model

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Synonyms

hypothesis space, hypothesis class, model class

Abstract

In machine learning (ML), the word *model* is used in different ways. Formally, a model is a hypothesis space $\mathcal{H}$: the set of candidate hypothesis maps from which an ML method picks (or learns) one. In applied ML literature and in software libraries, the word *model* also refers to the trained predictor, i.e., to the learned hypothesis returned by an ML algorithm; the EU AI Act uses this sense in the compound term general-purpose AI model (GPAI model). A different type of mathematical model is a probabilistic model, which specifies a family of probability distributions that characterize a data generation process.

Definition

Consider the problem of predicting tomorrow's maximum daytime temperature from today's morning temperature. Machine learning (ML) methods learn a hypothesis map $\hat{h}$ that reads in today's morning temperature and delivers an accurate prediction of tomorrow's maximum temperature. This learned hypothesis is chosen from a (typically large) set of candidate hypothesis maps, i.e., a hypothesis space $\mathcal{H}$.

The hypothesis space underlying an ML application is often referred to as the model of the method (Goodfellow et al., 2016, Sect. 5.1). For example, linear regression and logistic regression use the linear model as hypothesis space. A decision tree method uses a hypothesis space that consists of hypothesis maps generated by a flow chart. Large language model (LLM) systems use a hypothesis space consisting of non-linear maps represented by an artificial neural network (ANN).

Model training refers to the process of finding a hypothesis in the hypothesis space that yields accurate predictions. Strictly speaking, a trained (or fitted) model represents a learned hypothesis $\hat{h}$. In applied ML literature and in software libraries, the word *model* typically refers to a trained model, i.e., to a specific hypothesis map $\hat{h}$ (Goodfellow et al., 2016, Sect. 5.1; Murphy, 2012, Sect. 3.5.2; Prince, 2023). The EU AI Act uses the word *model* in the same sense (i.e., a learned hypothesis) in the compound term general-purpose

AI model (GPAI model) (European Parliament and Council of the European Union, 2024, Art. 3(63)).

A different type of mathematical model is a probabilistic model, which specifies a family of probability distributions. Each such probability distribution defines a data generator: data points are realizations of independent and identically distributed (i.i.d.) random variables (RVs) with the given probability distribution.

Fig. 1 illustrates these three uses of the word *model*: the hypothesis space, the trained model, and the probabilistic model.

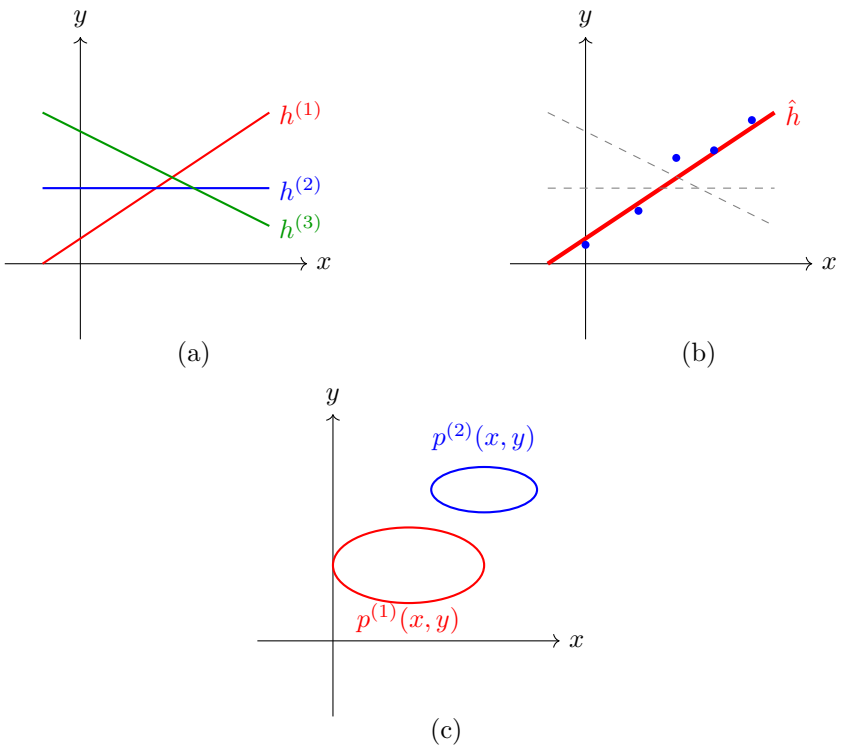

Figure 1: Three uses of the word *model* in ML practice. (a) Hypothesis space consisting of three linear maps. (b) Trained model: the learned hypothesis $\hat{h} = \mathcal{A}(\mathcal{D}^{(\text{train})})$ selected from the hypothesis space in (a) by an ML map $\mathcal{A}$ acting on a training set $\mathcal{D}^{(\text{train})}$ of data points (blue circles). (c) Probabilistic model consisting of two probability distributions for the generation of data points with feature x and label y

Cross References

hypothesis space, hypothesis, model parameter, parametric model, training, ERM, probabilistic model, probability distribution, decision tree, neuron, ANN,

transformer, LLM, GPAI model, AI system

References

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