ISSN: 2278-4632
Vol-10 Issue-7 No. 1 July 2020

Applications of Neural Networks in Different Domains

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Abstract - Humans are the only creatures on earth to create and develop technologies. Neural networks is the trending technology and its impact is felt in almost all the fields at present. It is an art of making the machine to learn based on the training and to implement according to the application. The hardware implementation of deep neural networks (DNNs) has recently received tremendous attention: many applications in fact require high-speed operations that suit a hardware implementation. However, numerous elements and complex interconnections are usually required, leading to a large area occupation and copious power consumption. In this paper, we tried to give an insight of machine learning and presented different domains in which Neural Networks are being practically used.

Keywords: Machine learning, Neural Networks, Applications, VLSI, Image Processing

1. INTRODUCTION

A lot of progress in different technologies has been achieved over centuries. Of all the inventions, we can confidently say that Computer is the one, which greatly affected the lives of people. A computer is an electronic machine that works based on the commands given. It has made the life of people easy. The modern development is machine learning in which the machine is trained on various types of inputs so that they can be used instead of humans for testing, classification and prediction.

1.1 Machine learning

Some programs and codes are very lengthy and practically not possible for humans to implement. But a machine learning algorithm can have with a large amount of data and searches for a model which delivers the output intended by the programmer. Lot of examples specific to the precise output for a given input will be collected which are used by a machine learning algorithm and produces a program that does the job. The program generated by the learning algorithm may contain millions of numbers unlike typical hand-written program. Properly developed networks not only work on the trained data but can also adapt to new inputs. Some examples are Recognizing patterns, Recognizing anomalies and Prediction of future stock prices.

ISSN: 2278-4632
Vol-10 Issue-7 No. 1 July 2020

Neural networks are inspired from biological neurons which have ability to learn. A neural network with more than two layers can be treated as deep neural network which have become most popular due to their high performance. Neural networks have ability to adapt themselves when the input or output changes hence they are user friendly and reliable.

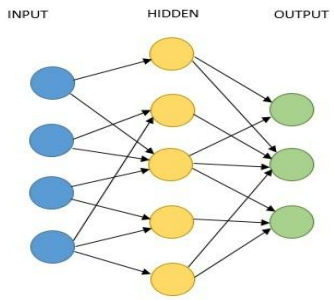

Fig.1. A simple neural network

There are two basic types of machine learning. They are:

1.1.1. Supervised Learning

This is a simpler method in which, the machine is made to learn what the input is and output in specific. Labeled data is used to train the algorithms. They use training data to learn the relation between input and output. They have high accuracy. Some examples of supervised learning are Support Vector Machine, Neural Network, Linear logistics regression, etc.

1.1.2. Unsupervised learning

Unsupervised machine learning helps to finds all kind of unknown patterns in data. In this, only the input unlabeled data is given so the complexity is high and accuracy is lower. The learning method take sin real-time unlike supervised learning. Some examples of unsupervised learning are cluster algorithms, K-means, hierarchical clustering etc.

1.1.3. Neural Networks

Artificial neural networks are synthetic imitation of biological neurons within the human body that produce response according to the circumstances. ANNs are interconnection of many layers of artificial neurons driven by activation functions that enables neurons. Similar to traditional machine algorithms, there are certain values that neural nets learn in the training phase.

Actually, every neuron has static bias value which is unique to each layer, and this bias is added to the product of inputs and random weights. The obtained value is passed to an appropriate activation function which decides the final value to be given out of the neuron. There are various activation functions available as per the nature of input values. Once the output is generated from the final

ISSN: 2278-4632
Vol-10 Issue-7 No. 1 July 2020

neural net layer, loss function (input vs output) is calculated and backpropagation is performed where the weights are adjusted to make the loss minimum. Finding optimal values of weights is a key aspect.

- **Weights**

  The inputs are multiplied with numerical values called weights. Based on the difference between actual and predicted values, these weights are adjusted by the network.

- **Activation Function**

  It is a mathematical formula which helps the enable a neuron

- **Input layer**

  It represents dimensions of the input vector.

- **Hidden layer**

  The represents the intermediary nodes that divide the input space into regions with (soft) boundaries. It takes in a set of weighted input and produces output through an activation function.

