PYTHON PROGRAMMING AND MACHINE LEARNING

DEEP LEARNING

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Objectives

- Understand the application of transfer learning and able to implement a simple transfer learning classifier

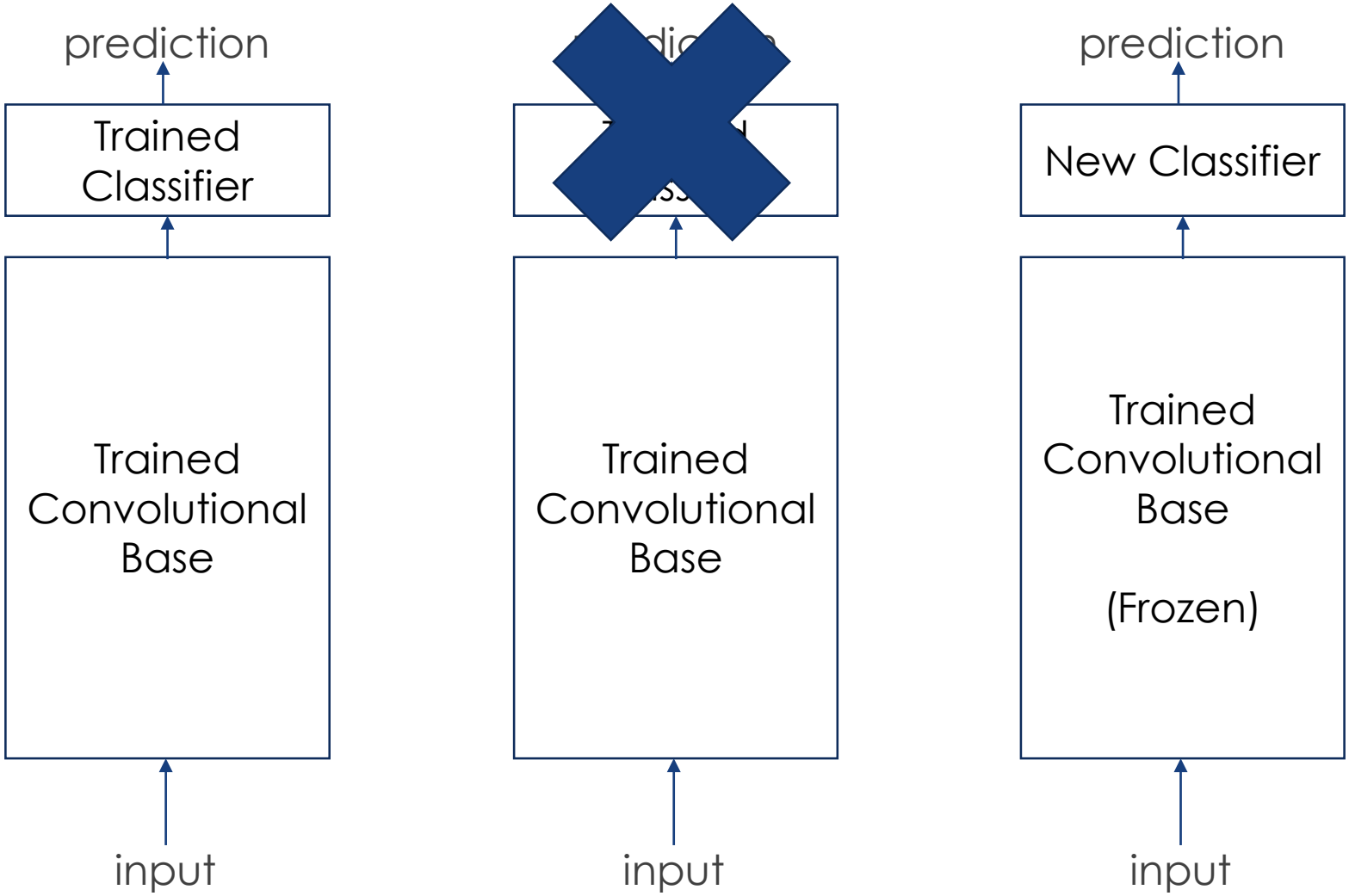
- Understand major deep learning architecture and their related terminology

TRANSFER LEARNING

Transfer Learning

- Instead of training a deep learning model from scratch, we take a known good model and use it as the base/starting point for another model
- We train the new model using our data and labels
- We can get a good result quickly

