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**Role of Inhibitory Neurons in Information
Decoding in Artificial Neural Networks
with Synaptic Inductive Memory**

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Abstract

In the present work, LTD and LTP were designed by increasing and decreasing the inductance of the inductor based on the input information of the neural network containing EPSP and IPSP neurons with synaptic memory. Compression and interpretation of information, as well as the use of inhibitory neurons to decode information, are among the features of the proposed scheme. Inhibitory cells were used to decode information. In artificial neural networks (ANN), information decoding is done by special algorithms. An ANN with inductor memory not only has the common features of artificial neural networks such as STDP, but is also free from the common disadvantages of these neural networks. With the practical use of IPSP neurons in ANN, the speed of information transmission, interpretation, and processing is significantly improved. Practical simulation of the activities of a natural neural network, including compression, storage, and decoding of information, in an artificial neural network is the main result of the present design.

Keywords: Artificial Neural Networks, Inhibitory Neurons, Synaptic Induction Memory

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1-Introduction

Artificial neural networks (ANNs) are capable of simulation of the processing and interpretation of information. The advantages of neural networks include high processing speed, error generalization, flexibility, problem-solving power, learning, etc. Although many of the activities of the neural networks such as the self-consciousness performance or the role of inhibitory neurons in the human brain are still unknown, conducting studies to solve the problems of the ANNs can be an effective step toward the interpretation of the performance of natural neural networks such as the human brain. .

In this regard, the major instances of simulation include the simulation of neuron activities in the neural network such as the LTP and LTD synaptic memory, the EPSP and IPSP excitatory and inhibitory neurons, plasticity property, or on the whole, the STDP. The use of memory storage as a synaptic memory has resulted in significant changes in the structure of neural networks [1]

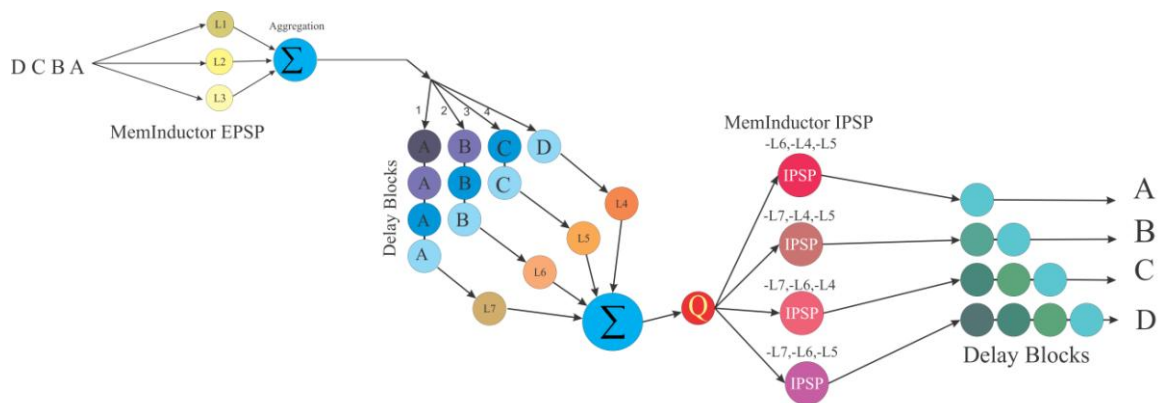
Considering their wide use in different industries [2], ranging from UAVs to medical applications, neural networks have some general and common disadvantages that have influenced the application of neural networks. Some of the major disadvantages of the ANNs include their high complexity, time-consuming learning, etc .

In natural neural networks, each neuron is responsible for a wide range of activities [3]. However, in ANNs, neurons act more specifically. The compression and decoding of information in a natural neural network lead to the increased speed of information interpretation and inhibitory neurons play a fundamental role in decoding the information .[4]

ANN with inductor memory is a research design concerning the non-exclusiveness of the neuron activities and the role of inhibitory neurons in information decoding, which consequently increases the speed, reduces construction costs, and eliminates the need for learning through common methods in the ANNs.

2-Block diagram

Neurons with different weights receive the information and then different interpretations of the information are aggregated. Using the time delay, the received information is compressed in a spike waveform in a time unit. The same waveform is decoded by the inhibitory neurons. Also, by using the delay blocks, the information is sorted in the time unit based on the initial order. The possibility of decoding will be investigated in the following sections (Fig.2-1).



