EURO^2

Fundamental Concepts of Generative Machine Learning

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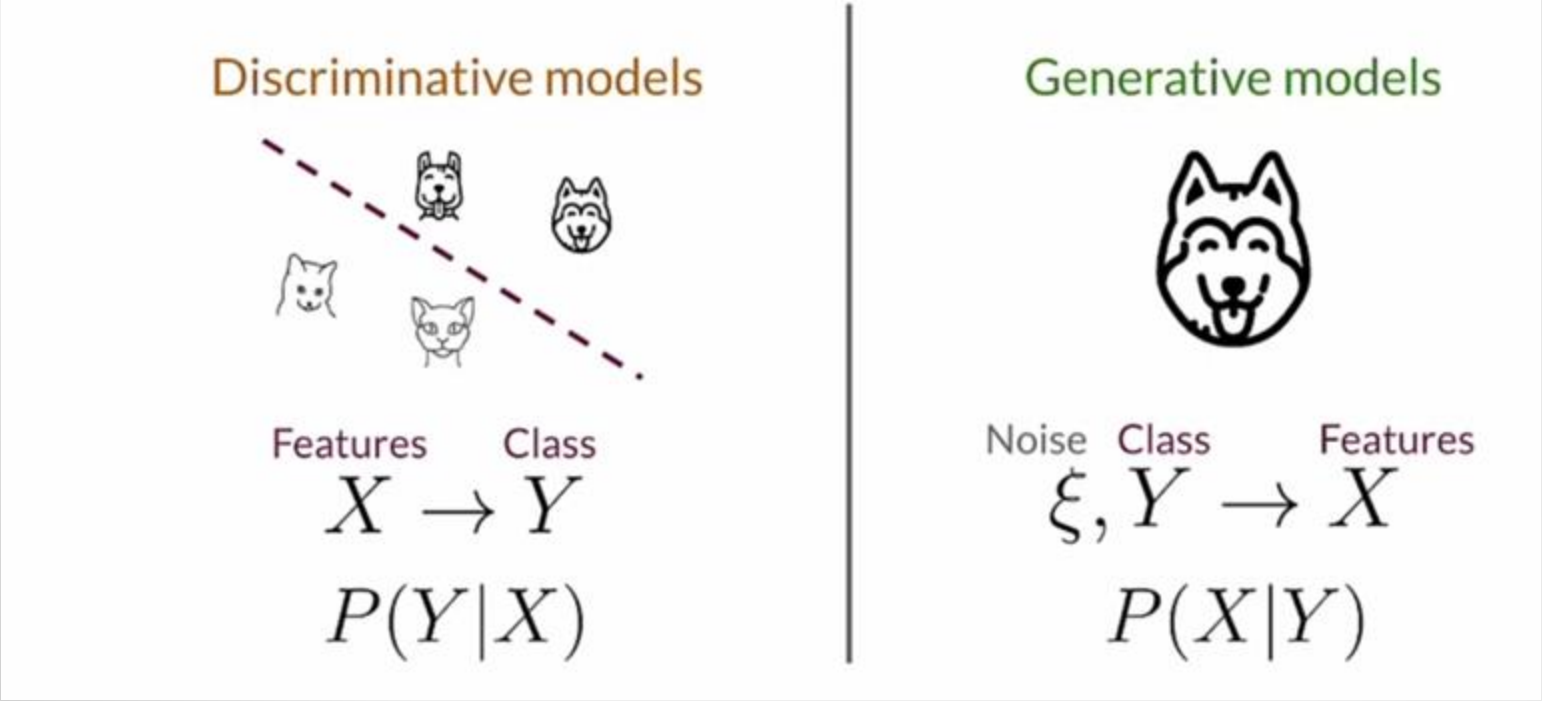
Lesson 1: Mathematical Background

Welcome to Part I: “Mathematical Background”

This part includes four subsections:

- **Generation vs. Discrimination in Machine Learning**
- Data Distribution, Sampling, Inference and Generation
- Expectation and Likelihood
- Evaluation for Generative Models, Distribution Distances, Divergence and Entropy

