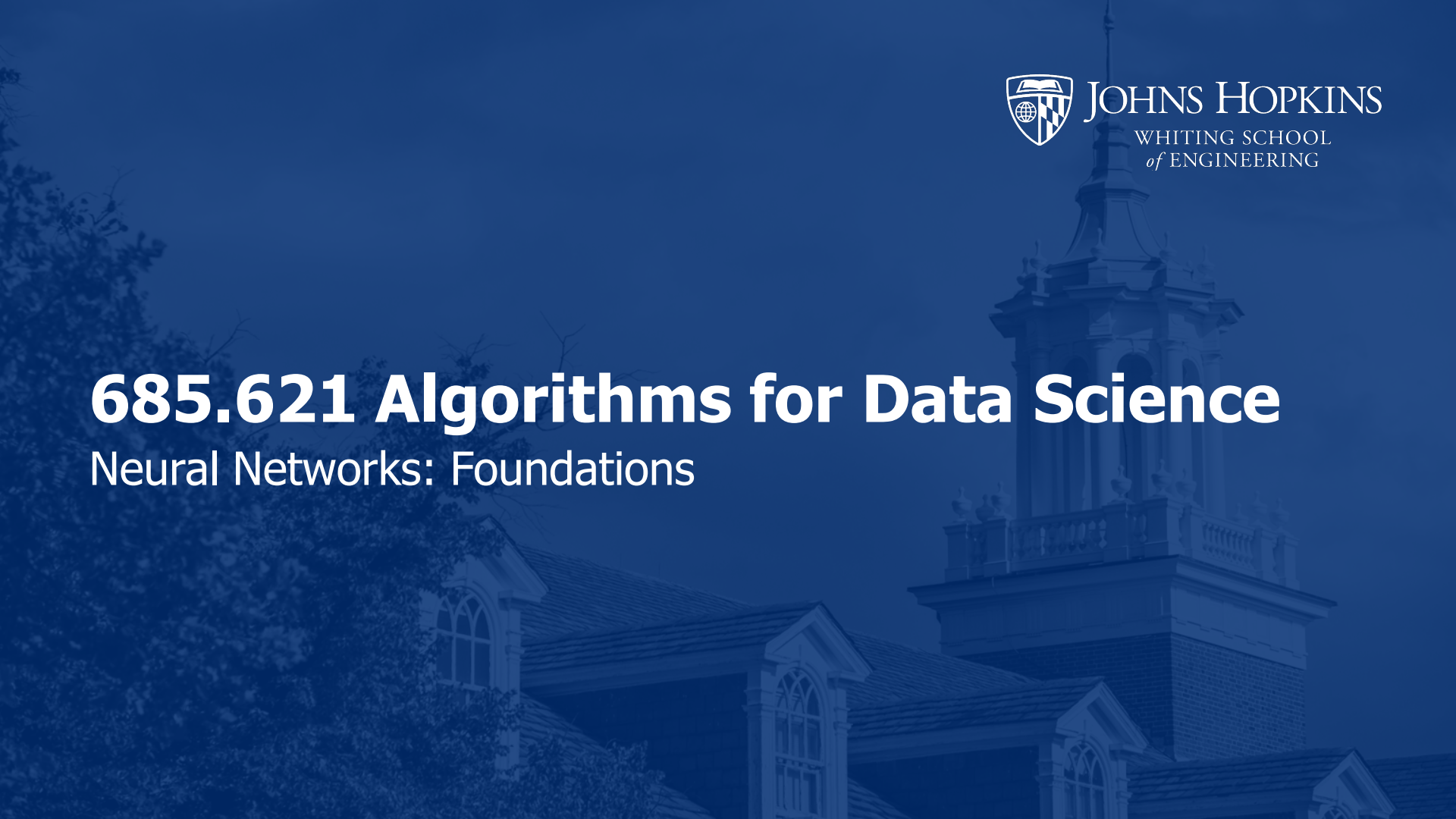
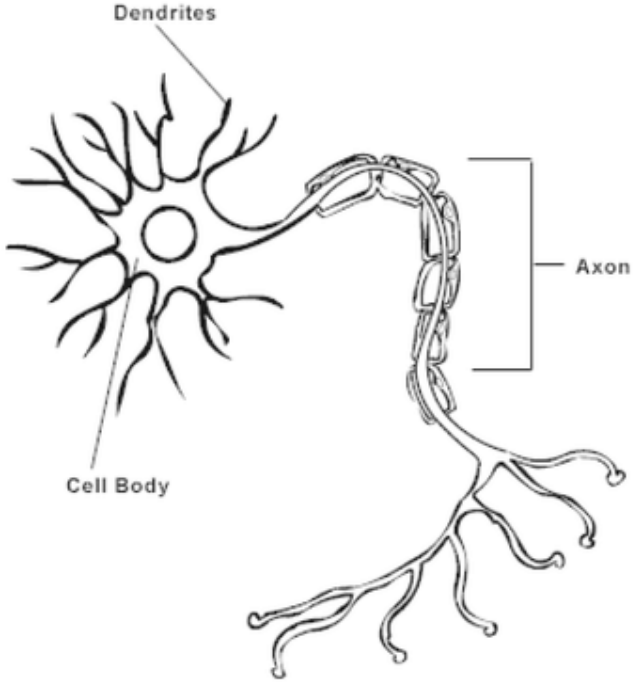


