University of Roehampton London

Machine Learning

Dr Changjiang He, Dr Kuo-Ming Chao
Computer Science| School of Art
University of Roehampton

University of Roehampton London

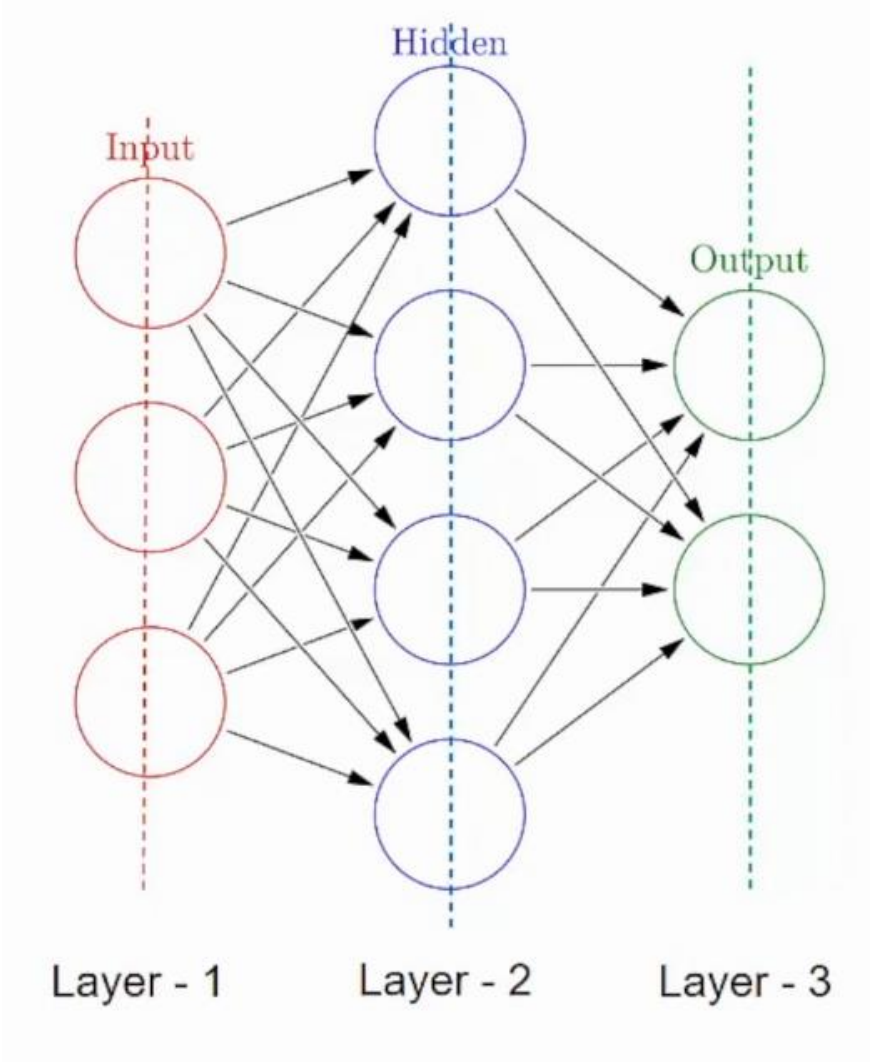
Lesson 5.2

Layers

Layer

University of Roehampton London

- A neural network is made up of vertically stacked components called **Layers**.
- Each dotted line in the image represents a layer.

