

Chapter 20

A Hybrid GA–GSA Algorithm for Optimizing the Performance of an Industrial System by Utilizing Uncertain Data

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ABSTRACT

The main objective of this chapter is to present a novel hybrid GA-GSA algorithm to permit the reliability analyst to increase the performance of the system by utilizing the uncertain data. Since the analysis based on the collected data mostly contains a lot of uncertainties, the corresponding results obtained do not tell the exact nature of the system. Therefore, to handle this issue, the proposed algorithm maximizes the Reliability, Availability, and Maintainability (RAM) parameters simultaneously for increasing the performance and productivity of the system. The conflicts between the objectives are resolved with the help of intuitionistic fuzzy set theory. The optimal design parameters corresponding to each component of the system are evaluated by solving a nonlinear optimization problem and compared their results with other methods. The stability of these optimal parameters is justified by means of pooled t-test statistics. Based on these optimal design parameters, an investigation has been done for finding the most critical component of the system for saving money, manpower, and time, as well as increasing the performance of the system. Finally, to illustrate the methodology, a numerical example is studied.

1. INTRODUCTION

With modern technology and higher reliability requirements, systems are getting more complicated day-by-day and hence job of the system analyst or plant personnel becomes so difficult to run the system under failure-free pattern. In the competitive market scenario, reliability and maintainability are the most important parameters that determine the quality of the product with their aim of estimating and predicting the probability of the failure, and optimizing the operation management. From a system

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effectiveness viewpoint, reliability and maintainability jointly provide system availability and dependability. Increased reliability directly contributes to system uptime, while improving maintainability reduces downtime. If reliability and maintainability are not jointly considered and continually reviewed, serious consequences may result. Therefore, the primary objective of any industrial system is to acquire quality products/systems that satisfy user needs with measurable improvements to mission capability and operational support in a timely manner, and at a fair and reasonable price. These features address reliability, availability and maintainability (RAM) as essential elements of mission capability. Often, reliability of the component is not specific. This is due to that the reliability of a component/system depends on operational and environmental conditions. Therefore, it is not possible to determine a fixed number that lies, between zero and one, which shows reliability of a component in all conditions. Moreover, in the early design phase reliability of a system may be taken into account and hence it is difficult to determine the reliability specifically. Further, the causes may be age, adverse operating conditions and the vagaries of manufacturing processes which affect each part/unit of the system differently, and thus the issue is subject to uncertainty. To this effect, both probabilistic and non-probabilistic methods are used to treat the element of uncertainty in reliability analysis. Conventional reliability theory is based on the probabilistic and binary state assumptions. Although the probability approach has been applied successfully to many real worlds engineering, reliability problems, but still there are some limitations of the probabilistic method. For instance, probabilistic methods are based on a mass collection of data, which is random in nature, to achieve the requisite confidence level. But in large scale the complicated system has the massive fuzzy uncertainty due to which it is difficult to get the exact probability of the events. Thus results based on probability theory do not always provide useful information to the practitioners due to the limitation of being able to handle only quantitative information. Moreover, in real world applications, sometimes there is insufficient data to accurately handle the statistics of the parameters. This is particularly true at the tail of the distributions, where reliability is very high and therefore failure observations are extremely rare. Also, at early stages of new product development, the available data (numbers of testing samples, recorded failures on test) are limited, so the required confidence level may not be met if probabilistic methods are used. The subjective information is also not captured during reliability analysis by probabilistic methods (Garg et. al. 2014b,c). Also in a real-life situation, these parameters are analyzed based on the data which are collected from the various historical records/log books etc., which are usually out of date and hence if data are used as such in the analysis then the computed results may have a high range of uncertainties. In today's highly reliable industrial systems, it is impossible to obtain enough failure data for statistical analysis. Any unfortunate consequences of unreliable behavior of such equipments or systems have led to the desire for reliability analysis. Due to these limitations, the results based on probability theory do not always provide useful information to the practitioners and hence probabilistic approach to the conventional reliability analysis is inadequate to account for such built-in uncertainties in the data. To overcome these difficulties, methodologies based on fuzzy set theory are being used in the risk analysis for propagating the basic event uncertainty. The probabilistic approaches deal with uncertainty, which is random in nature, while the fuzzy approach deals with the uncertainty, which is due to imprecision associated with the complexity of the system as well as vagueness of human judgments (Garg and Sharma, 2012a). Therefore, in recent year's system reliability, availability and maintainability become an important issue in evaluating the performance of

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