At a Glance.

- three main components of machine learning (ML): data, model and loss
- data consists of data points, each characterized by
  - features: properties that can be measured easily
  - labels: properties that cannot be measured easily
- model consists of hypothesis maps
- loss measures the quality of a hypothesis map

Data point = An Image $\mathbf{z}$

Features:

- $x_1, \ldots, x_d$: Colour intensities of all image pixels.
- x_{d+1}: Time-stamp of the image capture.
- x_{d+2}: Spatial location of the image capture.

Labels:

- y_1: Number of cows depicted.
- y_2: Number of wolves depicted.
- y_3: Condition of the pasture (e.g., healthy, overgrazed).

Data point = An Audio Recording $\mathbf{z}$

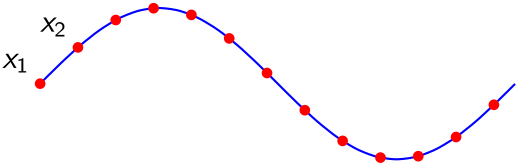
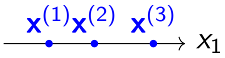
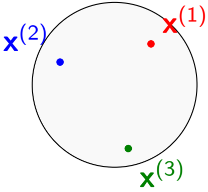


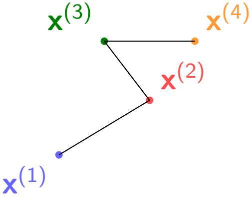
Figure: An audio signal (blue waveform) $\mathbf{z}$ and its discretized signal samples (red dots) which can be used as its features $x_1, \ldots, x_d$.

Feature space

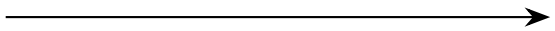
- often we use a fixed number $d \in \mathbb{N}$ of features
- stack them into a feature vector $\mathbf{x} = \big(x_1, \ldots, x_d\big)$
- feature vectors belong to some feature space $\mathcal{X}$
- most widely-used (by far) choice is $\mathcal{X} = \mathbb{R}^d$



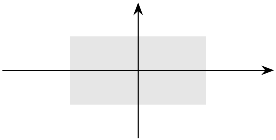




Label space

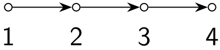


(a) $\mathcal{Y} = \mathbb{R}$ (regression)



(b) $\mathcal{Y} = \mathbb{R}^2$ (multi-label regression)

(c) $\mathcal{Y} = \{y_1, y_2\}$ (binary classification)



(d) $\mathcal{Y} = \{1, 2, 3, 4\}$ (ordinal regression)

Figure: Examples of label spaces and corresponding ML flavours.

Goal of ML: Predict Label from Features

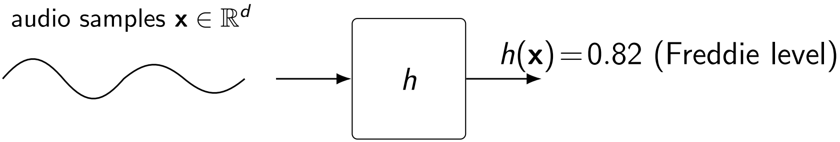


Figure: A hypothesis $h : \mathcal{X} \rightarrow \mathcal{Y}$ maps the features $\mathbf{x} \in \mathcal{X}$ of a data point to a prediction $h(\mathbf{x}) \in \mathcal{Y}$ of the label. For example, the ML application https://freddiemeter.withyoutube.com/ uses the samples of an audio recording as features predict how closely a person's singing resembles that of Freddie Mercury.

Model = A Set of Hypothesis Maps

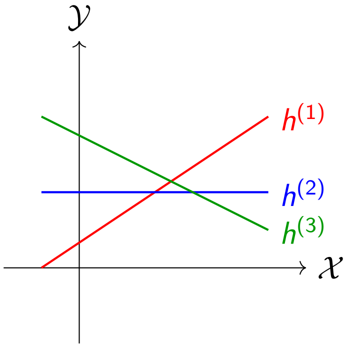
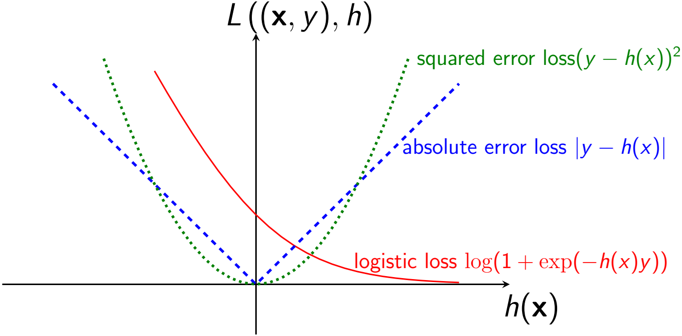


Figure: A hypothesis space $\mathcal{H} = \{h^{(1)}, h^{(2)}, h^{(3)}\}$ consisting of three linear maps.

Which one of the hypothesis maps is the best?

Loss function



A loss function $L((\mathbf{x}, y), h)$ measures the error (or "loss"), incurred by predicting the label y of a data point with feature vector $\mathbf{x}$.

Which Loss function should we use?

The shape of the loss function influences

- computational complexity,
- predictive accuracy,
- interpretability

of resulting ML methods.

Contact

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