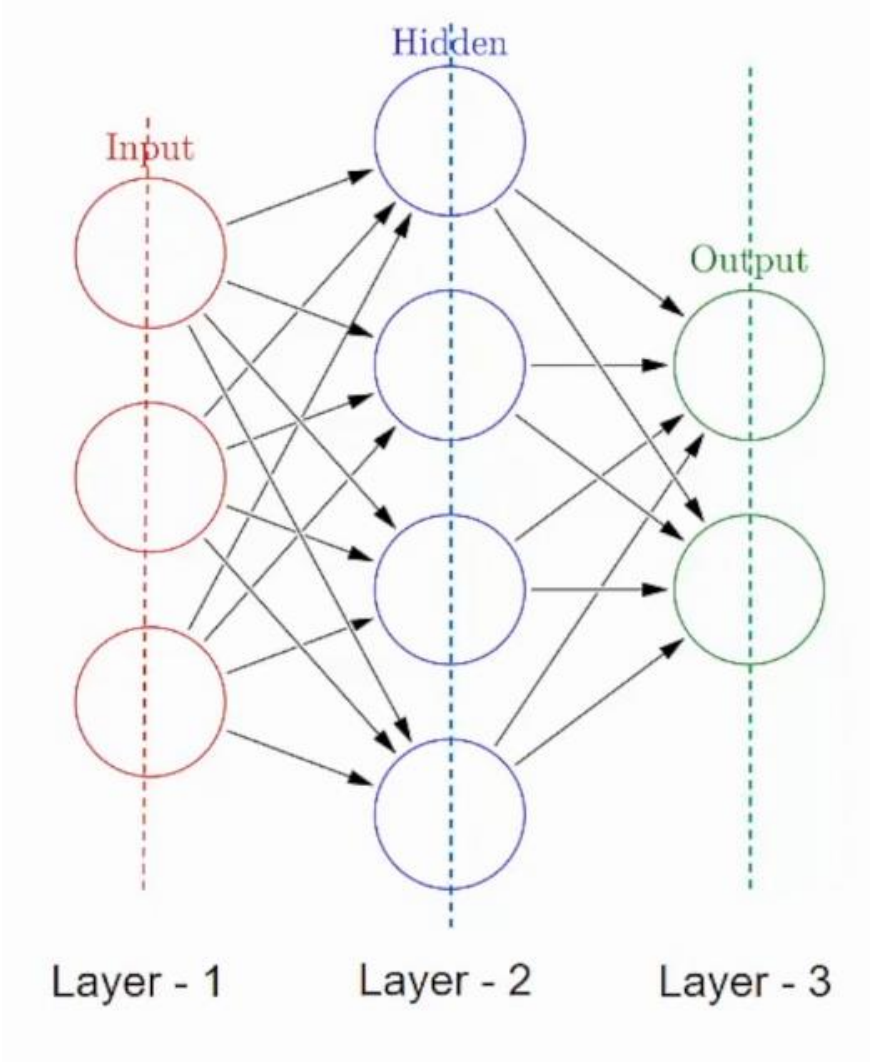


Layer

University of Roehampton London

There are three types of layers in a NN

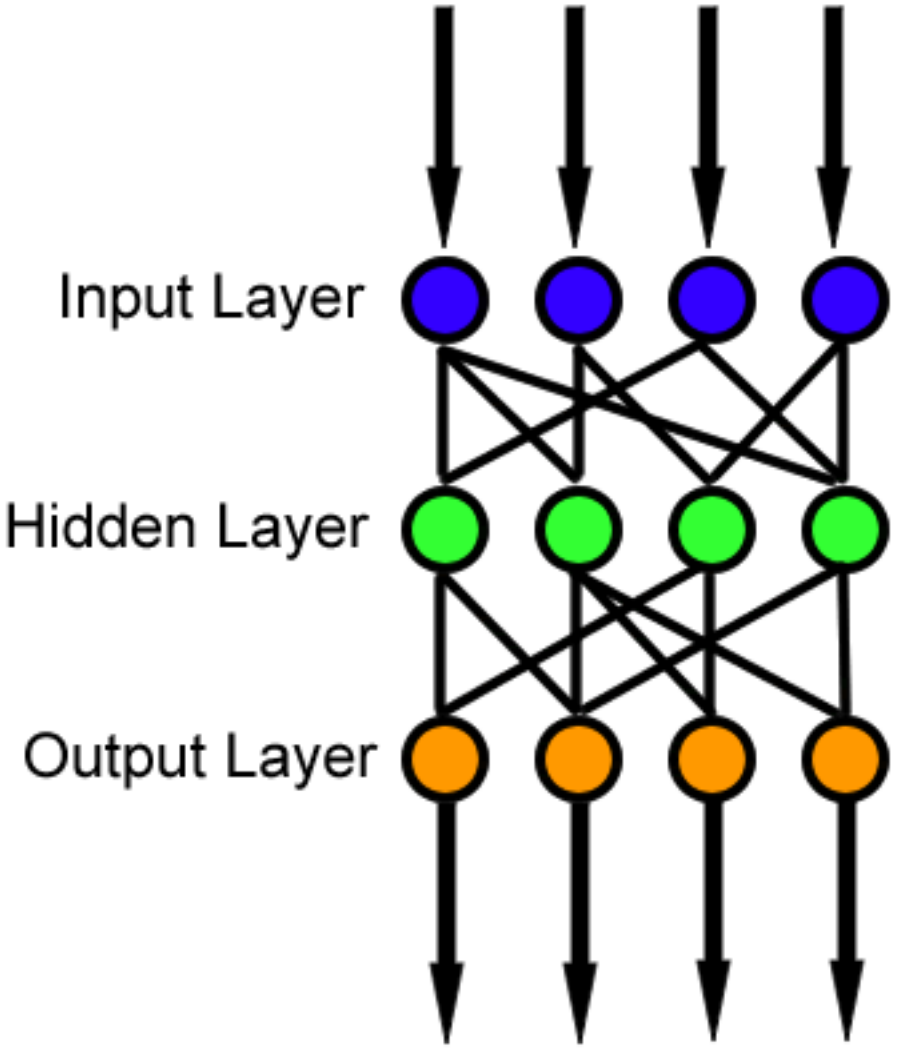
- Input Layer
- Hidden Layer
- Output Layer



Input Layer

University of Roehampton London

- The input layer of a neural network is composed of artificial input neurons.
- It brings the initial data into the system for further processing by subsequent layers of artificial neurons.
- The input layer is the very beginning of the workflow for the artificial neural network.



Hidden Layer

University of Roehampton London

- The second type of layer is called the hidden layer. Hidden layers are either one or more in number for a neural network.