Transfer Learning Procedure



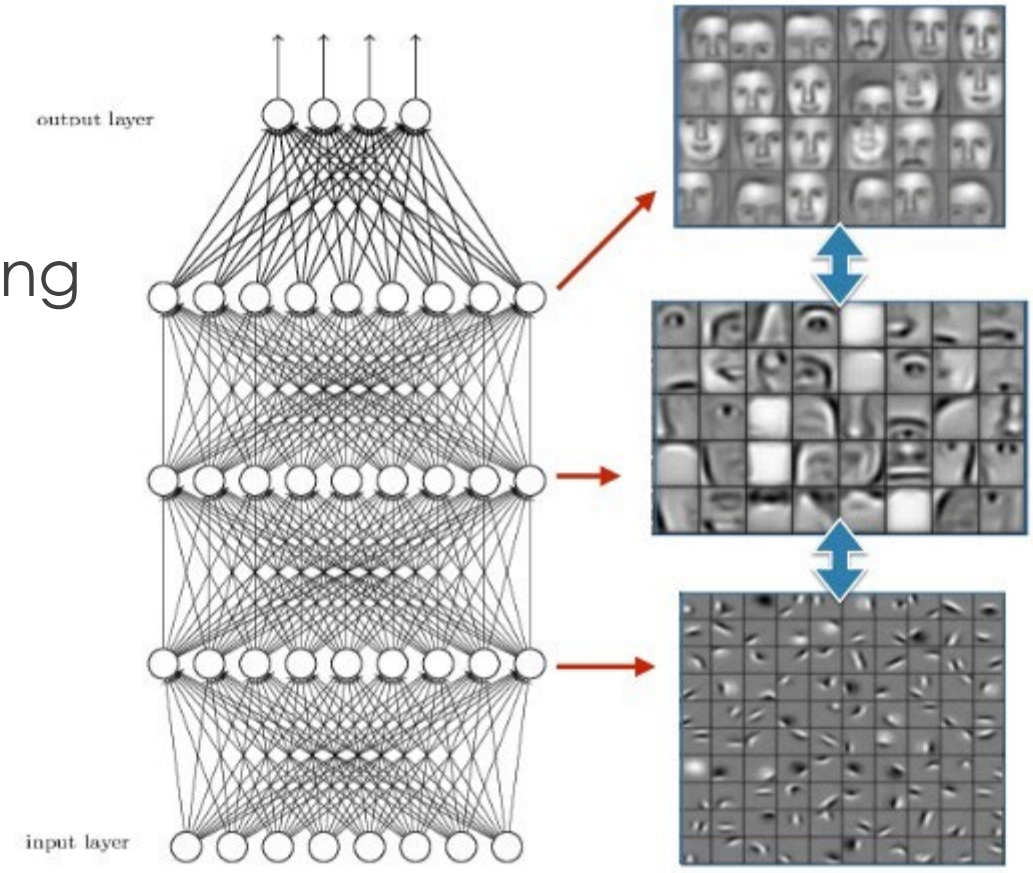
Original Model

Remove the Top

Replace with a new classifier

Intuition behind Deep Learning Model

- The perceptrons in the network represent different concepts
- Imagine them as a detector for something
- The lower layers contains low level detectors
- The higher layers contains high level detectors



Transfer Learning

- When we do transfer learning, we use the high level detectors to provide us useful features from our samples.
- We then train our neural network classifiers based on these features

DEEP LEARNING ARCHITECTURES

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A mostly complete chart of

Neural Networks

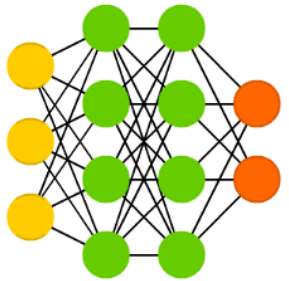
- Backfed Input Cell
- Input Cell
- Noisy Input Cell
- Hidden Cell
- Probablistic Hidden Cell
- Spiking Hidden Cell
- Output Cell
- Match Input Output Cell
- Recurrent Cell
- Memory Cell
- Different Memory Cell
- Kernel
- Convolution or Pool

Perceptron (P)

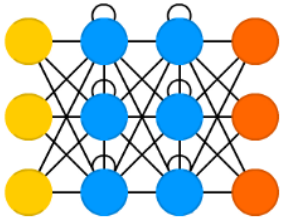
Feed Forward (FF)

Radial Basis Network (RBF)

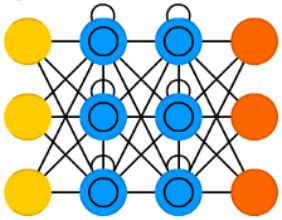
Deep Feed Forward (DFF)



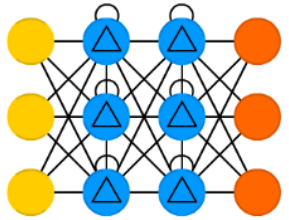
Recurrent Neural Network (RNN)



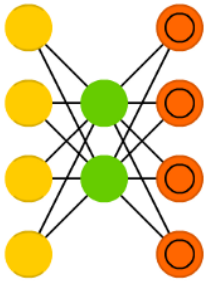
Long / Short Term Memory (LSTM)



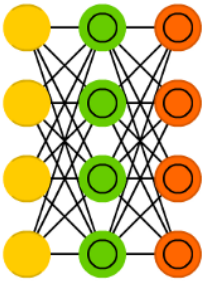
Gated Recurrent Unit (GRU)



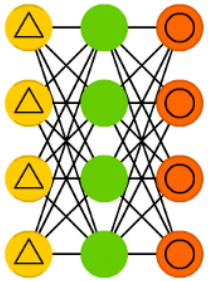
Auto Encoder (AE)



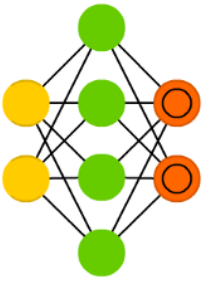
Variational AE (VAE)

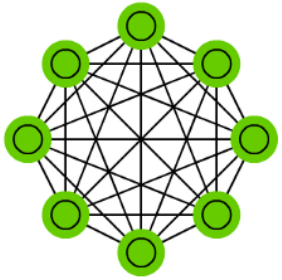
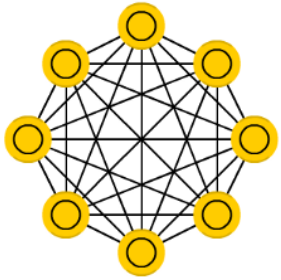
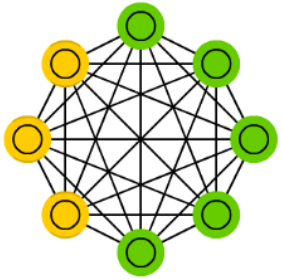
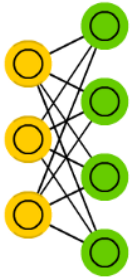
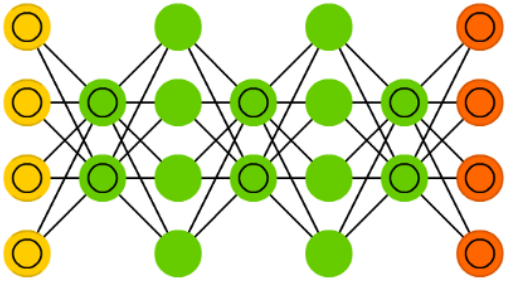


Denoising AE (DAE)

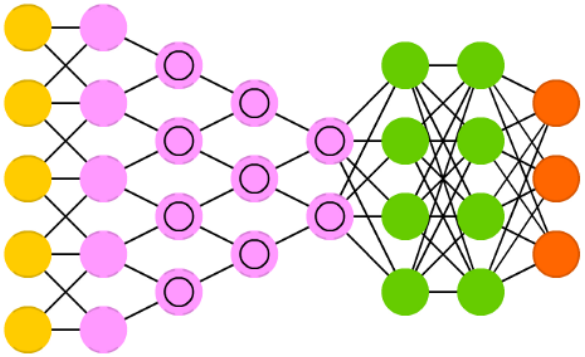


Sparse AE (SAE)

