Ms. Sushmita Chakraborty
Assistant Professor, Patna Women's College(Autonomous)
Bailey Road, Patna
Email-id:sush123.chakraborty@gmail.com

A study of Role of Machine Intelligence with Neuromorphic Computing

Abstract: *The Artificial neural network is based on the Machine learning method that evolved from the pretend idea of the human brain and the system which consists of a large number of simple and highly interconnected elements which process and form an architecture that is based on the structure of several context portions of the brain. This paper defines how the role of technology evolves in the machine for firing a large number of neurons to make the machine intelligent and the machine works like the human. Hence, amachine that is based on neural networks is often capable of doing work that humans and animals do wellbut conventional computers often do poorly. The neural network has emerged in the past few years in the area of unusual opportunity in research, development and, application in various real-world problems neural network has various characteristics and capabilities that another technology is not to be provided.for example, reading human handwriting, reading and writing different languages like Korean, Chinese, Japanese, etc., compensation the alignment for in the text, interpreting the noise, and signals, and predicting whether the proposed loan is good or not. This paper presents a brief introduction to neural a network that is based on Machine learning and briefly describes it.*

Keywords: *Artificial intelligence, Machine Learning, Smart machine, neural network*

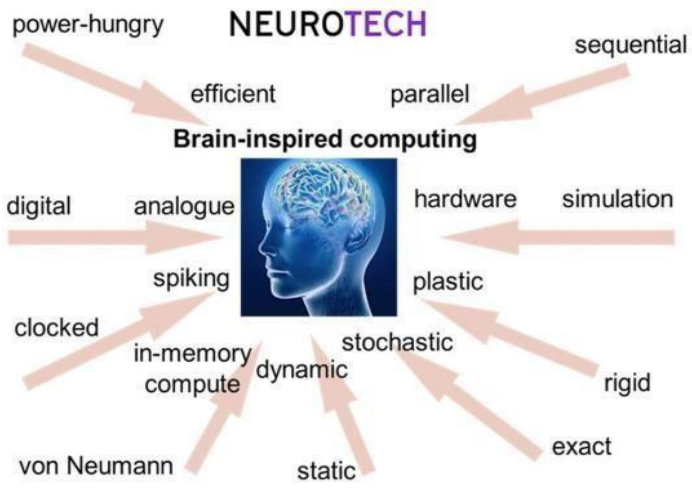
INTRODUCTION

This paper provides an exhaustive survey of neuromorphic computing. Neuromorphic computing has become popular architecture instead of von Neumann‟s architecture based on computer applications such as perceptron. The artificial neurons that are connected to each other are based on a biological neural network which is a theoretical neuroscientific model and also a challenging machine learning technique which is based on the von Neumann architecture. Machine intelligence with Neuromorphic Computing is defined and divided into Machine intelligence and Neuromorphic Computing. Machine intelligence is an umbrella term that is used to describe the accuracy of a machine learning, deep learning, orclassical algorithm output.

To describe machine intelligence there are two terms Artificial intelligence and machine learning. Artificial intelligence machine learning and machine intelligence are similar to each other, Whereas Artificial intelligence is composed of systems that allow computers to imitate/perform human cognitive processes or perform tasks that used to be done by humans.

Machine learning is defined as systems that enable a computer system to learn from inputs, without directly using linear programming. Machine learning is a set of computational techniques within a larger system that uses data to create a model for future data. Machine intelligence is a technology that enables a technology (a machine, device, or algorithm) to interact with its environment intelligently machine intelligence is created when machines are programmed with some aspects of human intelligence that include problem- solving, learning, and prioritization. With these abilities, machines will be able to solve complex sets of problems.

Neuromorphic Computing refers to the designing of computers that are based onthe systems and similar to the human brain and the nervous system. Inspired by the human brain and the functioning of the nervous system, Neuromorphic Computing was introduced in the 1980s with the ability to work and perform a task like the human brain, in the field of technology neuromorphic computing has placed. (Put the human brain into a machine that works and performs a task like a human). These computers are specifically known for their rapid response system because their processing is highly rapid. Neuromorphic computers are built to work like a human brain with a rapid response system is a major highlight.



