Training a Network of Spiking Perceptrons for use in Robot Arm Control

Phill Rowcliffe
Department of Informatics
University of Sussex
Falmer, Brighton
UK
phillipr@sussex.ac.uk

Jianfeng Feng
Centre for Scientific Computing
University of Warwick
Coventry
UK
Jianfeng.Feng@warwick.ac.uk

Abstract

A more plausible biological version of the traditional perceptron is presented here based on the Integrate-and-fire (IF) model. This model encodes biological behaviour such as the mean interspike interval, refractory period, voltage threshold and has synaptic input current of the form:

$$\bar{i}_{syn}(t) = \sum_{j=1}^{n} w_{ij}^{E} E_j(t) - \sum_{j=1}^{m} w_{ij}^{I} I_j(t) \tag{1}$$

where $E_j(t)$ and $I_j(t)$ are the renewal processes (Poisson process being a special case), for $t \geq 0$, and $w_{ij}^E > 0$, $w_{ij}^I > 0$ the magnitudes of the EPSP and IPSP. The total current input into the neuron is summed over all excitatory and inhibitory synapses: n and m respectively.

These neurons exhibit non-linear properties and we will show that these biological models have more in common with Radial Basis Function (RBF) mathematical models than classical perceptrons. We will also show that it is possible to train such a biologically inspired neuron model by seeking to minimise the output error. We will derive a learning rule from the mean interspike interval of the neuron's output:

$$< T_i(r) >= \frac{2}{L} \int_{\frac{V_{rest}L-\mu_i}{\sigma_i}}^{\frac{V_{thre}L-\mu_i}{\sigma_i}} g(x)\, dx \tag{2}$$

where L is the decay rate of the IF model, V_{thre} is the voltage threshold, V_{rest} is the membrane resting period and $g(x)$ is *Dawson's Integral* as defined in [1].

We will present results showing how this learning algorithm can successfully train a single neuron to solve the XOR problem, see Figure 1.

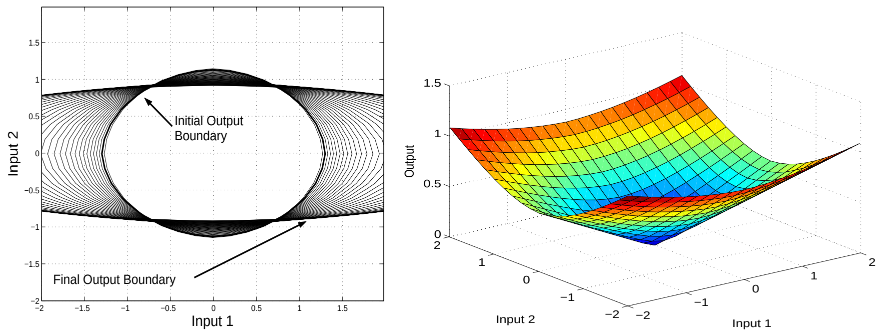

Figure 1: The figures show how the output decision boundary of a *spiking* perceptron changed during the iterative training cycle. The left figure shows how the decision boundary changes during training on the *XOR* problem. The right plot shows the final output decision plane of the trained spiking perceptron.

We will further show how a network of such neurons, with the appropriate learning rule, can be used to solve more complex curve fitting tasks.

Finally we will present the approach we have taken in adapting a network of spiking neurons for the control of a robot arm, specifically for use in goal-detection. We have adapted a version of the learning algorithm for use in backpropagation through time. In a simulated robot arm environment we have trained the network on a series of trajectories and tested the network to locate specific targets within its environment.

References

[1] J. Feng, "Is the integrate-and-fire model good enough? - a review," *Neural Networks,* vol. 14, pp. 955-975, 2002.