Compression , Interpretation , And transmission of analog data

Figure-2.1: The information is compressed in a waveform after being aggregated and aligned, and then the inhibitory neurons decode the information from a waveform by applying a negative potential difference (voltage).

3-Inductors with memory

In a DC current, the inductor resists the spike instantaneous current and prevents the passage of the spike current. However, if the inductor's inductance is reduced through the inductor's core, then a considerable amount of the spike current will pass through the inductor. On this basis, in the inductor with memory, the input analog information will reduce the inductor's inductance variable and, consequently, result in a time delay in the spike current and encoding of the information in the network (Fig.3-1).

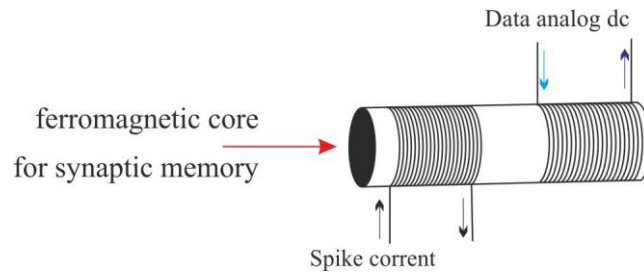


Figure-3.1: The input analog information has DC current and causes an increase and reduction in the inductor's inductance through the core and, consequently, results in a time delay in the output spike current. The inductor's core is made of ferromagnetic material that, only by the repetition of an activator (exciter), obtains magnetic properties, causes weight, and eventually results in the creation of the LTP and LTD synaptic memory.

The inductor opposes the current variations in the circuit. If the inductance of the primary coil is suitable, the inductor will prevent the passage of the spike current. The varying DC current will pass through the second coil. Selecting the appropriate secondary coil will result in an appropriate magnetic field in the primary coil, leading to the reduced inductance of the primary coil, and, as a result, the spike current will pass through the primary coil with a specific time delay.

Therefore, the inductor current of the input information in the inductor's core results in reduced inductance in the primary coil.

Creating a time delay in the spike current is indeed an increase in the intensity of the spike current so that due to the creation of the time delay, the spike voltage is reduced as well (Fig.3-2).

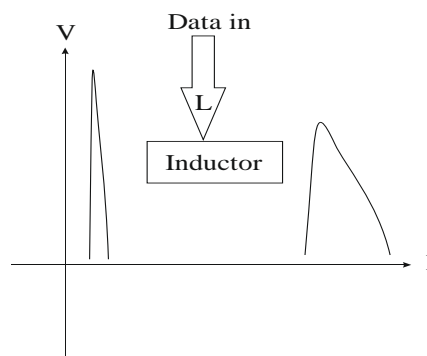


Figure-3.2: When the inductor's inductance is reduced, the spike current passes through the inductor, and also as a result of the reduction of the inductance based on the information, a time delay occurs in the spike current.

Each inductor in the neural network has an excitation threshold, which is dependent on the inductance of the primary coil and lets the spike current pass through it as a result of the voltage and current variations of the input information in the secondary coil within a certain range of voltage and current. To cover the details of each part of the information of different inductors with different inductances, the primary coil receives the information in the neural network in parallel form and as a result of the aggregation of the outputs of these inductors, details of the information are aggregated in a spike peak. The number of the input spikes of the inductor is determined by an electronic circuit based on the current intensity of the information induced to the inductor's core and, consequently, based on the input information, the spike is produced. Figure (3.2) illustrates the simple scheme of the spike production based on the sound intensity and spike encoding based on the sound features in the circuit's output graph.