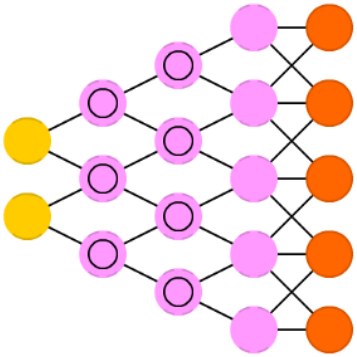


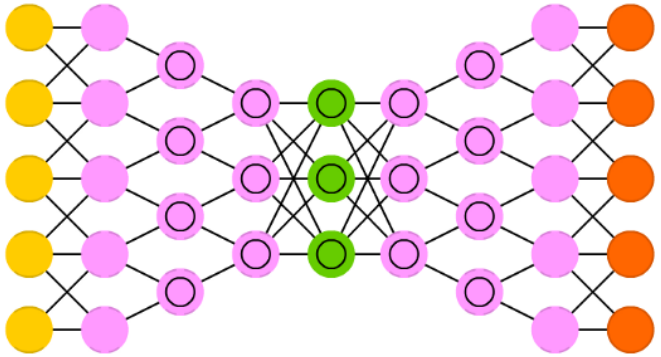
Deep Convolutional Network (DCN)



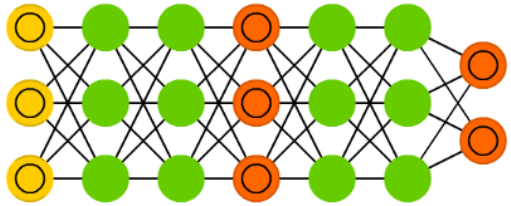
Deconvolutional Network (DN)



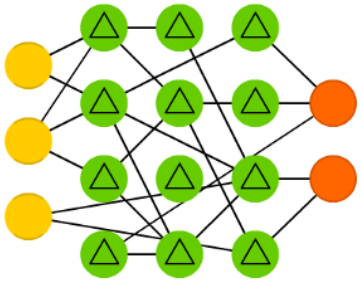
Deep Convolutional Inverse Graphics Network (DCIGN)



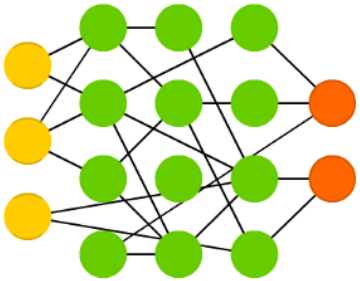
Generative Adversarial Network (GAN)



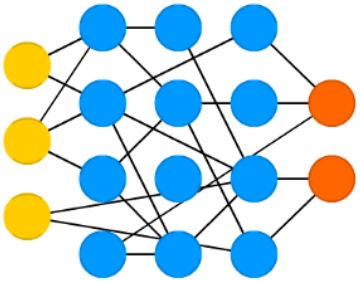
Liquid State Machine (LSM)



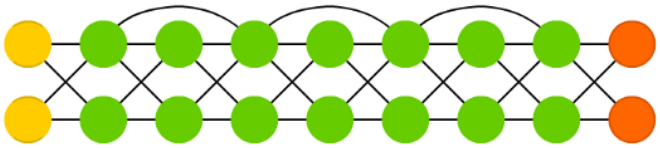
Extreme Learning Machine (ELM)



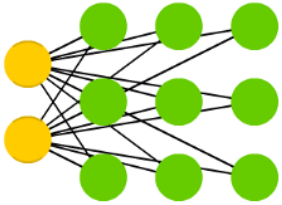
Echo State Network (ESN)



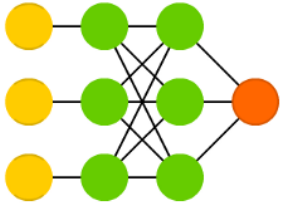
Deep Residual Network (DRN)



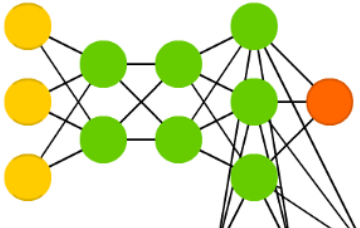
Kohonen Network (KN)



Support Vector Machine (SVM)



