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COMPARATIVE STUDY OF DIFFERENT NEURAL NETWORKS

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Abstract

The purpose of the Artificial Neural Network (ANN)(a functional emulation of a simplification of the biological neurons), is to create helpful "computers" for actual issues and duplicate sophisticated data evaluation methods such as classification, pattern recognition, and generalisation using basic, widespread, and strong computer systems referred to as artificial neurons. ANNs are fine-grained parallel systems. The ANN's intelligence and its ability to solve challenging puzzles derives from the extensive connectivity that provides the great computational power of neurons its enormous parallel distributed architecture. The current spike interest in ANN is primarily due to ANN architectures and algorithms to be included into real-time VLSI technology applications. The ANN model is simple to use for output parameter prediction, assisting in the best choice of machining parameters for process planning and operating parameter optimization. The theory, models, and implementations of ANNs are briefly described in this paper. Future trends as well as potential application areas are also examined

Index Terms: *Artificial Neural Network (ANN), Feed Forward Network, Artificial Neuron, Biological Paradigm, Pattern Recognition.*

1. INTRODUCTION

Since a long time ago, brain research has been a fascinating field. With advances in electronics and computer science, it was anticipated that we could construct some artificial intelligence systems using the brain's natural style of thinking.

The first step toward artificial intelligence was made possible in 1943 when mathematician Walter Pitts and neurophysiologist Warren McCulloch published a study on the functioning of neurons. Some of the riddles offered by the new models have been resolved by mathematical analysis, but many more have to be answered.

Due to their parallel structure, neural networks may function even when one component fails. It is applicable to any application. A neural network picks up new information and does not require programming. ANN is thus gaining popularity for making predictions regarding specific parameter results. Once appropriately trained, ANNs can be used in machining processes to predict response parameters from process parameters. Applying the ANN to these processes requires care and requires training to use. Since the architecture of ANN differs from that of microprocessors, it ought to be simulated. For big neural networks, a lot of processing time is needed [1].

2. ARTIFICIAL NEURAL NETWORK

Artificial neural networks (ANNs) are computational or mathematical models that are motivated by a human's central nervous system (in particular the brain), which is susceptible of machine learning as well as pattern classification. ANNs are used in electronics engineering and related disciplines. Since an animal's nervous system is more sophisticated than a human's, a system created in this manner will be able to handle more challenging issues. In general, artificial neural networks are portrayed as highly interconnected "neurons" that can estimate quantities from inputs. Fig.1 shows a basic neural network. A neural network is similar to a web of interconnected neurons, which may number in the millions.

The body performs all parallel processing with the aid of these interconnected neurons, and a person or animal's body is the best illustration of parallelization.

Artificial neural networks are now the clustering of basic artificial neurons.

By building layers and connecting them, this grouping takes place. The other aspect of "designing" networks to solve complicated problems in the real world is how these levels connect to one another.

Therefore, patterns and trends that are too complex to be observed by people or other computer approaches can be

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extracted using neural networks, which have a higher ability to infer meaning from complex or imprecise data.

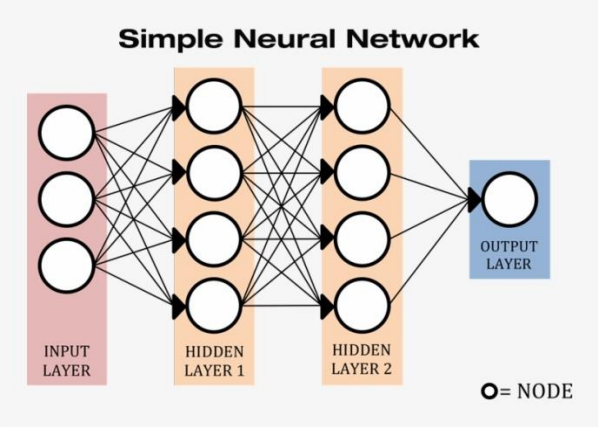

Fig 1: Simple Neural Network

Neural networks were developed as a result of research into the human central nervous system. Simple artificial nodes that are joined together to form a network are referred to as "neurons," "processing elements," or "units" in an Artificial Neural Network (ANN).