Source: Fig1. https://www.innovationnewsnetwork.com/wp-content

Neuromorphic computing is brain- inspired computing for machine intelligence. It works on neural networks like the human nervous system of Neuron which is the part of the brain likewise CPU which is the brain of a computer. It provides Deep learning that revolves around software-based algorithms and architectures. It is a neural circuit of the brain. In this computing, a chip is put inside it and all computations happen in memory. Memory is the base of neuromorphic chips which can be used as both memory units and computation units. Perform a task efficiently and rapidly provide information.

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The main classification of neural networks is classified into two types i.e., Neurobiological networks and Artificial Neural networks. The Biological neural network is a network that is composed of a living body's nervous system. With the continuous evolution of Science and Technology, Artificial Intelligence has gradually turned into Bionic Technology.

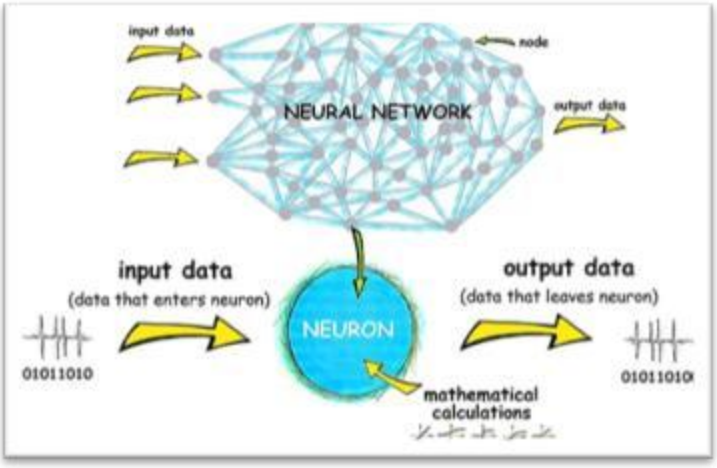

Fig3.https://www.frontiersin.org/files/Articles/560631/frym-09-560631-HTML/image_m/figure-3.jpg

So, the Artificial Neural Network has been compared to the various information, transmission, and processing methods of the Neurobiological network. The Artificial Neural Network simulates the biological brain and Nervous system. In an Artificial Neural network system, every neuron is connected to each other and forms a complex computing network system that is similar to the biological neural network. There are many advantages of Artificial neural networks such as parallel processing, independence, strong nonlinear ability, fault tolerance, etc. The wide use of this network in image recognition, pattern evolution, and Machine Learning.

Neuromorphic architecture has several expressed and special requirements such as low power consumption, memory allocation, and processing. It has a strong ability to calculate complex computational speed compared to the concept of traditional Von-Neumann Architecture. So, the

neuromorphic architecture will be an appropriate choice for implementing machine learning algorithms.

Objective:

The objective of neuromorphic computing is to make computers behave like a human brain, work as like as similar to the human nervous system, and neuromorphic computing posits the engineering of computers in a way that comprises a million artificial silicon neurons that enabled to transfer of electric spikes from one to another. Neuromorphic computing achieves this brain as human and performs the function and efficiency by building artificial neural systems that implement "neurons" similar to the human brain.

- To study neuromorphic computing which is based on neural networks. It is a method of computer engineering in which elements of a computer are modeled after systems in the human brain and nervous system.
- It also refers to Machine Intelligence i.e. how the machine thinks and behaves like a human.
- To observe the evidence of neural networks for the development of machine intelligence, finding the data sets that are used to study the concept of brain-like „spiking" computational framework, neuromorphic Computing regarding the, realize of artificial intelligence while reducing the energy requirements of computing platforms.
- To actively and intelligently monitor its environment by learning and predicting the evolution of the various environmental features (e.g. Alexa, Google translator, Apple Siri).
- Proactively taking actions that maximize the chances of success for some predefined goal, in which a wireless system, pertains to some demand after quality-of- service.
- To carry out the activity of a computer system which includes neuro-science i.e. systems just behave and act like a human brain. It also defines the system memory which learns the activities which are mostly and frequently used and also responds whenever needed.