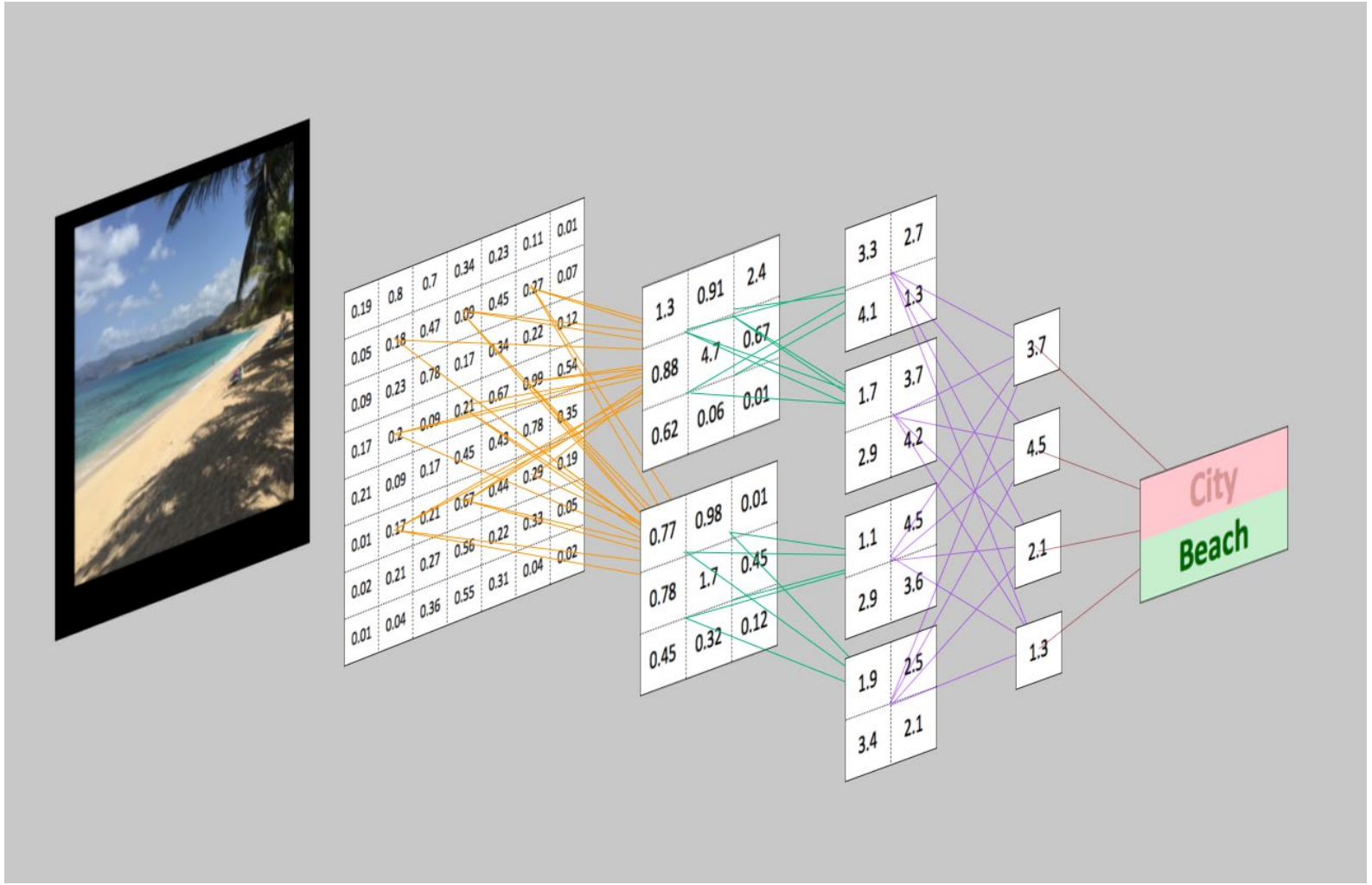
Neural Turing Machine (NTM)



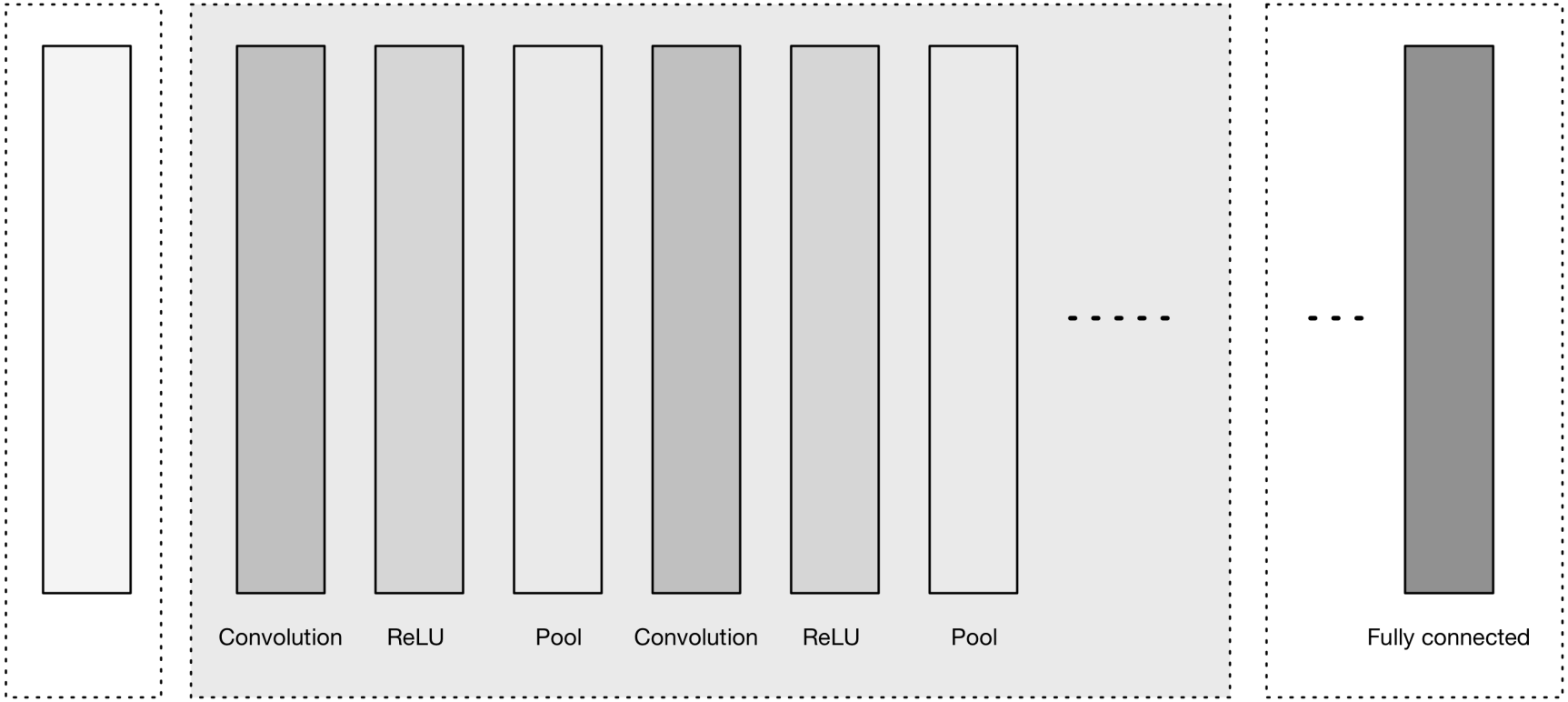
Convolutional Neural Network

- The goal of a CNN is to learn higher-order features in the data via convolutions.
- They are well suited to object recognition with images and consistently top image classification competitions. They can identify faces, individuals, street signs, platypuses, and many other aspects of visual data.
- Other applications
  - optical character recognition,
  - analyzing words as discrete textual units
  - analyzing sound.

