

Point Estimation: Key Concepts

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Outline

1 Method of Moments

2 MLE

Method of Moments

The Method of Moments

consists of equating sample moments and population moments moments

Population moments

$$\mu_r(\theta) = E_{\theta}(X^r) = \int_{-\infty}^{\infty} x^r f(x; \theta) dx$$

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Solve the resulting system of equations for θ

$$X \sim N(\mu, \sigma^2)$$

$$\begin{aligned}\hat{\mu}_{MOM} &= \bar{X} \\ \hat{\sigma}_{MOM}^2 &= \frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n}\end{aligned}$$

MOM and unbiasedness

Are MOM estimators unbiased estimators?

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$$X \sim U(0, \theta)$$

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Intuition

Suppose I tell you I have 100 cookies in my backpack. The cookies are of two types: chocolate chip cookies and fortune cookies. Moreover, I tell you that the number of fortune cookies is either 10 or 90. You draw a cookie out of my backpack at random and see that it is a fortune cookie.



Intuition

Based on this data, what is more likely: there are

- ① 10 fortune cookies and 90 chocolate chip cookies, or
- ② 90 fortune cookies and 10 chocolate chip cookies?

Based solely on one sample (fortune cookie), 2 is more likely.

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Bernoulli

$X \sim \text{Bernoulli}(\theta)$

Observations: 3 successes and 2 failures

Which of the following values for θ is the most likely:

0.2 0.4 0.6 0.8

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Likelihood?

$$L(\theta|x) = \prod_i \theta^{x_i} (1 - \theta)^{1-x_i}$$

$$L(\theta|x) = \theta^{\sum_i x_i} (1 - \theta)^{n - \sum_i x_i}$$

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$$L(0.2|x) = 0.0051$$

$$L(0.4|x) = 0.023$$

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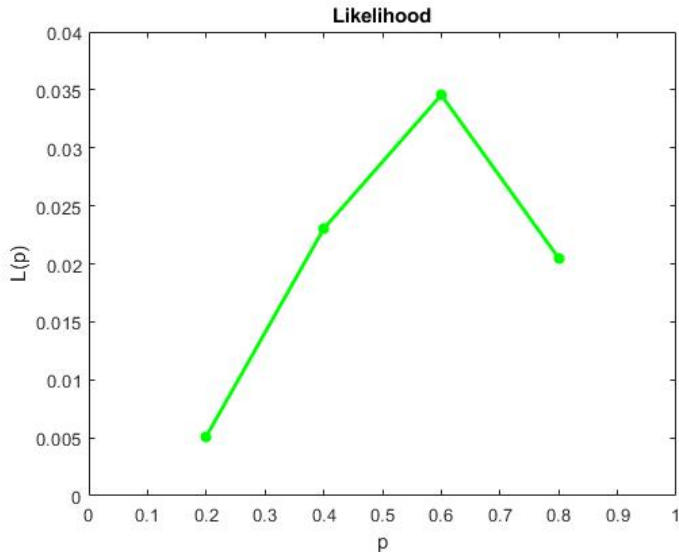
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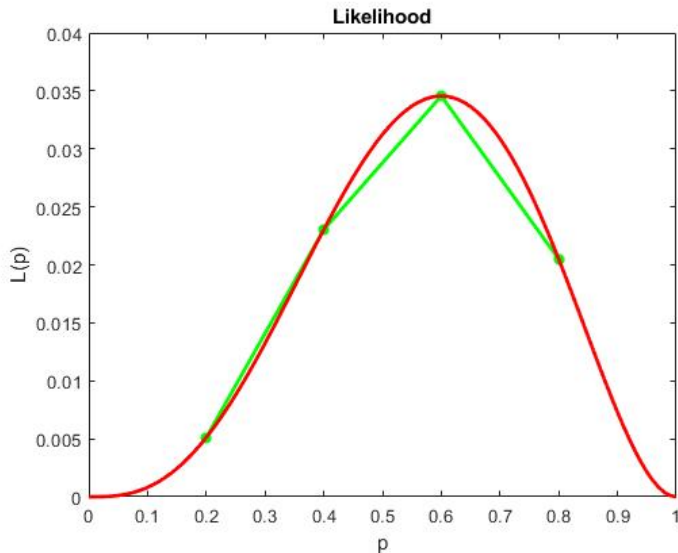
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Gaussian

$$X \sim N(\mu, \sigma = 10)$$

Observations:

160 170 166 173 172

Likelihood

$$L(\mu|x) = \prod_{i=1}^n \left(\frac{1}{\sqrt{2\pi\sigma^2}} \exp \left(-\frac{(x_i - \mu)^2}{2\sigma^2} \right) \right)$$

$$L(\mu|x) = \left(\frac{1}{\sqrt{2\pi\sigma^2}} \right)^{n/2} \exp \left(-\frac{\sum_{i=1}^n (x_i - \mu)^2}{2\sigma^2} \right)$$

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$$L(164|x) = 3.7 \times 10^{-8}$$

$$L(168|x) = 5.74 \times 10^{-8}$$

$$L(172|x) = 4.01 \times 10^{-8}$$

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$$\log(L(164|x)) = -17.113$$

$$\log(L(166|x)) = -16.793$$

$$\log(L(168|x)) = -16.673$$

$$\log(L(170|x)) = -16.753$$

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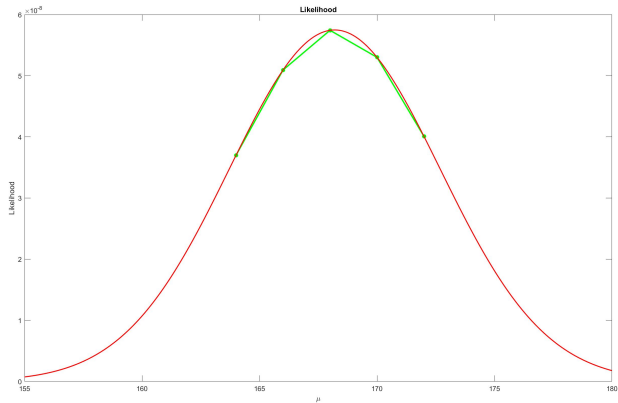
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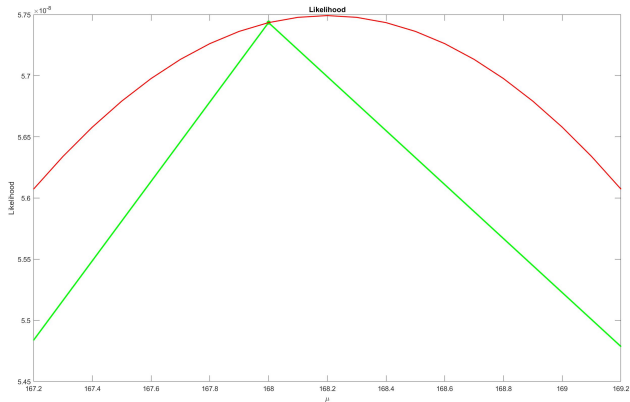
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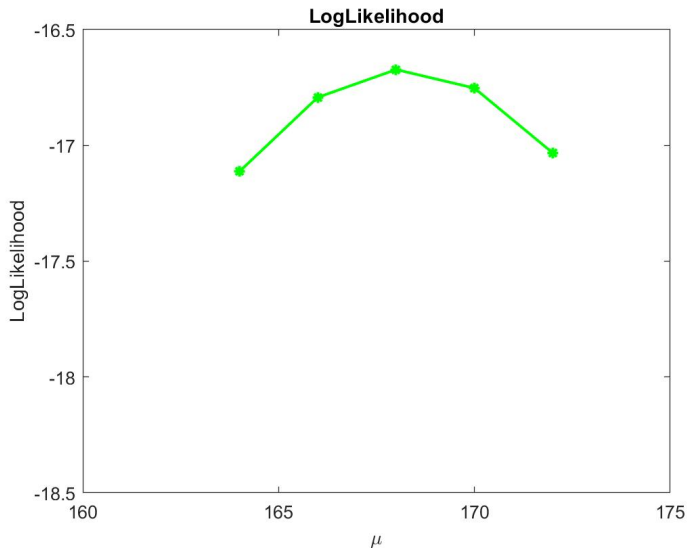
Gaussian-Likelihood



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Gaussian-LogLikelihood



Gaussian-LogLikelihood

