Section: Experimental Results

For testing we used,

System: Dell Latitude 7420
A computer requirement:

- Processor: i7 CPU @ 3.00 GHz
- RAM: 32.0 GB
- System Type: 64-bit OS
- Operating System: RAVSim Windows version.

We used these WTA network models (list of conditions) in our testing,

- WTA with $i = j$
- WTA with fully connected network
- WTA with i != j

Note: where 'i' is the source neuron index, and 'j' is the target neuron index

We used three different models (mentioned above) for testing and each model used six different sets of neurons (100, 200, 300, 400, 500, 1000) and for each set of neurons tested 10 times, and the graphs are based on average values of each set of neurons.

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List of Condition: ‘i == j’:

List of Conditions	Simulator	Neurons	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Average
I = j	RAVSim v1.0	100	0.033	0.036	0.031	0.035	0.036	0.035	0.033	0.033	0.034	0.032	0.0338
		200	0.054	0.049	0.047	0.051	0.05	0.049	0.051	0.049	0.048	0.054	0.0502
		300	0.069	0.063	0.059	0.066	0.062	0.069	0.067	0.063	0.065	0.062	0.0645
		400	0.075	0.085	0.077	0.08	0.084	0.087	0.085	0.08	0.083	0.079	0.0815
		500	0.097	0.096	0.095	0.096	0.1	0.098	0.092	0.11	0.099	0.097	0.098
		1000	0.219	0.223	0.213	0.218	0.212	0.22	0.218	0.214	0.215	0.221	0.2173
	Brain2	100	0.066	0.064	0.062	0.065	0.075	0.072	0.07	0.069	0.066	0.063	0.0672
		200	0.203	0.125	0.091	0.186	0.091	0.096	0.156	0.178	0.099	0.095	0.132
		300	0.113	0.116	0.229	0.112	0.204	0.115	0.22	0.226	0.119	0.209	0.1663
		400	0.144	0.137	0.255	0.135	0.226	0.221	0.209	0.22	0.199	0.227	0.1973
		500	0.258	0.266	0.261	0.258	0.275	0.279	0.259	0.278	0.271	0.255	0.266
		1000	0.412	0.405	0.406	0.41	0.404	0.402	0.408	0.411	0.409	0.401	0.4068

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List of Condition: ‘i != j’:

List of Conditions	Simulator	Neurons	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Average
i != j	RAVSim v1.0	100	0.164	0.176	0.177	0.18	0.165	0.177	0.175	0.178	0.174	0.176	0.1742
		200	0.539	0.53	0.535	0.526	0.531	0.54	0.551	0.535	0.547	0.545	0.5379
		300	1.259	1.23	1.236	1.237	1.232	1.234	1.238	1.245	1.231	1.238	1.238
		400	2.041	1.963	1.961	2.052	1.965	1.951	2.123	1.954	1.96	2.09	2.006
		500	3.464	3.113	3.215	3.5	3.26	3.003	3.459	3.268	3.112	3.525	3.2919
		1000	11.824	12.99	13.034	13.605	11.856	14.034	11.996	13.575	12.534	13.081	12.8529
	Brain2	100	3.327	3.407	3.418	3.474	3.668	3.429	3.355	3.48	3.265	3.416	3.4239
		200	12.563	12.57	13.063	14.083	13.103	13.603	13.414	12.977	13.327	13.393	13.2096
		300	29.007	30.12	30.153	30.773	30.569	30.312	29.514	30.718	30.554	30.549	30.2269
		400	50.755	50.507	49.518	53.563	52.98	54.301	56.568	54.855	53.474	55.032	53.1553
		500	74.828	73.994	74.657	74.42	75.024	72.967	73.786	74.836	75.047	74.375	74.3934
		1000	305.868	304.18	328.348	325.053	313.049	368.396	343.111	320.797	303.516	372.759	328.5077

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List of Condition: 'Fully Connected Network':