CNN



CNN Architecture Overview



Input layer

Feature-extraction layers

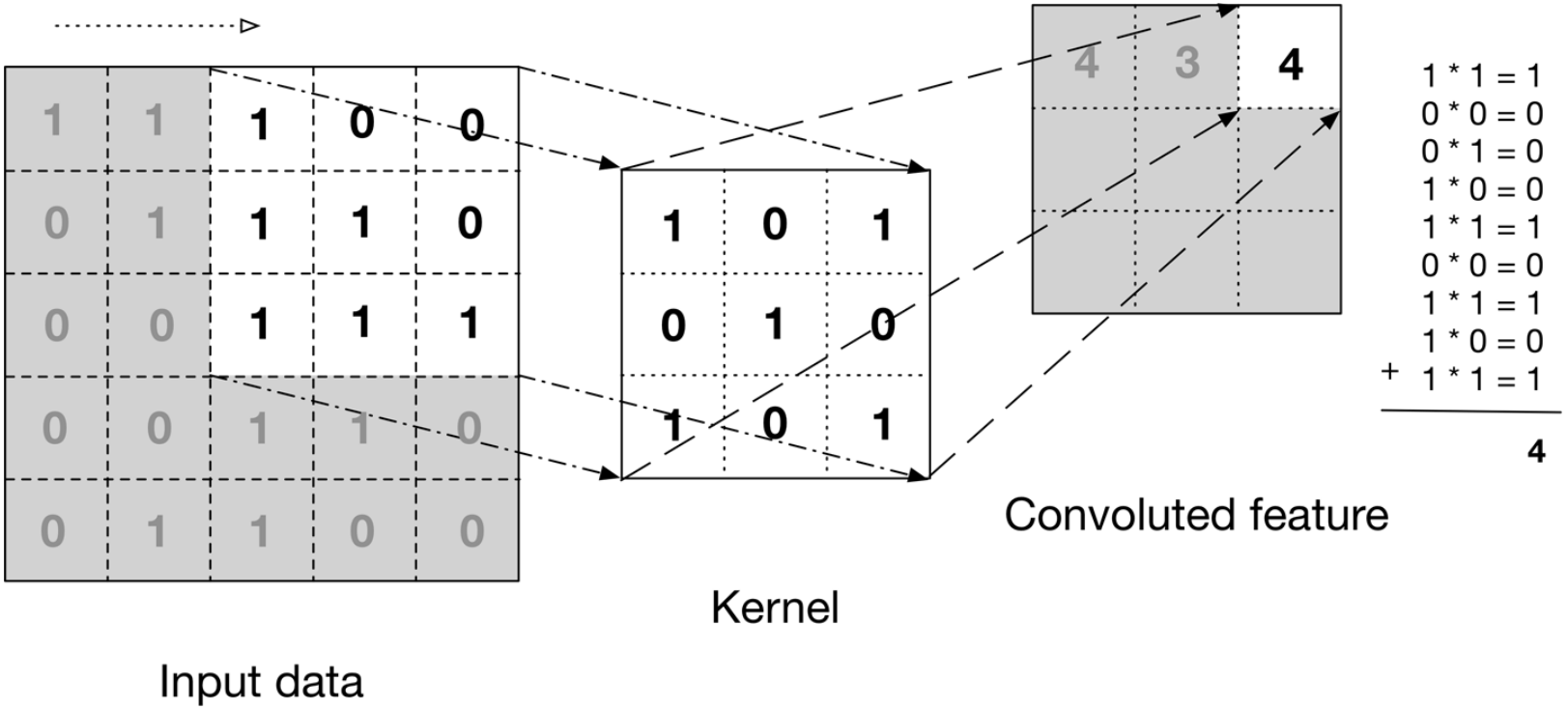
Classification layers

CNN General Pattern

The feature-extraction layers have a general repeating pattern of the sequence:

- Convolution layer
  - We express the Rectified Linear Unit (ReLU) activation function as a layer in the diagram here to match up to other literature.
- Pooling layer
  - These layers find a number of features in the images and progressively construct higher-order features. This corresponds directly to the ongoing theme in deep learning by which features are automatically learned as opposed to traditionally hand engineered.

Convolution



CNN Summary

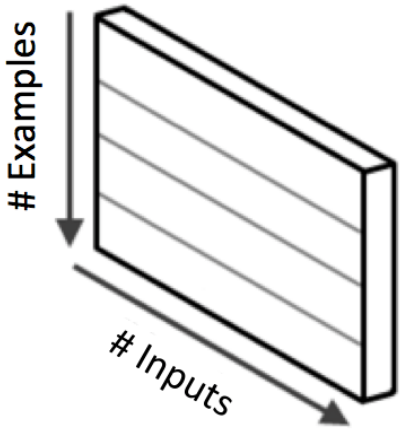
- Evolved for specialized feature extraction from image data.
- Layers that are good at finding features no matter where they "roam" across columns.
- Very common for image classification.

Recurrent Neural Network

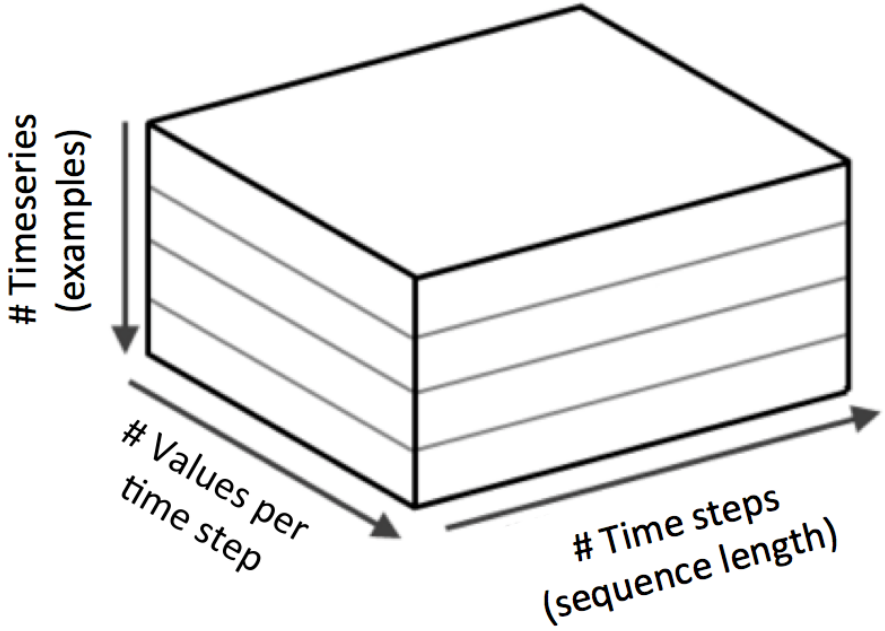
- Popular for their ability to send information over time steps
- Take each vector from a sequence of input vectors and model them one at a time. This allows the network to retain state while modeling each input vector across the window of input vectors.
- RNN is able to model the time dimension

RNN vs. Normal Feed Forward Data

Feed-Forward Network Data



Recurrent Network Data



Vector columns

	Values
albumin	0.0
alp	1.0
alt	0.5
ast	0.0
...	