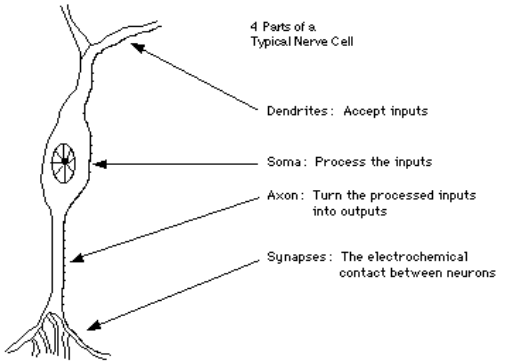

Fig 2 : A genetic Neuron

An artificial neural network doesn't have a single formal definition. However, the term "Neural Networks" may be used to refer to a class of statistical, mathematical, or computational models if they meet the following criteria:

1. Consists of sets of adaptive weights, or numerical parameters tuned by learning algorithms.
2. Be able to approximate non-linear functions of their inputs.

Conceptually speaking, the adjustable weights represent the strength of neural connections that are active during training and prediction.

Instead of having a distinct division of sub - tasks to which various units are assigned, neural networks behave similarly to biological brain networks in that they perform activities collectively and in parallel by the units. Neural network models are typically used in analytics, cognitive psychology, and artificial intelligence.

2.1 Working of Artificial Neural Network

The various ways these individual neurons might group together play a key role in how neural networks function. The human brain clusters information in such a way that it can process it in a dynamic, interactive, and self-organizing manner. In the biological world, minute parts are assembled into three-dimensional brain networks. These neurons appear to have almost limitless connectivity potential. In the case of any proposed or actual man-made network, that is not true. With present technology, integrated circuits are two-dimensional objects with a finite number of interconnecting layers.
At the moment, neural networks are only a simple grouping of artificially rudimentary neurons. By building layers and connecting them, this clustering takes place.

3. ANN THEORY AND MODELS

Artificial intelligence neural network models are fundamentally straightforward mathematical equations that define a function f: X->Y, a distribution across X, or both X and Y. However, models are occasionally also closely related to a specific learning algorithm or learning rule.
The definition of a class of such functions, where members of the class are produced by modifying parameters, connection weights, or features of the architecture like the number of neurons or their interconnection, is a popular usage of the ANN model.

In the phrase "artificial neural network," the word "network" refers to the connections that exist between the neurons in the many layers of each system. A model system consists of three layers. Input neurons in the first layer communicate with second-layer neurons via synapses before communicating with output neurons in the third layer via additional synapses. More layers of neurons will be present in more complicated systems, with some having more layers of input and output neurons. Typically, three different sorts of parameters characterize an ANN:

1. The way that distinct layers of neurons are connected to one another
2. The process of changing the connectivity weights through learning.

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3. The activation process that changes the weighted input of a neuron into its activation.

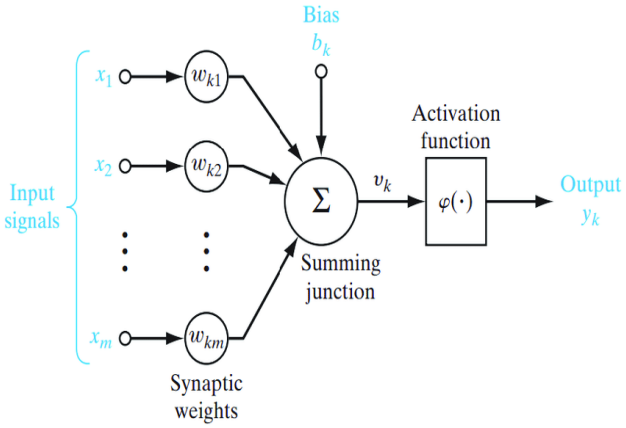

Fig-3 : Non Linear Model of Neuron

4. DIFFERENT TYPES OF NEURAL NETWORK

4.1 Conventional Convolution Neural Network:

The capsule network neural architectures, is a type of artificial neural network that comes under the machine learning system. It is most prominent in modelling a hierarchical relationship and closely imitating the biological neural systems. The development of the capsules network lays back on the concept of expanding the convolution network to reuse the end results to discover more steady and advanced exemplification of the developing capsules. Being a novel architecture in the neural networks and an enhanced approach of the prevailing neural network model especially for the tasks in computer vision, the capsule network have been designed as an alternative for the convolutional neural networks, as the CNN shows few limitations in accomplishing the applications of the computer vision in spite of its efforts in managing the accuracy in the areas where it is applied.

