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Automatic Neuromorphic Circuit Connection Software

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Introduction

The BioRC group is focusing on recreating the human brain's neural network using electronic circuits. This project will help researchers understand how the brain's large complex neural network works and help designers solve problems associated with large scale neural circuits. Currently, we are attempting to recreate the neural network of the C. Elegans worm which has a very small number of neurons in the hope of proving that we can actually recreate a neural network with circuits.

Problem

The human brain's neural network, or any neural network, is very complex as well as very large which presents many design problems.

- Very large number of components and connections.
- Unknown functionality of some components.
- Time consuming to create, connect, and simulate circuits.

Solutions

The former problems in the designing of these circuits prompted us to come up with software and tools to make the research, design, and simulation of these neural circuits easier for those working on the project. The goals of our project are to:

- Quickly change input parameter weights of circuits.
- Automate circuit connection from predefined connection list.
- Allow for creation of custom circuit connections.
- Create user friendly GUI that can be used by both engineers and non-engineers.

Fig. 1 (below): Example of GUI for Automatic Neuron Connection program.

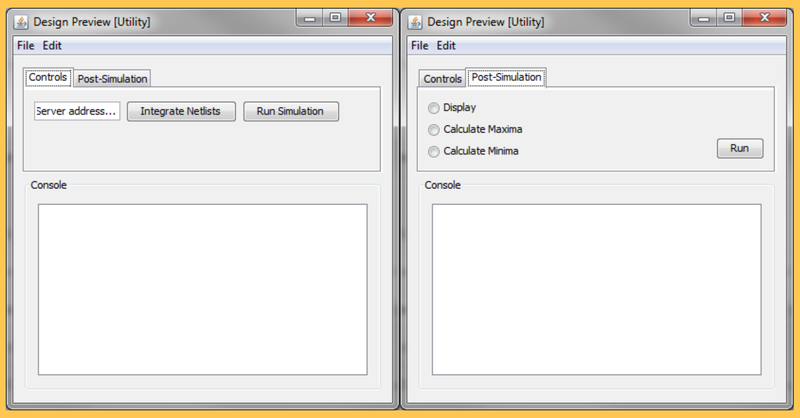


Fig. 2 (below): Program Diagram

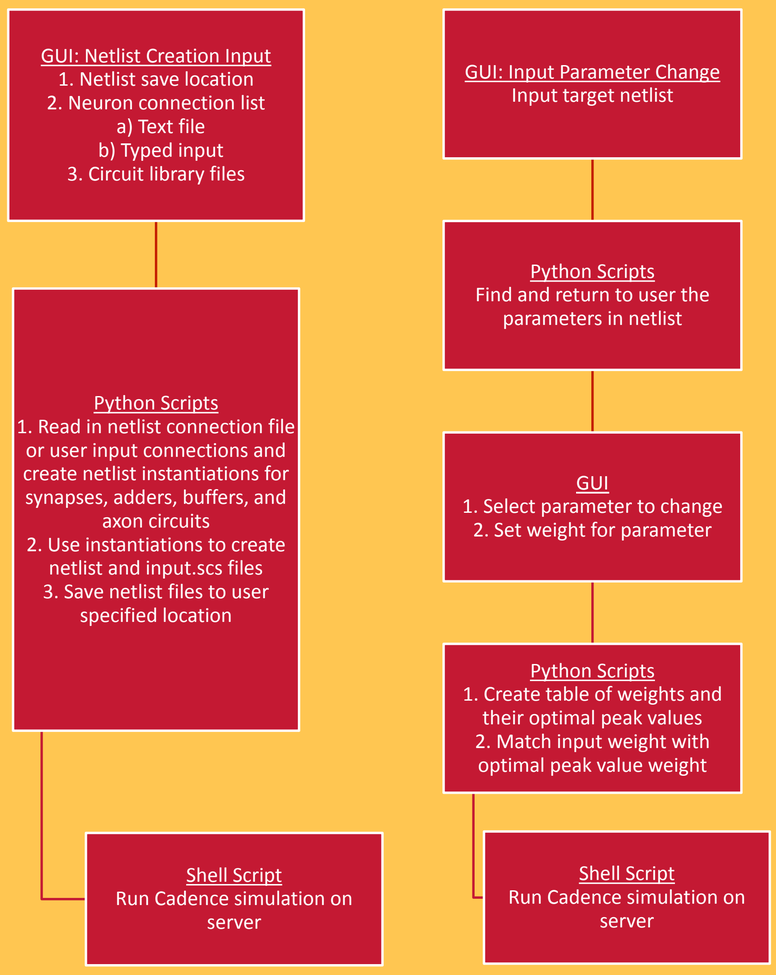
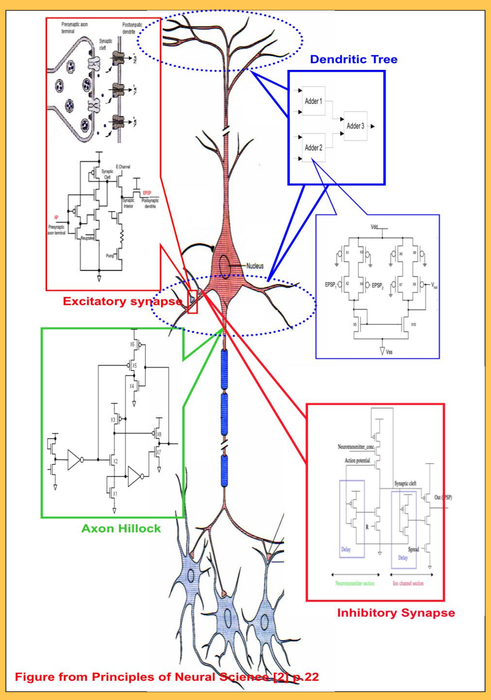


Fig. 3 (bottom): BioRC Group Circuits



At the top, we have fig. 1 which is an example of the GUI. Above is fig. 2, a diagram describing the current operational features of the software with some details about how they are implemented. To the left in fig. 3 are some circuits created by the BioRC group with relation to their biological counterparts.

Features

Adding the ability to easily change input parameter weights was the very first problem we wanted to address. By adding the feature to quickly change them and simulate the circuits in an application outside of the CAD program we could greatly decrease the time it takes to setup circuits for analysis.