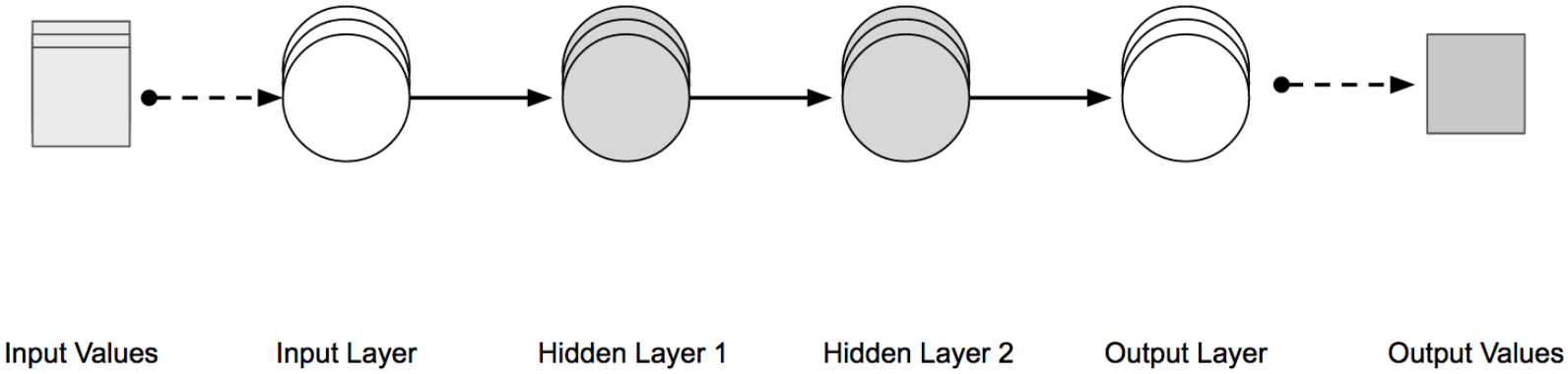
Vector columns

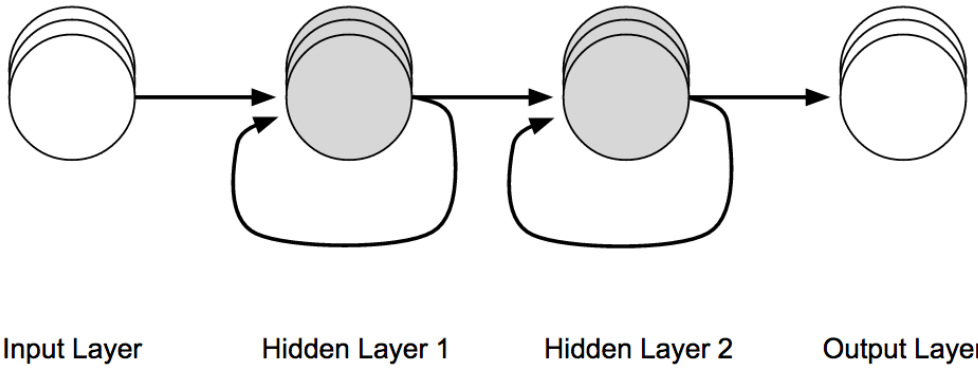
	0	1	2	3	4	...
albumin	0.0	0.0	0.5	0.0	0.0	
alp	0.0	0.1	0.0	0.0	0.2	
alt	0.0	0.0	0.0	0.9	0.0	
ast	0.0	0.0	0.0	0.0	0.4	
...						