The traditional convolutional neural network is shown below:

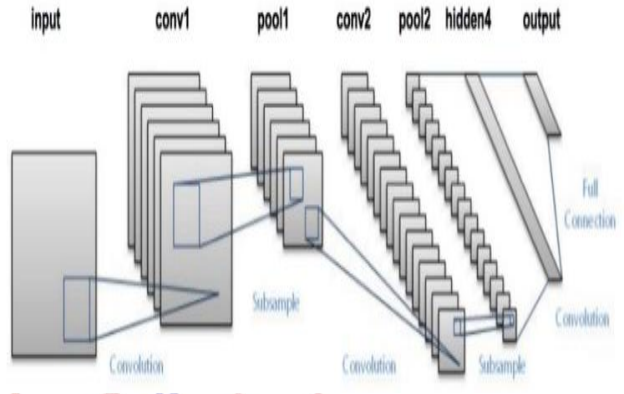

Fig 4: Conventional Convolution Neural Network

4.2 Capsule Neural Network:

The capsules in the approach represent the group of neurons that hold all the minute information about the spatial location of the object to reduce the adversities in the process of the segmentation and the detection. The capsule network engages the inverse steps of the computer graphics in representing the image. For e.g. in detecting an object the object is inwardly sub-divided into many parts and a relationship is developed between all the sub parts (hierarchical relationship) of the object, to represent the object. The fig.5 shows the architecture of the capsule neural network.

The capsule neural network architecture constitutes three main parts such as the input layer, hidden layer and the output layer , the hidden layer further constitutes , three more layers such as the convolutional layer, primary capsules (lower and high layer also known as digi-caps).

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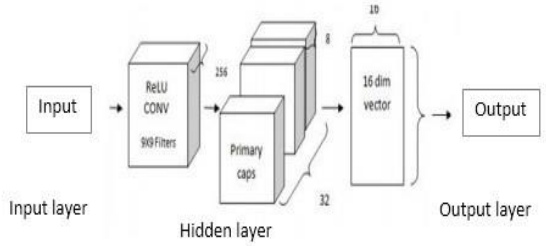

Fig 5: Capsule Neural Network

5. COMPARATIVE ANALYSIS OF CAPSULE NEURAL NETWORK

- The learning efforts of the capsules from the convolutional layer and the capability of the capsule to rebuilt the image of any size and any resolution reaching an accuracy of the 96.48% the fig.6 below shows the convolutional capsule neural network architecture.

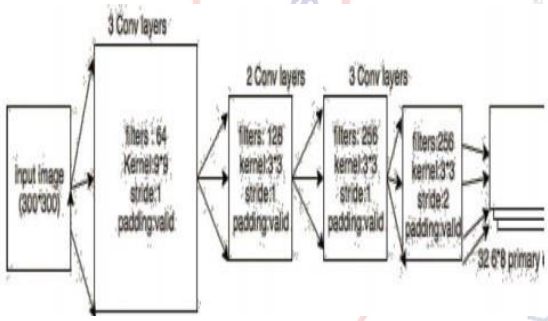

Fig 6: Convolutional Capsule Neural Network

- The capsule neural network in intelligent fault diagnosis (IFD), replacing the traditional fully connected CNN that degrade the performance by ignoring the location relationship of features. The capsule network employed in the fault diagnosis enhances the accuracy of the classification in IFD. The fault time frequency graphs are collected by the WTFA and the frequency obtained are used in training, and the parameters showing much alteration are chastened with the cost function, the dynamic routing is done and the length of the capsule is utilized identifying the fault in the diagnosis. The fig .7 shows the three layer capsule neural network architecture for the fault diagnosis.

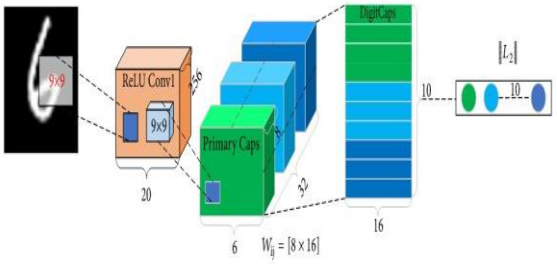

Fig 7: Three Layer Capsule Neural Network

- The CapsNet can be used in the image processing, for overcoming the limitations of the convolutional neural network, in the robustness of the affine transformation, and the identification of the images that are overlapped, the capsule neural network employed in the polyphonic sound event detection, improves the learning the learning rate and enhances the detection performances.

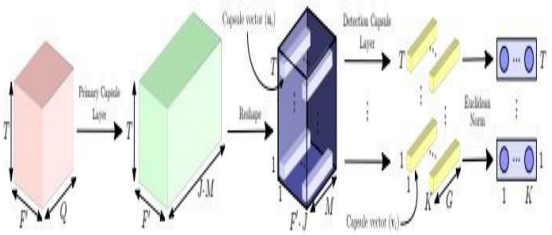

Fig 8: Caps Net in Polyphonic Sound Event Detection

5.1 Applications of Caps Net

The generative adversarial network utilizing the capsule neural network in the modeling image data distribution excels the performance of the convolution neural network. The table.1 showing the error rate of the Convolutional neural network and the capsule neural network shows the proficiency of the capsule neural network over the convolutional neural network.