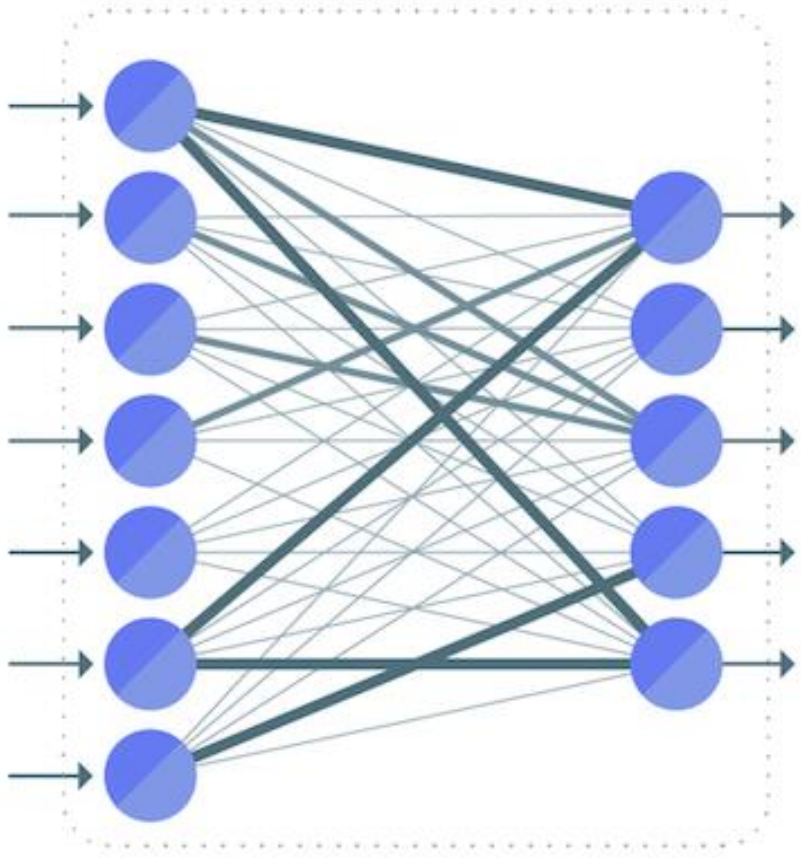
- In the above case, the number is 1. Hidden layers are the ones that are actually responsible for the excellent performance and complexity of neural networks.

- They perform multiple functions at the same time such as data transformation, automatic feature creation, etc.

Hidden Layer: Fully Connected Layer

University of Roehampton London

- Fully connected layers connect every neuron in one layer to every neuron in the next layer.
- Fully connected layers are found in all different types of neural networks ranging from standard neural networks to convolutional neural networks (CNN).



Hidden Layer: Fully Connected Layer

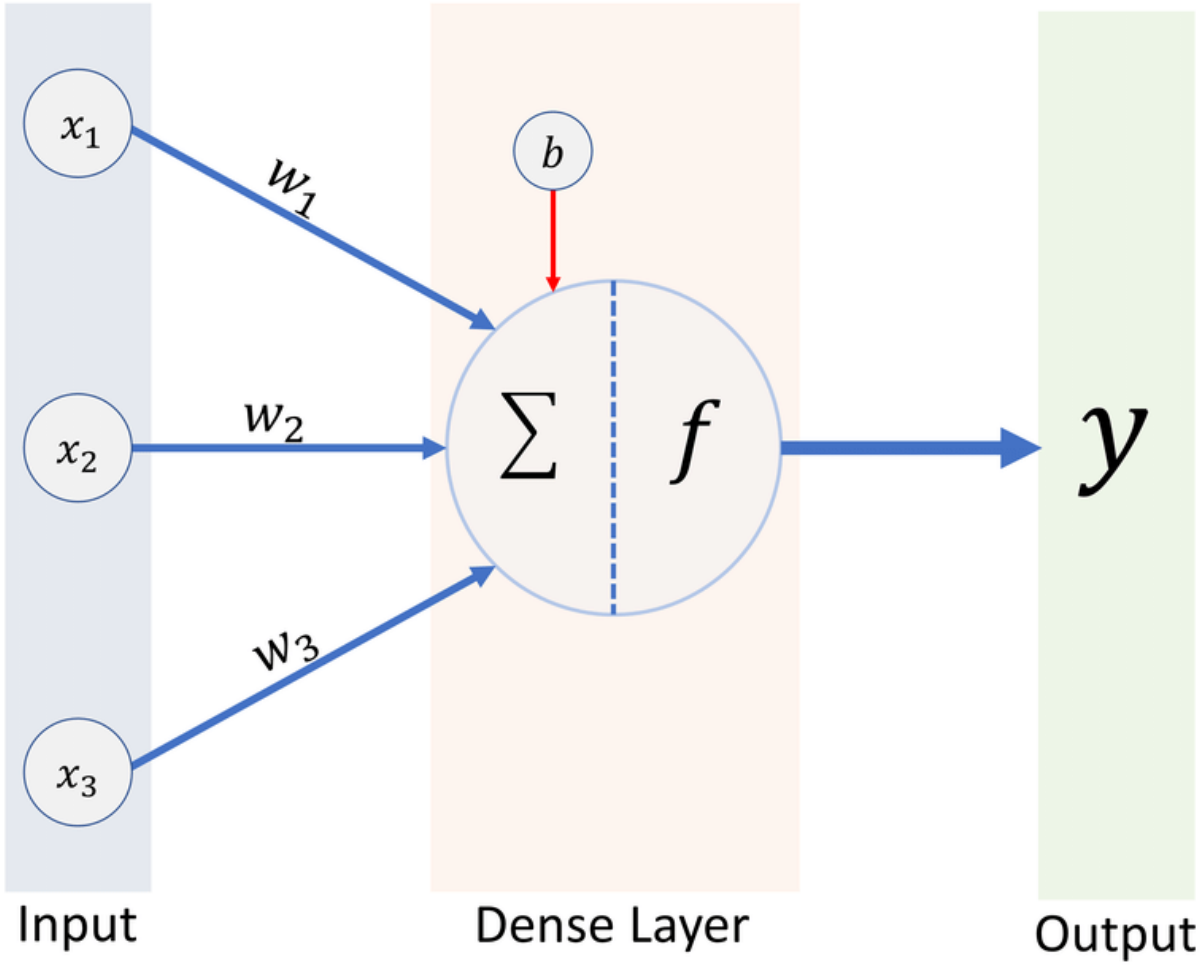
The input of the fully connected (dense) layer is

