Chapter Four

Neural Network

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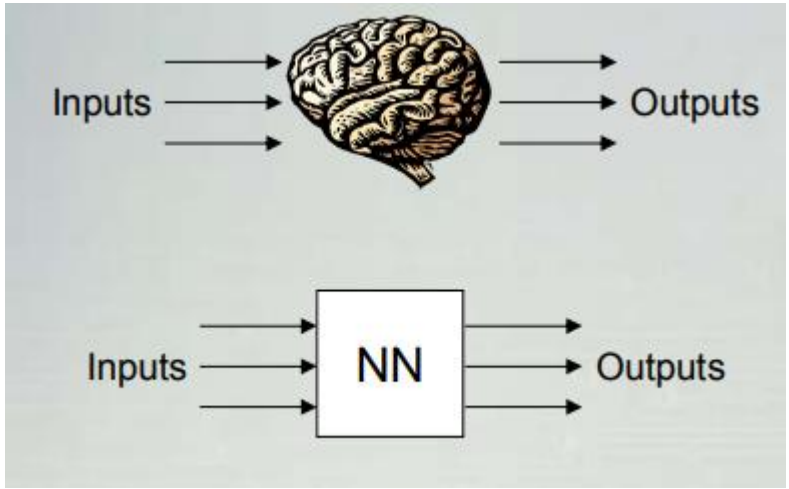
Introduction

- A neural network is an interconnected assembly of simple processing elements, units, or nodes.
- The processing ability of the network is stored in the inter-unit connection strengths, or weights, obtained by a process of adaptation to, or learning from, a set of training patterns.
- An extremely simplified model of the brain.
- Essentially a function approximator.
- Transforms inputs into outputs to the best of its ability.

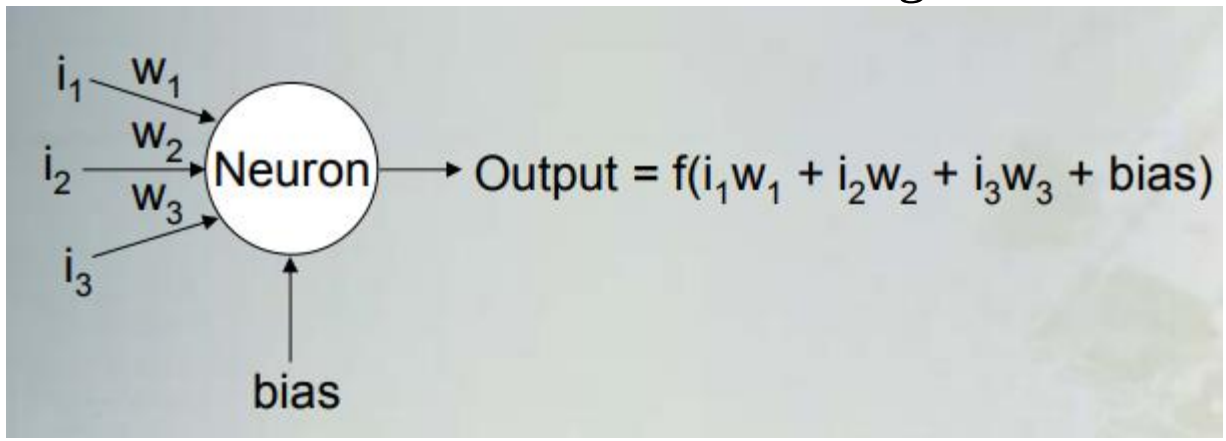


The application of ANN

- Classification
- Pattern recognition, feature extraction, and image matching.
- Noise Reduction
- Recognize patterns in the inputs and produce noiseless outputs.
- Prediction
- Extrapolation based on historical data

How do neural network work?

- The output of a neuron is a function of the weighted sum of the inputs plus a bias.



