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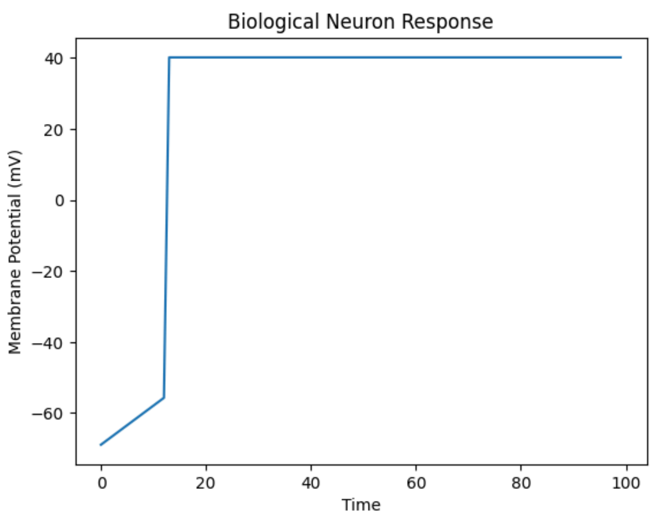
ITAI 4374

L03- Visualization

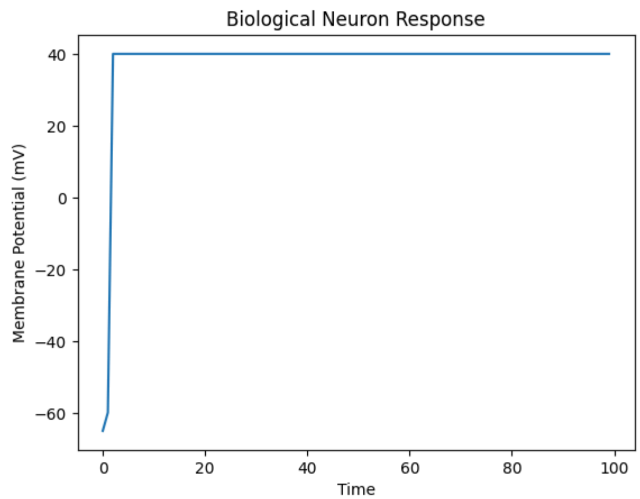
How does the input current affect the generation of action potentials?

The input current determines the membrane potential's increase over time. This means that a higher number means the neuron reaches its threshold faster, meaning it can send more signals in less time. A lower number, or even negative number, means it will take longer to start firing, if it ever does fire. A positive number also means that the voltage is increasing over time, until reaching the max potential. However, if you change it to a negative, the voltage will decrease over time, significantly altering the output.

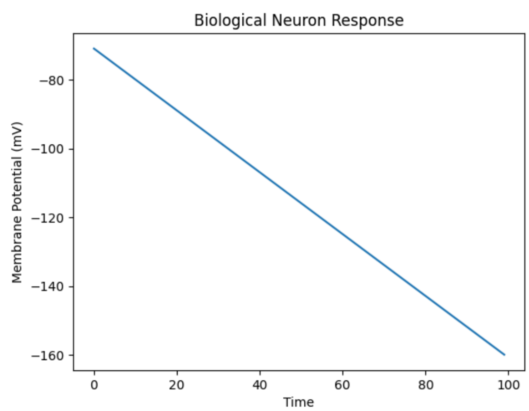
Here is the graph given with only the default numbers. It reaches its max potential at around 15.



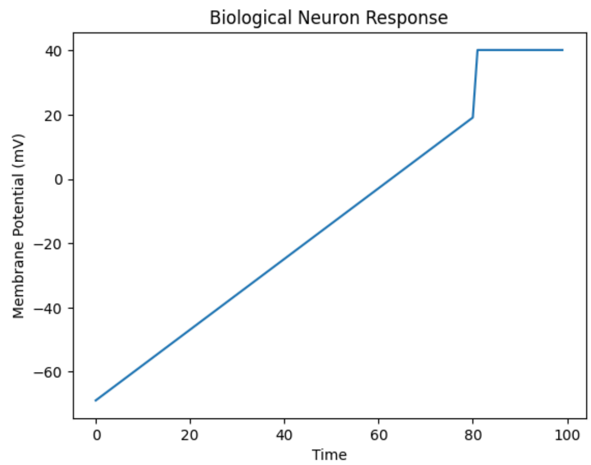
Next is the graph for five as the input current. Here you can see it reaches its max potential much faster.



