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Igor Kiulian

DYNAMIC IMAGE RECOGNITION USING SPIKKING NEURAL NETWORKS

Vinnytsa National Technical University

Abstract

The article considers the peculiarities of the use of spiking neural networks to recognize dynamic images, considered models of spiking neurons, and methods of modelling, their features.

Keywords: Spinking neural networks, spiking neuron, recognizing, forecasting.

Today image recognition of different nature (visual images - images, sound images - languages) is very urgent task. However, it is not always possible to successfully perform pattern recognition using computational tools based on the functioning of the algorithm. Here neural network methods and tools come to the aid of traditional methods and means, the main difference of such approach lies in the fact that it is possible to solve unformalized tasks for which there are no deterministic solution algorithms for some reasons [1].

An artificial neural network (ANN) is a mathematical model and its software and hardware implementation, built on the principle of functioning of biological neural networks - networks of nerve cells of a living organism. Biological neural network consists of a group or several groups of chemically or functionally related neurons. One neuron may be associated with many other neurons, and the total number of neurons and bonds between them can be very large. Connections, called synapses, are usually formed from axons to dendrites, although dendro-dendritic chips and other bonds are possible. In addition to electrical signal messaging, there are other forms of transmission that arise from neurotransmitter diffusion and have an effect on the electrical transmission of signals. Thus, biological neural networks are extremely complex [2].

Artificial intelligence and cognitive modeling try to simulate some properties of biological neural networks. Although they are similar in their methods, the first aims at solving specific problems, while the second is aimed at creating mathematical models of biological neural systems.

Over the last 10 years, artificial neural networks have been successfully applied to speech recognition, image analysis and adaptive control for building so-called software agents (in computer and video games) or stand-alone robots. Currently, most developed artificial neural networks for artificial intelligence are based on statistical estimates, classification, optimization and management theory.

Spiking neural network is the third generation of ANNs, which differs from the binary (first generation) and frequency / high-speed (second generation) ANNs by the fact that neurons exchanges short (in the biological neurons - about 1-2 ms) pulses of the same amplitude (in biological neurons - about 100 mV). It is the most realistic model of the ANN, from the physiological point of view [3].

Spike neural networks are best suited for solving the problem of recognizing dynamic images and have a number of important advantages over neural networks of the past generation:

- are dynamic, and therefore perfectly suited for working with dynamic processes (speech recognition and dynamic imaging);
- support multitasking, since the input data is processed in the neural network with feedback, and different groups read the neurons can be trained to solve various problems;
- capable of recognizing with prediction (that is, it is not necessary to have complete information about the object or know the result of the process);
- easy to train, as it is enough to train only the synapses of the output neurons;
- have increased performance of information processing and resistance to interference, since they use temporary provision of information;
- requires a smaller number of neurons, since each neuron of the spiking neural network replaces two neurons (excitatory and inhibitory) of the classical artificial neural network;

- have high speed and great parallelism potential, since for transfer pulse it is necessary to send only 1 bit;
- can train on evaluate stage.

The most expedient applications of spiking neural networks are recognition of images, sounds in the field of prosthetics, robotics and telecommunications, as well as forecasting.

The principle of work is shown in Figure 1. The network receives a series of impulses (spikes) at the inputs and outputs impulses at the output. Each moment, each neuron has some value (analogue of the electrical potential in biological neurons), and if this value exceeds the threshold, the neuron sends a single impulse, after which its own value falls to a level below the average value (analogue of the rehabilitation process in the biological neurons, so called refractory period) at 2-30 ms. After eliminating from equilibrium the potential of the neuron begins to smoothly strive to an average value.