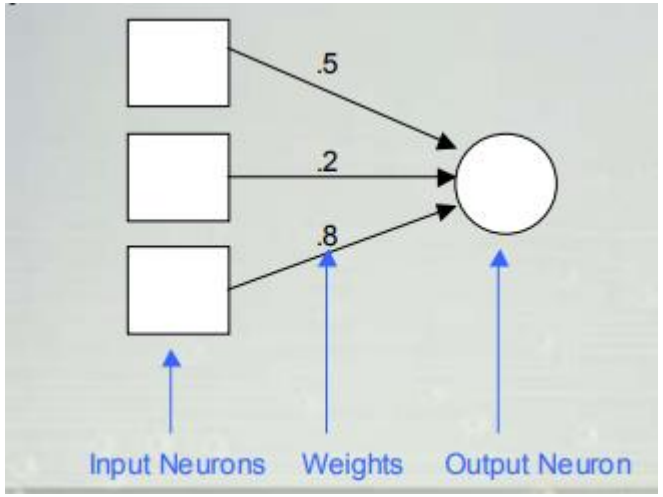
- The function of the entire neural network is simply the computation of the outputs of all the neurons.
- The weights in a neural network are the most important factor in determining its function.
- Training is the act of presenting the network with some sample data and modifying the weights to better approximate the desired function.

Where do the weights come from?

- Unsupervised Training: Only supplies inputs.
- The neural network adjusts its weights so that similar inputs cause similar outputs.
- The network identifies the patterns and differences in the inputs without any external assistance.

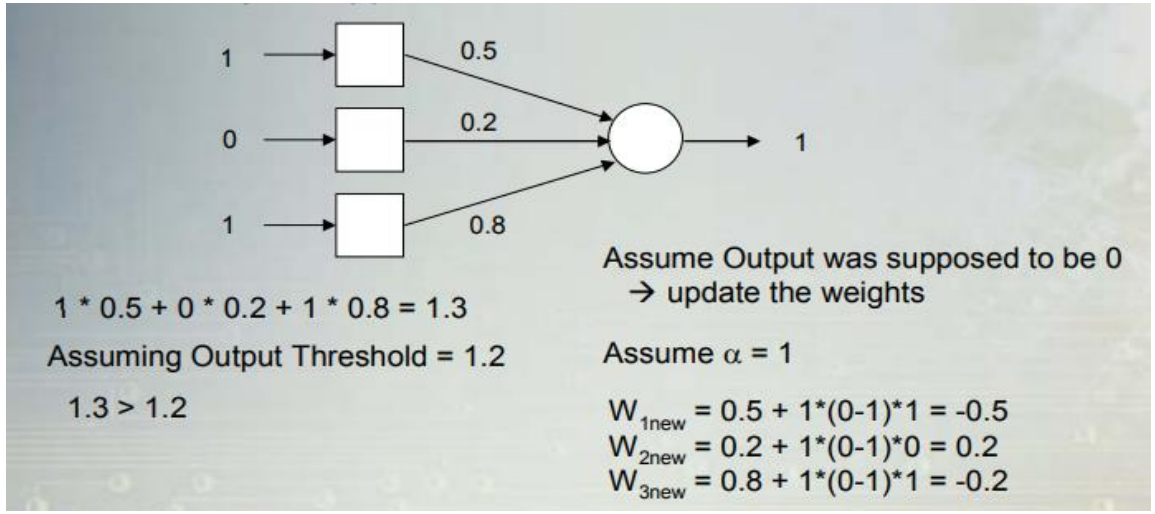
The perceptron

- First neural network with the ability to learn.
- Made up of only input neurons and output neurons.
- Input neurons typically have two states: ON and OFF.
- Output neurons use a simple threshold activation function.
- In basic form, can only solve linear problems.
- Limited applications