$$b + \sum_{i=1}^{n} x_i w_i$$

The output is

$$f\left(b + \sum_{i=1}^{n} x_i w_i\right)$$

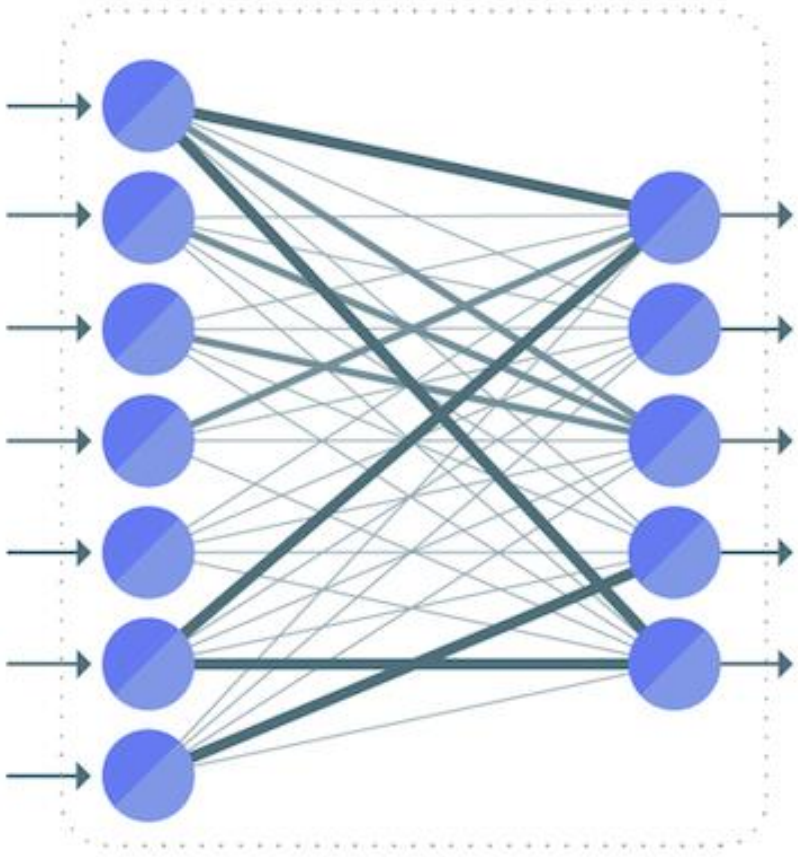
where f is the activation function



Hidden Layer: Fully Connected Layer

University of Roehampton London

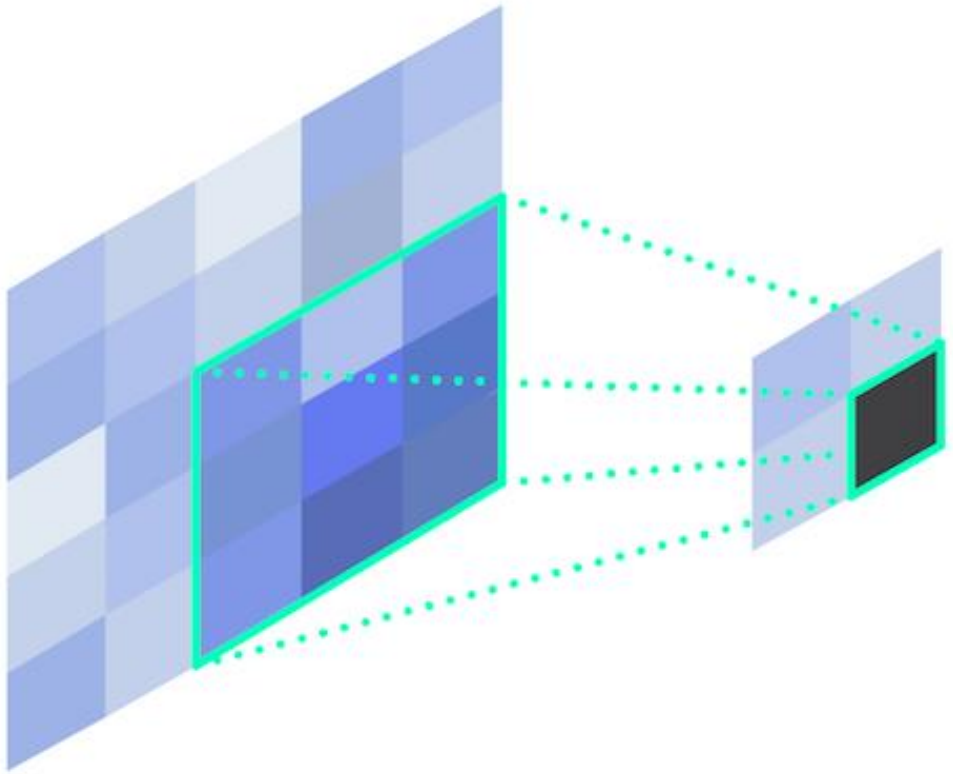
- Fully connected layers can become computationally expensive as their input grows, resulting in a combinatorial explosion of vector operations to be performed, and potentially poor scalability.
- As such, they are commonly used for specific purposes within neural networks such as classifying image data.



Hidden Layer: Convolution Layer

