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Artificial Neural Networks and Their Applications in Medical Diagnosis

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Abstract
An Artificial Neural Network (ANN) is a mathematical representation of the human brain neural system, reflecting its "learning" and "generalization" capabilities. This article aims to provide a comprehensive tutorial and a survey regarding ANN and its varied applications. The sight of ANN can be found in almost all the fields and applications ranging from multimedia to medical science. ANN when effectively used in medical science can predict accurate results while screening a patient's records and also suggest precautionary measures and treatments to improve world health. This technology will save time and avoid medical errors. ANN can be used to recognize patterns and predict various types of cancers like skin, brain and breast cancers. The readers can take away the subsequent contents from this article: A general wide introduction to ANN, Major areas where ANN is applied and their advancements, and also the applications of ANN in health care and medical diagnosis.

Keywords: *Neurons, quadcopter, Reinforcement, cluster, curves, protrusions, acute nephritis*

1. Introduction

The techniques in Machine Learning (ML) such as Artificial Neural Networks highly resembles the neural architecture of a human brain. This technology is precisely used to handle decision- making capabilities just like humans. ANNs are broadly applicable in science and research since they can display exceptionally non-linear frameworks in which the relationship among the factors in unpredictable or obscure. Neural Networks are best at recognizing patterns or examples in information and are appropriate for anticipating or gauging. Thus neural systems are broadly applied in different fields.

The objective of this paper is to analyse neural networks and their applications in various fields emphasizing more in the field of health care management. Disease complexity in both young and old age have been rapidly increasing which forces us to adapt the techniques of ML to take up precautionary measures by storing patient's records and to possibly predict their future health. Rising labour costs, industry expansion and advanced treatments demand the integration of ANN in these fields. Section I provides a brief introduction to Artificial Neural Networks. Section II discusses about major applications of ANN. Section III briefs the applications of ANN in therapeutic diagnosis.

2. Introduction To Artificial Neural Networks

An Artificial Neural Network can be defined as a set of computational nodes, called neurons, that are connected to each other.

A neuron is an information processing unit of the network. The synapse (the network links) accepts an external input or an input that is been generated by another neuron in the network. A summation unit commonly named as an Additive Junction computes and calculates the resulting sum of all the neuron inputs multiplied by their respective synaptic weights. A bias is added in a linear equation that is used to adjust the output along with the weighted sum of the inputs to the neuron. It probably will shift the activation function to either left or right. Bias is usually taken as fixed input at x0=1 in modern use

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cases. The result obtained is processed by an activation function that decides whether the neuron should be activated (fired) or not.

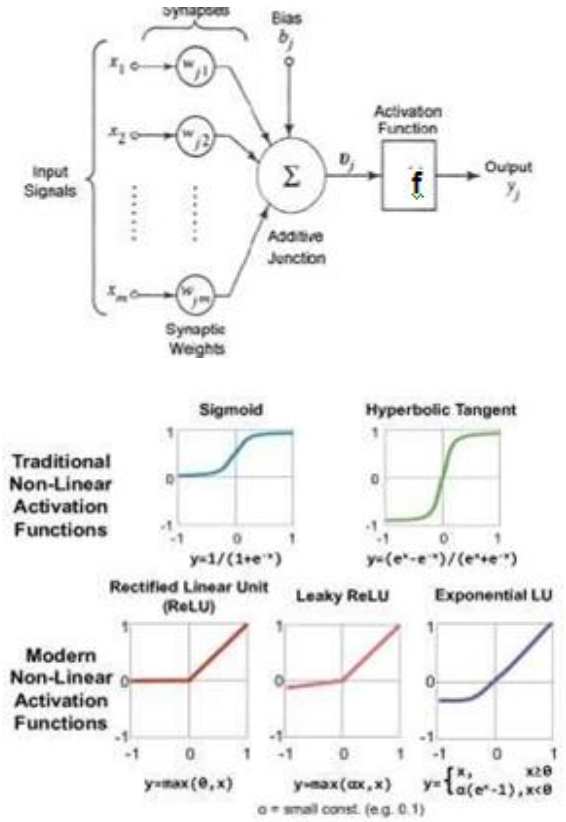

Figure 1: Model of a neuron

Figure Adopted from caffe Tutorial [46]

Input vector A=(x1, x2 …xm), where xm is the input at mth synapse. A weight is associated with each synapse and is stored in the weight vector W= (wj1, wj2...wjm), where wjm is the jth weight at the mth synapse. bj is the bias. Vj is the summation factor. i.e Vj=bj+x1wj1+x2wj2……xnwjn).Yj is the final output after processing.

