Deep Learning Background

Reinforcement Learning
School of Data Science
University of Virginia

Last updated: June 16, 2025

Purpose

Quick motivation and overview of deep learning

For details on DL, see Deep Learning by Goodfellow et. al.

Function Approximation and Deep Learning

As the state space grows, it can work better to use a function to approximate the Q function, rather than learn a table

Tables don't scale: updates are slow, and storage is prohibitive

Many approaches have been used for this function

Modern techniques favor deep learning

What is Deep Learning?

Deep Learning (DL) is a subset of machine learning

Uses a neural network with multiple hidden layers

Unlike traditional ML where predictors are selected by a human, in DL, predictors are learned as part of model training

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Deep Neural Network

Deep neural network

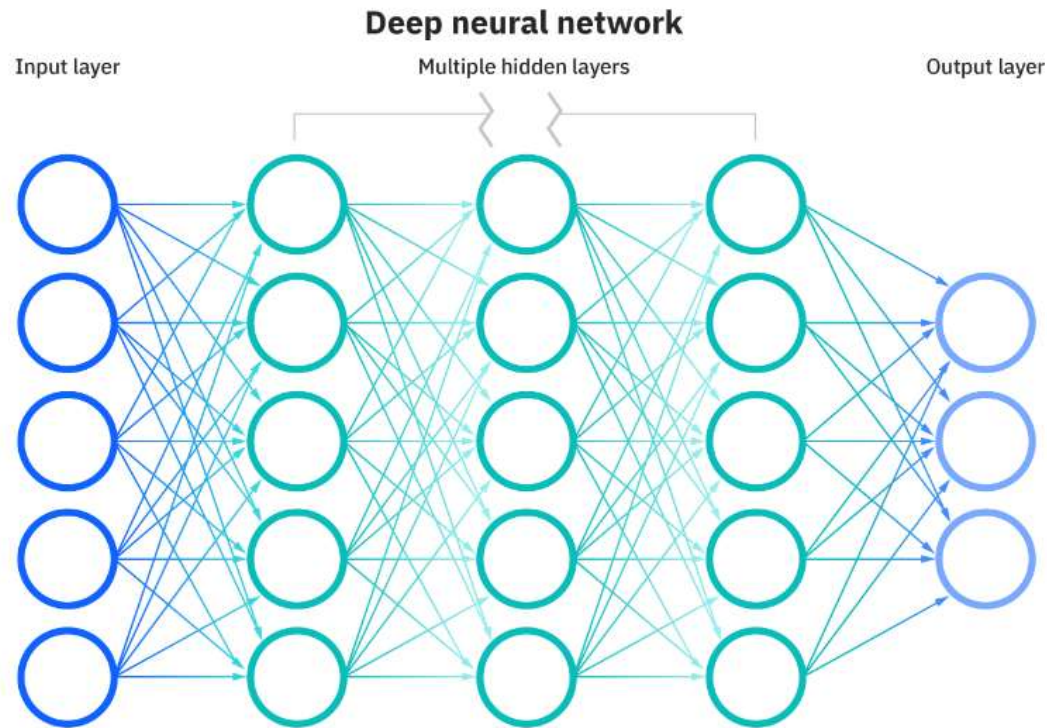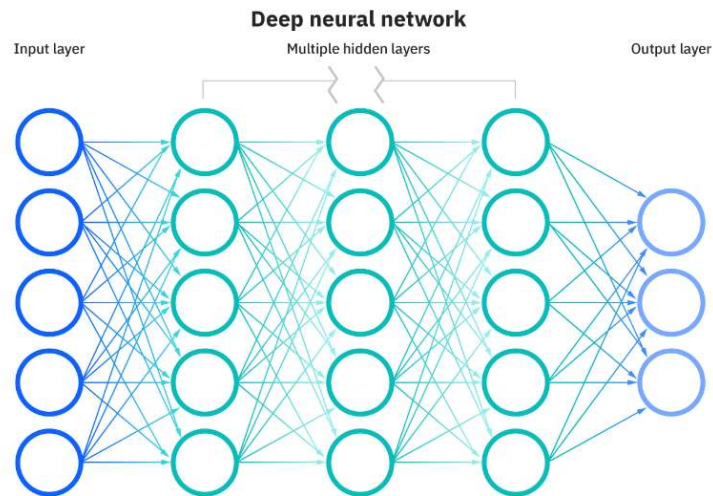Input layer   Multiple hidden layers   Output layer