List of Conditions	Simulator	Neurons	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Average
fully connected network	RAVSim v1.0	100	0.255	0.273	0.228	0.221	0.231	0.261	0.25	0.254	0.198	0.176	0.2347
		200	0.582	0.556	0.568	0.571	0.564	0.56	0.567	0.581	0.564	0.571	0.5684
		300	1.207	1.22	1.217	1.222	1.207	1.213	1.203	1.209	1.198	1.214	1.211
		400	2.002	2.109	2.088	2.11	2.067	2.073	2.114	2.11	2.096	2.09	2.0859
		500	3.686	3.724	3.998	3.832	3.604	3.657	3.69	3.731	3.751	3.749	3.7422
		1000	13.58	14.21	14.001	14.815	14.475	15.538	15.582	13.716	14.134	13.194	14.3245
	Brain2	100	5.485	3.419	4.013	3.95	2.292	3.244	4.989	2.494	2.943	3.247	3.6076
		200	14.664	18.223	16.555	15.238	14.9	15.428	16.987	14.99	15.834	16.45	15.9269
		300	31.03	31.471	33.561	33.371	31.451	33.37	30.911	33.099	34.615	34.734	32.7613
		400	66.833	66.347	70.411	63.028	66.704	65.779	66.195	66.739	65.805	66.182	66.4023
		500	96.75	86.22	82.985	83.716	85.529	79.173	81.406	80.306	85.734	80.78	84.2599
		1000	345.98	325.858	358.132	318.32	317.44	316.19	328.74	328.11	323.13	351.74	331.368

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Section: User Manual

About RAVSim

RAVSim stands for Real-time Analysis and Visualization Simulator. It is solely designed with the aim of helping early-stage researchers and students to fully understand the mechanism of SNNs where users can interact with the simulator in real-time by providing the essential parameters. Practically, RAVSim used to simulate LIF by using noisy input model.

RAVSim is developed on graphical programming language platform called LabVIEW (Laboratory Virtual Instrument Engineering Workbench) [1].

Leaky Integration and Fire by using Noisy Input model (NLIF) [2] has been implemented to perform real-time simulation. Furthermore, it is capable of Spike detection by using the continuous noisy input, Spike detection by using input current, and generating a winner takes all network (WTA) [3], which establishes communication between the neurons.

In this short document, you will learn how to use RAVSim to perform real-time experiments. The video demo of RAVSim can also be seen at [https://www.youtube.com/watch?v=Ozv0MXXj89Y].

Basic Requirements

A graphical programming approach LabVIEW Runtime 2021 or above.
A minimum computer requirement:

- Processor: i3 CPU @ 2.3 GHz
- RAM: 4.0 GB
- System Type: 32/64-bit OS
- Operating System: Mac OS, Window

To install Runtime LabVIEW:

https://www.ni.com/kokr/support/downloads/softwareproducts/download.labview.html#305931

1. Analysing the SNN model using RAVSim

In this section, you will learn how to analyze and visualize the SNN model in RAVSim.

1.1. Launching RAVSim

The front interface/welcome page of RAVSim, shown in Figure 1, will appear when you double-click on **RAV*Sim.app*** (for MAC OS) or **RAV*Sim.exe*** (for Windows OS).

Figure 1. Front interface/welcome. page of RAVASim.

On the bottom right side of the corner, the simulation is only for demonstration purposes by using the NLIF model. However, the same model is also used in the real-time simulation VI, where a user can analyze and visualize the model by increasing/decreasing the parameters, all during runtime.

1.2. RAVSim Menu Bar

A menu bar is **a graphical control element that contains drop-down menus**.

The menu bar's purpose is to supply a common housing for window- or application-specific menus which provide access to such functions as closing the RAVSim tool, interacting with a WTA network model manually, looking at the default parametric values of the LIF model, or displaying help or contact information.

Figure 2. Menu tab showing the drop-down listed features of a RAVSim tool.

Figure 3. By using the drop-down menu, users can use a manually generated WTA network.