Training the perceptron

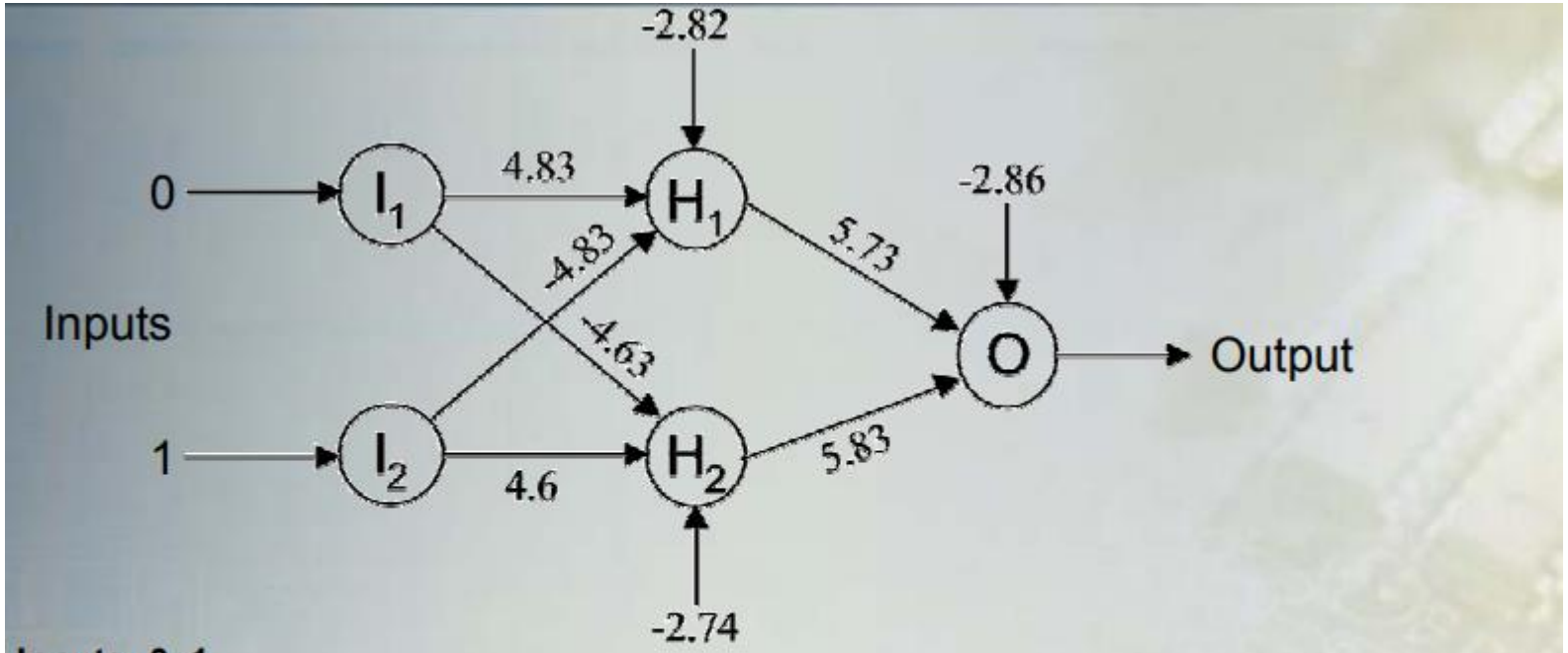
- Uses supervised training.
- If the output is not correct, the weights are adjusted according to the formula:
- wnew = wold + α(desired – output)*input α is the learning rate



Multilayer perceptron

- Most common neural network.
- An extension of the perceptron.
- Multiple layers: The addition of one or more “hidden” layers in between the input and output layers.
- An activation function is not simply a threshold: Usually a sigmoid function.
- A general function approximator.
- Not limited to linear problems. Information flows in one direction: The outputs of one layer act as inputs to the next layer.

Example of MP



Inputs: 0, 1

H_1: Net = 0(4.83) + 1(-4.83) – 2.82 = -7.65
Output = $1 / (1 + e^{7.65}) = 4.758 \times 10^{-4}$

H_2: Net = 0(-4.63) + 1(4.6) – 2.74 = 1.86
Output = $1 / (1 + e^{-1.86}) = 0.8652$