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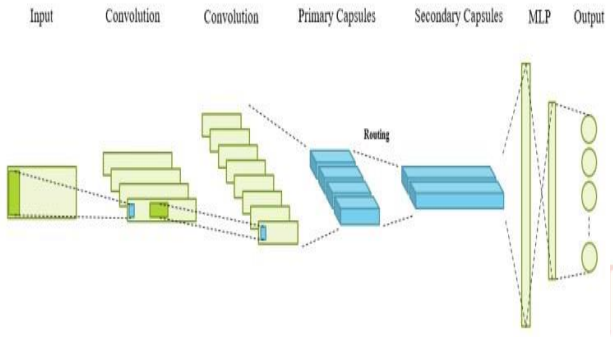

Fig-9:Structural Damage localization and quantification using Caps Net

Table 1: semi- supervised classification –MNIST

Model	Error Rate		
	n = 100	n = 1,000	n = 10,000
Convolutional GAN	0.2900	0.1539	0.0702
CapsuleGAN	**0.2724**	**0.1142**	**0.0531**

6. EFFICIENCIES OF THE CAPSULE NEURAL NETWORK

The capsule in the present in the capsule neural network, resemble the human brain in apprehending the required information's [2], it is equipped with huge potential of recognizing even objects that are complex from images captured with the very low quality, they learn better compared to the CNN by dividing the total images into sub –parts and hierarchical relating them and represents the picture with even better resolution than the CNN , the pooling layer in the CNN ignores the location relationship in the features leading to the degradation in the performance ,but the capsule shows effective feature extraction thus enhancing the classification accuracy[4]. The Caps Net causes prominent improvement in the performance of detecting the overlapped images and the sound compared to the convolution neural network [5]. The capsule neural networks surpasses the performance of the convolutional network in detection and the quantization of the structural damages as the convolutional neural network are impotent of realizing the rotations of the objects and the presence of the scaling within the objects [9]. The capsule network function as the capable alternative for the convolutional neural network in developing of the discriminator structures and other modules for the generative adversarial network [11].

7. CHARACTERISTICS OF NEURAL NETWORK

However, ANN uses its own regulations, and the more decisions it makes, the better decisions might become. In general, computers are good at calculations that take inputs, process them, and then give the result as per the calculations, which are done by using the particular Algorithm which is configured in the software. [6] The traits are essentially those that intelligent systems like robots and other applications of artificial intelligence should have. With the aid of a figure 10, fundamental and significant aspects of artificial neural networks are demonstrated:

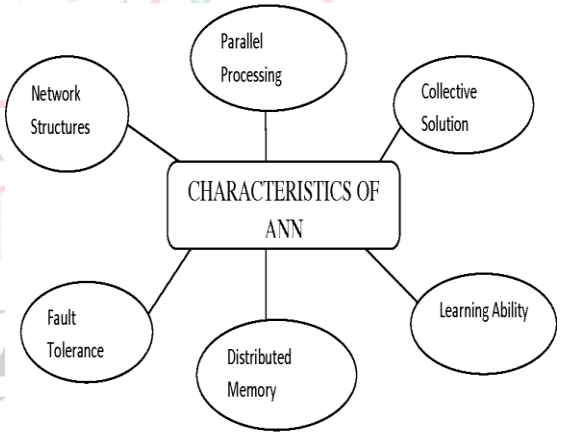

Fig-10: Characteristics of ANN

7.1 The Network Structures

An ANN's network model should be easy and straightforward. Recurrent and non-recurrent structures are the two main categories of structures. Associative or feedback networks and feed-forward networks are other

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names for the recurrent structure and the non-recurrent structure, respectively. [3, 4, 6, 7] In a feed-forward network, the signal can only flow in one direction, but in a feedback network, loops are added to allow the signal to travel in both ways. As depicted in the following figures:

