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A Survey on Pattern Recognition Using Spiking Neural Networks with Temporal Encoding and Learning

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Abstract – This paper, recognize of the patterns using spiking neural networks with temporal encoding and learning. Neural networks place the important role in cognitive and decision making process. Processing the different type of inputs lead to find the discriminate the pattern. Leaky Integrate Fire Neurons are used to recognize the patterns. During the recognition supervised learning method is used to make the decision. Temporal encoding and learning of spiking neural network is used to classify effectively. Different spiking neural networks learning algorithm are used to recognize the patterns and also analyze the performance of the particular algorithm which was used in the pattern recognition.

Keywords- Pattern recognition; Spiking Neural Networks; Cognitive and decision Making; Temporal Encoding; Supervised Learning.

1. INTRODUCTION

Pattern recognition is the process of classifying the particular data which was based on the prior knowledge or statistical information extracted from the pattern. Usually the pattern has to be classified using the collection of data. Several methods are used to implement the pattern recognition such as maximum entropy classifier, Naïve Bayes classifier, decision trees, support vector machine and perceptrons. These methods are less biological inspired so that Spiking Neural Network is used to recognize the pattern because it's having well biological evidence. Biologically inspired models provide the better computational power during the pattern recognition. Pattern recognition follows some steps to identify the particular pattern. Before processing the pattern, first identify how the information's are stored in the pattern. Two basic schemes are used to process the pattern; there is rate coding and temporal coding. Rate coding model is the rate of firing communication state that intensity of stimuli increase the rate of actions. In rate coding each and every neurons have to be fired, but it has to be choosen based on the probability. It may be character by using the firing neurons rather than the spiking neurons. Learning process of rate coding is the adaptive weight modification. And the other method is temporal encoding. Temporal pattern in train spike carry the information fast rather than the rate coding. Example of temporal coding is the latency coding which is ability of caring information within the spiking time. There are number of methods to classify the particular pattern but they are less performance, but spiking neural network having the best spiking time which is having high performance and accuracy for classifying the patterns. There are several spiking models such as, integrate-and-fire (IF) model, the Hodgkin-Huxley-type model and the Izhikevich model. IF model has the higher performance and simple when compare with another model. There are several algorithms are used to process the patterns like, Back propagation, bio spike timing dependent plasticity (STDP), spatiotemporal learning rule. In this paper patterns are identify using spiking neural networks and also analyze the performance and accuracy of the particular algorithm. Section 2 describes the Related work which is based on the pattern recognition , Section 3 deals with what are the steps are used to recognize the patterns Section 4 deals with the performance of pattern recognition algorithm and final section 5 describes the result and conclusion of this paper.

2. RELATED WORKS

There are several work exists for pattern recognition. In [1] recognize the patterns using bio inspired spiking neural network has been used. Iris related data sets are used to process the particular pattern. Leaky integrate fire neurons models are used to analyze the pattern which is based on the supervised learning mechanism. The whole system contains the encoding, learning process and readout. Temporal encoding and learning process is used in the spiking neural network which is used to recognize the patterns effective and efficient. Network training is used to increase the fast neural information processing. [2] This paper tells that how the multiple view of information are processing using the spiking neural network. The visual patterns are recognized using

integrate fire neurons. Each neurons are arranged in the hierarchical manner and information are processed each layer which are arranged in frame by frame. Each frame has to be changed its structure by using Hebbian-based training. The patterns are analyzed using Vidtimt data set and recognize the facial information. [3] In this paper spatiotemporal learning rule is used to analyze the particular information process by using Spiking neural network. During the training process neurons have to fired and learn by using the Hebbian-based training rule. This method applied to several inputs and analyzes the performance of the information in the memory system. [4] Paper deals that, classify the patterns using the spiking neural networks. The network has to fired using the integrate fire neurons and the neurons are classify using the supervised learning process. The system has to be processed by using following steps, encoding, learning and readout. This process has to be applied digital images like MINST and alphabetical letters and analyze the performance of the pattern recognition. It also apply the long term modification like spike time dependent plasticity. [5] This paper deals with that, analyze the spatial related data has to be processed using spiking neural networks different encoding and learning process are used to analyze the performance and accuracy of the classification. [6] This paper deals that encoding the data and process those data's using the back propagation algorithm, the temporal coding is used to process fast information as well same as the rate coding method. XOR problem related data's are processed using the spiking networks with back propagation algorithm and analyze the performance using bench mark of data.

