

Lecture Notes IV – Continuous distributions. Parametric density estimation.

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CDF and PDF. Sampling

Examples of continuous distributions

ML estimation for continuous distributions

ML estimation by gradient ascent

Reading: Ch.5, 6

CDF and PDF refresher

Cumulative distribution function (CDF)

$$F(x) = P[X \leq x] \quad (1)$$

1. $F \geq 0$ positivity.

2. $\lim_{x \rightarrow -\infty} F = 0$

3. $\lim_{x \rightarrow \infty} F = 1$

4. F is an increasing function

Probability density [function] (PDF)

$$f = \frac{dF}{dx} \quad (2)$$

$$P(a, b) = P[a, b] = F(b) - F(a) = \int_a^b f(x) dx \quad (3)$$

normalization condition

$$\int_{-\infty}^{\infty} f(x) dx = 1 \quad (4)$$

Examples of continuous distributions

$$\mathcal{F}_1 = \{u_{[a,b]}, a < b\} \quad \text{uniform} \quad (5)$$

$$f(x; a, b) = \begin{cases} \frac{1}{b-a}, & x \in [a, b] \\ 0, & \text{otherwise} \end{cases} \quad (6)$$

$$\mathcal{F}_2 = \{N(\cdot; \mu, \sigma^2)\} \quad \text{normal} \quad (7)$$

$$f(x; \mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad (8)$$

$$F(x; a, b) = \frac{1}{1 + e^{-ax-b}}, \quad a > 0 \quad \text{logistic} \quad (9)$$

$$f(x; a, b) = \frac{ae^{-ax-b}}{(1 + e^{-ax-b})^2} \quad (10)$$

ML estimation for continuous distributions

ML estimation by gradient ascent

$$l(a, b) = n \ln a - a \sum_i x_i - nb - 2 \sum_{i=1}^n \ln(1 + e^{-ax_i - b})$$

$$\frac{\partial l}{\partial a} = \frac{n}{a} - \sum_{i=1}^n x_i \frac{1 - e^{-ax_i - b}}{1 + e^{-ax_i - b}} = 0$$

$$\frac{\partial l}{\partial b} = - \sum_{i=1}^n \frac{1 - e^{-ax_i - b}}{1 + e^{-ax_i - b}} = 0$$