LSTM Networks

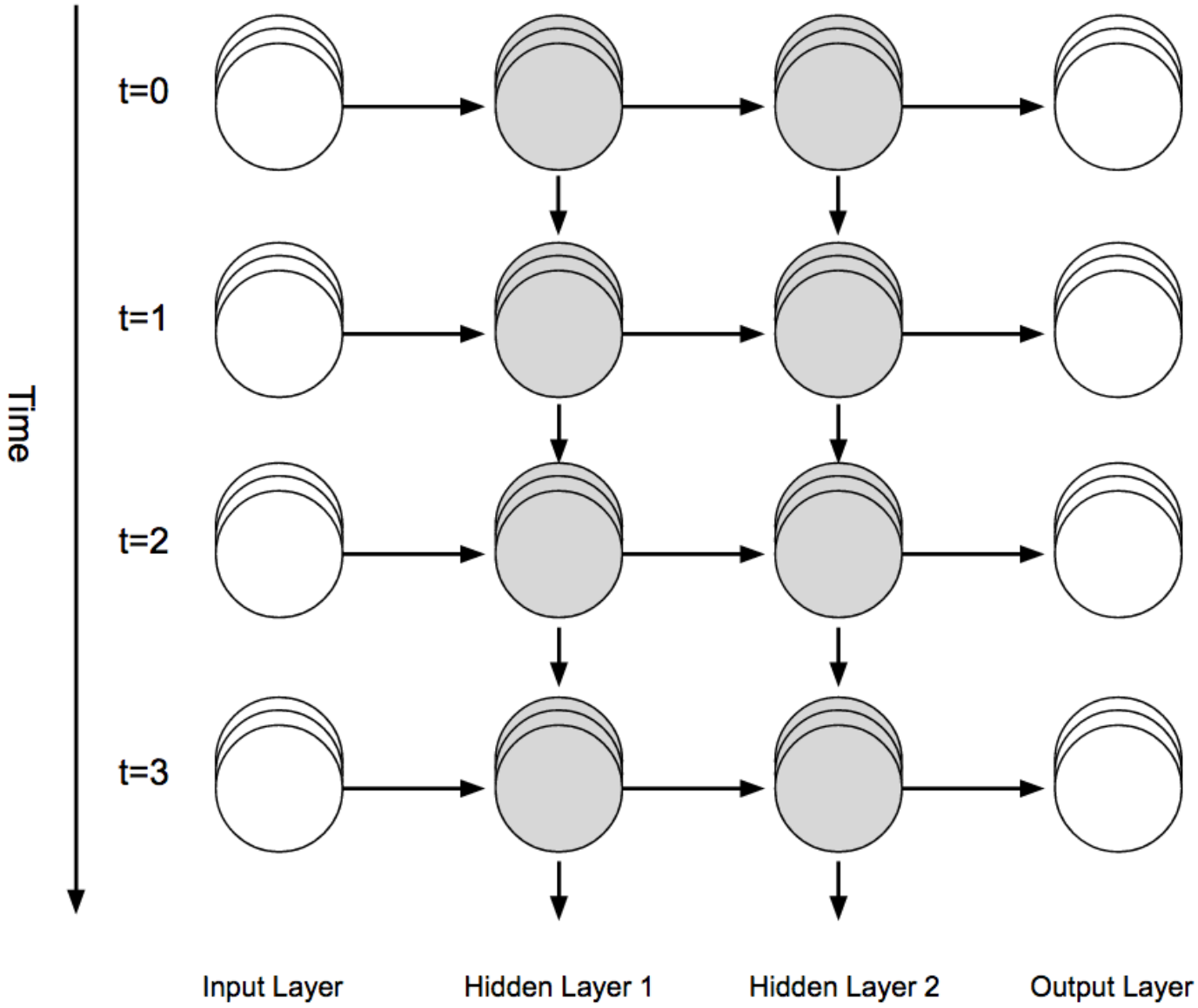
- LSTM networks are the most commonly used variation of Recurrent Neural Networks
- Introduced in 1997 by Hochreiter and Schmidhuber
- The critical component of the LSTM is the memory cell and the gates (including the forget gate, but also the input gate). The contents of the memory cell are modulated by the input gates and forget gates.

Normal Feed Forward vs LSTM





LSTM



Common use for LSTM

- Generating sentences (e.g., character-level language models)
- Classifying time-series
- Speech recognition
- Handwriting recognition
- Polyphonic music modeling