685.621 Algorithms for Data Science

Neural Networks: Foundations

What are Neural Networks



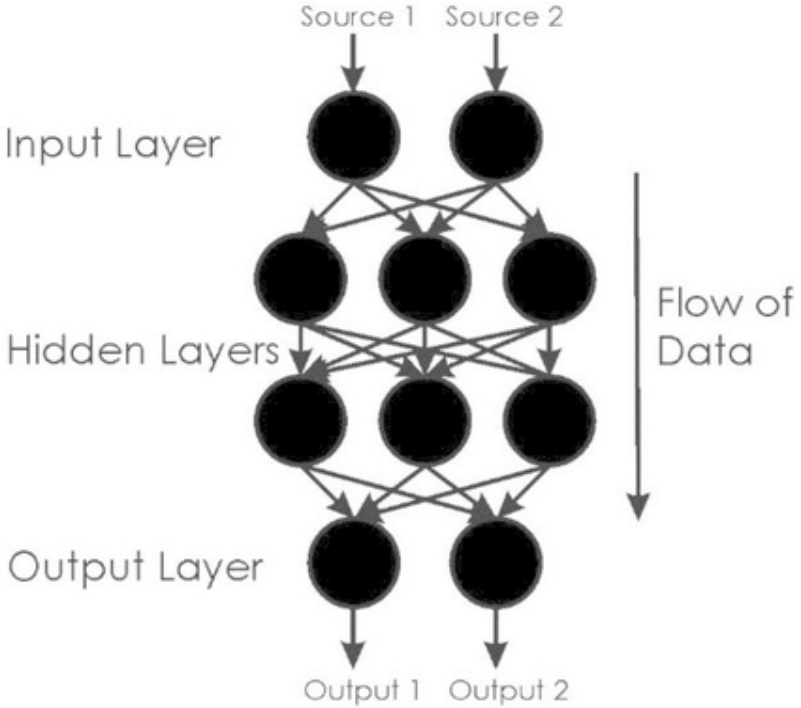


Figure 1—A typical neural network representation based on a biological neuro.
Sun, Jianlei (John) & Ma, X. & Kazi, M.. (2018). Comparison of Decline Curve Analysis DCA with Recursive Neural Networks RNN for Production Forecast of Multiple Wells. 10.2118/190104-MS.

