Discriminative vs Generative

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2015-03-22 22:44:20 +0800

Models in Machine Learning can often be divided into two main categories, *Generative* and *Discriminative*. The fundamental difference between them is:

- Discriminative models learn the (hard or soft) boundary between classes
- Generative models model the distribution of individual classes

In mathematics, discriminative models directly estimate posterior probabilities P(y|x), while generative models model class-conditional pdfs p(x|y) and prior probabilities P(y), therefore the joint probability distributions p(x,y).

Generative models often make some assumption on the underlying probability distributions and model it. Thus it is can be used to generate new samples from the learned distribution.

A simple way to distinct the two models is by considered the examples used during training. Generative model only needs examples of a particular class which it modelling. However, Discriminative model needs examples of at least two classes to find the boundary.

1 Examples

Some models can be seen as generative-discriminative pairs, e.g.,

• Classifiers: Naive Bayes and Logistic Regression

• Sequential Data: HMM and CRF

Neutral networks are discriminative model because they compute $p(output \mid input)$.

2 Discriminative and Generative Training

Training approaches can also be classified as discriminative or generative. Even though with the same model, we can choose different training approaches.

For example, the HMM-GMM model used in speech recognition, when we do MLE training with Baum–Welch algorithm, we are using a generative training method. However when we do MPE training, we are using a discriminative training method.