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DEEP LEARNING IN ECHOCARDIOGRAPHY: A Review

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Abstract: Artificial intelligence extending the horizon of all domains of science, technology and even our day to day life, a deep neural network is a subdomain of ANN which is also the subdomain of artificial intelligence. This review article will explain the role and current application, researches which comes under deep neural network in analysis of echocardiography, also discuss the limitations and challenges in it. Echocardiography is widely used to determine the various heart diseases, functions and also anatomy. Analysis and interpretation of echocardiography require expert knowledge, due to this it is costly, time-consuming and critical to take decisions. Interpretation of cardiac image using automated computer systems has drastically transformed the clinical practices by identifying the abnormalities in heart muscles motions, valve functioning, which help to determine the heart disease. Deep learning technique is used to analyse images, now it is being used in medical imaging problem and also even very useful for the physician for enhancement patients care. Unlike statistical approach, it requires large dataset of images for training the model for the specific problem. When deep learning is applied to large datasets, it determines and establishes the complex patterns and their relationship in the image. The computer learns through the large dataset and recognizes the desired pattern in the image. Although automated systems in medical science are not widely accepted, this technique not only helps practitioners but also academician.

Keywords: deep learning, echocardiography, heart disease, automation.

I. INTRODUCTION

Recent advancements in technologies of computer science both in hardware's and software's have a great impact in every domain of science and technology are significantly influenced and used by artificial intelligence (AI). AI is the ability of a machine(computer) to perceive its environment and perform measured action to maximize its chance of success for a specified goal [1]. In AI we whole effort is to mimic the intelligence of human being in the computer system or roughly in a machine with the different mechanism which is used by the human brain in decision making or problem-solving process of a particular problem. Our thinking process is very much complex, it all govern by our brain cells or nerve cells, to build a copy of brain is very difficult, so researchers try to copy the one or few behaviours of them to solve the same kind of problem as they are functioned in the human brain. Our brain evolved in thousands of years, we used to learn so many things since our childhood, our thinking process is not based upon one aspect of problem, is based upon various condition and situations, so taking decision or solve a problem by human beings is not difficult and also learning new things which have connections what we have learned in the past, is easy. Our modern computing devices are very fast, applying artificial neural network which is act as a simulator of biological neuron which is highly parallel, robust and scalable can solve many complex tasks such as weather forecasting, stock market prediction very quickly and with high accuracy. The deep neural network methodology is the sub-domain of the artificial neural network which also comes under the roof of machine learning and the process of learning is called deep leaning, it is mainly deals with the analysis of images. Heart diseases which are associated with vascular problem require to view the live internal structure of heart while its normal movement(beat), so that practitioners can identify the disease and also the severity of disease which help him to enhance the care of the patient, but it requires expert knowledge in this domain. With the help of echocardiography, one can look inside the heart while it is pumping blood to the body by expansion and contraction of heart chambers. In echocardiography laboratory, experts rigorously and carefully analyse and label of echocardiography images and videos every day which help us to learn and identify different heart diseases. Images are very complex in nature they have various information in them which is known as the pattern which makes them different from other images. This conclusion is the result of the Conscious and sub-Conscious state of mind and it also takes years of dedication and experiences. When we see an object, we identify its pattern, next time whenever we see another object which has a similar pattern as we saw previously, we draw a conclusion that, this is that type of object. Deep learning does the same thing as human being eyes, brain does, its input as a large dataset of images, identify patterns in them, it is different from a statistical approach in which we estimate values of pattern [2].

II. ARTIFICIAL INTELLIGENCE, MACHINE LEARNING, DEEP LEARNING

Advancement in technology in medical science whether in medicine, surgery or disease diagnosis expanding the boundaries of our thinking to make better decision support system, in other word expert system which can help in a various way. Machine learning is a component of Artificial Intelligence that describes the process for a computer to learn

from experiences and perform predefined tasks without prior knowledge [3]. Machine learning methodology again classified in supervised learning, semi supervised learning, and unsupervised learning which is based on what kind of data used for learning such as fully labelled, partially labelled, or unlabelled. out of various machine learning techniques one example it is an artificial neural network [4].

An ANN is a collection of layers of neurons and they are connected to each other according to their tasks and types, they have their own weights to reflect their inter-dependencies between other neurons or same neurons themselves which is more likely to be a human brain. In this network each neuron receives multiple inputs, weight, and bias, and combine them together in some mathematical way, coming towards all inputs determine the activation or firing of that particular neuron. Activated neurons give an output signal which determines the states of neurons in the very next layer until it reaches the neuron of the final layer which provides values of our desire output such as a classification, decision making or estimation of value (figure 1).