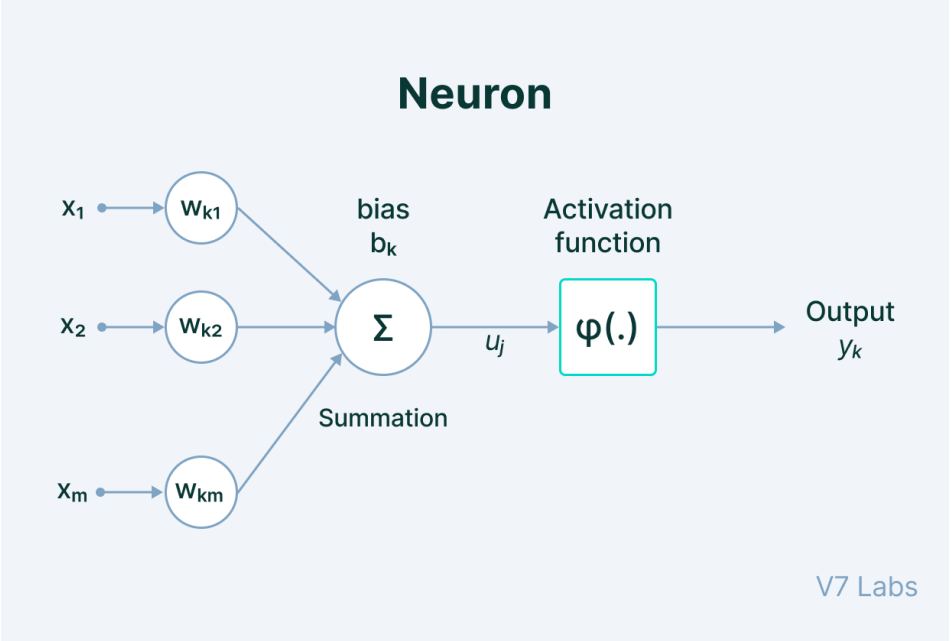
Why Neural Networks Matter

- Neural networks are the **powerhouse** behind technologies we use daily, from voice assistants to personalized recommendations.
- **Backbone** of AI applications
- Their **flexibility** allows them to be applied across **diverse domains**

(Pribanic, 2019)

Anatomy of a Neural Network

- If we look at this **Neuron** there are two distinct things happening within each:
  - The **summation** of the inputs and the weights (addition of bias)
  - An **activation function** to normalize the value into a particular fashion to be given as inputs to the next layer.