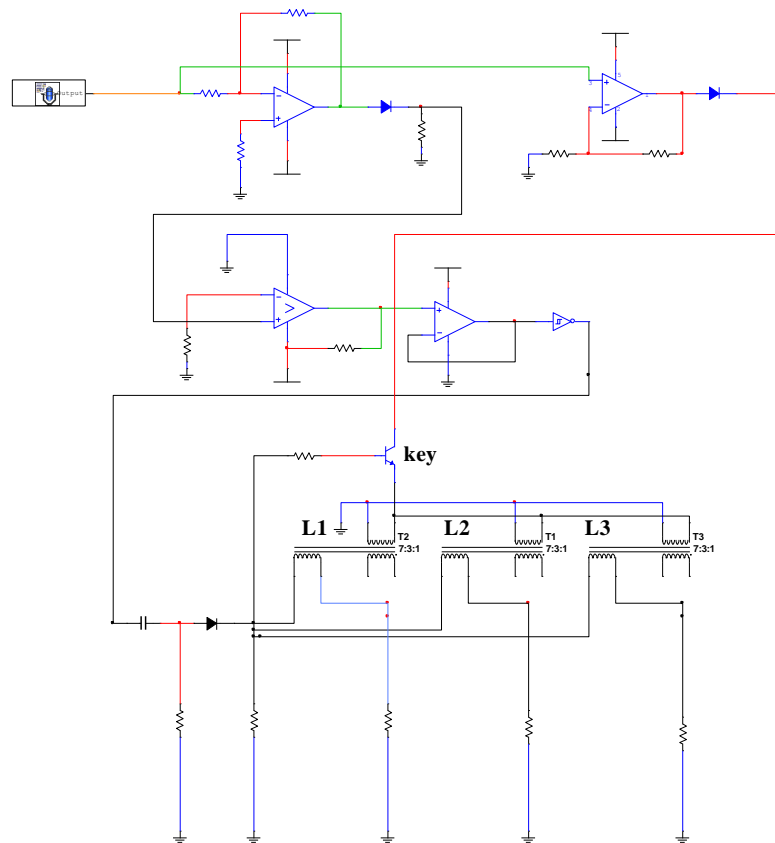


Figure-3.2: The half-cycle of the sound waves is applied to the inductor's core as a DC current by the transistor key. At the same time, a square pulse is generated from the sound waves' peak, which is then converted to the spike current by an integrator.

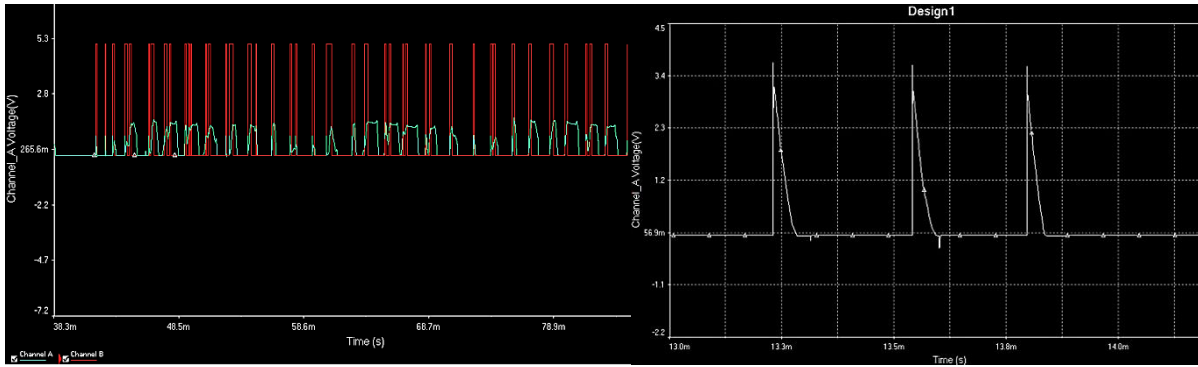


Figure-3.3: The sound features are encoded as spike current.

The inductors can be designed in such a way to be impermeable against the spike current and only exit the inductor only by reducing the inductance of the spike current.

In the EPSP inductors, the core current is opposite to the inductance and reduces it. However, in the IPSP inductors, by increasing the inductance, the entry of each spike to the inductor results in a potential difference, leading to a negative voltage in the circuit (Fig.3-4).

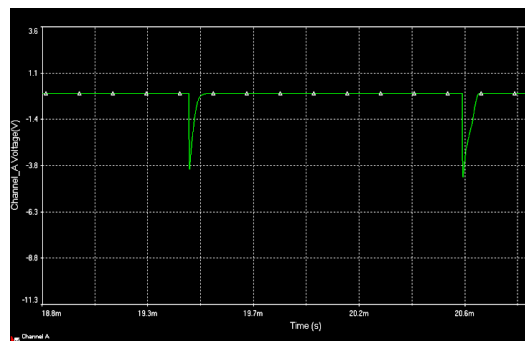


Figure-3.4: In the inhibitory inductors, the direction of spike current is opposite to the direction of the current in the excitatory inductors and, as a result, the produced wavelets of the spike have a negative voltage.

