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NEURAL NETWORK IN VERBAL BRAIN ARITHMETIC OPERATIONS WITH NEURAL NETWORK

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ABSTRACT

This article will explain how neural network is proficient to make the arithmetic operations like Addition, Subtraction, Multiplication and Division of binary numbers. As we know that our human brain is divided into two halves or hemispheres (Left and Right). The Left brain thinking is verbal (logic, analysis, computation and other functions), whereas Right brain thinking is Non-verbal (creativity, imaginary, intuition and other functions). Here the input layer of neural network is used to represent input, in the same manner hidden units are used to represent the encapsulated operations like conversion from decimal to binary and vice versa, the last layer output is used to produce the output values.

Keywords: Arithmetic Operations, Binary, Lobes, Neural Network, Neuron, Verbal brain

I. INTRODUCTION

One of the most important issues in the Neural Network field is learning, that is synaptic modification algorithm (also known as learning algorithms) that allows an arbitrarily connected network to develop an internal structure appropriated for a particular task. Although learning algorithms can be implemented for any kind of neural structure, feed-forward layered networks presents a simple architecture that makes them especially suitable for the study of general learning properties. In this networks composed of binary neurons, therefore neurons whose activity can only take two values zero and one. Generally speaking arithmetic problems, if soluble by feed-forward neural networks, admit several solutions with different architectures [1]. In the following section, the discussion on how the numbers are represented using binary numbers and how computers perform arithmetic operations using the binary representation are represented [8].

II. THE BRAIN

The brain is the most complex organ in the body. It is the organ that allows us to think, have emotions, move and even dream. Given this complexity, it should not be surprising that there are many ways to separate the parts of the brain. The brain and spinal cord make up the Central Nervous System (CNS) and all of the nerves found in our body make up the peripheral nervous system [2].

The brain is the structural and functional properties of interconnected neurons. How does the brain work and what does it actually do. These questions have fascinated and challenged countless on human beings over many

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centuries. Nerves reach from your brain to your face, ears, eyes, nose and spinal cord and from the spinal cord to the rest of your body. Sensory nerves gather information from the environment and send that information to the spinal cord to the rest of your body. The brain then makes sense of that message and fires off a response [3].

2.1. Lobes of the Brain

When we see a picture of the brain we probably think of a wrinkled gray blob, the wrinkles are called cortex and it is where the majority of brain cells or neurons reside. The cortex can be divided into four lobes with cerebellum and stem of the brain [2]. In other words there are six components inside of the brain, the Frontal lobe, Parietal lobe, Occipital lobe, Temporal lobe, Cerebellum and the brain stem [4].

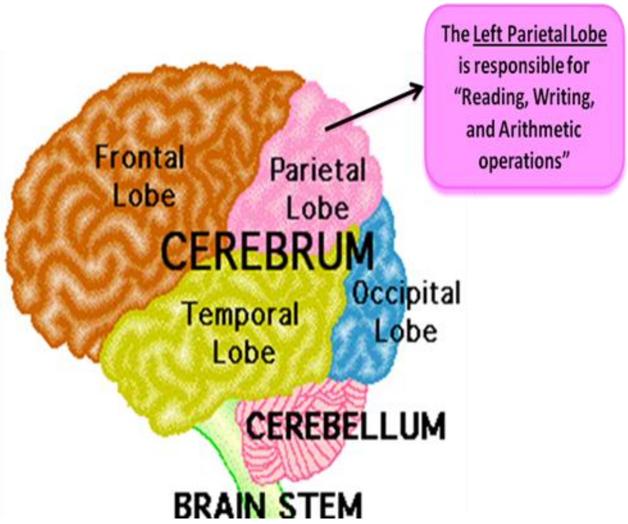

Figure. 1 Lobes of the brain

Front lobe: Responsible for higher-order functioning like Judgment, abstraction and motivation, self monitoring, motor planning, Personality, Awareness of abilities, Concentrations, Mental Flexibility, Speaking (expressive language). With an injury in this area, one may become disoriented [4].