University of Roehampton London

- A Convolution Layer is an important type of layer in a CNN.
- Its most common use is for detecting features in images, in which it uses a filter to scan an image, a few pixels at a time, and outputs a feature map that classifies each feature found.

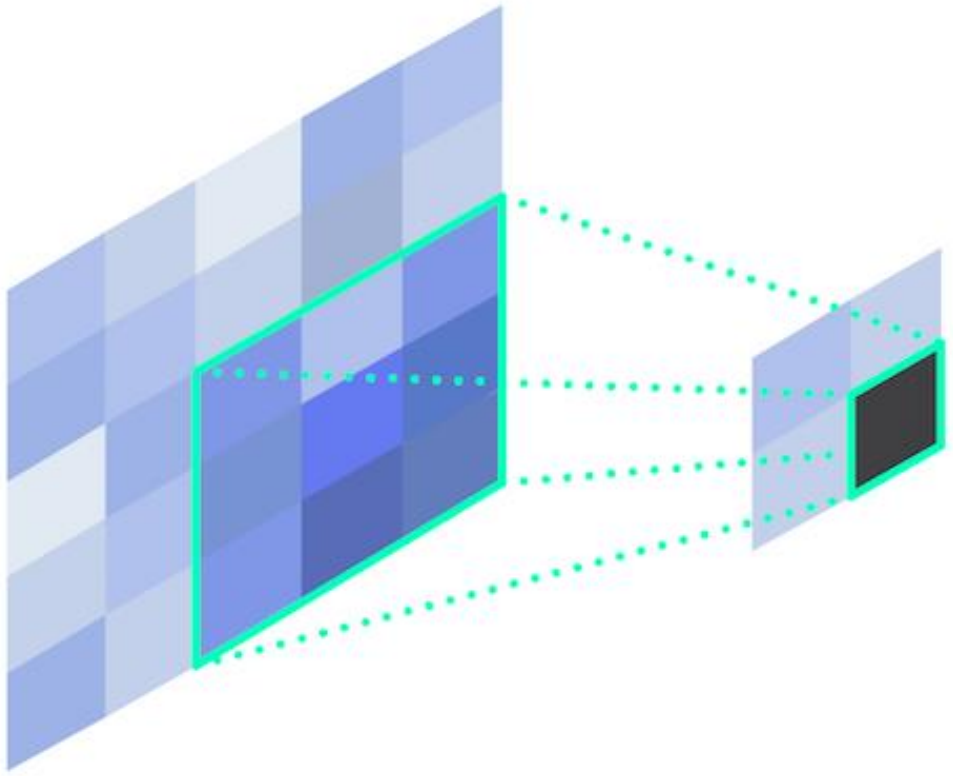


Hidden Layer: Convolution Layer

University of Roehampton London

- The filter (sometimes called kernel) is a set of n-dimensional weights that are multiplied against the input

- The filter's dimensions match that of the input (e.g., two dimensions when dealing with 2D images).