Due to the of the vastness of the circuits, we wanted to create a way for the researchers to automatically have their circuits connected. Our software can automatically create a circuit netlist using user input. Doing this allows users to focus on creating the circuits and not connecting them inside of the circuit CAD program

The software also needs to be user friendly in order to accommodate researchers that are not in the same discipline as the electrical engineers who are designing the circuits. We also wanted users to be able to create the netlists and simulate them remotely from their computers using their own software.

Complications

During the creation of this program we encountered several design complications that we have overcome or are currently addressing.

- Adder circuit propagation delays inside neurons which could affect circuit output.
- Load capacitance buildup between different circuits which could affect circuit output.
- Adapting to dynamic circuit redesigns and change in knowledge of neural networks.
- Integrating newer software with onsite servers that utilized outdated software.

Conclusion and Future Work

As it stands now, we have almost completed the main features of the software. Currently, we can build a neural network based off of a predefined connection list or user-input connections. We can also rapidly change input parameter weights within our program for testing. In addition, utilizing shell scripting, we have been able to make our software almost entirely independent from the USC server. This allows us to use any software which we may want while only using the USC server for Cadence simulation. We have also solved the issue with adder circuit delays. Finally we are addressing the load capacitance issue and are in the process of implementing our solution.

In addition to the features we have completed there are many more that we wish to add in the future.

- Machine learning algorithm to find best input parameter weights.
- Support for SPICE netlists and simulation.

Our final goal is an ambition but very important one.

- Fully functional CAD software for electronic circuits emulating neural networks.

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