Parietal lobe: The anterior (front lope) of the parietal lobe is responsible for tactile discrimination and recognition. The posterior (back part) of the parietal lobe is responsible for attention. The left parietal lobe is responsible for reading, writing, arithmetic and its other function is speech. The right parietal lobe is responsible for the comprehension of visuospatial relationships and understanding facial expression and tones in speech [5].

Occipital lobe: Located in the back of the brain, Responsible for regulation and processing of sight [5].

Temporal lobe: The temporal lobe is responsible for forming memories and processing the sound being recorded by the ears. It is placed at the bottom of the brain. Any damage to it can cause problem with language skill, speech perception and memory [6].

Brain stem: Connection from the spinal cord to lower areas of the brain. Responsible for autonomic functions: such as heart rate, blood pressure and breathing. Motor and sensory neurons pass through the brain stem [5].

Cerebellum: The back portion of the brain that assist in coordination movement. Damage often results in ataxia (un-coordinated voluntary muscle movements). Cerebrum is different from cerebellum, because cerebrum is the largest part of the brain, divided into left and right cerebral hemispheres [5].

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2.2 Basic characteristics of Verbal and Non-Verbal Brain

The human brain is made up of two halves. These halves are commonly called the right and left brain, but should more correctly be termed as 'Hemispheres'. For some reason, our right and left hemisphere control the opposite side of our bodies, so the right hemisphere controls our left side and processes what we see in our left eye while the left hemisphere controls the right side and processes what our right eye sees. The shapes of these two hemispheres are similar, but differences have gradually found in their functions. These two work together, to allow us to function as humans. The concept of right brain and left brain thinking developed from the research in 1960s of an American psychobiologist Roger W Sperry. He discovered that the human brain has two very different ways of thinking. One (the right brain) is visual and processes information in an intuitive and simultaneous way, looking first at the whole picture then the details. The other (the left brain) is verbal and processes information in an analytical and sequential way [7].

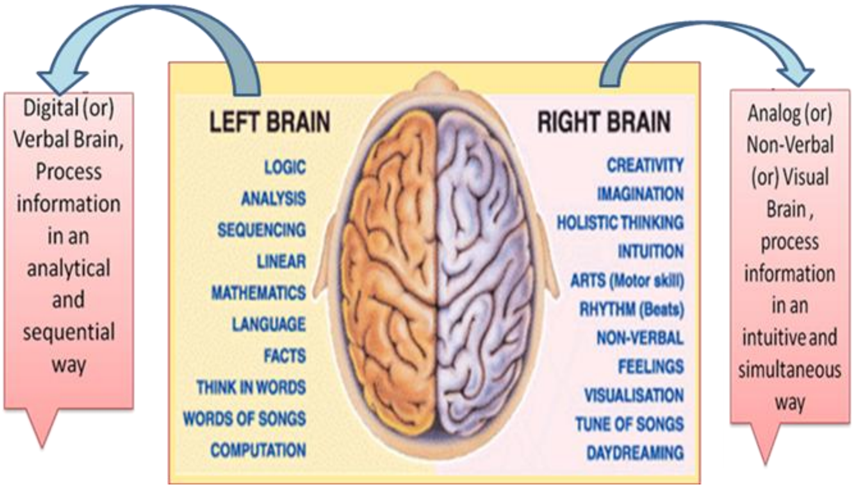

Figure. 2 Characteristic of Left and Right Brain

2.3 Numeracy of the Brain

The brain needs to coordinate multiple neural systems in order to be numerated. Effective neural interconnections are critical for success at mathematics in general. This section will discuss which systems in the brain have been identified for mathematical processing, how computation and creativity as different contributions to mathematical thinking are supported by separated but overlapping networks in the brain and implications from the relevant for structuring introductory and remedial mathematical curricula [14]. The principal of neural interconnectivity underpins the emergence of the various neural systems required for all facet of school learning. Arithmetic is perhaps the easiest to investigate in a neuro-imaging laboratory due to its emphasis on unambiguous correctness [14].