Research on Machine Learning Algorithms Based on Neural Network Technology

1. **Speed: -** According to the Speed advantage using software to simulate neural networks on a computer processor has a certain flexibility and does not require the use of hardware the speed of software to the simulation of neural networks is very slow and usually not suitable for all occasions, so hardware is used Computational processing of convolutional neural networks is a practical and effective method to solve the practical application of neural networks
2. **Fault tolerance** in this implementation application has certain instabilities, such that if when any problem occurs in any link, the entire processor system will lose function, and the main reason for this problem is that the single processor is not enough for Redundancy. As compared to the hardware structure, there is a reduction in overall performance, so the application can run normally. However, if we compare it with a software-based neural network, it has incomparable advantages. The neural network has a high degree of independence between layers as a feed forward neural structure. Each layer of the neural

network is calculated independently. They highly parallel artificial Neural network structures.

Influencing Factors:

(1) **Data set: -** According to (Yiqiang Lai et al, 2021), the sample variables in the research work mainly contain the following two characteristics.
   a) The big data sample selection.
   b) The samples should bedispersed.

(2) **Initialization: -** It includes two components which are weight and threshold. These two factors contain a certain impact on the operation process in the training.

(3) **Training Speed: -** speed of training contains basic parameters that also cause the speed of training to slow down.

Algorithm Analysis : Algorithm Analysis which is used in to write the machine combines the input gate and forget gate in LSTM.

Therefore, the writing mechanism of NTM is divided into two steps that are:

- The first step is to erase the memory
- The second step is to write the memory.

At time t, the write head outputs a weight vector w^t, an E-dimensional elimination vector e^t, and an E-dimensional addition vector a^t. Each element belongs to the interval [0, 1]. Then (t) e (t) the value of the memory matrix can be calculated according to formula (1) to formula (2):

$$e^{(t)} = \sigma(W^e h^{(t)} + b^e) \quad (1)$$

$$a^{(t)} = W^e h^{(t)} + b^a \quad (2)$$

$$M^{(t)} = M^{(T-1)} \square [1 - w^{(t)}(e^{(t)})] + w^{(t)}(a^{(t)})^T \quad (3)$$

Among them, 1 in formula (3) represents a matrix of all ones with a size of N×E, $h^{(t)}$ represents (t) the output of the controller at time t, and W^e are the weights and biases corresponding to the b^eelimination vector and the addition vector, respectively.

Network Hyperparameters and Their Tuning:

For each task, the hyperparameter is related to the task which needs to be adjusted. The value of the related parameter is shown in Table 1. The sequence length denotes the length range of the inputted sequence.

As reported earlier (Luping Shi et al,2015),

For example, In a task that is copied, its sequence length range is from 2 to 11. It should be defined that the input sequence contains the terminator ".", the multiplication sign "x" and the plus sign "+". So, the actual number of characters to be counted by the model is smaller than the sequence length. The minimum sequence length to be copied by the copy algorithm is 1 and the maximum length is So, the sequence length of each added range is from 1 to 10 and the sequence length of each multiplier range is from 1 to 10.

task	Sequence length	Memory size	Training times
copy	[2,11]	10 x 8	50000
addition	[4,22]	21 x 10	150000
multiplication	[4,22]	30 x 10	300000

Table 1. Task-related parameters

Experimental Research on Machine Learning Algorithms Based on Neural Network Technology

As reported (Luping Shi et al,2015), we have an example the machine learning algorithms to implement neural networks.