- **Output layer**

  It represents the output of the neural network.

Table 1 represents various types of neural networks starting from the simple perceptron with their applications.

Artificial neural network is a powerful data-driven, self-adaptive, flexible computational tool having the capability of capturing nonlinear and complex underlying characteristics of any physical process (e.g. Damage detection) with a high degree of accuracy. Due to their advantages like being able to operate on large data and adaptability, neural networks are being used in various fields now-a-days.

S.No	Name	Applications
1	Perceptron	i. Understanding the human brain ii. Scaling up for more advanced neural networks
2	Multi Layer Perceptron	i. Computer Vision ii. Natural Language Processing iii. Basis for other neural networks
3	Convolutional Neural Network	i. Image classification ii. Computer vision iii. Find characteristics / patterns in images

ISSN: 2278-4632
Vol-10 Issue-7 No. 1 July 2020

4	Recurrent Neural Network	i. Natural Language Processing ii. Stock Market Predictions iii. Time based data predictions
5	Autoencoders	i. Mostly for representing large amounts of data in a smaller, compressed way

Table 1. Different types of Neural Networks with applications

2. IMPLEMENTING NEURAL NETWORKS USING VLSI

Artificial neural networks (ANN) are parallel algorithms. Their parallelism makes them makes them suitable for parallel VLSI implementations, i.e. the development of dedicated circuits or architectures which can implement many operations in parallel.

Analog implementations rely on the fact that ANN involve simple operations. As many of these operations are non-linear, simple analog cells using a few transistors only are able to implement them efficiently. The required precision of ANN algorithms is usually limited and compatible with analog computations. As simple cells can be developed, integrating a large number of these cells in parallel is possible, leading to a high number of operations per second (MIPS). Moreover, real-world signals being analog, these implementations are able to process the incoming signals directly, without the need for convertors, filters, etc. Digital implementations do not permit parallelism to the same extent. While it is typical to find hundreds or thousands of analog cells working in parallel on a chip, digital cells, being much complex hence much larger, are limited in number to a few tens usually. Nevertheless, digital cells are more flexible, programmable, and thus may be developed for a wider range of applications. Concerning the speed of operations, there is no general rule differentiating analog and digital ones. Nevertheless, reminding that the number of MIPS is modulated by the degree of parallelism, digital implementations are less advantageous on this point. Most of the international electronic companies have developed VLSI neural chips using analog, digital or optoelectronic circuits. They have run various neural networks on them. Although it becomes possible to contain many neurons in a single chip, it is still difficult to contain a sufficient number of neurons for a broad range of practical applications. Therefore, cascadability is a necessary condition for any hardware of neural net- works, especially for the one aiming at real time operation. Multi-objective optimization for VLSI implementation of Artificial Neural Network (ANN) which is area-power-speed efficient and has high degree of accuracy and dynamic range.

ISSN: 2278-4632
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3. IMAGE PROCESSING

Image preprocessing is a popular application area. Several (regression) ANNs were developed for image reconstruction, image restoration and image enhancement. Often, these networks were not (or only partially) adaptive. In image processing, neural networks can be used for Image reconstruction, Image restoration, Image enhancement, Image compression, Data reduction and feature extraction, Feature extraction applications, Image segmentation, Object recognition, Image understanding.[1]
For some applications like object recognition, pre-trained networks can be helpful. These are the networks which are already trained on huge of data with large number of classes. For example, Alex-net is a popular pre trained network which can classify 1000 categories. With the help of transfer learning, one can apply pre-trained networks to any image data provided that the input image size is matched properly.

4. MEDICINE AND HEALTH CARE

Neural networks are swiftly finding different application areas within medical science. In addition to extensive application in diagnosis, ample development work is being undertaken in image processing and interpretation as well as signal processing and analysis. Computer-aided diagnosis is other main field of neural network applications in medical science. With the digitization of health care, hospitals are increasingly able to collect large amounts of data managed across large information systems. Machine learning technology is well-suited for analyzing such large medical data and providing effective algorithms .Considering the prevalent use of medical information systems and medical databases, ANN have found useful applications in biomedical areas in diagnosis and disease monitoring [3].