LSTM Unit as variant of a neuron

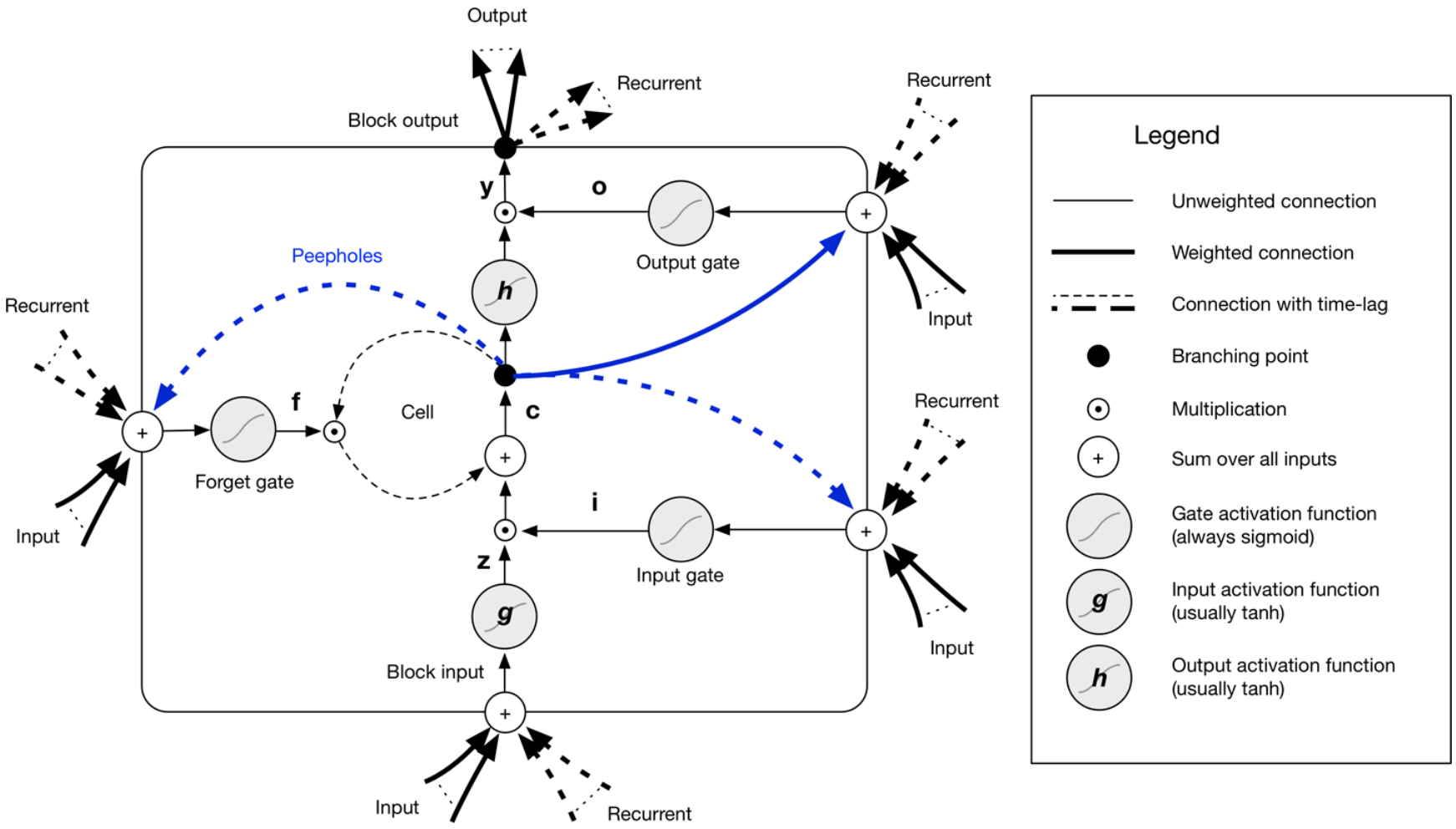


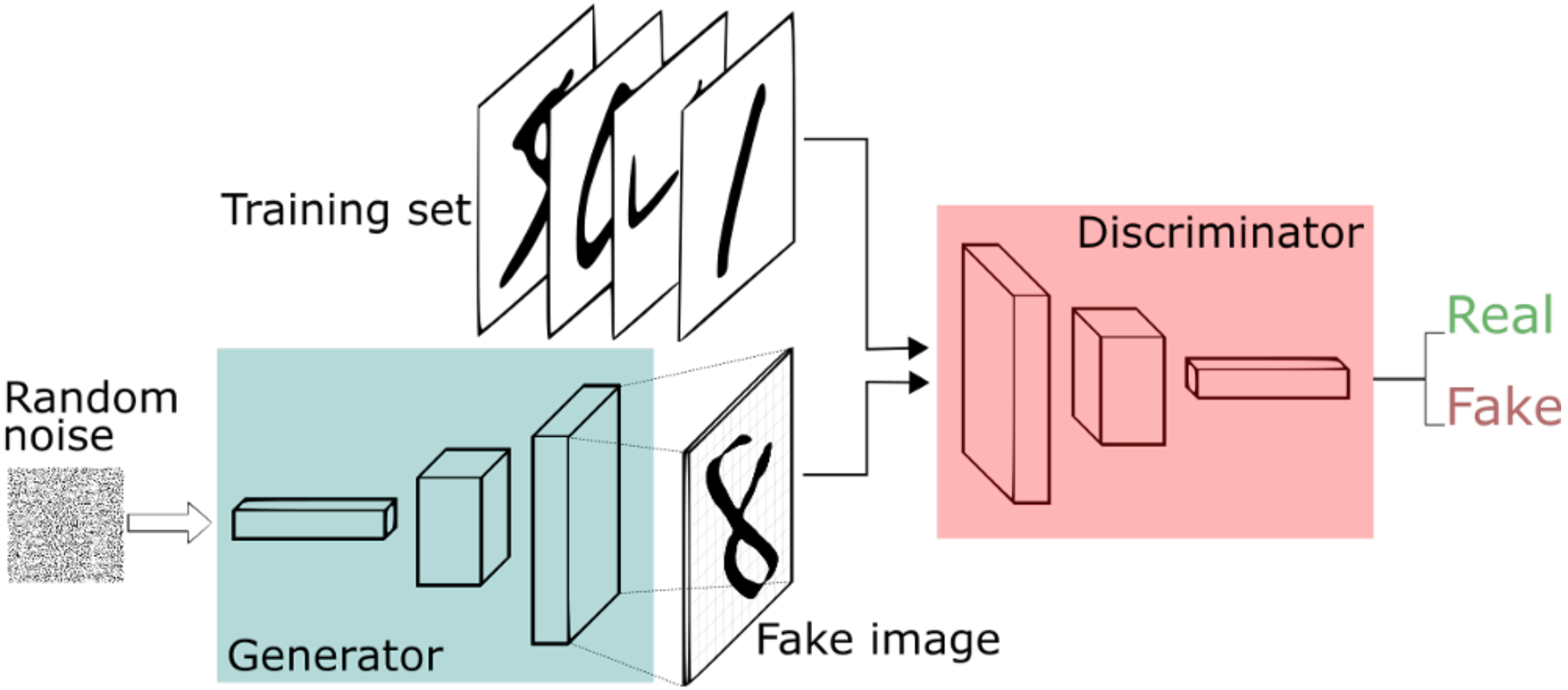
Image credit: Deep Learning book

Generative Adversarial Networks

- GANs have been shown to be quite adept at synthesizing novel new images based on other training images.
- Can be extended to model other domains such as :
  - Sound
  - Video
  - Generating images from text descriptions

Generative Adversarial Networks

- uses unsupervised learning to train two models in parallel.



Generative Adversarial Networks

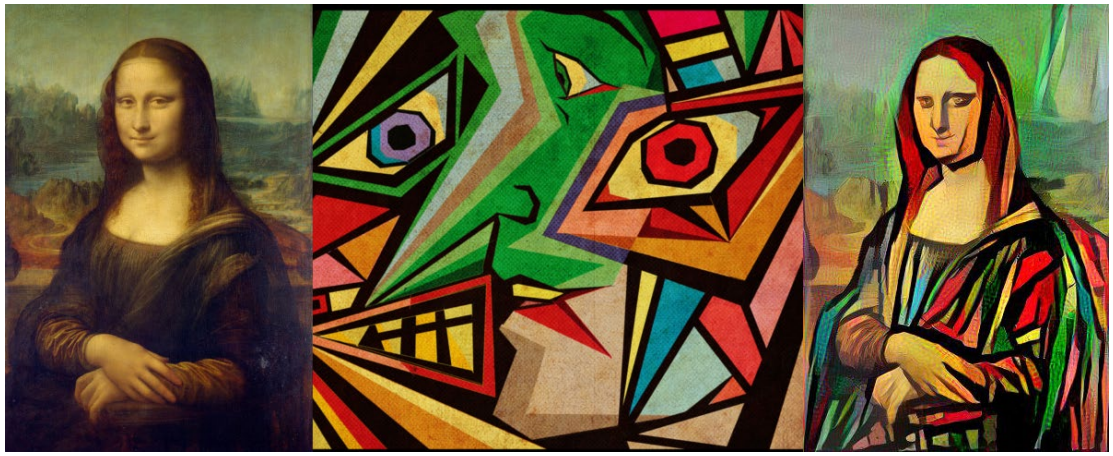
- Create a constant battle between the two network
- Generator try to fool the discriminator
- Discriminator try not to be fooled

- When modeling images, the discriminator network is typically a standard CNN
- The generative network in GANs generates data (or images) with a special kind of layer called a *deconvolutional layer*

GAN example

- DeepFake
  - https://www.youtube.com/watch?v=T76bK2t2r8g

- Style Transfer



Summary

- We have discussed
  - Transfer Learning
  - Convolutional Neural Network (CNN)
  - Recurrent Neural Network (RNN)
  - Generative Adversarial Network (GAN)
- These represent some of the exciting innovation in neural network and deep learning.
- There are a lot of opportunity for creative applications of these techniques.