Mehmet Yaşar Alıcı - 2016401378

EE550 ARTIFICIAL NEURAL NETWORKS

PROJECT5: CONTINUOUS HOPFIELD MODEL

PROJECT REPORT

Introduction

In this project, the Continuous Hopfied Model which is an extension of the Binary Hopfield Model was implemented and its energy function was analyzed. This model was inspired by biological neurons which have continious I/O characheristics and some processing delays as in a capacitive network. This is to say that an input will lag behind the outputs Vj of other neurons due to the input capacitance "C" of the call membraine, transmembrance resistance "R" and finite impedance "Tij^{-1}" between the output and cell body of cell i.

Analysis

We can use KCL to write the dynamics equations as

$$\mathrm{C_i}\ \frac{\mathrm{u_i}}{\mathrm{dt}} + \frac{u_i}{R}\ = \sum T_{(\mathrm{ij})}\ \mathrm{V_j} + \mathrm{I_j},$$

assuming the cell as a node in an electrical circuit. This system can be written in the state space as

$$\dot{x}\ = CTy(x)\ -\ Gx + CI$$

With this form, $\dot{x}\ =\ 0$ yielded the points where the equilibrium point is achieved. Then, in order to find the convergence properties of the system, we have the energy function,

$$E = -\frac{1}{2}\sum\sum T_{(\mathrm{ij})} v_i v_j\ \ + \sum 1/R_i \int_0^{\mathrm{v_i}} \mathrm{g}^{-1}(\zeta)\mathrm{d}\zeta$$

Where the second part of the RHS is a contribution of the continuous model over the discrete version. This is to say that the model operates within N-dim hypercube and the equilibrium points stays inside the cube. If the lambda increases too much, then the second term becomes negligible and the minimal states are found in the corners of the hypercube.

In this project, the stability of differential equations were studied via the neurodynamic model. A two neuron example was handled and the minimal energy points and energy contour maps are shown. Furthermore, an initial point was shown to converge to the nearest equilibrium point after iterations.

Finally, the effect of lambda was investigated. In the limiting case, when lambda is infinite, it is shown that the maxima and minima of the continuous Hopfield Network become identical to those of the corresponding discrete Hopfield Model.

Conclusion

This project essentially dealt with the dynamics of the Hopfield network. It was very helpful for me to make better sense of the energy function, model dynamics and intelligence behaviour.