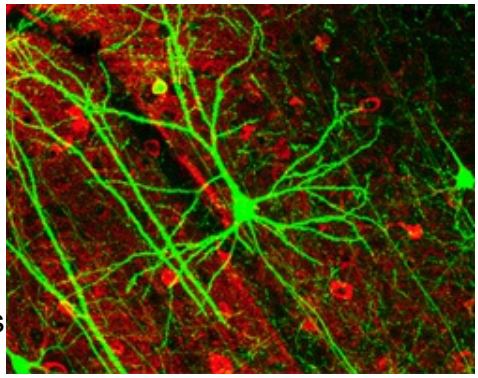
PLTW COMPUTER SCIENCE

Activity 4.2.2

Neural Networks

Introduction



One of the most readily available forms of inspiration for technological progress is nature. Historically humans have modeled many inventions after things that already exist in the real world. Software design is no exception, as you saw in the last activity.

As scientists learn more about the natural world, more biologically inspired designs are produced. The human brain is an organ that until very recently we knew little about. Today artificial neural networks are being used to solve all kinds of challenging problems

What natural phenomenon do you think will have a large impact on the development of technology in the future?

Materials

- Paper and a writing utensil
- Computers with Internet access

Procedure

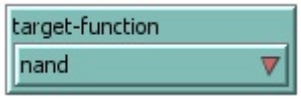
Part I: The Perceptron

1. Form pairs as directed by your teacher. Meet or greet each other to practice professional skills.
2. Open the model by selecting **File > Models Library** and then **Sample Models > Computer Science > Artificial Neural Net – Perceptron.**
3. Learn how neurons in your brain communicate:

> Refer to your downloadable resources for this material. Interactive content may not be available in the PDF edition of this course.

4. In this model, the Σ character marks the output node of the perceptron, which is a type of artificial neuron. There are three input nodes, one of which is marked with a 1 and has a constant value of one. The other two have either a -1 value (black) or 1 value (white). In this simulation you can choose which logical function you'd like your perceptron to learn using the

target-function menu shown here.



Use this menu to choose your favorite logic function. Click the **setup** button once and then choose input values using the menus in UI section 3, “Test perceptron”. Remember, -1 corresponds to the color black, and 1 corresponds to the color white. Click the **test** button to get an output value. Mark the values that you find in the table below. How many were correct?

Input-1	Input-2	Output
1	1	
1	-1	
-1	1	
-1	-1	

5. In the previous step, you tested an untrained perceptron. Switch `show-weights?` to “On” and you will see the real task of the simulation. The perceptron in this simulation is supposed to balance the weight given to each of the three input values. The weight is a value that is multiplied by the input value. The perceptron sums all three of the products and then makes its decision about output based on the result. If the result is greater than zero, then the perceptron outputs one. In all other instances, the perceptron outputs negative one. Answer the following questions:
    - How is the perceptron similar to a biological neuron?
    - What details of a biological neuron does the perceptron model ignore?
    - What details of a biological neuron does the perceptron model abstract?

6. You can click the **train** button to continuously train the perceptron. Training consists of the neuron producing an output for randomly generated input and then being told how well it performed. The perceptron is then given a chance to modify the weights of its inputs to attempt to do better during the next training session. Try training the perceptron on “and” for a few ticks and then switch the target-function to “nand” and manually test the perceptron as you did in Step 3. How did it do?

Part II: Neural Networks

7. If you attempted to train the perceptron on “xor” in the previous part of this activity, you found that it cannot learn that function. Researchers fixed this shortcoming of the perceptron by incorporating many of them together into a neural network. Perceptrons working together within a neural network are able to solve more types of problems than single perceptrons in isolation. Choose **File > Models Library** from the menu and then **Sample Models > Computer Science > artificial Neural Net — Multilayer.**
8. This model is very similar to the previous model; however, it has three output nodes, two of which are intermediary output nodes. This model simulates three perceptrons working

together to learn the logic functions. Take a moment to experiment with this model then answer these questions:
    - How is this model similar to how real neurons behave?
    - What details are abstracted in this model?
    - What details are ignored?
9. Use whatever tools you need in order to determine the effects of `varying learning-rate` and `examples-per-epoch`. Explain your results and justify your methods. Share out with the class as directed by your instructor.

Conclusion

1. Describe how a natural phenomenon other than the ones you have learned about might be used to create better software.
2. Assuming the availability of the technology, say a single neuron in your brain was exactly duplicated in a lab using artificial materials and then surgically replaced your old neuron.

    - Would you still be the same person, and why?
    - What if it were 10 neurons?
    - How many neurons would you need to replace before you'd no longer be the same person, and why?