based on existing data is a type of function approximation problem. Neural networks can be used to solve function approximation problems, typically through Multi-Layer Perceptron (MLP), Radial Basis Function (RBF) and CANFIS (Co-Active Neuro-Fuzzy Inference System) type networks.

Examples of function approximation applications in medicine include the prediction of patient recovery and automated changes to device settings. For example, data from studies of potential recovery level of patients can provide realistic estimates to patients while helping facilities cut costs by better allocating resources.

Sample study: Functional recovery of stroke survivors One study was able to use neural networks to predict with 88% accuracy the Functional Independence Measure (FIM) score among stroke survivors with moderate disabilities on discharge based on a small set of clinical variables and the admission FIM score.

Sample project: Body fat Using NeuroSolutions, this project can be used to illustrate multiple regression techniques. Accurate measurement of body fat is inconvenient/costly and it is desirable to have easy methods of estimating body fat that are not inconvenient/costly.

Predict the Progression of medical data overtime

Predicting the progression of medical data over time is a type of time-series prediction problem. Neural networks can be used to solve time-series problems, typically through Time-Lagged Recurrent (TLRN) type network.

Examples of time-series predictions in medicine include the prediction of cell growth and disease dispersion. For example, data from studies of muscle stimulation patterns of arm movements can be used to control mouse movements on a computer screen.

Sample Study: Control of Arm Movements Application

Using an artificial neural network (ANN) controller to learn and store optimal patterns of muscle stimulation for a range of single joint movements, one study found a new approach to the control of point to point, single joint arm movements. Stimulation patterns that minimize muscle activation or muscular effort are obtained from an optimal control strategy. Neural network topologies considered in this study are feed forward, recurrent feedback, and time delay.

IEEE Transactions on Rehabilitation Engineering (1994) N Lan, HQ Feng, PE Crago

Identify specific characteristics in medical imagery

Identifying specific characteristics in medical imagery is a type of image processing problem. Neural networks can be used to solve image processing problems, typically through Principal Component Analysis (PCA) type network.

Examples of image processing in medicine include the detection of characteristics in ultrasound and x-ray features. For example, image data from studies of mammograms can be used for the detection of breast cancer.

Sample Study: Mammography

One study found that neural networks provide a useful tool to aid radiologists in the mammography decision making task. With clinical cases, the performance of a neural network in features extracted of lesions from mammograms by radiologist was found to be higher in distinguishing between benign and malignant lesions than average performance of radiologist alone, without the aid of a neural network.

Group medical data based on key characteristics

Grouping of medical data based on key characteristics is a type of clustering problem. Neural networks can be used to solve clustering problems, typically through Self-Organizing Map (SOM) type network.

Examples of clustering in medicine include the detection of key characteristics in demographics or pre-existing conditions. For example, data from studies combined with sensitivity analysis can reverse engineer a biologically plausible relationship from real world data.

Sample Study: Temporal Gene Expression Data

Temporal gene data can be used to create gene networks where they would be used to represent regulatory interactions between genes over time. The reverse engineering of gene networks & extraction of regulatory relationships between genes in temporal gene expressions data is a major obstacle in systems biology.

V. CONCLUSION

Neural Network have been successfully implemented in many applications including medicine. Neural Network, which simulates the function of human biological neuron, has potential of ease implementation in many applications domain. The main consideration of NN implementation is the input data. Once the network is train, the knowledge could be applied to all cases including the new cases in the domain. Studies have shown that NN predictive capability is a useful capability in medical application. Such capability could be used to predict patient condition based on the history cases. The prediction could help doctor to plan for a better medication and provide the patient with early diagnosis.

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