Discriminative vs Generative Models



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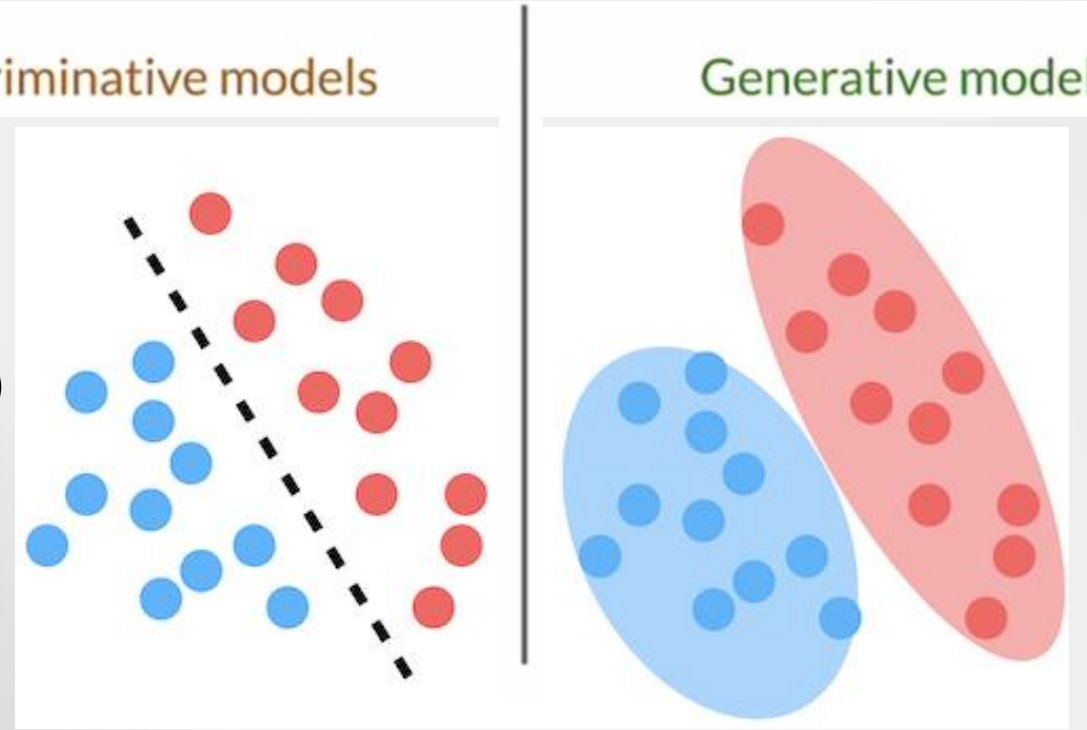
Discriminative vs Generative Models

- Logistic regression
- Scalar Vector Machine
- Neural networks (CNNs)
- etc



- Naïve Bayes
- Bayesian networks
- Markov random fields
- Hidden Markov Models
- Gaussian Mixture Models
- etc

“decision boundary”

“distribution”

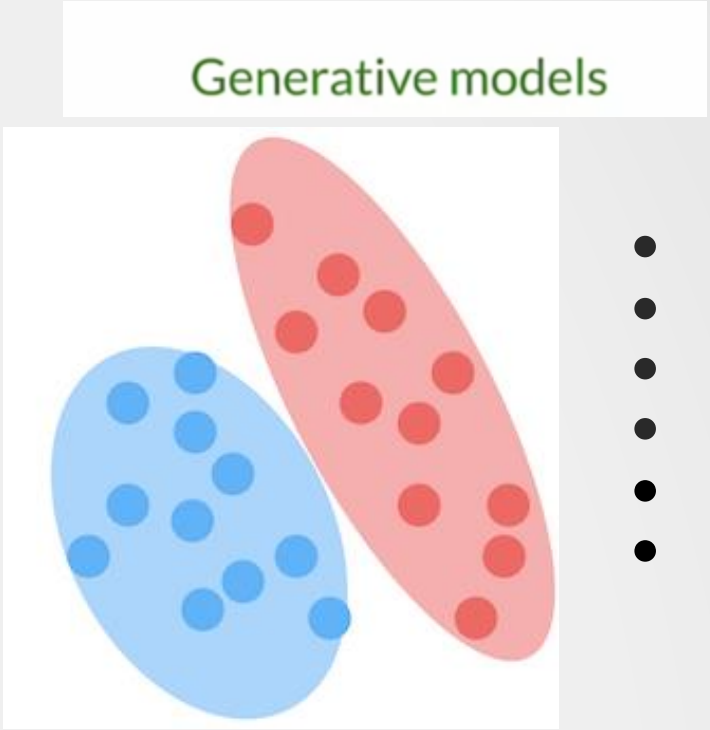
Before the age of GANs, conventional ML scrutinised classifiers into these two categories.