There is a evidence for differences between the neural networks associated with each of the four basic arithmetic operations: addition, subtraction, multiplication and division. This is not to say that these networks are completely independent from one another. They are overlap notably in the frontal and parietal areas, but they also include areas of brain which seem to be unique to each arithmetical operation. There is no specific brain area or module for doing arithmetic. Rather, arithmetical brain functioning relies on the cooperation of neural systems supported b y various functional modules located in many different parts of the brain across both hemisphere [14].

III. NEURAL NETWORK

The simplest definition of a neural network, more properly referred to as an Artificial Neural Network (ANN), is provided by the inventor of one of the first neurocomputers, Dr.Robert Hecht-Nielsen. He defines a neural network as " a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs" [10].

3.1 Biological Neuron

We have roughly 86 billion neurons in our brains. But unlike the common saying, we don't just use 10% of them; we use most of them all the time. Neurons are the cells in the brain that convey information about the world around us, help us make sense of the world and send commands to our muscles to act. They are exquisitely responsive to the world around us, enabling us to learn. Learning can change the shape of a neuron, what that neuron projects to and its signaling efficiency [10].

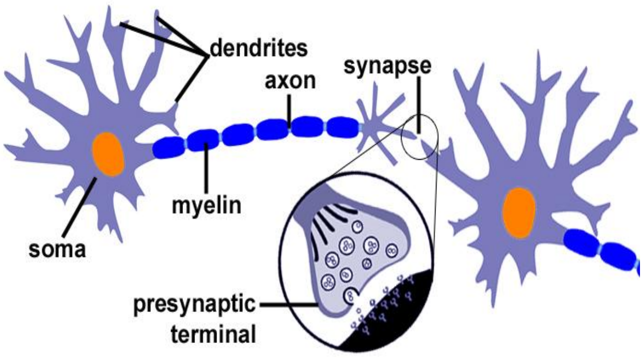

Figure. 3 The structure of Biological Neuron

Most neurons are made up of the following parts: the nucleus (which contains the genetic instruction), the soma or cell body, dendrites (branch-like structures which receive information from other neurons), axons (long tubular pathways which send information to other parts of the brain) and an (axonal) presynaptic terminal. The presynaptic terminal connects to other neurons via synapses. Many axons are surrounded by myelin, essentially sheaths which help axons quickly send signals over long distances [10].

It is still unknown about how the brain trains itself to process information. In the human brain, a typical neuron collects signals from others through a host of fine structure called dendrites. The neuron sends out spikes of electrical activity through a long thin stand known as an axon, which splits into thousands of branches. At the end of each branch, a structure called a synapse converts the activity from the axon into electrical effects that inhibit or excite activity from the axon into electrical effects that inhibit or excite activity in the connected neurons. When a neuron receives excitatory input that is sufficiently large compared with its inhibitory input, it sends a spike if electrical activity down its axon. Learning occurs by changing the effectiveness of the synapses so that influence of one neuron on another changes.

3.2 Artificial Neuron

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements working in unison to solve specific problems.ANN, like people it learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process [11].