Example: **NTM stands for the Network Hyper parameters and Their Tuning For each task, the hyper parameters related to the task that needs to be adjusted, and the values of the desired parameters areshown below the sequence length to represent the length range of the input sequence.**

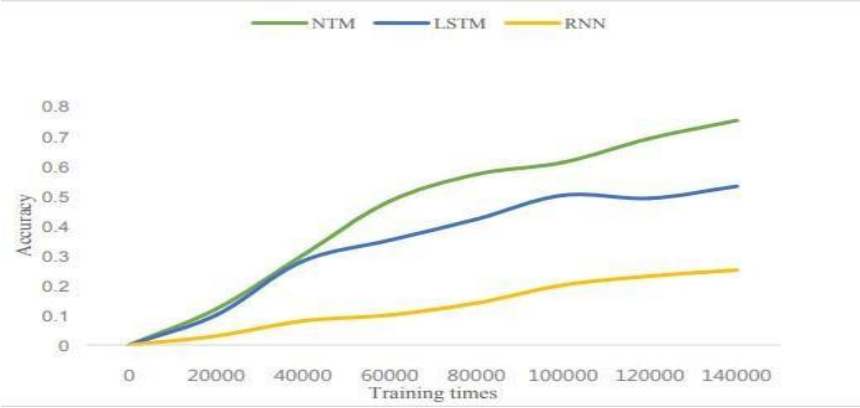

Fig.4.Lai_2021_J._Phy s. Conf ._Ser._2066_012041%20(1).pdf

For example, in a copy task, the sequence length ranges from 2 to 11. It should be noted that the input sequence includes the terminator ".", the plus sign "+" and the multiplication sign "×". Therefore, the actual number of characters to be memorized by the model is smaller than the sequence length. The minimum length of the sequence to be copied by the copy algorithm is 1 and the maximum is 10; in addition, the length of each addend ranges

from 1 to 10; in multiplication, the length of each multiplier ranges from 1 to 10.

Features of a NeuromorphicComputing:

- **Rapid Response System:** Neuromorphic computers are specifically known for their rapid response system because their processing of data very is highly rapid. This computer is built towork like a human brain andperform the task as same ashumans.
- **Low Consumption of Power:** Neuromorphic machines work when electric spikes or signals are passed through the artificial neurons this concept are work on of Spiking Neural Networks (SNN).
- **Higher Adaptability:** Neuromorphic computers work according to the demands of technology. With changing of times, neuromorphic computers adapt themselves and change from time to time resulting inaccurate and efficient working.
- **Mobile Architecture:** computers system that used to consume vast space for working, whereas a neuromorphic computer is mobile and handy. That do not require much space and are highly efficient in terms of space occupancy

Spiking Neural Unit (SNN):

This is confirmed by earlier workers (Hitesh Dureja et al,2021), The input is filtered in some way that usually a low pass filter in spiking neurons. They fire when a state variable exceeds a threshold. It is calculated using the Dirac Delta function where „tk" is the spike time. To express learning in an SNN as minimization of a loss function across an extensive number of training samples which is similar to old machine learning. A learning process includes finding sets of synaptic weights which allow scattered representation that is performed while decreasing the sum of all scattered coding losses in the sparse coding case. SNN naturally learning proceeds online where training samples are sent to the network sequentially.

Future Scope:

Neuromorphic chips are the key to breaking through the development direction of Von Neumann"s structure limitations. It is because the operations of neural networks are the processing of neurons and synapses. The conventional processor instruction set was developed for general-purpose computing and consists of arithmetic operations (addition, multiplication, subtraction, and division) and logical operations (AND- OR-NOT). Neuromorphic chips often require hundreds or thousands of instructions to complete the processing of neuron computing and making the low processing efficiency of the hardware inefficient.

Neural computing needs a completely different design than the von Neumann Architecture currently. The processing and storage are integrated into the neural network in comparing the von Neumann structure there is separated and realized respectively by memory and computation. It has inevitably restricted separate storage and handling structure which has caused a lower efficiency over the impacts of the neural network applications. A new generation of architecture like neuromorphic chips and integrated computing designs will be used in the long-term planning.

