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Functioning of a Computer like Human Brain Using Non-Traditional Architecture

Ananya Banerjee[1], Koushik Karmakar[2], Shreya Ghosh[3] and Soumili Biswas[4]

Faculty, Department of Computer Science and Engineering, Narula Institute of Technology, Kolkata, India[1, 2]

Student, Department of Computer Science and Engineering, Narula Institute of Technology, Kolkata, India[3, 4]

Abstract: Artificial Intelligence (AI) and its applications are going to bring rapid changes in human civilization. Von Neumann computers represent traditional computers which are not very much suitable for its data-centric artificial intelligence applications. For that efficient non-von Neumann computing platforms are required. However, role of memory is also very much important. Phase-change memory (PCM) plays a vital role in this kind of computing. This technology may be used in the development of specialized computing substrates for spiking neural networks which may be used in brain-inspired computing. This brain-inspired computing follows non-von Neumann approach in its working. Though present AI algorithms and technology works on von Neumann architecture, but it has its own limitations. To overcome these limitations alternative architecture in compared to traditional one must be developed for better performance.

Keywords*:* Artificial Intelligence, Von-Neumann, Phase-Change-Memory

I. INTRODUCTION

Computer architecture is one of the pillar of Computer Science and Engineering and hence a good topic for research works. In last few years a lot of resrach works have been carried out and rapid changes took place in this field. A few decades ago when computer science was started as a separate subject, a computer was simply a electro mechanical device and a single computer had occupied almost a room alone. Since then a lot of changes have taken place. Nowadays a digital computer is just an electronic device. A smartwatch is also a full fedged computer having a very powerful computation capacity. Even research is going on to make the computer architecture smart enough so that it becomes intelligent one and can take decision by itself. It will behave like human being. It can work like a human brain. In this paper a brief description of this emerging field is given. Section II describes traditional computer architecture along with the computational memory concept. Deep learning process is described in section III. Conculsion has been drawn at section IV.

II. TRADITIONAL ARCHITECTURE AND COMPUTATIONAL MEMORY

Von-Neumann Architecture: John Von Neumann is a scientist and mathematician cum physicist who have developed modern day computer system. It works based on the concept of the separation between saved packages along with the data-centric utilization. Through the use of the special package in the software system, one single unit can perform multiple tasks like running computer programs, playing videos and computer games and perform many other similar functions. However, with the new invention in 2020, this traditional concept has been changed to some extent. A lot of new architectures have been designed to overcome the short comings of the traditional system. Big companies like Intel, HP, IBM, Google are playing the leading role here. They have designed new architecture based on non-von Neumann system. These systems not only removed the bottleneck of traditional system but also started a new era in the history of the computing technology.

Non Von-Neumann Architecture: Any computer system which doesn't follow the traditional Von-Neumann system architecture may be called non Von-Neumann Architecture. A non von Neumann system may not follow the traditional sequential flow of control concept. It means there is no register that works at par with the program counter of the system. Its initial aim is to avoid the use of two von Neumann bottleneck caused by the common usage of the CPU. A non-von Neumann system avoids repetitive processing through the execution of the numerical as well as logical operations on different memory units. It helps and removes the shortcomings of the traditional system of polynomial-time problems. Some problems like this can be solved in a faster way through this non-von Neumann method.

One of the main features of brain-inspired computing is the simultaneous use memory and processing unit. With the stored data in the storage space it is possible to have in-place computing. In this architecture memory should not be treated as a passive storage unit but to use it to the maximum extent possible. Many computational activities like the arithmetic and logical operations; machine learning may be used here.

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Main aim of this technique is to capture a bigger signal using a sub-Nyquist sampling rate. Signal is restructured accordingly. With a matrix measurements are modeled. Then it is stored in the memory. It is compressed with O (1) complexity. From this compressed system original signal is re-generated. It is done through one message passing algorithm.

Fig. 1 Traditional digital computer

III. DEEP LEARNING PROCESS

Such techniques and algorithms show excellence in performing human-like activities especially in voice recognition and image processing. It is designed based on neural network system of human brain. Weights of such neural nets are updated regularly. As a result it gives much accurate results. Multiple of such crossbar arrays represent multiple layers of such network. However, it takes a long time to train this neural network if the problem is very large. Deep learning method which is a subset of machine learning technique can be used for better performance and optimal results. There are several deep learning methods. A few of them are described below:

A. Backpropagation

An essential component of neural net training is backpropagation. It involves adjusting a neural net's weights according to the error rate—or loss—obtained in the preceding epoch, or iteration. Lower error rates are guaranteed by carefully calibrating the weights, which also increases the model's generalizability and reliability.

Advantages: It is simple to implement since prior understanding of neural networks is not required. Since there are only the inputs and no extra parameters, programming is simple.
It expedites the procedure by not needing to master a function's functionality. Because of its simplicity and wide applicability, the model is versatile.

Drawbacks: Good training data is crucial since it can influence the model's performance. Additionally, noisy data may have an impact on backpropagation and contaminate its outcomes. Training and acclimating backpropagation models might take some time. A matrix-based technique is necessary for backpropagation, which may cause other problems.