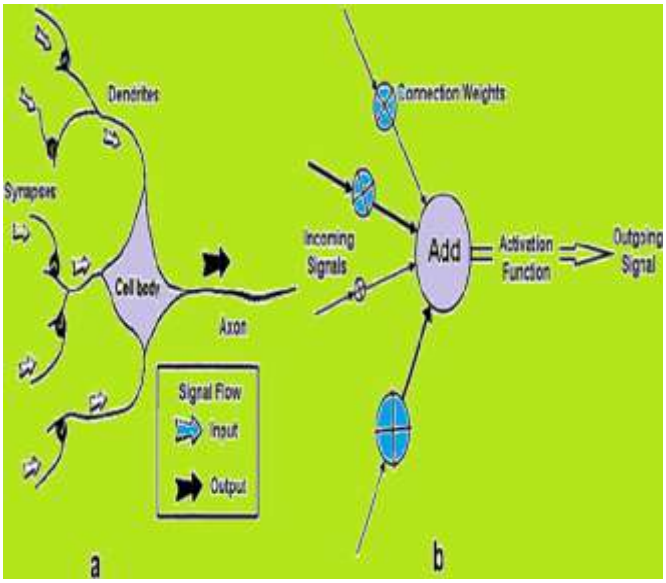

Figure 1. a. biological neural network and b. artificial neural network analogy.

Learning is a process in which weights are adjusted between the interconnection of neurons by providing data samples, to get the desired output. As the number of neurons increases and grow of sample size, the complexity of the learning process of deep neural network also increases. Due to the limitation of computing power and increasing size of samples, the success rate of a machine learning algorithm depends upon features extraction from raw samples to reduce to the number of neurons which finally reduce the complexity of computation and also cost. Deep learning was come to exist to overcome this limitation by learning automatically from representing features in samples. Extracting desired optimal features, deep neural network used a number of cascaded multiple layers of neurons for learning of multiple levels of abstraction. In well-designed neuron network structures, deep learning is able to do the same task with good performance such as image recognition, voice recognition and prediction of activity of drug molecules [5].

Figure 3 shows the example of deep learning model using supervise learning approach in it used convolution neural network to identify echocardiography views [6]. The motive behind the research was to identify whether an image is recorded from an apical four-chamber view, a parasternal short-axis view, or a parasternal long-axis view. The input of the Convolutional layer is a fairly taken standard echocardiographic images, and the output is the probabilities of the different outcomes of corresponding images, which are used to determine the most similar view. During deep learning process images are analysed through multiple layers of deep learning model of abstraction allows the computer to identify the view automatically from the image taken from. In this convolutional neural network example, features are learned from data by it in the training phase (all echocardiographic image dataset) instead of manual extraction. Limitation of this method is, it is time consuming due to the analysis of large dataset also very complex.

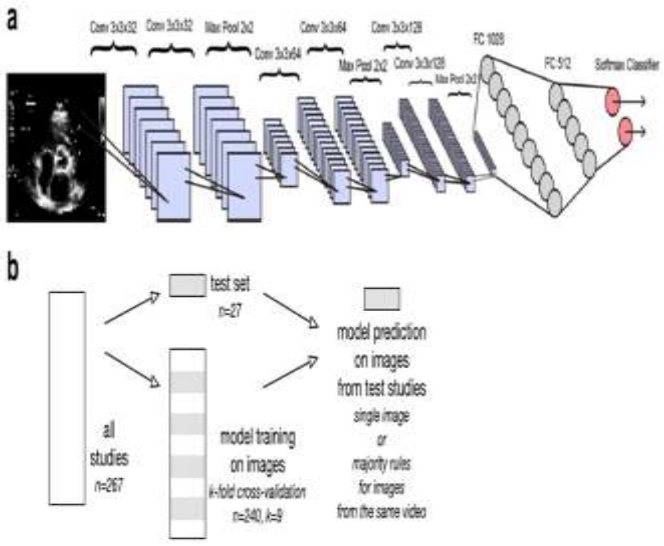

Figure. 2 Image classification model using convolution neural network.

a). there are six CNN layers and two fully connected layers of 1028 and 512 nodes used for neural network classification algorithm. The used classifier is softmax (pink circles) having up to 15 nodes b). the whole dataset of images was split into three-part training, validation and testing and test data was not used for validation and training.