Artificial Intelligence is the current and future of our coming generation in Neuromorphic Computing. In the fourth and the third wave or era of AI, neuromorphic computing will take over the technological advancements in the field and become the driving force of artificial intel igence"s future scope. AI (Artificial Intelligence) is faced with a number of challenges like heavy processing, hardware, and software storage capacity. The third wave of neuromorphic computing in AI will most likely put a stop to these challenges and enable human-like activities performed by computers.

Limitations:

Neuromorphic devices represent as and mimic aspects of the brain's architecture and dynamics with the aim of replicating its hallmark functional capabilities in the aspect of various terms:

- Computational power
- Energy efficiency

mapping of a high-dimensional parameter space, which is required to be done for each chip individually. A faster calibration routine.

On the other hand, it is necessarily involved in taking shortcuts such as assuming independence between the influence of hardware parameters, thereby potentially leading to systematic deviations from the target behavior.

As reported by (Matthew Stewart, 2019), These are the following Limitations followed in Machine learning with Neuromorphic Computing: -

- **Ethics: -** amount of data that is coupled with the rapid development of processor power and parallelization of a computer system has now possible to obtain a huge amount of data. Yuval Noah Harari referred to a putative new stage of civilization which is trusting algorithms and data more than own judgment andlogic.
- **Deterministic Problems:** Machine learning with neuromorphic computing consist of running computer models that simulate computational modeling like global weather, emissions from the planet, etc., Using a neural network that has thousands of inputs to determine whether it will be any changes in later, possibilities and deterministic problems, it misses the entire physics. However, this is not a limitation for long because many researchers look at physical constraints nowadays.

- **Data: -** Machine learning algorithms for neuromorphic computing require large amounts of data before they begin useful results.

  It consists of two attributes: -

  a) **Lack of Data: -** Reusing data is not a good idea and augmentation of data is useful to some extent but having more data is always the optimal solution.

  b) **Lack of Good Data: -** Some data usage likelihood to be the algorithm to be more equitable by straying data set along relevant axes.

- **Misapplication: -** This limitation consists of a random system. Applying machine learning to two variables may not be easy and it violates physical laws.

  It is basically of two ways:-

  a) P-hacking: - these are not true correlations of accessing a large set of data and it responds to the noise in the measurements.

  b) Scope of the Analysis: - it lacks a number of qualities associated with the confirmatory analysis.

- **Interpretability: -** it has a lack of interpretability of the methods. Humans follow interpretation by following rules that go beyond technical processes. Machine learning aims to achieve it by practicing and in long-term learning.

Suggestions:

Nowadays, there are a lot of explorations on how to simulate or create synthetic synapses. ASIC is the kind of chip that is designed with stronger performance, smaller size, less power consumption, more progress, and lower cost in developing hardware and software designs. ASIC needs research and development time. It has high-risk technology marketing that will play a major obstacle to future promotion. However, It has a good mold size, great energy consumption, great reliability, strong confidentiality, high computing performance, and high computing efficiency.

Eventually, the algorithm, architecture, and programming scheme of adaptive neuromorphic computing is a wide blank and it will take time to reach the finish line that replaces von Neumann architecture. But over time the frontiers of neuromorphic computing knowledge are being pushed and the possibilities which we think about right now will change the world drastically.

Conclusion:

Although in recent years, neuromorphic computing has been known and gained widespread attention but is still considered to be in its infancy stage. A single application at the hardware and software level is mostly focused on the existing solution and the majority of the solutions are only suitable for handling limited applications.

