PABNA UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF INFORMATION AND COMMUNICATION ENGINEERING
COURSE NAME: ENGINEERING STATISTICS
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ASSIGNMENT TOPIC: MLE ILLUSTRATION FROM POISSON AND NORMAL DISTRIBUTIONS

Submitted By:

Tahsina Saba

Roll: 220622

Reg: 1065469

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Dept. of Information and Communication Engineering

Submitted To:

Dr. Md. Sarwar Hosain

Associate Professor

Department of Information and Communication Engineering

WHAT IS MAXIMUM LIKELIHOOD ESTIMATION (MLE)

- MLE is a method to estimate parameters of a distribution based on observed data.
- It finds the values that maximize the likelihood of the data.
- Widely used in statistics, machine learning, and engineering.

GENERAL MLE STEPS

- Define the probability distribution of the data.
- Construct the likelihood function.
- Take log-likelihood for easier differentiation.
- Differentiate, set derivative = 0, and solve for the parameter(s).

POISSON DISTRIBUTION

Models count data (e.g., number of calls per hour)

PMF: $P(X = x) = (e^{-\lambda} * \lambda^x) / x!$, $x = 0, 1, 2, \ldots$

Parameter: λ = average rate of events

MLE FOR POISSON DISTRIBUTION

Likelihood: $L(\lambda) = \prod [e^{(-\lambda)} * \lambda^{xi} / xi!]$

Log-likelihood: $\ln L(\lambda) = -n\lambda + \ln(\lambda) * \Sigma xi + C$

SOLVING FOR MLE – POISSON

$d/d\lambda \ln L = -n + (1/\lambda) * \Sigma xi = 0$

$\rightarrow \hat{\lambda} = \Sigma xi / n = \bar{x}$

MLE of λ is the sample mean.

NORMAL DISTRIBUTION

Models continuous data (e.g., height, weight)

PDF: $f(x) = (1/\sqrt{(2\pi\sigma^2)}) * e^{(-(x - \mu)^2 / 2\sigma^2)}$

Parameters: μ = mean, σ^2 = variance

MLE FOR NORMAL DISTRIBUTION

Log-likelihood:

$\ln L = -n/2 \ln(2\pi) - n/2 \ln(\sigma^2) - (1/2\sigma^2)\, \Sigma(xi - \mu)^2$

MLE RESULTS – NORMAL DISTRIBUTION

Estimated Mean: $\hat{\mu} = \bar{x}$

Estimated Variance: $\hat{\sigma}^2 = (1/n) * \Sigma(xi - \bar{x})^2$

MLE SUMMARY TABLE

Poisson: $\hat{\lambda} = \bar{x}$

Normal: $\hat{\mu} = \bar{x}$

Normal: $\hat{\sigma}^2 = (1/n) * \Sigma(xi - \bar{x})^2$

APPLICATIONS OF MLE IN ENGINEERING

- Signal processing
- Quality control
- System reliability analysis
- Parameter estimation in communication systems
- Machine learning model fitting

CONCLUSION

- MLE finds parameters that make observed data most likely.
- Poisson and Normal MLEs are intuitive and based on sample stats.
- Widely applicable in engineering and data analysis.