III. IDENTIFYING DISEASE STATES THROUGH DEEP AND MACHINE LEARNING

Machine learning algorithms have been applied over clinical dataset to recognize clinical disease states. Sengupta et al proposed a machine learning model in their paper which is able to differentiate constrictive pericarditis (CP) from restrictive cardiomyopathy (RCM) along with confirmation from multimodality imaging and surgical pathology. Echocardiographic images from 94 patients analysed along with speckle-tracking echocardiography image attribute combined them with 2D transthoracic (TTE) echocardiography images including measurements. An associative memory-based machine-learning algorithm was created by them. Associative memory classification algorithm was used in the machine-learning technique using the top 15 speckle tracking echocardiography image variables which were able to classify the disease state with appreciable accuracy and area under the curve (AUC) of 89.2%. The result was superior to individual echocardiographic parameters value e′ (AUC 82.1%) and global longitudinal strain value (63.7%). By combining four echocardiographic variables e′, E/e′, septal, and posterior wall thickness had an AUC of 94. After combining with the top 15 speckle-tracking variables and applying through the associative memory classifier algorithm the accuracy significantly increased to 96.2%. The same group of authors used a machine-learning algorithmic approach to find the feasibility to in male patients between physiologic hypertrophy of athletes opposed to hypertrophic cardiomyopathy2. After observing the results of this research, it can be said that the use of this clinical model was capable to differentiate between disease pathologies and the combination of speckle tracking echocardiography parameters into their proposed model demonstrated the diagnostic ability of 2D echocardiography with Doppler parameters. Zhang et al proposed.The utilization of deep learning to generate feature representation from the image directly. Using groups of patients having hypertrophic cardiomyopathy with varying patterns of left ventricular thickening and cardiac amyloidosis, there were two separate convolutional neural networks trained for disease detection. Those models were capable to classify hypertrophic cardiomyopathy and cardiac amyloidosis with accuracy, AUC 0.9 and 0.84, respectively.

AUTHOR/S	YEAR	RESEARCH CONTRIBUTION
JO˜AO FIGUEIRA[7]	2018	EJECTION FRACTION CLASSIFICATION IN TTE
SUMEET GANDHI[8]	2018	REVIEW ARTICLE
ALI MADANI[9]	2018	VIEW CLASSIFICATION OF ECHOCARDIOGRAM
GOPALKRISHNA VENI[10]	2018	LEFT VENTRICLE SEGMENTATION
ALLEN LU[11]	2018	DETECTING ANOMALIES USING MULTI-VIEW
ANDREA[12]	2018	AUTOMATIC MYOCARDIAL STRAIN IMAGING
SUYU DONG[13]	2018	LEFT VENTRICLE SEGMENTATION IN 3D ECHOCARDIOGRAPHY
MOHAMMAD H[14]	2018	LEFT VENTRICLE SEGMENTATION USING RECURRENT FULLY - CONVOLUTIONAL NETWORK
VASILY ZYUZIN[15]	2018	LEFT VENTRICLE IDENTIFICATION
HASMILA A[16]	2018	HEART WALL MOTION ANALYSIS
JOSÉ FERNANDO RODRÍGUEZ[17]	2018	AORTIC VALVE DISEASE
FATEMEH TAHERI DEZAKI[18]	2017	CHARACTERISATION OF CARDIAC CYCLE PHASE

IV. STUDY WITH DEEP LEARNING IN ECHOCARDIOGRAPHY: A RECENT RESEARCH

Table 1. shows the current research on deep learning and echocardiography

Table 1.

V. DEEP NEURAL NETWORK IN PERSPECTIVE

As growth in Artificial Intelligence in the past few decades is just like exponential with outstanding opportunities now offered by its subdomain, deep learning (Figure 2). In this way, AI is expanding the horizons of echocardiography by providing supplementary tools for physicians to improve the patient care. There are various vendor software programs that used automation to enhance the accuracy and efficiency of tracings which are identified by experts. Last few

decades, there is a tremendous increase in computation power which allows us to analyse dataset which bought deep learning technique to a new level of possibility. The scope of deep learning in cardiac imaging is still in birth and being discovered as models are being created, along with large dataset of images for training which also entirely different from the traditional statistical model. Deep learning model when applied to large image datasets, it is capable of unrevealing highly complex relationships and patterns combining all properties of that image. It is impossible that in echocardiography interpretation machine will completely replace echocardiography experts. The deep neural network model will be capable to help the physicians in the identification and diagnosis of pathology or lack thereof, although, clinical judgment will always be of vital importance. In current advancement and development of deep learning, in spite of capability of unlocking of various diseases, it still a block box. The error generated due to machines will always need to be preserved by humans to guarantee that do no harm. In the sphere of medical imaging and diseases diagnosis accountability and responsibility play a very important role, since medical imaging is opening the door to the additional invasive diagnostic treatments and testing, which may uncover a patient to excessive risk. Definitely, in current medical practices, doctors will ultimately need to take responsibility for interpretation of output comes from deep neural network model. Even if they have many limitations in deep learning, it is an impulsive force in medical imaging technique and will be the one of the most important contribution of the future of echocardiography imaging technique. As a researcher, we will have to build or modelled some deep learning model which push the horizon of technologic discovery.

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