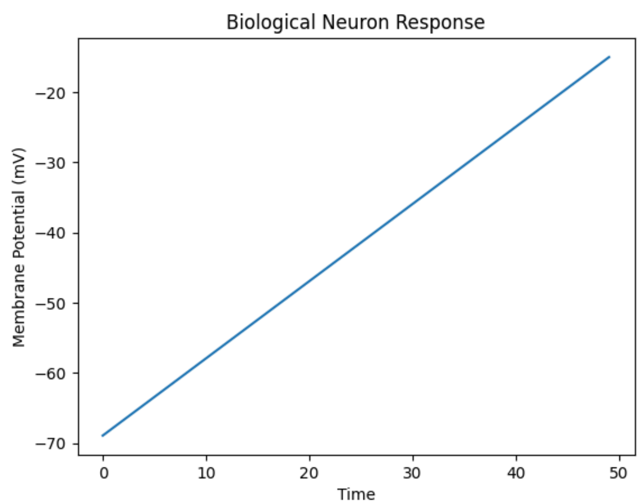
Lastly is the graph with a negative one for the input current. The graph steadily declines rather than reaching a max. It is interesting to me that it starts off over the max potential of the other graphs. I went to chatGPT to figure out why, and it seems that this is because it causes a spike when the threshold is reached before decaying, unlike the others that continue firing when the max is reached.



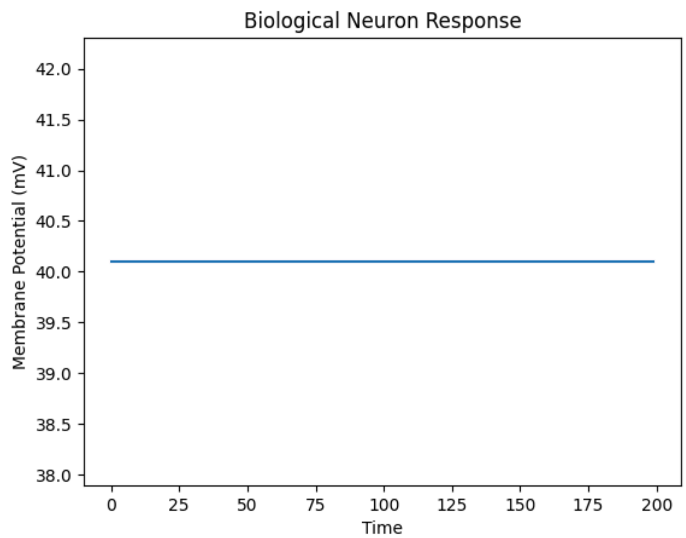
When the input current is lower than the threshold, it takes much longer to reach the peak potential and plateau there, meaning it takes a much longer time to start sending signals. Here, I set the threshold at 20 instead of -55, so it did not reach the potential until almost 80.



If the simulation did not allow for the time needed for the neuron to fire, it simply never would. This is shown in the next graph where I limited the steps to 50, so the potential is never met, and you never see the plateau.



The neuron's response can change drastically with varying input currents. It is dependent on how fast the membrane potential increases, as this impacts if it can reach the threshold fast enough to send a signal. If the membrane potential is low it rises slowly, requiring more steps to reach the threshold. If those steps are not included then it will never reach it and never fire. If it is high it will reach the threshold in very little time, meaning it will fire often. However, if you set the threshold equal to the resting potential, it will immediately fire and stay at the membrane potential.



Part Two of Code- Analyzing Results:

For the following section I will be rounding all the numbers to the nearest thousandth. Note that I changed the output in the activate function in the code. When I looked into other ways to do this, I got different results. However, as this is what was assigned, I am going to default to it. Something else worth noting is that I had to change the random number to a set value to accurately compare the outputs.

Sigmoid: 0.68

ReLU (Rectified Linear Unit): 0.74

tanh (hyperbolic tangent): 0.63

The sigmoid function keeps the value between 0 and 1. It signifies how activated the neuron is, almost like a percentage. In this case, it would be 68%. If the input is small, it will be closer to zero. If the input is large, it will be closer to 1. For the ReLU activation, if the input is negative, the output will be zero. If the input is positive, the output will be very close to the input. This means that -1 and -5000 will give the same output of 0, but 4 and 1200 will give outputs close to 4 and 1200, respectively. Lastly, the tanh function keeps the values between -1 and 1, so it is similar to the sigmoid function, but can get more specific since it can give negatives as the output value.

Compare to Biological Neuron Model:

The first comparison I want to make is that the biological neuron model had more numbers and values that could change. It was more customizable, or perhaps just easier to customize compared to the artificial neuron models.

For further analysis, the biological neuron model gave a graph showing the gradual changes based on the input. From there, once it reaches the threshold, there is an action (signal), where it then plateaus. This also means that it either hits the threshold and fires or it does not.

The artificial neurons are difficult to compare as there is not a graphical output. However, based on the code, the artificial neurons do not include “steps”, so I do not believe it is timed in the same way. Based on my knowledge of neural networks, the signal is sent but assigned a weight based on the input values and the function it is given (ReLU, tanh, sigmoid). This means it does not behave in the same way. It is not a yes or no like the bio neuron. It is a “yes, but…” based on the assigned value. That is to say, yes the signal is sent, but depending on other signals being sent it may not be acted on immediately.