4-Aggregation

A set of inductors with memory collect different interpretations of the information. By aggregating these interpretations, there will be only one spike waveform for each information unit (Fig.4-1) (Fig.4-2)

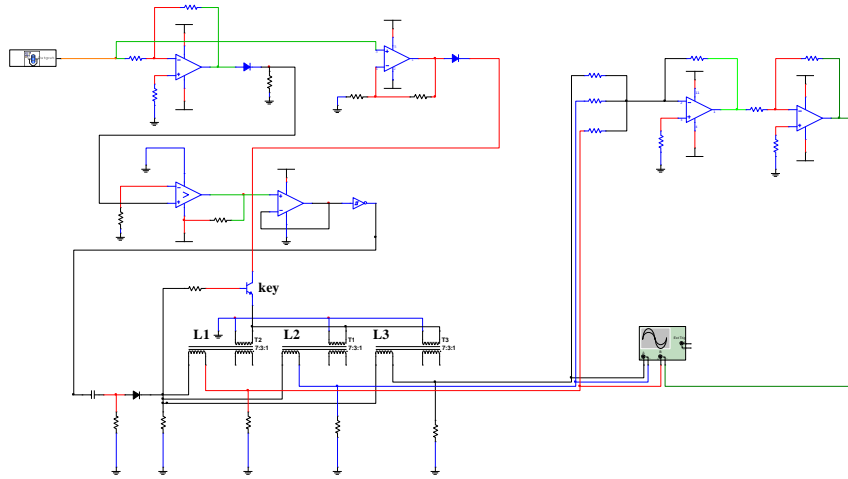


Figure-4.1: The inductors' outputs with different weights are aggregated by OPAMP. This circuit has been used for audio aggregation.

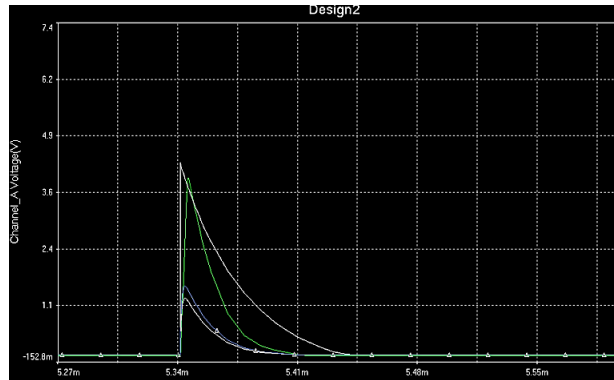


Figure-4.2: The green graph is the result of the aggregation of the other three graphs so that there is only one waveform for each information unit.

5-Compression

By using an analog demultiplexer, multiple waveforms of the spike current, which are flowing linearly and consecutively in the circuit, are compressed by the delay blocks in a spike waveform and then encoded by inductors with constant frequency (Fig.5-1)

