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Advanced Lifetime Distributions in Reliability Engineering

Pradeep Kumar Jha[1] and Shalini[2]
[1]University Department of Mathematics, T.M. Bhagalpur University, Bhagalpur, Bihar, India.
[2]College of Agricultural Engineering Ara, Bihar Agricultural University Sabour, Bhagalpur, India.
shalinipoddar52@gmail.com

Abstract: *Reliability analysis plays a critical role in engineering systems, where ensuring the longevity and dependability of components is paramount. This paper explores the theoretical underpinnings and practical applications of lifetime distributions in reliability analysis. Key probability distributions such as exponential, Weibull, and gamma distributions are reviewed, emphasizing their relevance in modeling lifetimes of engineering components. Novel modifications to these distributions are proposed to address complex reliability scenarios involving variable failure rates and censoring. Analytical methods for parameter estimation, including the maximum likelihood approach, are discussed in detail, along with goodness-of-fit tests to evaluate model suitability. Furthermore, the paper highlights the role of reliability functions, hazard rates, and mean time to failure (MTTF) in assessing system performance. Case studies from diverse engineering fields, including electrical systems, mechanical structures, and software reliability, illustrate the practical applicability of the theoretical framework. The findings underscore the importance of advanced lifetime models in optimizing system design, maintenance schedules, and risk management strategies, making this study an essential contribution to the field of reliability engineering.*

Keywords: Lifetime distributions, Reliability analysis, Hazard rate, Estimation, Goodness-of-fit, Failure modeling, Risk management.

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