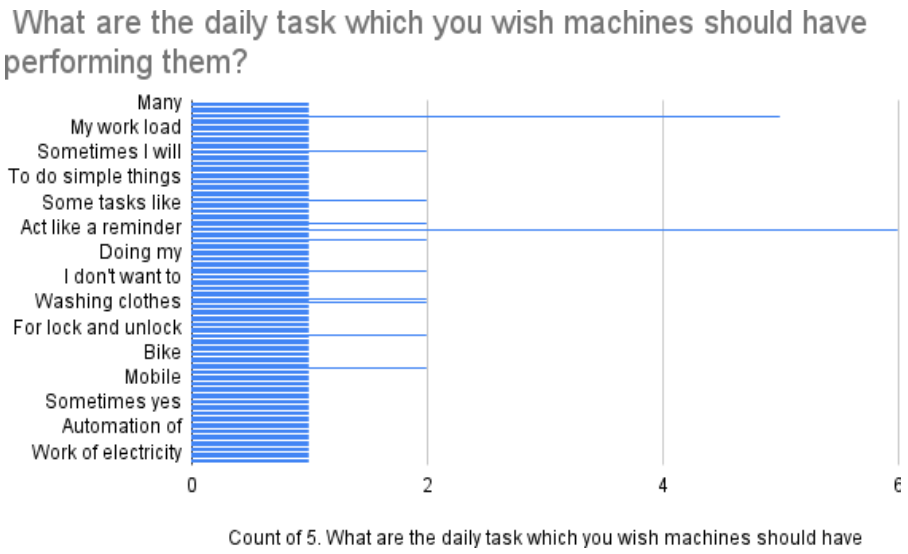

Fig:5

According to our survey, we have observed that there are many tasks that people or humans want to do with help of a machine. Although these systems are already implemented in the current scenario there is a lack of availability for people.

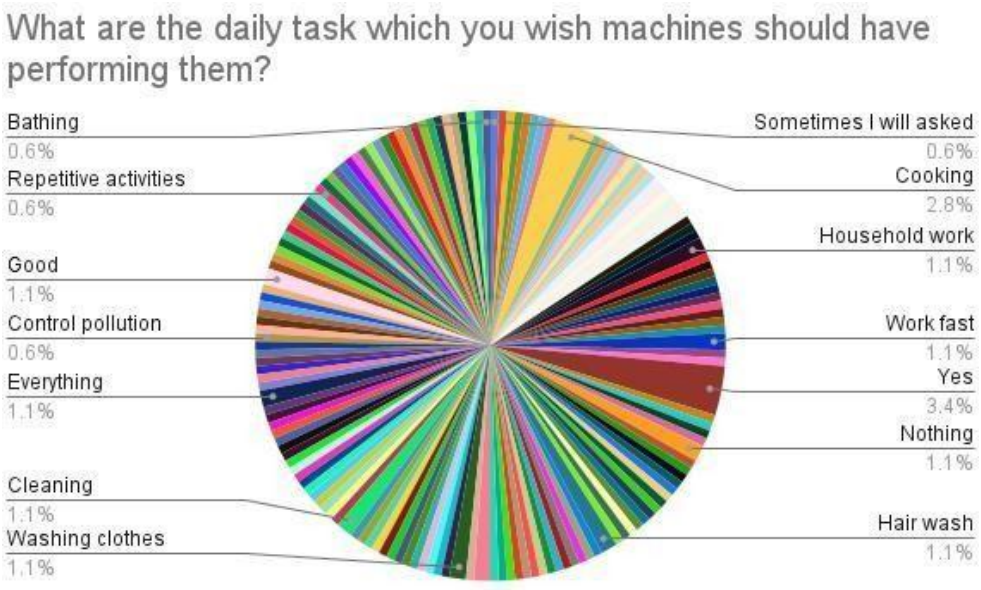

Fig:6

In the observation, generally, people wish to perform tasks the machines only those tasks which are day-to-day work. They want their problems to be solved bymachines.

In addition, there are many software- based neural network applications are deployed but hardware-based is rare to find because it takes more time, cost, and different algorithms, and architectures. It can process and improve the final software-level application that quantifies hardware attributes hence a testable solution for a specification component.

We strongly believe that in the upcoming time neuromorphic computing using hardware and software implementation will blow the world out. It will be consisting of low-power neuromorphic processing systems using different advanced algorithms.
The objective of neuromorphic computing is to make computers behave like a human brain and work as similarly as a human along the lines of the human nervous system, and where neuromorphic computing posits the engineering of computers in a way that comprises millions of artificial silicon neurons enabled to transfer electric spikes from one another.

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