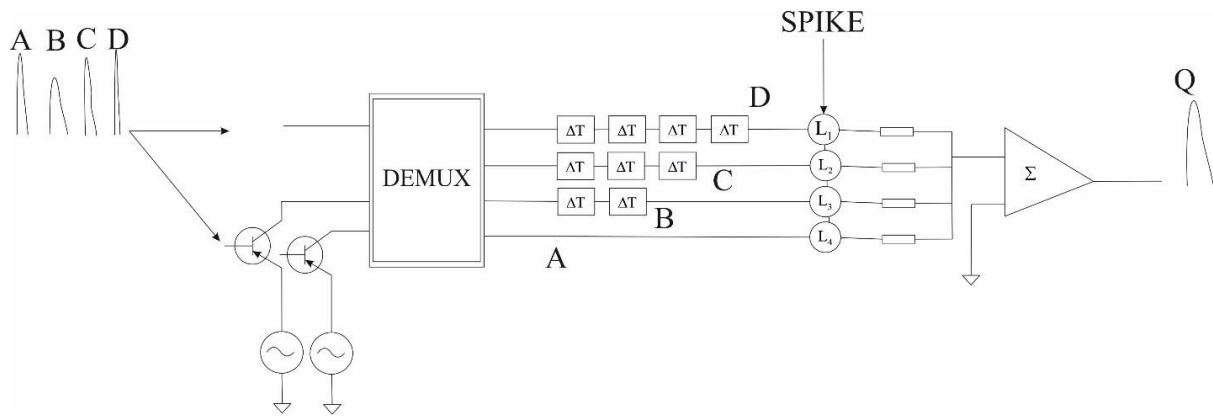


Figure-5.1: The analog demultiplexer gives the spike current wavelets to the delay blocks based on the number of the spike current waveforms. Then, each block aggregates all wavelets simultaneously in such a way that there is only one spike peak from the dataset. The constant-frequency inductors encode the information in such a way that it can be decoded.

In order for fast transmission and storage of information, compression is the most appropriate method in the ANNs. Nonetheless, information decoding is yet more important, which is dependent on the inductors shown in Figure (5-1).

6-Memory

The LTP synaptic memory is created based on the repetition of an activator (exciter) by creating magnetic property in the inductors' core. Due to the presence of instantaneous spike current as well as the constant changes in the inductor's inductance made by the input information, it is impossible in normal conditions to create a permanent magnetic field in the inductor's core because the rectified monopoles in small zone inside the ferromagnetic core are constantly changing due to the changes in the intensity and direction of the magnetic fields. Thus, permanent magnetic property in the inductor's core is created only when an exciter is repeated several times, as a result of which the inductor's inductance remains constant, and thus the core can maintain its magnetic property .

With the creation of permanent magnetic property in the inductor's core, the inductance and resistance of the inductor in the network change, and the network's reaction to the exciters changes based on the received information .

On this basis, the ANN produced by this type of inductor has the neuroplasticity property.

The long-term memory of the network consists of the rings of inductors so that with the rotation of the spike current in these rings, the information is stored in them (Fig.6-1).

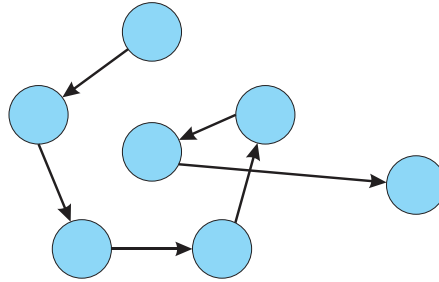


Figure-6.1: The information is stored for a long term in cycles of neurons by creating the LTP and LTD synaptic memories.

The information is electronically aggregated and compressed and, at the same time, structurally classified by very different neurons. For example, the information related to volume, color, size, etc. is received by the sensory section, and then separately compressed and, finally, stored in the memory.

When new information is received from the sensory section, it is sent to the memory before being stored. Then, if the compressed information is at the same level as the memory-specific neuron's excitation threshold, the entire storage process is stopped and the memory is re-read. Of course, another short-term memory stores the information for a certain period in order to create the information reaction (Fig.6-2).

During the process of memory re-reading, different pieces of information are decoded and, accordingly, different commands are issued.