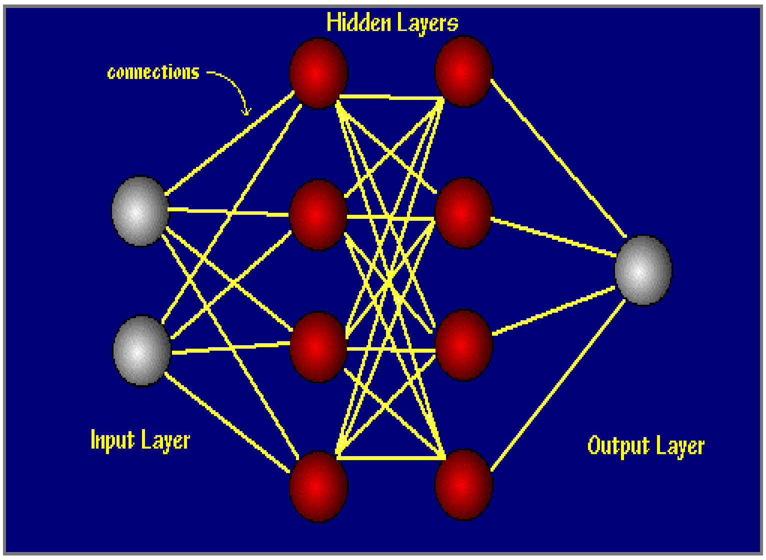

Figure. 4 Model of Neural Network

Neural networks are typically organized in layers. Layers are made up of a number of interconnected nodes which contain an activation function. Patterns are presented to the network via the input layer which communicates to one or more hidden layers where the actual processing is done via a system of weighted connections. The hidden layers then link to an output layer where the answer is output as show in the above figure. Most ANN contains some form of learning rule which modified the weights of the connections according to the input patterns that it is presented with. In sense, ANN learn by example as do their biological counterparts, a child learns to recognize dogs from examples of dogs [12].

3.2.1 The model of Artificial Neuron

We conclude these neural networks by first trying to deduce the essential features of neurons and their interconnections. We then typically program a computer to simulate these features. However our knowledge of neurons in incomplete and our computing power is limited, our models are necessarily gross idealizations of real network of neurons [11].

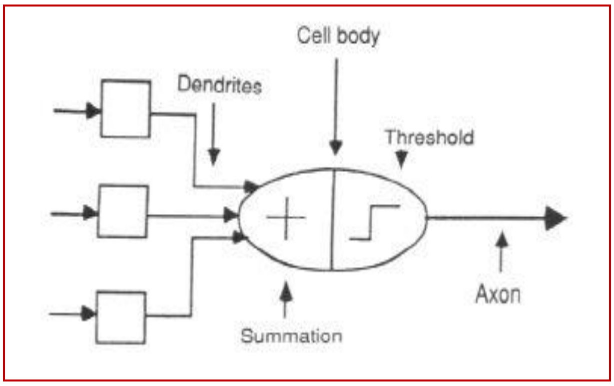

Figure. 5 Model of Artificial Neuron

IV. COMPUTING CONCEPT

Computer store and process number, letters and word that are often referred to as data. How do we communicate data to computers?. And how do the computers store and process data?. Since the computers cannot understand the Arabic number or the English alphabets, we should use some 'codes' that can be easily understood by them. In all modern computers. Storage and processing units are made of a set of silicon chips, each containing a large number of transistors. A transistor is a two-state device that can be put 'off' and 'on' by passing an electric current through it. Sine the transistors are sensitive to currents and act like switches. We can communicate with the computers using electric signals, which are represented by the code '1' and no-pulse conditions. For the sake of convenience and ease of use, a pulse is represented by the code '1' and a no-pulse by the code '0'. They are called bits, an abbreviation of 'binary digits'. A series of 1s and 0s are used to represent a number or a character and thus they provide a way for humans and computers to communicate with one another. This idea was suggested by John Von Neumann in 1946. The numbers represented by binary digits are known as 'binary numbers'. Computers not only store numbers but also perform operations on them in binary form. Below section discuss how computers perform arithmetic operations using the binary representation [ ].

4.1 Binary Number System

The numbers represented by binary digits are known as binary numbers. The binary number system is numeral system that represents numeric values using only two digits 0 and 1, which are known as bits. Therefore, the base of the binary number system is 2. Each bit position in a binary number represents a power of the base 2. The internal functioning of a computer system is carried out in binary number system format. All the decimal numbers that a user enters in a computer system are first converted into binary numbers and then, the arithmetic operations are performed on them. The results are again converted into its decimal equivalent and are displayed to the user [8].