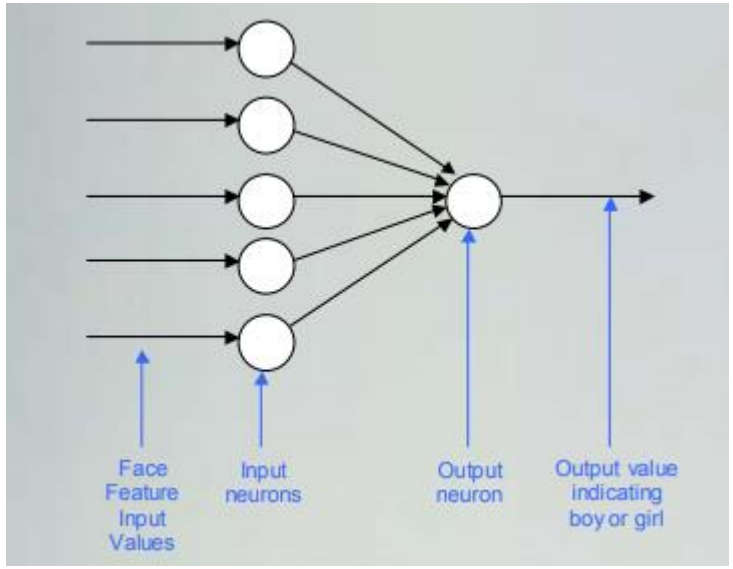
O: Net = $4.758 \times 10^{-4}(5.73) + 0.8652(5.83) – 2.86 = 2.187$
Output = $1 / (1 + e^{-2.187}) = 0.8991 \equiv$ "1"

Case study

- A simple toy problem was used to test the operation of a perceptron.
- Provided the perceptron with 5 pieces of information about a face – the individual's hair, eye, nose, mouth, and ear type.
- Each piece of information could take a value of +1 or -1.
- +1 indicates a "girl" feature
- -1 indicates a "guy" feature
- The individual was to be classified as a girl if the face had more "girl" features than "guy" features and a boy otherwise.

Cont.

- Construct a perceptron with 5 inputs and 1 output.
- Train the perceptron with 24 out of the 32 possible inputs over 1000 epochs.

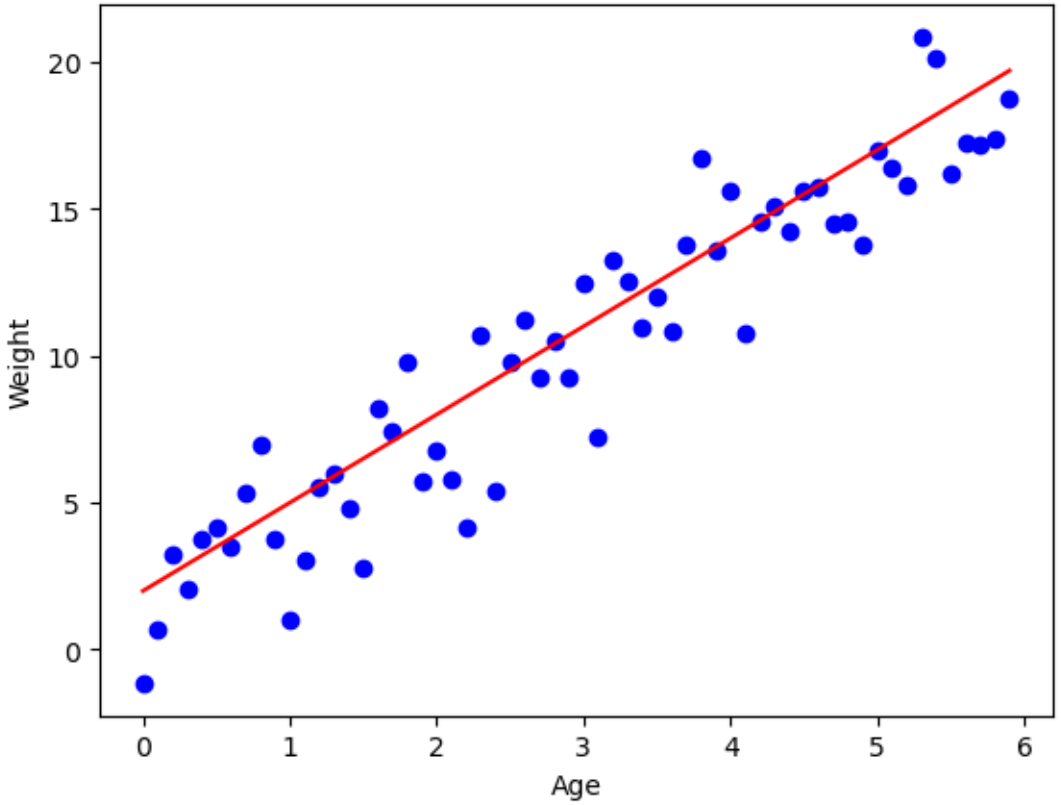


- The perceptron was able to classify the faces that were not in the training set.