Illustration of fully-connected multi-layer perceptron (MLP)

Deep Q-Network

Introduces non-linearities through non-linear activation functions

Deep neural network
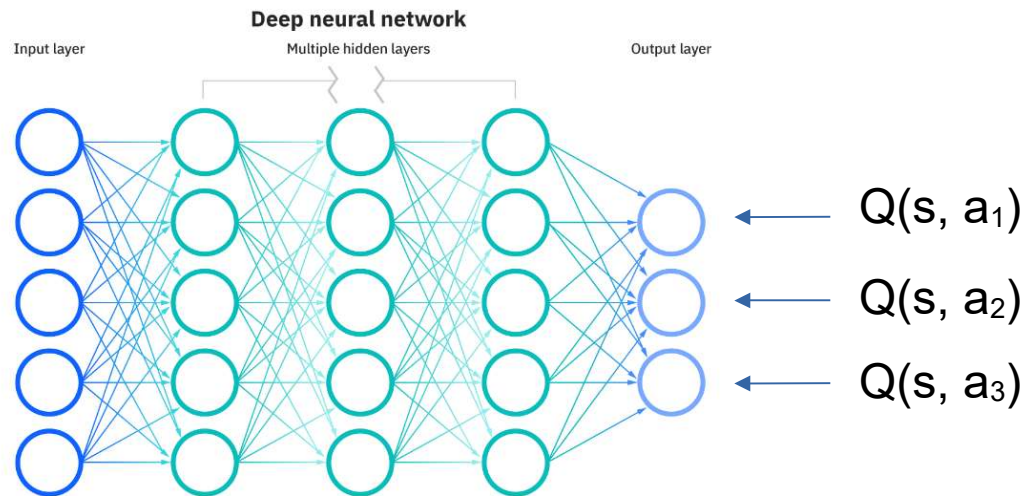
Input layer · Multiple hidden layers · Output layer

Deep Q-Network

Introduces non-linearities through non-linear activation functions
Mechanically, pass state vector as input
Output layer holds Q(s, a)

$Q(s, a_1)$

$Q(s, a_2)$

$Q(s, a_3)$

Architectures

Some Deep RL approaches use conventional architectures like:

- MLP

- Recurrent neural network (LSTM, GRU)

There are also customized Deep RL architectures:

- Dueling Networks

Will study these later

References

Deep Learning. Goodfellow, I., Bengio, Y. , Courville, A.