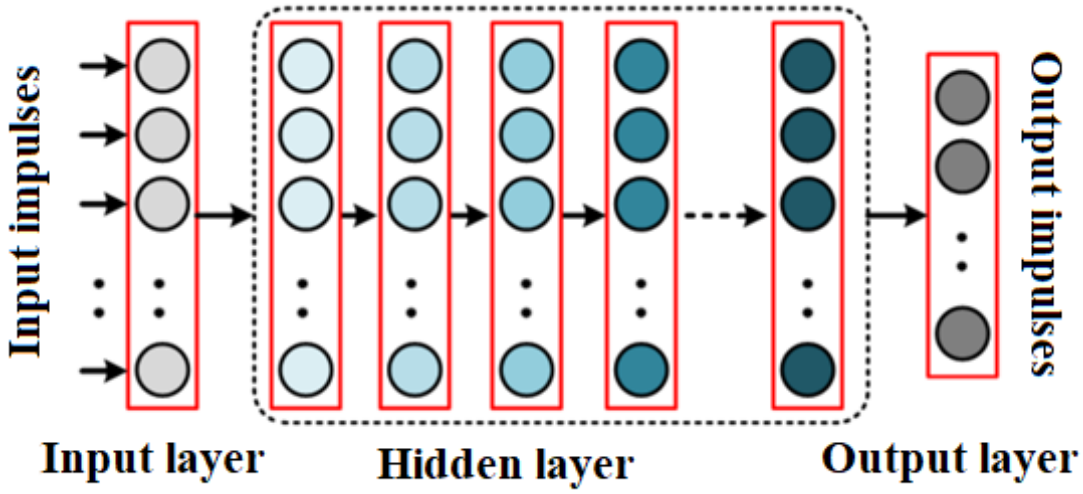

Figure 1 – Spiking neural network

Mathematical model

Existing models of spiking neurons can be divided into two groups [4, 5].

1. Models of conductivity - similar process of work of ion channels:
   - Hodgkin–Huxley model;
   - Izzhikevich model;
   - FitzGuy – Nagumo model;
   - Hindmarsh – Rose model ;
   - Morris – Lekar model;
   - Wilson – Kovan model;
   - Galves – Loherbach model;
   - Multi-chamber model;
   - Cable theory of dendrites.
2. Porous value models - generate a pulse at a certain voltage level:
   - "Integrate-and-fire" model;
   - "Leaking-integrate-and-fire " model.

Architecture

There are several main types of training methods for spiking neural networks:

1. STDP method (modified Hebb's rule);
2. Backpropagation training;
3. supervised Hebbian learning;
4. ReSuMe method;
5. deep learning.

The architecture of spiking neural networks can be divided into the following groups:

1. Feedforward neural network (FNN) – the data are transmitted strictly in one direction: from inputs to outputs, feedback is absent, and processing can take place in many layers;
2. recurrent neural network (RNN) – individual neurons / neuronal populations interact with each other, it means that there is an inverse relationship. Such machines of this kind have their own dynamics and high computational ability;
3. Mixed neural network – inside neural network some populations of neurons belong to the type of FPP, and some to the RNN. Interaction between populations can be both unidirectional and combined.
    a) Synchronous chain violation - is a multilayer circuit in which impulse activity can be extended in the form of a synchronous wave of transfer of packets of impulses from one population to the next;
    b) Reservoir calculations - the reservoir ANN consists of a reservoir made according to recurrent rule, and output neurons.

REFERENCES

1. Колесницький О.К. Моделювання імпульсної нейронної мережі у задачі розпізнавання багатовимірних імпульсних послідовностей / О.К. Колесницький, С.М. Богатчук, М.В.Крещенецька, С.С.Яремчук // Вісник Вінницького політехнічного інституту. — Вінниця: УНІВЕРСУМ-Вінниця, 2008. — №5, С.62-66.
2. Штучна нейронна мережа — [Електронний ресурс]. — Режим доступу: https://uk.wikipedia.org/wiki/Штучна_нейронна_мережа
3. Импульсная нейронная сеть — [Електронний ресурс]. — Режим доступу: https://ru.wikipedia.org/wiki/Импульсная_нейронная_сеть
4. A new biologically plausible supervised learning method for spiking neurons / A. Taherkhani, A. Belatreche, Y. Li, L. Maguire — Bruges: ESANN; D-Facto, 2014. — 16 p.
5. Networks of spiking neurons: the third generation of neural network models. Neural Networks / W. Maass. — Amsterdam: ELSEVIER, 1997 — 27 p.

Igor Kiulian — student, group 1CS-18m, Faculty of information technology and computer engineering, Vinnytsa National Technical University, Vinnytsia.

Науковий керівник:
Присяжна Олеся Дмитрівна *кандидат філологічних наук, старший викладач кафедри іноземних мов Вінницького національного технічного університету prysyazhnalesya@gmail.com*

Prysyazhna Olesya Dmitrievna *Candidate of Philology Sciences, Senior Lecturer of English, the Foreign Languages Department, Vinnytsia National Technical University, Vinnytsia prysyazhnalesya@gmail.com*