Generative Classifier

A “generative classifier” is a statistical model of the joint probability distribution:

$$P(X,Y)$$

- on given observable variable $\mathbf{X}$
  - Observation $\stackrel{\text{def}}{=}$ Feature
- and target variable $\mathbf{Y}$



“distribution”

- Naïve Bayes
- Bayesian networks
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- Hidden Markov Models
- Gaussian Mixture Models
- etc

Generative Classifier (vs Generation)

A “generative classifier” is a statistical model of the joint probability distribution:

$$P(X,Y)$$

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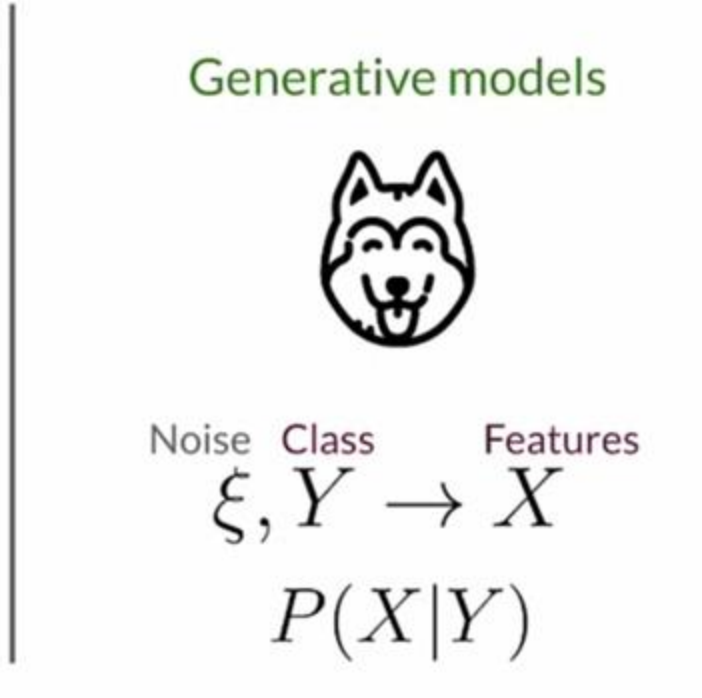
“*When a new observation is fed to a generative classifier, it tries to predict which class would have most likely generated the given observation.*"



“distribution”

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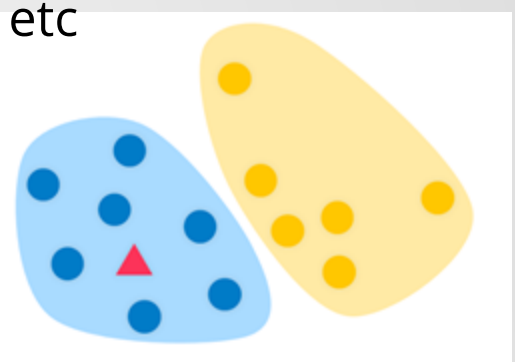