In digital electronics binary numbers are the most important tool for giving digital inputs. The number system first introduced in human history for counting purpose. Different numbers for counting are represented by different symbols. Binary number system was introduced by an Indian scholar Pingala in around fifth second centuries in BC. Long and short syllable were used by him to illustrate the two types of numbers, it is more like Mores code. Gorrdeiws Lwibniz in 1679 introduced the modern type of binary number system which we still

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use. Any kind of decimal number can be represented by binary number system. The use of this system is popular in digital electronics because the on and off mode can be pretty easily understood by this [9].

4.2 Binary Arithmetic Operations

Arithmetic operations on binary numbers are performed in the manner as on decimal numbers. The basic binary arithmetic operations are [8]:

4.2.1 Binary Addition

In the binary number system, the simplest arithmetic operation is binary addition. The first and perhaps the most important of them all is binary addition and it is the easiest of them all [8].

- Rules of binary addition:

  0 + 0 = 0, with no carry

  0 + 1 = 1, with no carry

  1 + 0 = 1, with no carry

  1 + 1 = 0, with carry 1

Example:

```
 11    ←— carry
  11   ←— number 1
+101   ←— number 2
----
1000
```

4.2.2 Binary Subtraction

In the binary number system, another simplest arithmetic operation is binary subtraction [8].

- Rules of binary subtraction

  0 – 0 = 0, with nor borrow

  0 – 1 = 1, with borrow 1 from the more
  Significant bit

  1 – 0 = 1, with no borrow

  1 – 1 = 0, with nor borrow

Example:

```
   111    ←— borrow
 110011   ←— minuend
-  10110  ←— subtrahend
 -------
 011101   ←— Difference
```

4.2.3 Binary Multiplication

The same rules applied to the binary multiplication are the same as those applied for decimal multiplication. For example, two binary numbers ‘x’ and ‘y’ are to be multiplied using partial products process. In the partial product process, each digit of ‘x’ is multiplied with all the digits of ‘y’ and for each digit of ‘x’, the product will

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be written in a new line, shifted leftward. The sum of all lines gives the final result of the multiplication of two binary numbers. The sum of all lines gives the final result of the multiplication of two binary numbers [8].

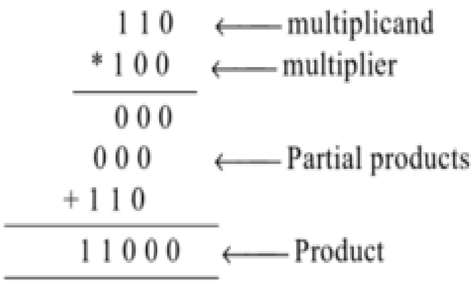
- Rules of binary multiplication

  0 * 0 = 0

  0 * 1 = 0

  1 * 0 = 0

  1 * 1 = 1, with no carry and borrow bit



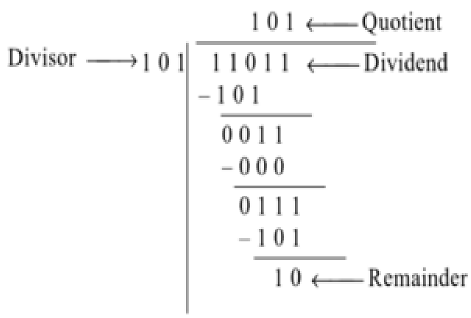
4.2.4 Binary Division

In the binary number system, the fourth arithmetic operation is binary division. This is comprised of other two binary arithmetic operations, multiplication and subtraction.

- Rules of binary division

Rules for division of binary numbers are the same as those applied for the division of decimal numbers.

