Probabilistic Generative Models & Probabilistic Discriminative Models

What are Probabilistic Models?

- Probabilistic models are an essential component of machine learning, which aims to learn patterns from data and make predictions on new, unseen data.
- They are statistical models that capture the inherent uncertainty in data and incorporate it into their predictions.
- Probabilistic models are used in various applications such as image and speech recognition, [natural language processing](), and recommendation systems.
- In recent years, significant progress has been made in developing probabilistic models that can handle large datasets efficiently.

Categories Of Probabilistic Models

These models can be classified into the following categories:

- Generative models
- Discriminative models.
- Graphical models

Generative models

- Generative models aim to model the joint distribution of the input and output variables.
- These models generate new data based on the probability distribution of the original dataset.
- Generative models are powerful because they can generate new data that resembles the training data.
- They can be used for tasks such as image and speech synthesis, language translation, and text generation.

Discriminative model

- The discriminative model aims to model the conditional distribution of the output variable given the input variable.
- They learn a decision boundary that separates the different classes of the output variable.
- Discriminative models are useful when the focus is on making accurate predictions rather than generating new data.
- They can be used for tasks such as image recognition, speech recognition, and sentiment analysis.

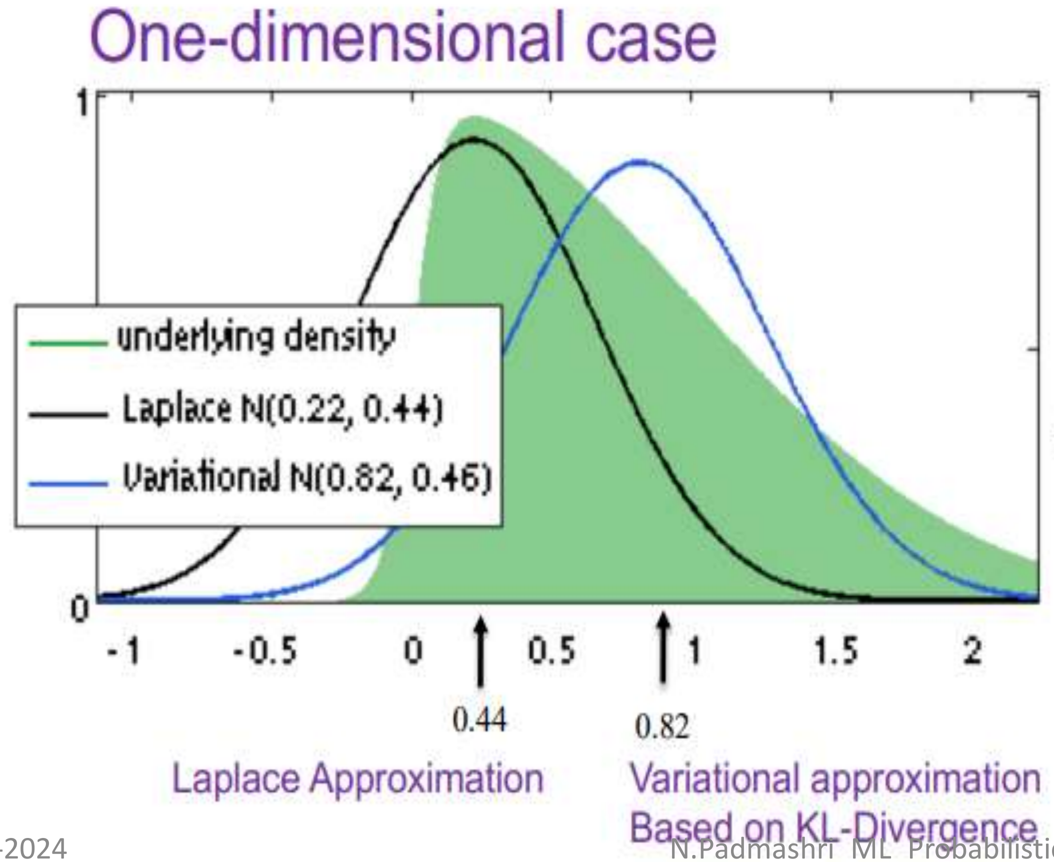
Laplace Approximation

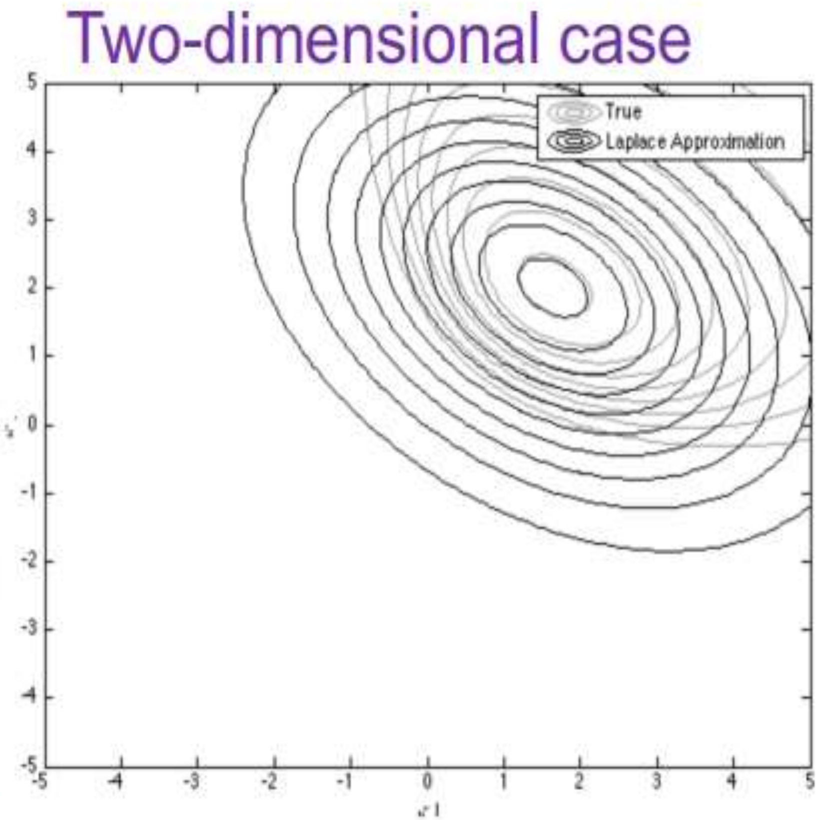
Topics in Laplace Approximation

- Motivation
- Finding a Gaussian approximation: 1-D case
- Approximation in M-dimensional space
- Weakness of Laplace approximation
- Model Comparison using BIC

What is Laplace Approximation?

- The Laplace approximation framework aims to find a Gaussian approximation to a continuous distribution





Laplace approximation framework

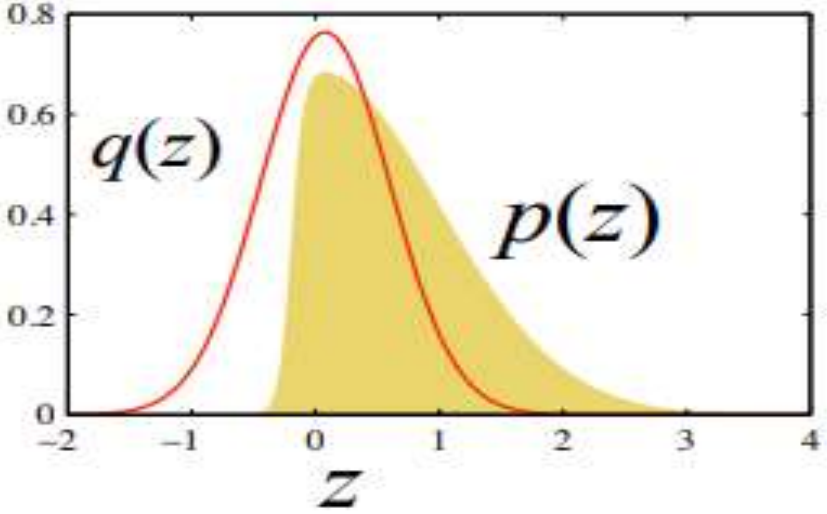
- Simple but widely used framework
- Aims to find a Gaussian approximation to a probability density defined over a set of continuous variables
- Method aims specifically at problems in which the distribution is unimodal
- Consider first the case of single continuous variable

Laplace Approximation: 1D case

- Single continuous variable z with distribution p(z) defined by

$$p(z) = \frac{1}{Z} f(z)$$

where $Z = \int f(z)\,dz$ is a normalization coefficient



- Value of Z is unknown f(z) is a scaled version of p(z)
- Goal is to find Gaussian approximation q(z) which is centered on the mode of p(z)
- First step is to find mode of p(z)
  - i.e., a point z0 such that p'(z0)=0