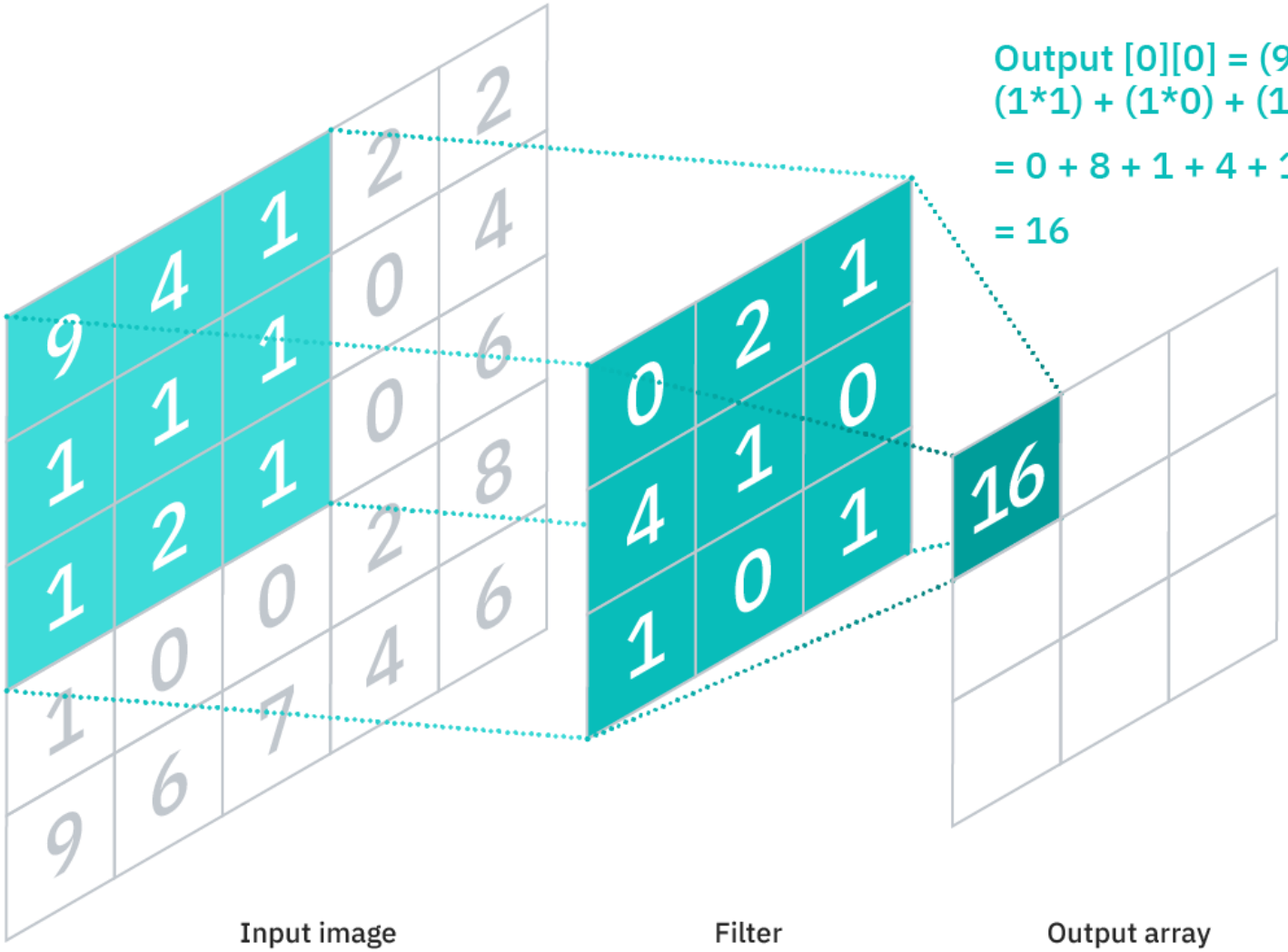
Hidden Layer: Convolution Layer

University of Roehampton London

- The filter describes the probabilities that a given pattern of pixels represents a feature.

- Thus, the number of filter weights (i.e., size of the filter) are smaller than the input, and the multiplication performed by the layer's convolution process is performed on "patches" of the image that match the filter size.

Hidden Layer: Convolution Layer



Output [0][0] = (9*0) + (4*2) + (1*4) + (1*1) + (1*0) + (1*1) + (2*0) + (1*1)