OVERALL STRUCTURE

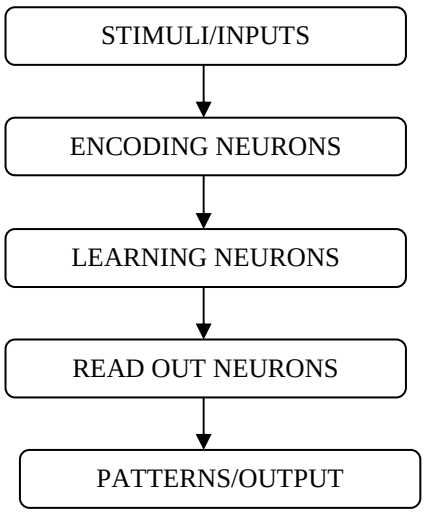

Fig 1: Over all structure of the pattern recognition

3. SPIKING NEURAL NETWORKS

Spiking neural networks (SNN) used to analyze the patterns, the basic SNN architecture is explain following structure.

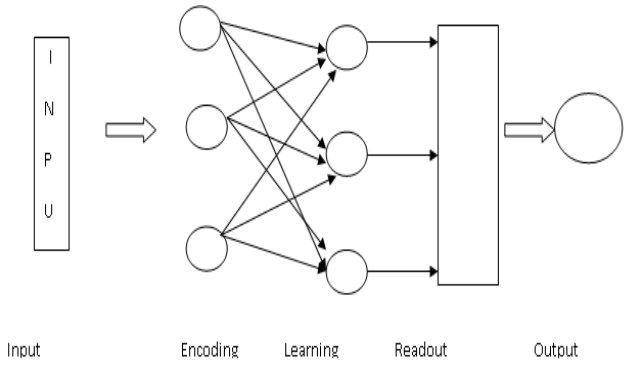

Fig 2: Architecture of Spiking Neural Networks

3.1 PATTERN RECOGNITION STEPS IN SPIKING NEURAL NETWORKS

SNN is used to recognize the memory which has several parts, Encoding part, learning part and Readout part. Each stimuli (input) has several component, those components are connect to the encoding part and the spiking information has to be trained using the learning process. During the learning the weight has to be updated and read out process has been used to extract the particular patterns.

3.1.1 ENCODING PART

Encoding is the process of generating the spiking patterns from the input stimuli. Temporal encoding is used to generate the spiking patterns rather than rate code. Latency code is example for the temporal coding which is encoding the information in the time responsive of encoded window. When encoding the information each neuron has to be fired. Encoding process each component has to be selected and convert the input points into the latency information. The binary information has to be converting into the temporal pattern of discrete spiking patterns.

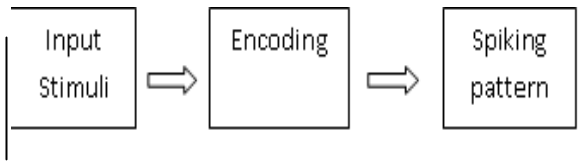

Fig 3: Input Encoding for pattern recognition

3.1.2 LEARNING PART

Learning neurons place the important role for classifies the particular patterns. Learning network consists layer of tempotrons. Each encoding neurons are connected to the learning neurons. The structures

of learning neurons are equal to the number of encoding neurons. The tempotrons has to be classified the task which load has to be less than the critical value. The neurons generate the action spikes when the internal neurons cross the firing threshold values.

3.1.3 READOUT PART

The main goal of the readout process is to extract the particular pattern from the input stimuli of the learning neurons. In this the patterns are represented using the binary values because the classification of patterns only the 1 or 0 which means, it either classify using fired neurons (1) or un fired neurons (0). The total N learning neurons of the output can be representing a maximum number of 2^N classes of patterns