Vj = $b + \sum_{i=1}^{n} x_i w_i$

Y = f(vj)

$$(z) = \begin{cases} 0 & \text{if } z < 0 \\ 1 & \text{if } z \geq 0 \end{cases}$$

Choice of the activation function purely depends on the problem that is been defined. The Most broadly used activation functions are Sigmoid and Rectified Linear Unit (ReLU). Other activation functions are Step function (which is based on a threshold value) Hyperbolic Tangent (Tanh), Likely ReLU, and Exponential ReLU [2]. Neural Networks does not follow a centralized approach; rather perform their tasks simultaneously with the flow of the data abiding the set rules.

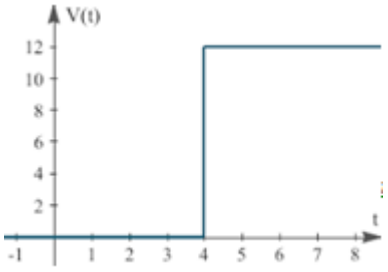

Figure 2: Step Function

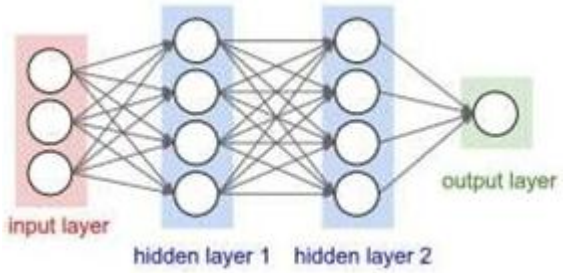

Figure 3: ANN Structure (MLP)

Neural Networks are classified based on the layers that are present in the network. A Feedforward single layer network usually consists of just an input layer and an associated output layer that outputs the results. A Feedforward Multilayer Perceptron (MLP) Network comprises of one or more number of hidden layers that acts as major processing units. The connections between the nodes in a Feedforward neural network do not form a cycle. The input layer accepts the inputs and forwards that to the next layer without performing any complex tasks. The hidden layer accepts the inputs and performs high level computational and mathematical tasks to generate the results that are sent to the output layer. There can be n number of hidden layers based on the complexity of the problem.

An ANN has two different phases, training and testing. The dataset gathered will be divided into training, validation and test sets. The training is either supervised (Learning with a teacher), unsupervised (Learning without a teacher) and Reinforcement training based on the problem domain.

3. Applications Of Artificial Neural Networks

Various applications of ANN has been cited ranging from multimedia to medical space. In this section, various such examples are described to know the applications of ANN as well as their future enhancements.

Image Processing and Character Recognition

Image processing in ANN is done by segmentation i.e. dividing the whole picture into smaller chunks that are coherent, based on some criterion. The ANNs is trained to classify the image based on texture, connecting edge pixels, identification of surfaces and clustering of pixels [17]. Character recognition and

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Script Recognition are very good examples for the applications of ANN. Classification and Clustering techniques are widely used to detect and group the characters. Optical Character Recognition deals in recognizing and classifying the characters from an image. Various parameters such as strokes, curves, protrusions classifier are used to recognise the character. These parameters which are also called as features or properties are derived from the image by using a spatial pixel-based calculation. They are identified with the help of Feature Vectors. The ANN-based system recognizes the fonts that it was not trained on with high efficiency. Better Feature Extraction techniques shall be used for better precision of results [16]. These will be widely used in audio e- books and to recognize Devanagiri and other ancient manuscripts.

Forecasting: Demand Forecasting is an important segment of the supply chain management. Accurate Forecasting is very much essential for business operations to be stable. Forecasting helps organizations to make accurate complex decisions and help them in achieving their pre-set goals. ANN models can predict future demands and losses of an organization. TANSIGMOID, LINEAR and LOGSIGMOID transfer functions are majorly used for forecasting models. MAD, MAPE and MSE are used to estimate the accuracy of the models [18].

Table 1 : Observations derived from [18]

Functions	MAD	MAPE	MSE
TANSIGMOID	1.16257	1.51048	2.646
LINEAR	2.4871	3.13985	8.8474
LOGSIGMOID	2.9140	3.76319	24.11

ANN model with TANSIGMOID transfer function is better in this case when compared to others based upon MAD, MAPE and MSE [18].