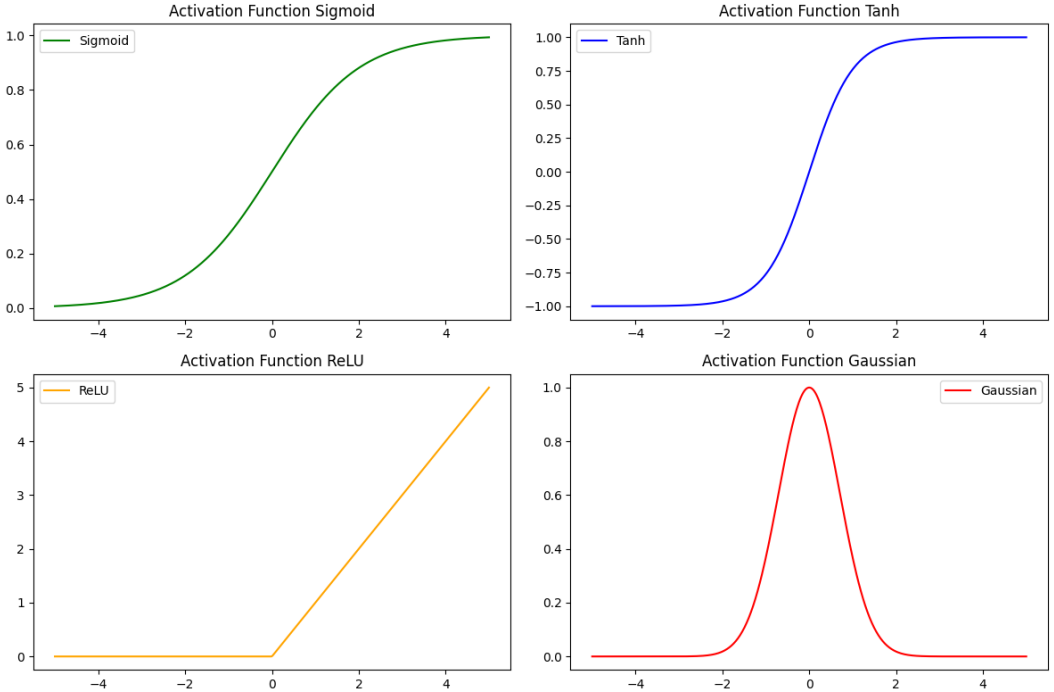


https://animalia-life.club/qa/pictures/artificial-neural-networks

Activation Functions

Activation Functions

- **Sigmoid**: squashes values into (0, 1), often used for binary classification
- **ReLU**: *max* (0,*x*) accelerates convergence and mitigates vanishing gradients
- **Tanh**: Ranges in (-1, 1), often helpful in recurrent architectures
- **Softmax**: Normalizes a vector of logits into a probability distribution, used in multi-class classification



Layers of a Network

- **Input Layer**: Initial Layer that receives **raw input data**.
- **Hidden Layer(s):** Process information between the input and output layers, **performing complex transformation** via connection and activation functions
- **Output Layer**: Final Layer that produces the **predictions/results**

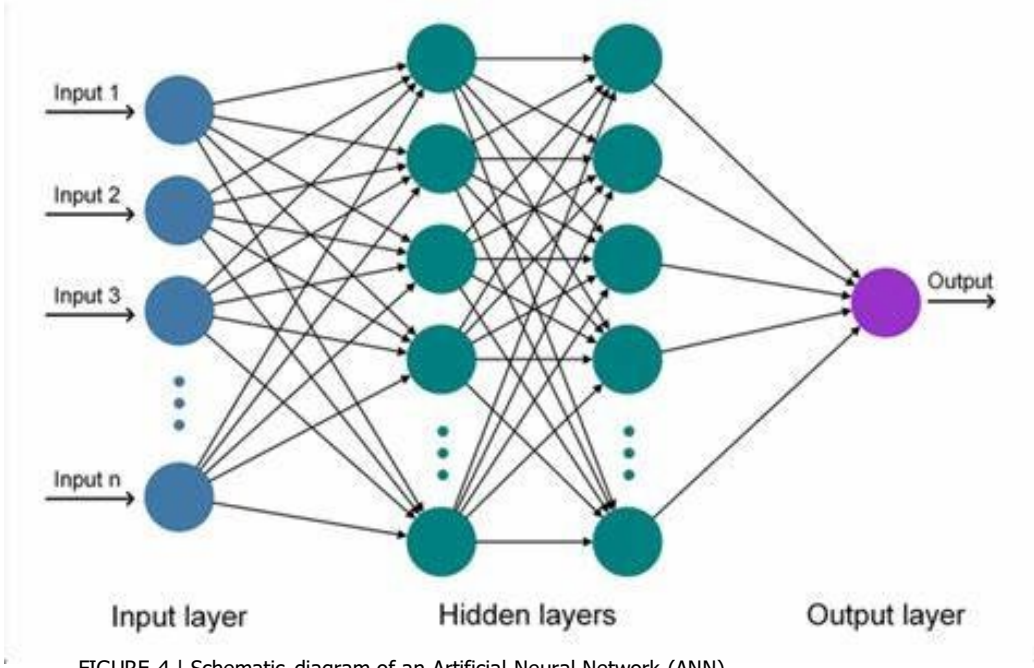


FIGURE 4 | Schematic diagram of an Artificial Neural Network (ANN).
Sahraei, Amir & Chamorro, Alejandro & Kraft, Philipp & Breuer, Lutz. (2021). Application of Machine Learning Models to Predict Maximum Event Water Fractions in Streamflow. Frontiers in Water. 3. 652100. 10.3389/frwa.2021.652100.