For example, if we consider cardiovascular medicine: a)diagnosis and treatment of coronary artery disease b) general interpretation of electrocardiography c) cardiac image analysis and d) cardiovascular drug dosing are the four categories in which ANNs can be applied. Similarly neural networks are playing a vital role in diagnosis of cancer; the inputs may be ultrasound, MRI, or histopathology images. They are useful for detecting the tumor, whether the cancer is benign or malignant, severity of cancer and the characteristics post chemotherapy. Telemedicine offers health care providers elaborate solutions for remote monitoring designed to prevent, diagnose, manage disease and treatment and can include machine learning techniques to predict clinical parameters such as blood pressure. Preliminary diagnosis of high-risk patients (for disease or attributes) using neural networks provide hospital administrators with a cost-effective tool in time and resource management [4].

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5. INDUSTRY

Industries are another key area which use neural networks in real time. Some of the examples of applications of neural networks will be like: In gasolines, neural networks can be used for fault detection in a virtrification process The ANNs application areas include; computer security, business, finance, bank, insurance, the stock market, electricity generation, management, nuclear industry, mineral exploration, mining, crude oil fractions quality prediction, crops yield prediction, water treatment, and policy. The ANNs have proven to be particularly adequate to solve many different problems in the food processing, food engineering and food properties domains. Therefore its usage has become quite frequent and in general the results obtained consubstantiate the fact of being a powerful tool, very practical and low resource consuming [7].

Here's a list of other neural network engineering applications currently in use in various industries and Business applications:

i. **Aerospace:** Aircraft component fault detectors and simulations, aircraft control systems, high-performance auto-piloting, and flight path simulations
ii. **Automotive:** Improved guidance systems, development of power trains, virtual sensors, and warranty activity analyzers
iii. **Electronics:** Chip failure analysis, circuit chip layouts, machine vision, non-linear modeling, prediction of the code sequence, process control, and voice synthesis
iv. **Manufacturing:** Chemical product design analysis, dynamic modeling of chemical process systems, process control, process and machine diagnosis, product design and analysis, paper quality prediction, project bidding, planning and management, quality analysis of computer chips, visual quality inspection systems, and welding quality analysis
v. **Mechanics:** Condition monitoring, systems modeling, and control
vi. **Robotics:** Forklift robots, manipulator controllers, trajectory control, and vision systems
vii. **Telecommunications:** ATM network control, automated information services, customer payment processing systems, data compression, equalizers, fault management, handwriting recognition, network design, management, routing and control, network monitoring, real-time translation of spoken language, and pattern recognition (faces, objects, fingerprints, semantic parsing, spell check, signal processing, and speech recognition)
viii. **Banking**: Credit card attrition, credit and loan application evaluation, fraud and risk evaluation, and loan delinquencies

ISSN: 2278-4632
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ix. **Business Analytics**: Customer behavior modeling, customer segmentation, fraud propensity, market research, market mix, market structure, and models for attrition, default, purchase, and renewals

x. **Defense**: Counterterrorism, facial recognition, feature extraction, noise suppression, object discrimination, sensors, sonar, radar and image signal processing, signal/image identification, target tracking, and weapon steering

xi. **Education**: Adaptive learning software, dynamic forecasting, education system analysis and forecasting, student performance modeling, and personality profiling

xii. **Financial**: Corporate bond ratings, corporate financial analysis, credit line use analysis, currency price prediction, loan advising, mortgage screening, real estate appraisal, and portfolio trading

xiii. **Securities**: Automatic bond rating, market analysis, and stock trading advisory systems

xiv. **Transportation**: Routing systems, truck brake diagnosis systems, and vehicle scheduling.

6. CONCLUSION

The use of neural networks appears overpowering. The application of Neural Networks is made possible practically by integrating on hardware using VLSI. Lot of active research is being done to overcome the shortcomings of digital implementation by using optimized techniques. With the progression of computer and communication technologies, the whole process of doing business has gone through a huge transformation. More and more knowledge-based systems have made their way into a large number of companies. In this paper we tried to project some of the applications of neural networks. But they are not limited to only these and it is obvious that the future is of Neural Networks.

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