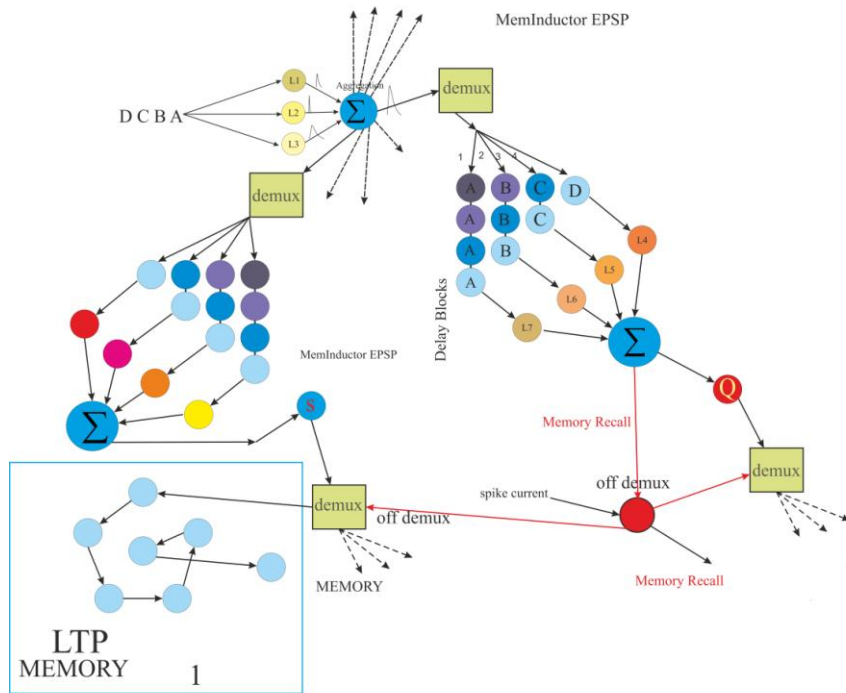


Figure-6.2: Different features of each information unit are compressed separately and then stored in separate memories. Each unit of the input information, before entering the memory, is compared with the previously stored information and in the case of similarity, the storage process is stopped and the memory is re-read.

7-Decoding

The information can be decoded only by the IPSP inhibitory cells in the circuit so that they reduce a certain amount of the maximum current from the current and then obtains the intended current from a compressed peak (Fig.7-1)

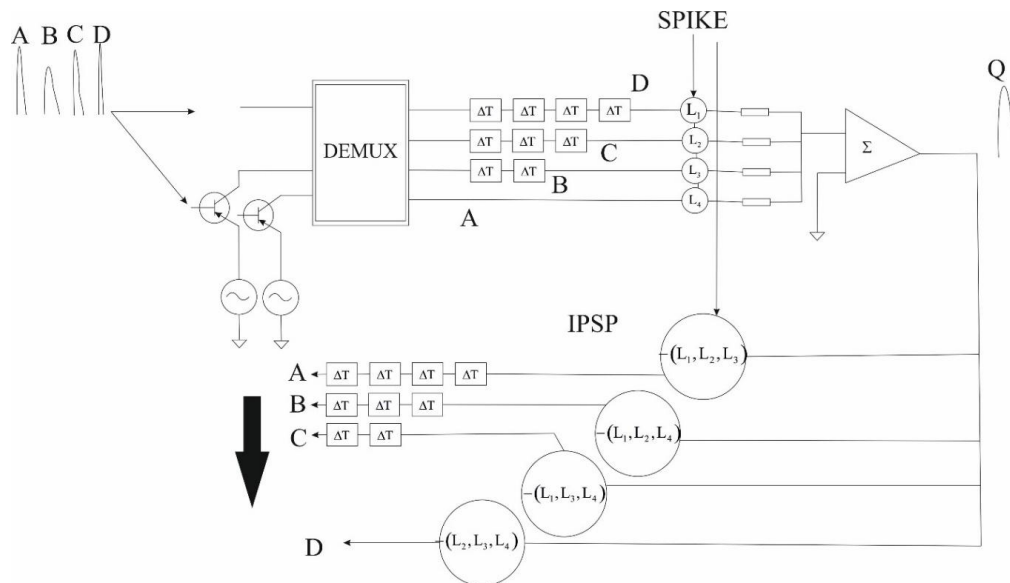


Figure-7.1: One of the major properties of information decoding by inhibitory neurons is that the decoding process is performed in a very short time and only the time-quantitative conversion of the information is a bit time-consuming.

The neurons, which affect each separate input peak before compressing the information, are each an operator and co-phase the information units in time. As a result of this instantaneous interaction of the information in multiple parallel decoding inductors, the information is reproduced and retrieved by reducing the augmented current to the input current.

8-Results

The non-exclusivity of neurons' activities in ANN leads to the property of neural flexibility in ANN, which reduces the complexity of the network. One of the most important features of any neural network is the speed of compression, transmission, and decoding of information, which leads to a higher speed of classification and interpretation of information, as well as a faster response to a stimulus (activator). As a result of processing compressed information By the artificial neural network, it creates integrity in the network. The classification and comparison of related information based on the intensity of the pulse is the achievement of this project.

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