Speech and Language Processing

ANN has significantly improved the accuracy of Speech recognition and Natural Language Processing which is finding its way towards the future of AI Chabot. The ANN model recognizes the speakers based on their speech waveform distribution. Using the statistical Gaussian Mixture Models (GMM). The system identifies the speakers using correlation coefficient analysis. The system developed by Godfrey Mills [19] showed the average recognition rates of 77% for 5-words utterances and 43% when it was increased to 20-words, both in case of trained system and an average of 18% for 20-words, in case of new samples.

Robotics: ANNs have been very successful in the field of robotic tasks such as grasping things with a robotic arm [10], motion planning for ground robots [11], visual navigation [12], and control to stabilize a quadcopter [13] and driving strategies for autonomous or driverless vehicles [14]. Autonomous Robots are developed to perform tasks in various fields. Robots are used to monitor and rescue activities in case of natural or manmade disasters [20]. Robotics is also getting a wider scope in driverless cars and navigating robots. The motion controlling ANN is trained with a backpropagation algorithm which uses potential fields for obstacle detection and avoidance [21].

Gaming: Recently, many games like chess and other role play games are using ANN to compete with human intelligence. These require the model to be highly trained and many rely on reinforcement learning [15].

4. Applications of Ann in Medical Diagnosis

Applying the techniques of ML to diagnose diseases is well-known. Artificial Neural Networks provides a powerful tool to help doctors analyse, model and make sense of complex clinical data across a broad range of medical applications [1]. Many Healthcare systems these days promise to provide the best care facilities to their patients with improved technologies. Implementing ANN could possibly reduce the risk factor with its accurate results and can be highly cost-effective. They are considered very useful in making complex decisions in health care management, ranging from performing critical operations until managing the patient's confidential records. ANN can be modelled to tackle critical decisions and operations during surgeries with low chances of mortality. ANN is also used in many systems managed by health care. Classification is an important tool in most of the medical diagnosis cases.

ANN has played a significant role in the field of medical science and genomics to gain insight into the genetics of diseases such as autism, cancers, and spinal muscular atrophy [3-6]. They have also been used to detect cancers such as skin, brain and breast [7-9].

Qeethara Kadhim Al-Shayea[1] developed an ANN model that can accurately predict the infected ones suffering from acute nephritis and heart diseases. In the case of nephritis, the data set consisting of symptom parameters such as temperature, Occurrence of nausea, Lumber pain are used to train the model. In the case of identifying heart disease, classifying patients as infected (1) or non- infected (0) is done by using Single Proton Emission Computed Tomography (SPECT) images. Feed-forward backpropagation neural networks are used as a classifier to distinguish between infected and non-infected [22]. Lavenerg Marquardt backpropagation algorithm was used to train the model. The model showed an accurate prediction of 99% in the case of acute nephritis and 95% in the case of classifying heart disease.

Heart disease may be a leading explanation for death, however, it is not inevitable. Wherein you cannot amendment some risk factors like hereditary, age or sex. R. Das, I. Turkoglu and A. Sengur [23] proposed that when SAS based software (v.9.1.3) was

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used to diagnose heart disease, 89.01% classification accuracy from the experiments was achieved.

O. Er, N. Yumusak and F. Temurtas [24], proposed that diseases such as chronic obstructive pulmonary, pneumonia, asthma, lung cancer that are related to the chest can be diagnosed by using multilayer probabilistic learning, Vector quantization and generalized regression neural networks.

According to the World Health Organization, around 30 million people suffer from various forms of diabetes. Elda Xhumari and Petrika Manika [25] presented a research on diagnosing diabetes in their early stage by the use of ANN. Multi-layer model and back propagation algorithm were used to train the model. The reliability of the model amounted to 89.5%.

The future awaits to see a robotic nurse that is capable of doing tasks similar to or much more efficiently than humans and predict diseases in the much earlier stages so that it can be prevented from being worse.

5. Conclusion

ANN is a tremendous technology that has seen its footprints in various fields by now. Implementing ANN models in medical science has reduced the risk factors related to critical health issues. Identifying diseases helps Doctors to diagnose the problem and save human lives to a major extent. Results of various techniques referred to in this paper showed that the proposed diagnosis neural network models could be useful for identifying the infected persons much accurately. In the near future the domain of medical science will see a relative growth with the help of ANN.

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