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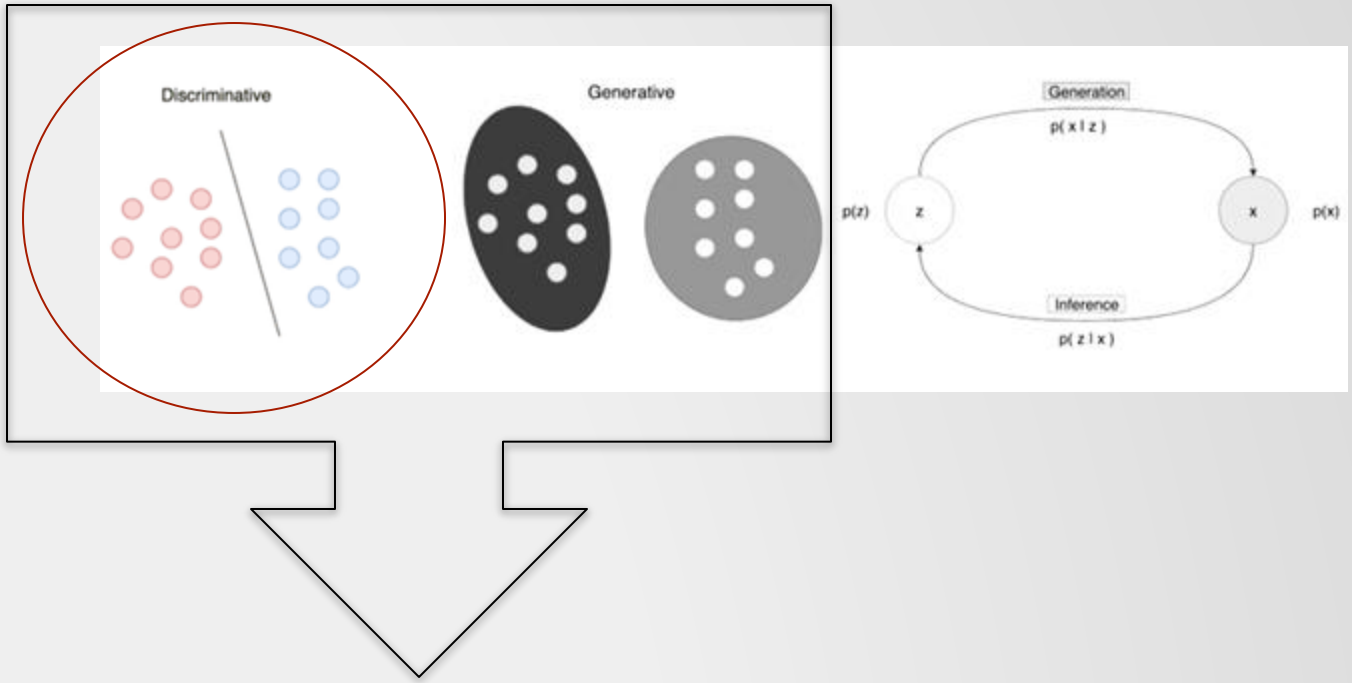
Classification vs Generation

Discriminative models (or classifiers) are machine learning models that learn to classify input data into different categories based on a set of features.



classifiers

These models learn to distinguish between different classes of data **without necessarily modeling the underlying probability distribution of the data**.