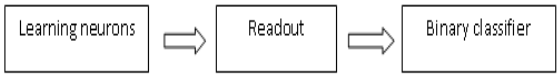

Fig 4: Readout process for pattern recognition

3.2 TEMPORAL LEARNING RULES

Temporal learning rule goal is deal encoded information with spiking time. The spiking time is based on the Spiking time dependent plasticity (STDP). STDP plasticity depends on intervals between pre and post synaptic spikes. The basic mechanism of the STDP is Long term Potential and Long term Depression. The neuron model used here is Leaky integrate model neuron which was driven by synaptic current generation. The potential of the neurons of the synaptic is weight sum of the post synaptic, which was defined by [1]

$$V(t)=\sum_i Wi \sum_{ti} K(t-ti)+V_{res} \quad (1)$$

Here Wi and ti represents the synaptic efficiency and fire time of ith afferent. V_{res} represent the rest potential where k represents the normalized PSP kernel. A neuron is fired when V (t) crossing the input threshold value, after the potentially smoothly decrease to the V_{res}. In the classification process each neurons has to be classifies either fired or not fired (P^+ or P^-). The fail of tempotron update process in each neuron, which is the same instructor time (T). From learning process it has the supervised learning method and the learning process has to be gained by the neural activities.

3.2.1 LEARNING FROM THE NEURAL ACTIVITES

Several activities has to be increased the memory pattern, the synaptic weight has to be taken each and every binary values or from the continues distribution. In Hopfield neurons the memory patterns are expressed by the activities of neurons which may be active (1) or inactive neurons (2). The temporal has to separate from the spatiotemporal pattern due to the learning rules. The pattern has to be classified by using binary and ternary patterns. This is shown in following fig 5 and 6.

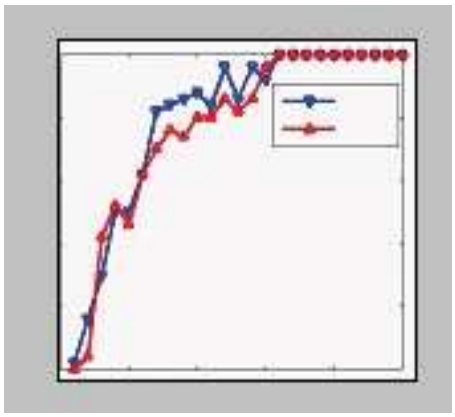

Fig 5 : Binay pattern classification

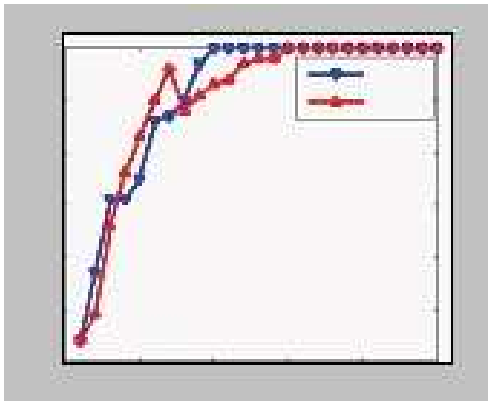

Fig 6 : Ternary pattern classification

4. PERFORMANCE ANALYSIS

Spiking Neural Network is used to classify the particular pattern for different kind of inputs like iris data, digital images, alphabetical letters and other data's. SNN has three different types of steps encoding the input data, learning the neurons, readout process. During the encoding process the input data has to be converting to the spiking information. And those spiking data has to be trained and readout that information is to extract the particular patterns from the input data. Table 1 shown the performance details of the pattern recognition.

NO	PAPER	INPUT	METHOD	ACCURACY	REF
1	Brain Inspired Spiking Neural Network With Temporal Encoding And Learning	Iris Data	STDP	99.63%	[1]
2	Pattern Recognition In Spiking Neural Network With Temporal Encoding And Learning	MINST images and digital images	STDP	99.1%	[2]
3	The Spatio temporal Learning Rule And Its Efficiency In Separating Spatiotemporal Patterns	Spatio temporal Data	Hebbian Rule for learning	85%	[3]
4	Fast And Adaptive Network Of Neurons In Multi View Visual Pattern Recognition	Vidtimt Data	Structural Adaption and Frame by frame operation	95.7%	[4]
5	Error Back Propagation Temporally Encoded Neurons Of Spiking Neural Network	XOR problem and Benchmark Data's	Spike prop and Error propagation	97.1%	[5]

6. RESULT AND CONCLUSION

From the above analyze Spiking Neural Network has to be identify the patterns from different type of inputs like iris data, cancer data, digital images, and alphabetic letters. For processing those data's each and every input has to be encoded and trained using different training rules and recognize the patterns. Spiking Neural Network is based on firing the neurons. So that the Spiking networks will provide the best result for recognize the patterns.

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