B. Stochastic Gradient Descent (SGD)

For training linear classifiers and regressors under convex loss functions, like those of (linear) Support Vector Machines and Logistic Regression, Stochastic Gradient Descent (SGD) is a straightforward yet incredibly effective method. While SGD has been around for a while in the machine learning field, it has only lately attracted significant interest in the context of large-scale learning.

Advantages:
Simplicity is there in implementation. There are several options for fine-tuning the code.

Drawbacks:
Numerous hyperparameters, including the regularisation parameter and the number of iterations, are necessary for SGD.
The scale of features affects SGD.

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C. Learning Rate Decay
One more method that helps in learning faster. It reduces learning rate gradually. Like previous methods it has several advantages and drawbacks too.

Advantages:
It increases performance and reduces learning time.

Drawbacks:
This method gives better performance but it is computationally expensive.

D. Max-Pooling
Another method used in deep learning process. Here a max filter is used.

Advantages:
Biggest advantages of this method are that dimensions and computational costs are reduced.

Drawbacks:
It has few drawbacks too. It considers maximum element only and thus sometimes absurd results are generated.

E. Batch Normalization
In this method input is given batchwise to a layer. .

Advantages:
It increases stability of the network by reducing other factors like covariant shift. This method also trains the network in a faster rate.

Drawbacks:
One of the drawbacks of this method is that computational overhead is generated during training.

IV. CONVOLUTION NEURAL NETWORK (CNN)

Convolution neural networks (CNN) are a subclass of neural networks that are particularly good at processing input with a topology resembling a grid, like images. A binary representation of visual data is what makes up a digital image. It is made up of a grid-like arrangement of pixels with pixel values to indicate the colour and brightness of each pixel. The moment we perceive an image, the human brain analyses a tremendous quantity of data. Every neuron functions within its own receptive area and is interconnected with other neurons to include the whole visual field. Similar to how each neuron in the visual field only reacts to stimuli inside the confined area known as the receptive field. A comparison between CNN and deep learning is given in table1 below.

TABLE1 CNN VS. DEEP LEARNING METHODS

CNN	Deep learning
It is one type of neural network developed based on the concept of human brain. A lot of connected neurons are there in the human brain. CNN models that.	It is a type of machine learning which is based on ANN techniques. It also models human brain.
Its performance can't be compared to that of the deep learning method.	Its performance is always better in compared to CNN method.
It is one kind of feed-forward neural network method.	It is one type of recursive neural network method
Time taken to train the model is usually shorter.	Time taken to train the model is usually longer
It is used for different tasks like the classification, clustering, prediction and many other purposes.	It is used for different purposes like computer games, speech recognition and many other tasks.

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V. RECURRENT NEURAL NETWORK (RNN)

One kind of artificial neural network that makes use of sequential or time series data is the recurrent neural network (RNN). Popular applications like voice search and Google Translate integrate these RNN algorithms, which are frequently employed for ordinal or temporal problems like language translation, natural language processing (NLP), speech recognition, and image captioning. Recurrent neural networks (RNNs) like feedforward and convolutional neural networks (CNN), learn from training data. Their ability to use information from previous inputs to affect the present input and output sets them apart. Recurrent neural networks rely on the previous parts in the sequence to determine their output, in contrast to typical deep neural networks, which presume that inputs and outputs are independent of one another.

VI. CONCLUSION

This technique gives an overview of how high-performance computing is possible. It showed how the use of AI devices can develop the system. However, the maximum use of the current AI research is focused on the rational system only. However, reducing the time and distance is a great challenge and is a topic for research. Use of extra memory can solve this problem to some extent. Besides this a lot of research is going on in other fields too using AI technique. In future there will be a lot of development based on AI technique.

REFERENCES

[1]. Goodman and Millar K. (1992). A Programmer's View of Computer Architecture with Assembly Language examples from the MIPS RISC Architecture: Oxford Press.
[2]. Mehonic A. and Kenyon A. J. (2022). Brain-inspired computing needs a master plan. Nature, 604, 255-260.
[3]. Pearson M. , Armstrong D. and Mcgregor T. (2002). Design of a processor to support the teaching of computer systems, 1.
[4]. Kaur K. and Nayyer S. (2017). A Review and Hypothesis on Intel CoreTmi5 Processors, ISSN No: 0975-8364
[5]. Kendall J. D. and Kumar S. (2020). The building blocks of a brain-inspired computer. Applied Physics Reviews, 7(1).
[6]. Chakraborti A., Karmakar K. and Banerjee A. (2022). Different Sensors in Modern day Healthcare Service. In Computational Advancement in Communication, Circuits and Systems: Proceedings of 3rd ICCACCS 2020, 163-169, Springer Singapore.
[7]. Furber S.B. (2016). Brain-inspired computing. IET Computers & Digital Techniques, 10(6), 299-305.
[8]. Karmakar K., Saif S., Biswas S. and Neogy S. (2022). An Intelligent Vehicular Communication-Based Framework to Provide Seamless Connectivity in WBAN. In Advances in Communication, Devices and Networking: Proceedings of ICCDN 2021, 583-591, Singapore: Springer Nature Singapore.
[9]. Karmakar K. and Banerjee J.S. (2011). Different network micro-mobility protocols and their performance analysis. Int. J. Comput. Sci. Inf. Technol, 2(5), 2165-2175.