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COMPARATIVE PERFORMANCE ANALYSIS OF PARAMETER ESTIMATION METHODS FOR THE BINOMIAL DISTRIBUTION

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Estimating parameters of probability distributions is a fundamental aspect of inferential statistics, as it directly affects the accuracy, efficiency, and robustness of inference. This study compared the performance of three parameter estimation methods; Minimum Hellinger Distance Estimation (MHDE), Minimum Density Power Divergence Estimation (MDPDE) and Maximum Likelihood Estimation (MLE), for the Binomial distribution, with a focus on both efficiency and robustness under varying conditions. Monte Carlo simulations were conducted by systematically varying sample size (n), success probability (p) and contamination levels, under a fixed number of trials, to identify the most suitable estimation method. Contamination was introduced by replacing a proportion of observations generated from the Binomial distribution with the number of trials, thereby generating synthetic data with outliers. The estimators were evaluated using key metrics such as bias, variance, and Root Mean Squared Error (RMSE). Results indicated that MLE produced the lowest RMSE on clean data, but its performance deteriorated in the presence of contamination. In contrast, both MHDE and MDPDE showed greater stability and reliability against outliers. Furthermore, increasing the success probability slightly reduced the RMSE for MLE, while MHDE and MDPDE remained relatively stable. With larger sample sizes, MHDE displayed a slight decrease in RMSE, suggesting improved efficiency compared to MDPDE. Notably, MHDE and MDPDE outperformed MLE under higher contamination levels, while MDPDE converged to MLE in uncontaminated settings. Overall, MHDE demonstrated superior robustness and efficiency in contaminated scenarios, making it a compelling alternative to MLE for practical applications.

Keywords: Binomial density, Maximum Likelihood Estimation, Minimum Density Power Divergence, Minimum Hellinger Distance, Parameter estimation