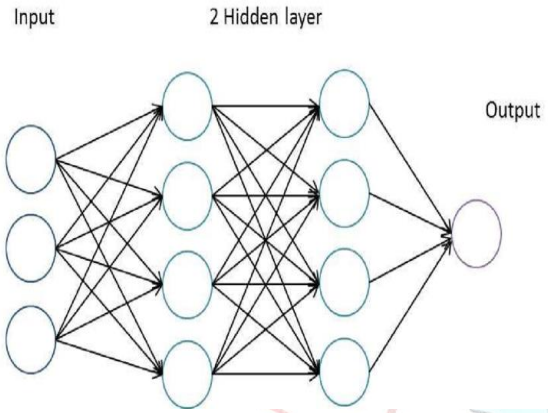

Fig-5 : Feed Forward Network

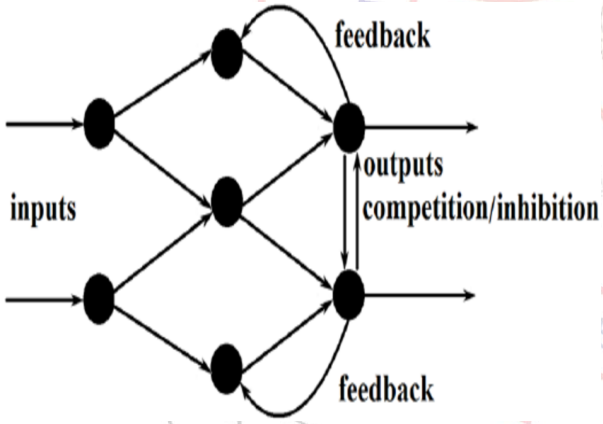

Fig-6 : Feedback Network

7.2Ability of Parallel Processing

Only the idea of parallel processing in the computer industry is known as ANN. The human body performs parallel processing in its extremely sophisticated human neurons, but we execute it in ANNs using fundamental and straightforward parallel processing methods, such as matrix calculations. [7]

7.3Distributed Memory

ANN is very vast system so single unit memory or centralized memory cannot fulfill the need of ANN system so in this condition we need to store information in weight matrix which form a long term memory because information is stored as patterns throughout the network structure. [7].

7.4Fault Tolerance Ability

Because ANN is a very complicated system, fault tolerance is a must. Because even if one component fails, the system as a whole won't be affected as much; nevertheless, if all components malfunction simultaneously, the system will completely fail. [7]

7.5Collective Solution

ANN is a networked system. The result is the summation of all the outputs, which follow the processing of multiple parameters, which is how a system's output is a collective output of diverse input. Any user of the ANN System will find the partial answer irrelevant. [7]

7.6Learning Ability

In ANN, the majority of learning rules are applied to create models of processes, adapt the network to its changing environment, and gain important information. Supervised, Unmonitored, and Reinforcement Learning are these learning techniques. [7]

8. ADVANTAGES OF NEURAL NETWORK

There are many uses for neural networks, and in this article we've covered some of the most significant ones:

1. Adaptive learning: Neural networks are capable of picking up new skills.
2. Self-Organization: During learning, a neural network, or ANN, can produce its own representation of the data.
3. Real-time operation: Parallel computations can be done in neural networks or ANNs.
4. A strong method for data security is pattern recognition. Neural networks acquire the ability to identify patterns in a data set.
5. Learning is used to create the system rather than programming. Neural networks enable the analyst to focus on more engaging tasks by teaching themselves the patterns in the data.

9. LIMITATIONS OF NEURAL NETWORK

The limitations of ANN are as follows:-

1. One of ANN's [or neural networks] shortcomings is that it cannot tackle problems that arise in daily life.

2. No organized approach is offered.

3. There is not one recognized model for the construction of neural networks.

4. An ANN's output quality may be unexpected.

5. A lot of ANN systems don't explain how they resolve issues.

10. APPLICATIONS OF NEURAL NETWORK

Artificial Neural Networks' real-time applications include the following:
1. Functional approximation, which includes modeling and prediction of time series.
2. Call control—answer an incoming call while driving with the speaker on by swiping your hand across the phone.
3. Classification, which includes sequential decision-making, pattern detection, and the recognition of patterns and sequences.
4. Use basic hand motions to volume-control or skip tracks on your media player.
5. Data processing, which includes compression, blind signal separation, grouping, and filtering.

11. CONCLUSION

In this article, we covered the artificial neural network (ANN), how neural networks function, ANN characteristics, benefits, and drawbacks, as well as ANN applications. ANN has a number of benefits over traditional methods. A network should typically train pretty well, depending on the application and the strength of the internal data patterns. This is relevant to issues where the relationships may be complex or nonlinear. After researching artificial neural networks, we came to the conclusion that as technology advances, so does the need for artificial intelligence. This is because parallel processing allows us to perform multiple tasks at once.
Therefore, parallel processing is necessary in the modern era since it allows us to save money and time on tasks involving electronics, computers, and robots. If we discuss the future work, we can state that we need to create additional algorithms and programme to overcome the artificial neural network's constraints and increase its usefulness for a variety of applications.

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