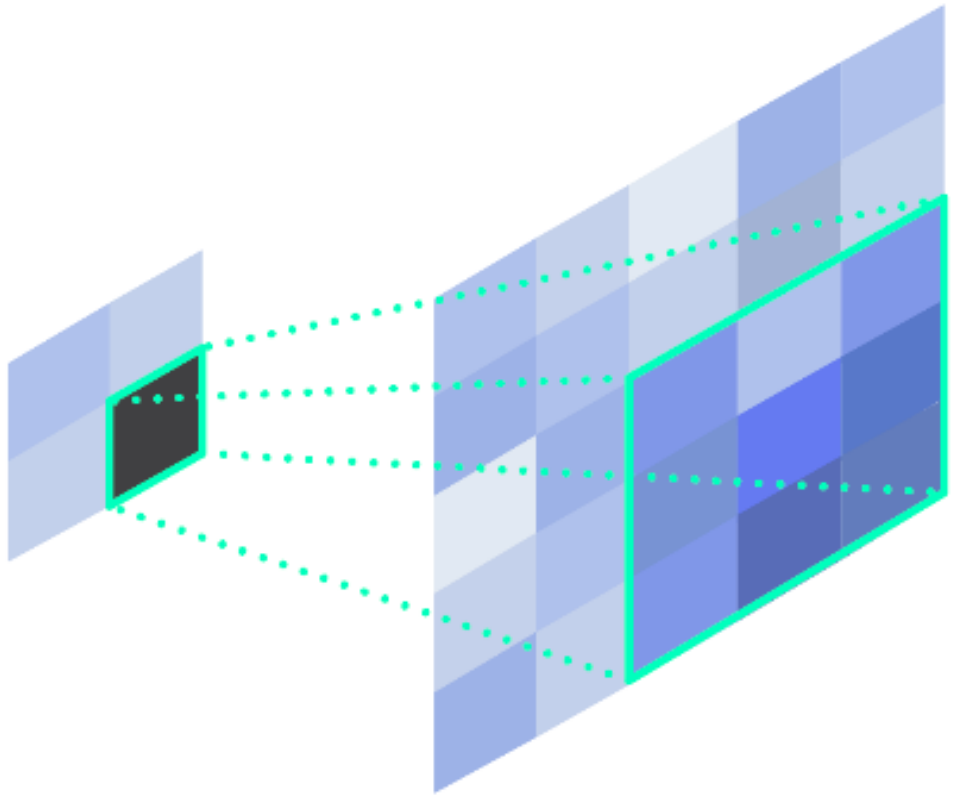
= 0 + 8 + 1 + 4 + 1 + 0 + 1 + 0 + 1

= 16

Hidden Layer: Convolution Layer

University of Roehampton London

- A Deconvolution Layer is a transposed convolution process that effectively upsamples data to a higher resolution.

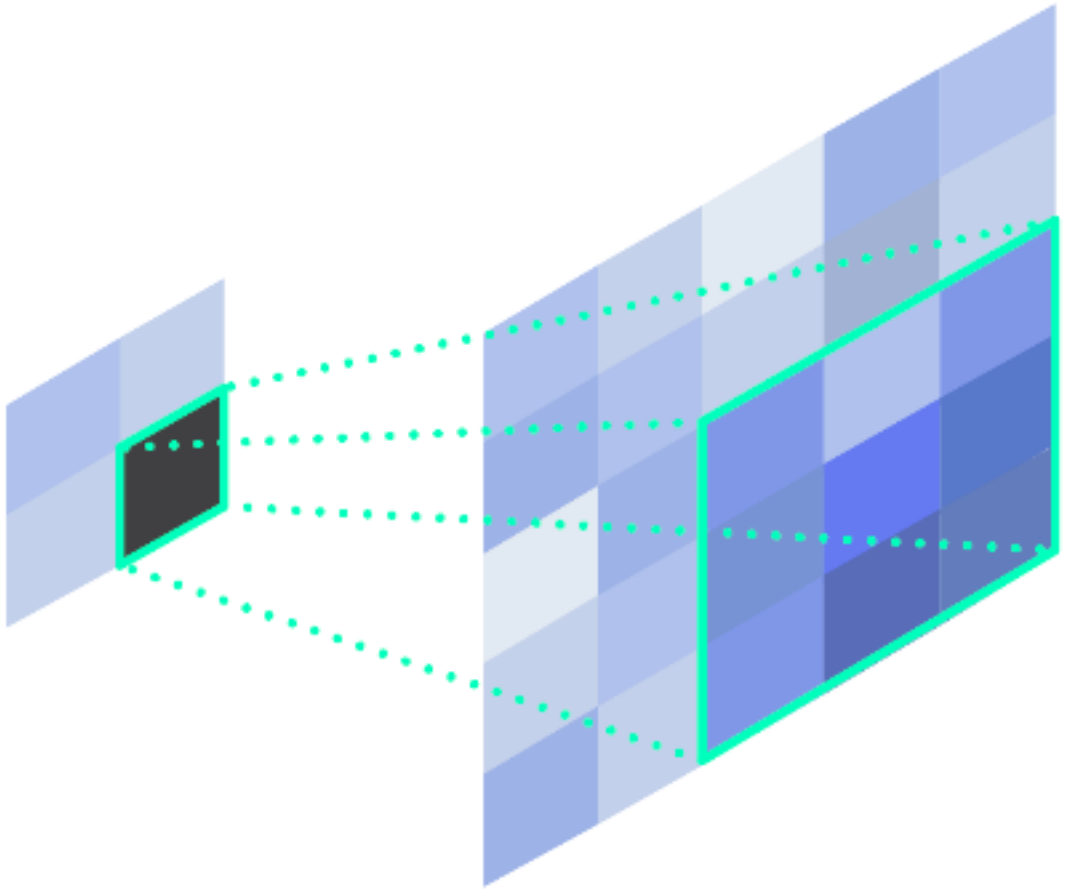


Hidden Layer: Convolution Layer

University of Roehampton London

- This can include image data and/or feature maps generated from a convolution layer, or other types of data.