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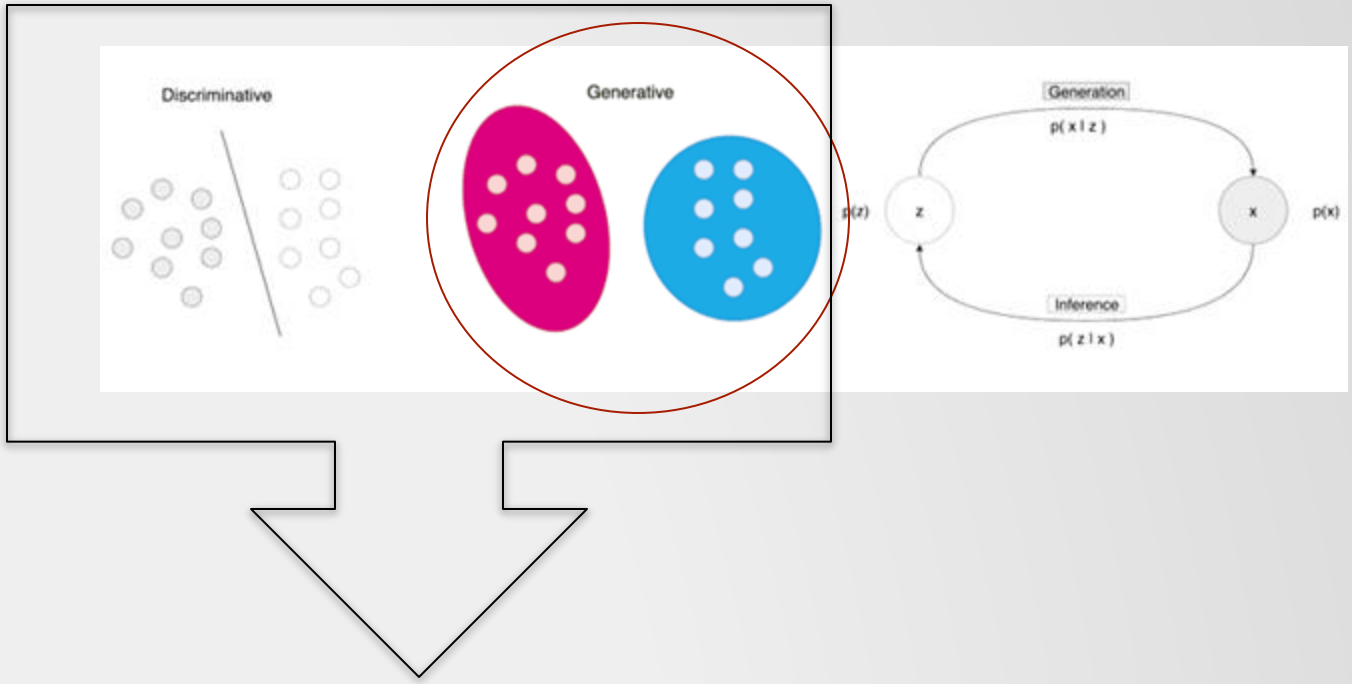
Classification vs Generation

Generative classifiers are models that **learn to model the probability distribution of the input data for each class separately, and then use Bayes' rule to calculate the posterior probability of each class given the input**.



classifiers

These models can be used to classify new data points into different categories based on their likelihood under each class distribution.

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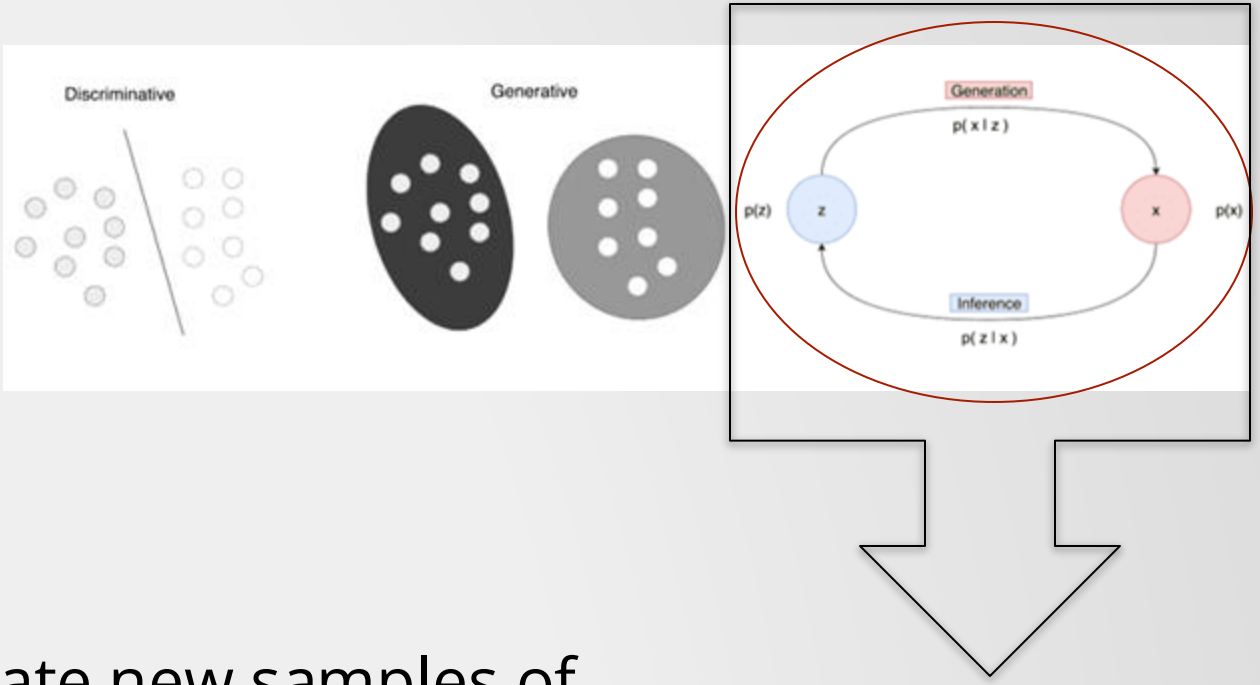
Classification vs Generation

