NERVOUS System Tutorial – Spiking Neural Network with VHDL

This tutorial demonstrates the concept of Spiking neural network (SNN) using a FPGA based LIF (leaky integrate and fire) model. You will be able to observe basic behaviours of SNN from simulation and see how signals can be encoded and decoded between bit vectors and spike trains.

To participate in this tutorial, you will need:

1. Vivado 2022.1 installed.
2. The "DATE_SNN_VHDL_tutorial.zip", which includes this script and a Vivado project.

Execution:

1. Open the Vivado project "DATE_SNN_tutorial".
2. Open "Neuron_top_level_tb" in simulation sources. This is a testbench for a single spiking neuron with 4 dendrites (inputs). There are many things can be customized here:
   a. Line 17-22 are neuron's parameters, such as resting potential or threshold potential.
   b. Line 26-29 are the spike train pattern that will be fed into the neuron as a loop.
   c. Line 93-107 are setting of dendrite's weights. You could alternately randomize weights or set them to a specific value.
3. Click "run simulation", choose the window of waveform configuration "Neuron_top_level_tb_noEncoder_behav.wcfg". run the simulation for a certain period, and you may now observe the behaviour of the neuron.
4. Try different parameters, input, weights if you want.
5. Close the simulation, open "Neuron_with_Encoder_toplevel_tb" and set it as the top-level. This is a testbench for a single spiking neuron with 4 dendrites, with an encoder and decoder. Parameters, weights, inputs (decimal number this time) can
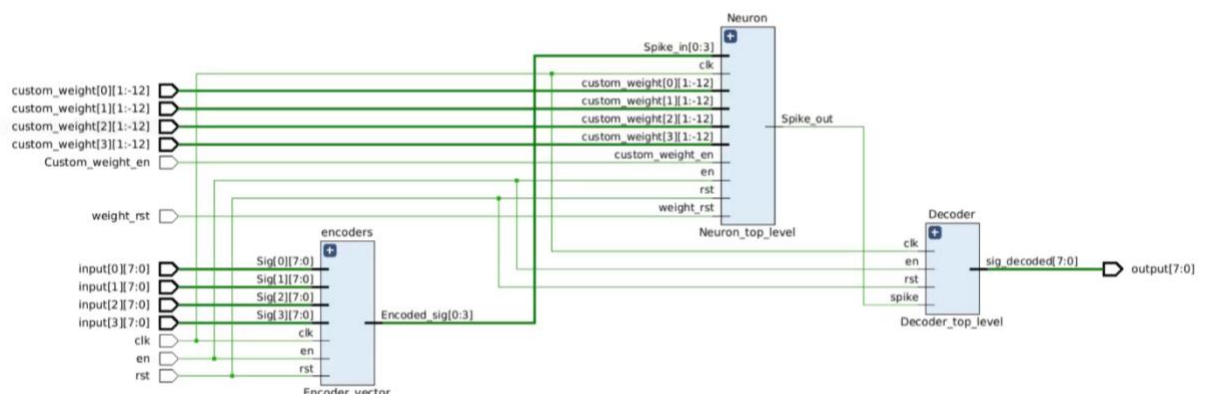
be customised as needed. Figure 1 shows how the encoder and decoders are connected to the neuron.

Figure 1. RTL schematics of the circuit with the encoder and decoder

6. Run the simulation, and you may observe how a probabilistic encoder could change the behaviour of neuron.

Troubleshooting

1. If there are any error mention something like "illegal subtype indication….", please check if the language type of all files is set to VHDL 2008 and if you are using the correct version of Vivado.
2. If there is a window pop up say "boost::filesystem::remove: The process cannot access the file because it is being used by another process:……". When running the second simulation. Please close the previous simulation manually.