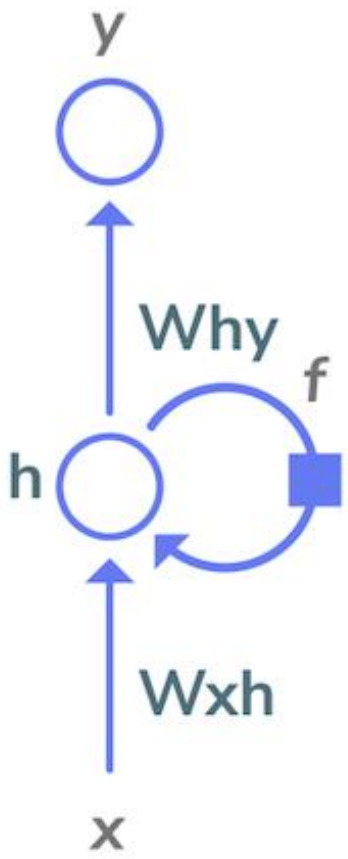
- For image data, the upsampling resolution output by deconvolution may be the same as the original input image or may be different.



Hidden Layer: Convolution Layer

University of Roehampton London

- A Recurrent Layer includes a "looping" capability such that its input consists of both the data to analyze as well as the output from a previous calculation performed by that layer.



Hidden Layer: Convolution Layer

University of Roehampton London

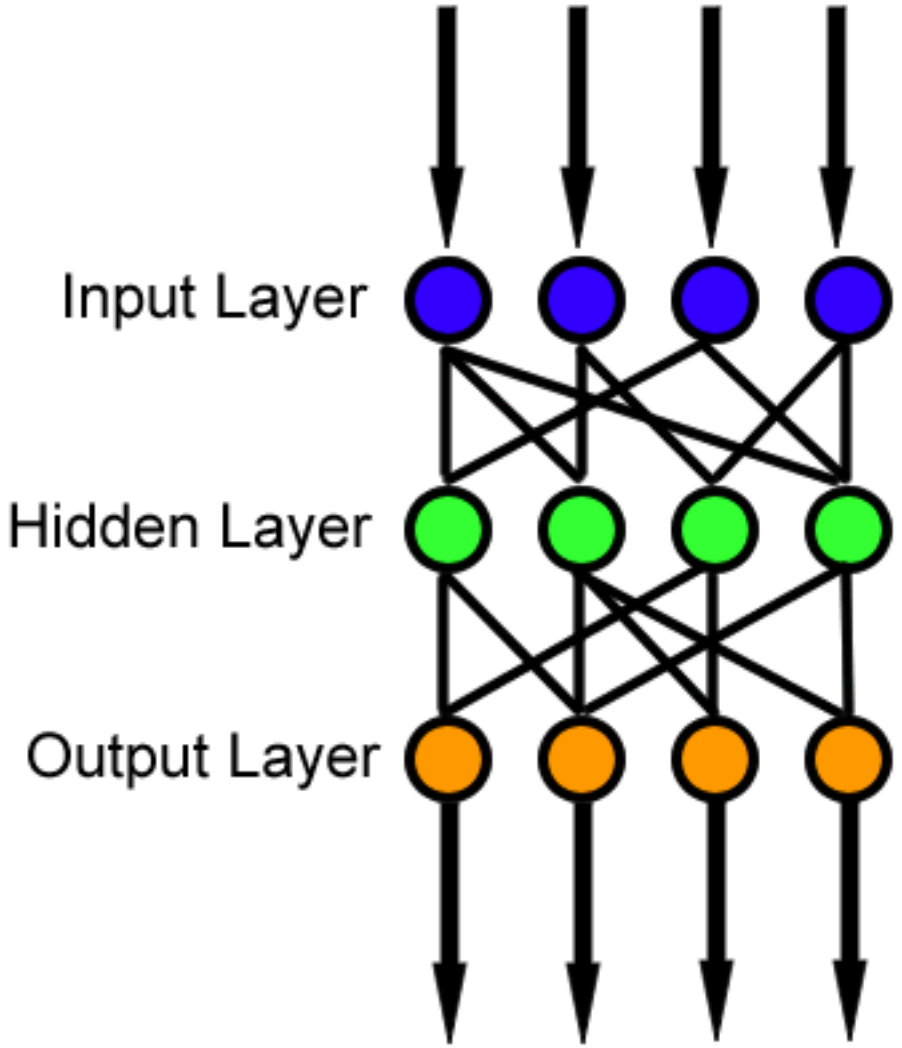
- Recurrent layers form the basis of recurrent neural networks (RNNs), effectively providing them with memory (i.e., maintain a state across iterations), while their recursive nature makes RNNs useful for cases involving sequential data like natural language and time series.

- They’re also useful for mapping inputs to outputs of different types and dimensions.

Output Layer

University of Roehampton London

- The output layer in an artificial neural network is the last layer of neurons that produces given outputs for the program.
- Though they are made much like other artificial neurons in the neural network, output layer neurons may be built or observed in a different way, given that they are the last “actor” nodes on the network



Output Layer

University of Roehampton London

- The output layer is the layer in a neural network model that directly outputs a prediction. All feed-forward neural network models have an output layer.

- There are perhaps three activation functions you may want to consider for use in the output layer; they are:
  - Linear
  - Logistic (Sigmoid)
  - Softmax

An Example

University of Roehampton London