Figure 4. By using the drop-down menu,
users can see the default parametric values of a model.

Figure 5. By using the drop-down menu from a **Help list**, users can see the relevant information

2. Generating a Real-time Simulation Enjoinment

As soon as the "Generate RAVSim VI" button (This will bring up a virtual instrument shown in Figure 6) is clicked the user will enter into the real-time simulation environment. And a "Run_Spikes.vi" dialogue box will pop up, where the user can enter the desired values of the parameters for analyzing and visualizing the simulations in run-time. The users can enter these values immediately or they can go with the default values and can also change the values accordingly during the time of the simulation.

Figure 6. RAVSim Virtual Instrument specifically for a LIF model

2.1. Runtime Experimentation VI

Real-time experimentation of the RAV-Simulator provides a lot of flexibility for the user to interact with the SNN model at any point in time. Figure 7 shows the simulator's screen overview after hitting the “Run Spike” button.

Plots in the Figure 7, shows the spikes generated with the values which the user has inserted. And they can change the values of the parameters like the threshold, reset potential, etc during the run-time. Right plot, show the spike detection by using continuous noisy input and the left plot shows the users, how neurons are communicating with each other and how many times one neuron is interacting with the other, and also the left plot menu option 2nd, visualize the plot that shows the detection of spikes using the input current.

Once the simulation is started, the user can increase or decrease the parametric values of a model by using the left bottom “external Parameter Values” table and observing their effects on the SNN model during run time.

Figure 7. Real time Experimentation of RAV-Simulator for SNN.

Figure 7 also shows the screenshot of the real-time simulation of a LIF by using continuous noisy input and neuron communication plot taken randomly. This figure shows that unlike NLIF events with default parametric values, users can interact with the model and change the concentration of model input to any level and at any instant of time. In case the concentrations of the input model are required to be triggered to threshold level instantly, the neuron communication plot displays the runtime graphically neuron excitation results.

3. Additional features in RAVSim

If a **STOP** button (icon located at the top right corner in Figure 7.) is pressed, "RAVSim VI" navigates the user back to the home screen.

In in Figure 7, the bottom right we have provided the selection of the external plots, mixed-signal plots, and WTA network for the ease of the user and also change the runtime simulation values. With the mixed-signal plot, one can visualize the graphs of the input currents and the continuous signals values which are depicted in figure 8. It also allows the user to capture the graphs for documentation or reporting purposes which is will be saved in the relative path of the simulator. In order to go back to the real-time environment, click on the "Continue Simulation" button.

And for navigating to the WTA mechanism the user has to click on the "WTA Network" in external plots and a window will pop up, where we can visualize the neuron communication graph which is shown in figure 9. Two types of communication graphs can be analyzed at this moment with two different conditions. The first one is the source index equal to the target index and the second one, the source index of the neuron is not equal to the target index. We can select the required graph from the "list of conditions" dropdown. We also capture the graphs or we can continue back to the simulation.

Each screenshot is saved at location, where "Documents/Screenshot/Screenshot_name".

Alert – When the **STOP** button is pressed, the user navigates to home page and the stop button in home page can be used to terminate the RAVSim tool immediately.

Tip – The functionality of graphical plots, including simulation colors, can be changed by using a left click on the plot legend and selecting the desired drip down option.

Figure 8: Mixed-Signal Plot

Figure 9: WTA Mechanism

The runtime simulation option, available in RAVSim v1.0, shown at the bottom right corner of a VI in Figure 7. The option is described below:

- **Simulation Speed**: This option allows user to increase or decrease the simulation speed by entering the numerical values which is considered as milliseconds values.

Alert – Make sure the triggered threshold value is always greater than the membrane reset potential.

Refer

[1]. NI LabVIEW, https://www.ni.com/de-de/shop/labview.html.

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[3]. Yanqing Chen. Mechanisms of winner-take-all and group selection in neuronal spiking networks. Frontiers in computational neuroscience,11:20, 2017.