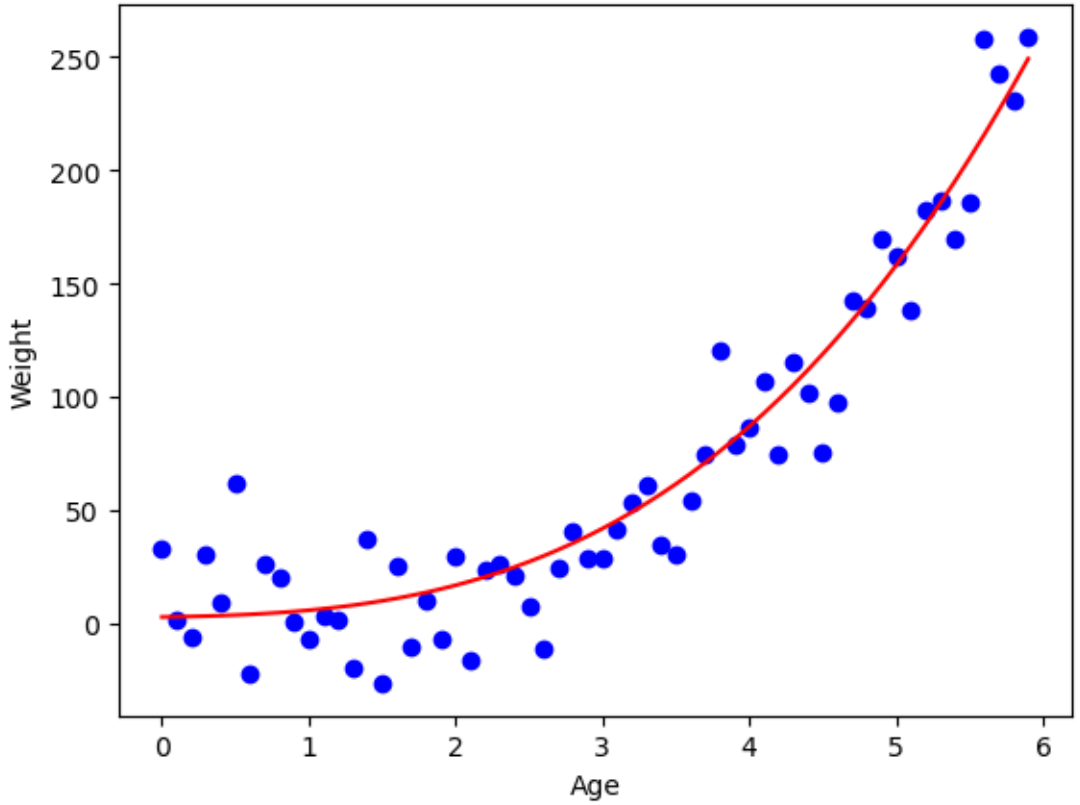
Non linear regression

- Non-Linear regression is a type of polynomial regression.
- It is a method to model a non-linear relationship between the dependent and independent variables.
- It is used in place when the data shows a curvy trend and linear regression would not produce very accurate results when compared to non-linear regression.
- This is because in linear regression it is pre-assumed that the data is linear.

Cont.



- Linear separable data.



- Non-linearly separable data.

Chapter review questions

1. Define neural network.
2. Compare simple perceptron and multilayer perceptron.
3. Describe some of the applications of the perceptron.
4. What is the difference between linear and non-linear regression?
5. Mentions the application of simple, and multilayer perceptron.
6. Explain the application of linear and nonlinear regression.