Adaptive Age Replacement Strategies based on Nonparametric Predictive Inference

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Abstract

We consider an age replacement problem using nonparametric predictive inference (NPI) for the lifetime of a future unit. Based on n observed failure times, NPI provides lower and upper bounds for the survival function for a future lifetime X_{n+1}, which are lower and upper survival functions in the theory of interval probability, and which lead to upper and lower cost functions, respectively, for age replacement based on the renewal reward theorem. Optimal age replacement times for X_{n+1} follow by minimising these cost functions.

Although the renewal reward theorem implicitly assumes that the corresponding optimal strategy will be used for a long period, we study the effect on this strategy when the observed value for X_{n+1}, which is either an observed failure time or a right-censored observation, becomes available. This is possible due to the fully adaptive nature of our nonparametric approach, and the next optimal strategy will be for X_{n+2}. We compare the optimal strategies for X_{n+1} and X_{n+2} both analytically and via simulation studies.

Our NPI-based approach is fully adaptive to the data, to which it adds only few structural assumptions. We discuss the possible use of this approach, and indeed the wider importance of the conclusions of this study to situations where one wishes to combine the statistical aspects of estimating a lifetime distribution with the more traditional Operational Research approach of determining optimal replacement strategies for lifetime distributions which are assumed to be known.

Keywords: $A_{(n)}$; Adaptive age replacement strategies; Nonparametric predictive inference; Renewal reward theorem.