Example:



V. NEURAL NETWORK FOR ARITHMETIC OPERATIONS

Although the mathematics involved with neural networking is not a trivial matter, a user can rather easily gain at least an operational understanding of their structure and function [10]. The neural network for the arithmetic operations (addition, subtraction, multiplication and division) is depicted below. Neural network discover mathematical laws directly. The below figure shows how a mathematical law or relation can be mapped into a network, in which the activation functions of hidden layer represents corresponding mathematical operators and output layer will produce the corresponding results of the inputs [12].

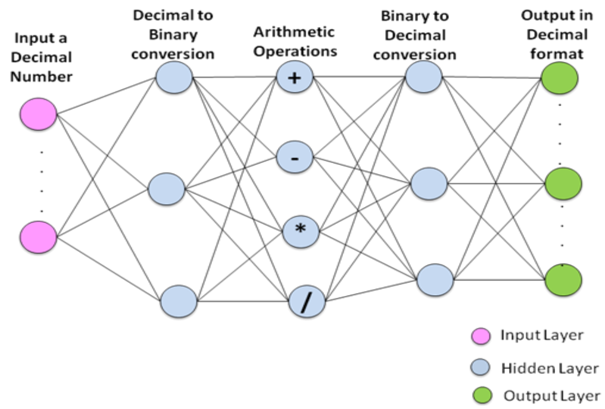


Figure. 6 Neural network for arithmetic operations

This network tries to explain, how it is possible to make arithmetic operation as big as we want. The main thing here is, the network is working on binary numbers. So, when programming the input was given in the form decimal and the conversion of binary equivalent of the input was done by the hidden layer and when network produces a binary number, again it will converted into decimal number as output for user convenience [13].

5.1 Algorithm

The algorithm for arithmetic operations of two numbers is as follow:

1. Write the two decimal numbers to make Arithmetic Operations such as : Addition, Subtraction , Multiplication and Division.
2. Convert these two decimal numbers into its equivalent binary format.
3. Add, Subtract, Multiply and Divide the two binary formatted numbers and write down the result.
4. Finally convert the result to its corresponding decimal format .

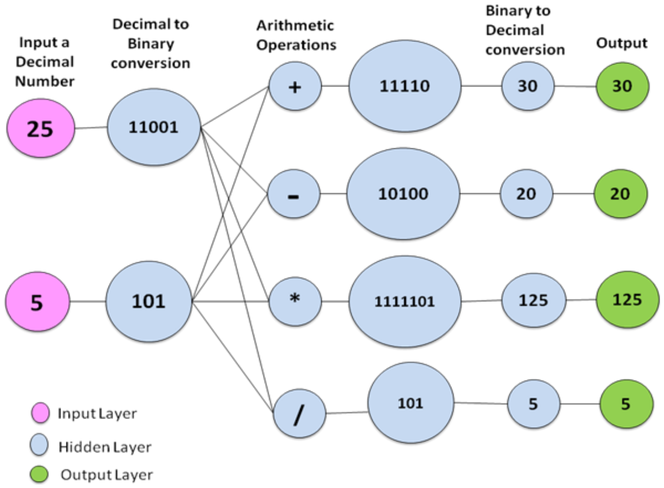


Figure. 7 An example for solved arithmetic operations with neural network

We model the learning process as a feed-forward arithmetical neural network. The inputs to the network are decimal numbers, and the output is also a decimal numbers. From decimal to binary conversion and binary decimal conversion are take place in hidden layers. The network is trained on a sufficient number of examples, which are only a tiny fraction of all possible inputs. After training, given decimal of two unseen numbers, the network generates the outputs. It has therefore learned the concept of numbers without direct supervision and also learned the arithmetic operations [15].

VI. CONCLUSION

In this paper we have shown that the feed-forward neural networks are able to learn certain arithmetic operations. The capacity of neural networks for learning arithmetic operation from decimal to binary conversion and vice versa was examined. We examined end-to-end learning from a neural network perspective as a model for perception and cognition: performing arithmetic operations. The effectiveness of the neural network approach has been tested on the following arithmetic operations.

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