Generative (or generation) models are **machine learning models that learn to model the probability distribution of the input data.**



These models can be used to generate new samples of data that resemble the original data distribution.

generators

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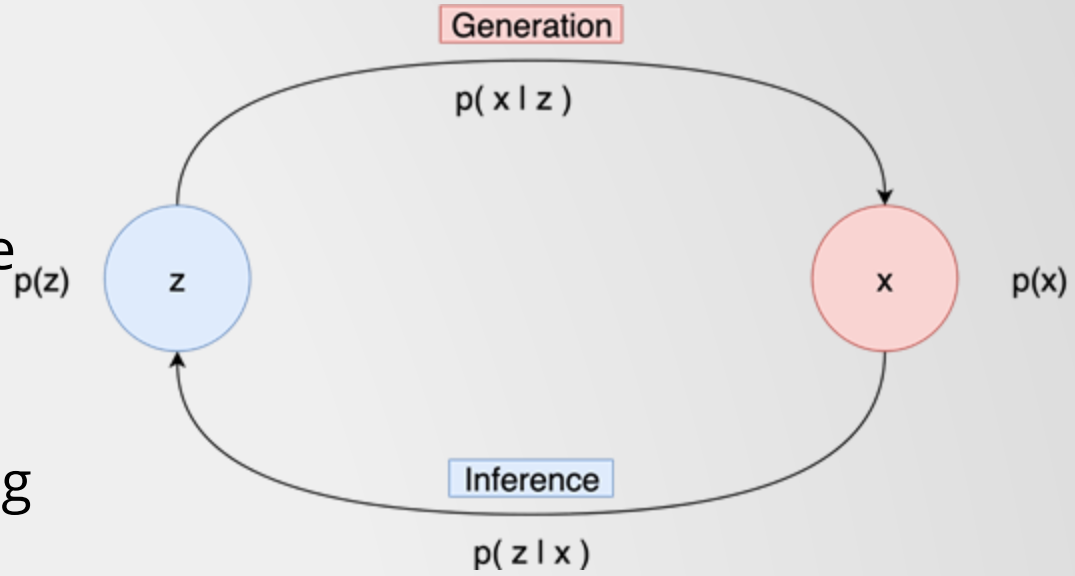
Generation

- $p(z)$: a noise distribution (i.e. latent space)
- $p(x|z)$: is the generation process, i.e. the generation of a new sample x, given a noise vector z
- $p(x)$: is the data/observation distribution.
- $p(z|x)$: is the inference process, i.e. extracting the noise vector z that would generate the sample x.



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Next lecture:

Part I: “Mathematical Background”

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Thanks

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