Machine Learning for Neuroscience

ML4NS

Slides and notebooks: `https://ml4ns.github.io`

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1. Introduction to Machine Learning

In lecture 1, we cover some of the basic concepts of machine learning. Machine learning is all about teaching machines, usually computers, to learn from data to make decisions or predictions without being explicitly programmed to do so. Machine learning algorithms have a wide variety of applications, including in medicine and clinical research, where it can be more challenging for humans to manually develop algorithms to perform the desired tasks and/or identify patterns from large volumes of data.

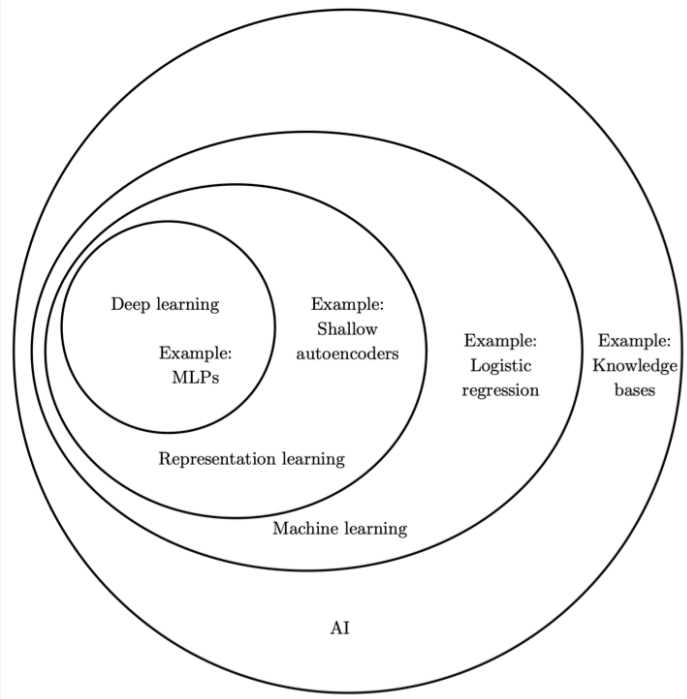

Figure 1. AI and Machine Learning
Source: Deep Learning, Ian Goodfellow et al., MIT Press.

In this first lecture, we discuss the core themes of machine learning, particularly in relation to artificial intelligence. We introduce the key components of machine learning development and summarise the three main types of machine learning approaches (supervised, unsupervised and reinforcement learning). We further expand on the objectives of the different types of supervised and unsupervised learning methods, citing examples for each. We also provide a concise discussion of the advantages and limitations of each method. Finally, we consider the importance of having a way to evaluate model performance in terms of suitability for use in real-world applications. Figure 1 shows some key topics related to AI and machine learning.

In principle, machines learn in two ways: by experience (i.e., unsupervised learning) or by examples (i.e., supervised) learning. In unsupervised learning, a machine learning algorithm explores a dataset, learns

patterns from the data, and/or identifies correlations between different parts of the data. An example of unsupervised learning is a clustering algorithm that can learn to group a dataset into different clusters based on their inherent similarity. In supervised learning, a machine learning method is given a set of examples and the outcome labels (i.e., training data). Supervised learning algorithms use different methods to learn to predict an outcome (e.g., if a patient has a disease or not based on a set of observations/measurements) by learning from the given examples and training the model to make sufficiently accurate predictions. The input data usually contains several attributes (e.g., age, heart rate, blood pressure, and body temperature for a patient data). These attributes are often referred to as features or dimensions in machine learning. Machine learning models usually accept the input data as a set of vectors in which each feature is a column (or a row if you consider a vertical vector).

There is another category of machine learning models called reinforcement learning. In reinforcement learning, an intelligent agent takes a series of actions to maximise a cumulative reward. For example, an intelligent agent learns to predict treatment regimes in a patient process, and each time it makes a correct prediction, a reward is given. Each time it makes a mistake, a penalty is applied. The method continues to learn until it converges to a stable and sufficiently reliable solution, or you can imagine an intelligent agent that learns to navigate a robot in an environment with different obstacles, and the reward is avoiding the obstacles. Reinforcement learning is seen as one of the three main machine learning categories alongside supervised and unsupervised learning methods.

The first tutorial (Python for Beginners) aims to build your familiarity with Python and some core Python libraries relevant to machine learning, including those used for data analytics and visualisation. The second tutorial (Machine Learning for Beginners) will then demonstrate the key techniques for machine learning development, including data pre-processing, building a model and model evaluation.

A corresponding assessment will help you evaluate your understanding of basic machine learning concepts and demonstrate the skills you have learned so far.