What are neural networks?
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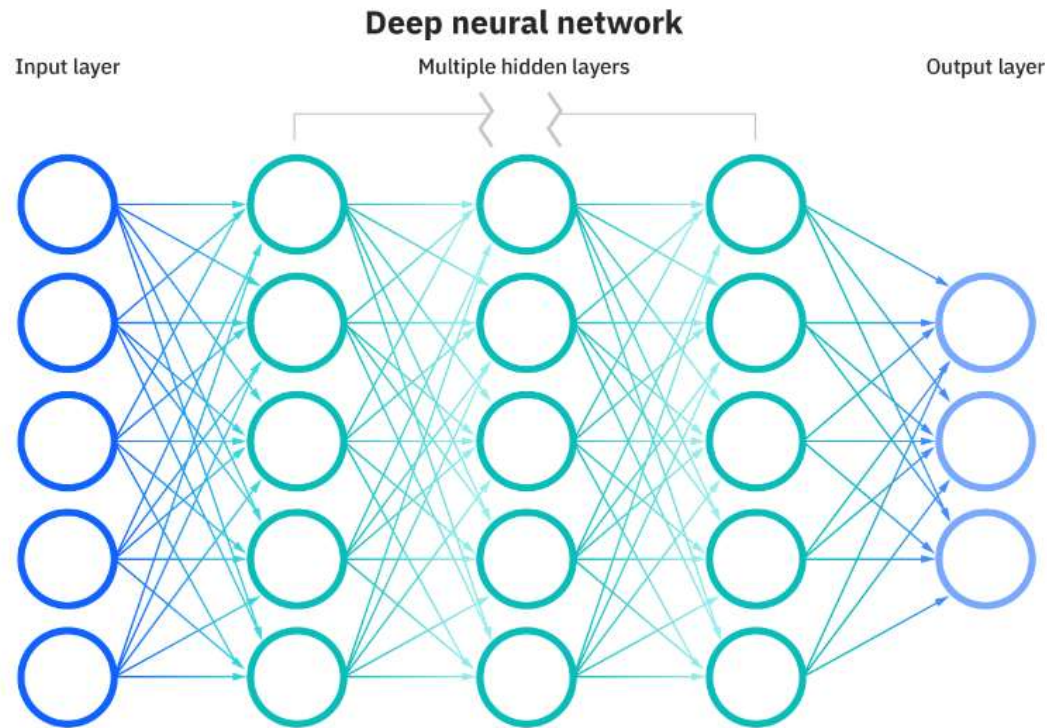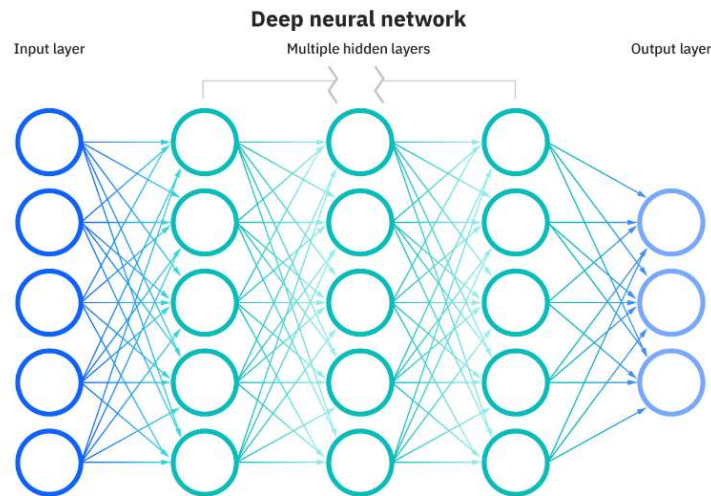
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Deep Q-Network

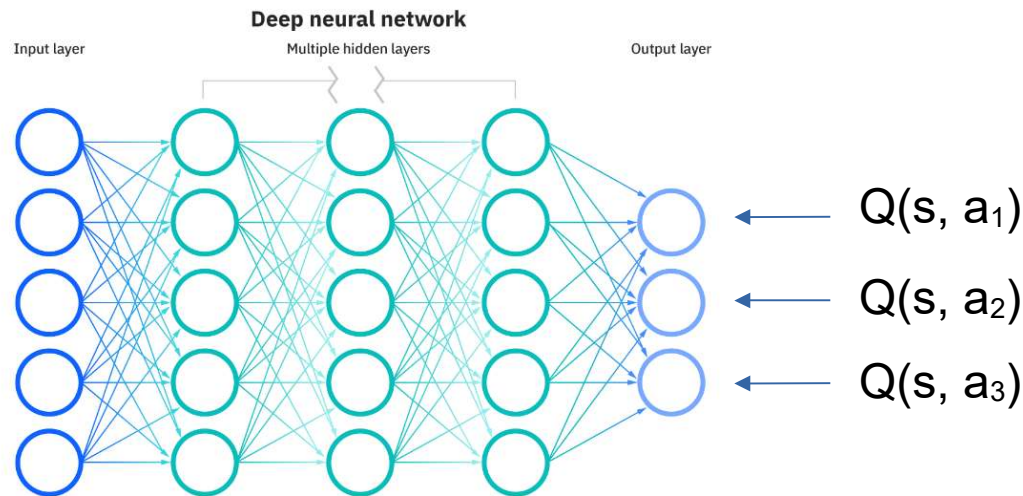Introduces non-linearities through non-linear activation functions

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