

Statistical Reliability Modeling and Failure Prediction in Engineering Systems

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Abstract: Reliability engineering plays a critical role in ensuring the safety, availability, and performance of engineering systems. Statistical reliability modeling provides quantitative methods to estimate failure behavior, predict system lifetimes, and support maintenance decision-making. This paper reviews statistical reliability models and modern failure prediction techniques used in engineering systems. Traditional approaches such as Weibull analysis, exponential models, and proportional hazards models are discussed alongside emerging machine learning-based prediction methods. A comparative analysis of different reliability models is presented, highlighting their advantages, limitations, and applications in industrial systems. The study demonstrates that integrating statistical methods with data-driven approaches improves failure prediction accuracy and supports predictive maintenance strategies.

Keywords: Reliability Engineering, Failure Prediction, Weibull Distribution, Proportional Hazards Model, Machine Learning, Predictive Maintenance