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A model for allocation and optimization of reliability complex network using Particle Swarm Optimization and Genetic Algorithms

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Abstract

The reliability of computing the Complex Network using probability theory as a complex system is the main topic of this paper. The reliability assignment and optimization issue was dealt with using the Genetic Algorithm (GA), which has the ability to deal with complex issues that are typical in engineering systems. A higher number of duplicates are frequently necessary when the cost of execution is significant. In addition to GA, we use the particle swarm optimization (PSO) technique. This method is based on how accumulating organisms behave. In order to compare the resilience and durability of the algorithms that aid in determining the fitness of a particular system, two algorithms will be used in this paper.

1 Introduction

Due to the system's technological significance to the engineering of the space industries, Udriste [1], Hatem [2], and Imad [5] conducted the first studies on the subject. Then, since this system is referred to as a sophisticated network requiring research, the reliability of each path in the system was assessed. Saad et al. [3] have focused specifically on this paradigm and the issue of growing reliability. In this article [4], the subject of optimal dependability assignments was also explored. Most optimization issues can be resolved using any evolutionary method, including "Genetic Algorithm (GA) and Particle Swarm Optimization (PSO)". At the University of Michigan in the 1970s, John Holland developed the idea of GA [4]. Because they employ recurrent procedures to reach the desired alternatives, Genetic Algorithms are also known as global search heuristics. GA frequently provides overly simplistic solutions to a variety of issues. GA makes use of a number of biological processes, such as selection, crossover or recombination, mutation, and reproduction. GA can be used to solve challenging optimization issues since it can handle both discrete and continuous variables. Many sectors have adopted GA, including data processing, energy systems, optimization, configuration, and timing. Swarm Intelligence, a cutting-edge distributed paradigm, can effectively handle the optimization challenges (SI). Each particle in PSO is said to represent a viable alternative that is updated during the decision-making process, according to two independent sources of input [5].The first (cognitive behavior) is based on one's own experiences, whereas the second (social behavior) is based on peer experience. In other words, after making decisions, people tend to believe that their neighbors' alternatives are excessively good and that the pattern of the right choice is favorable. Although PSO has demonstrated in many ways that it can handle a variety of optimization problems [6,7], finding solutions to complex engineering problems still takes a lot of time to accomplish [4, 7]. This research compares and contrasts PSO with GA in attempt to identify the more powerful algorithm.

2 Allocation of reliability and Complex Network optimization

Take into account a complicated system with components linked to reliability [2]. We make use of the notes below:

$C_i(R_i) =$ element i cost;

$0 \leq R_i \leq 1 =$ reliability i component;

$R_s =$ reliability of the system;

$C(R_1, ..., R_n) = \sum_{i=1}^{n} a_i c_i(R_i)$ is the total system cost, in which $a_i > 0; R_s$ is greater than 0;

$R_G =$ objective of systems reliability.

There are many possible outcomes due to the system's modular design and the unique functions of each component. The same capacity is provided to us via a variety of system components, each with various degrees of dependability. The system's ability to correctly allocate resources to all components or selected ones is the ultimate goal. Problems are necessary for nonlinear programming [6,7]. Despite not being linear, the constraint serves a purpose and incurs costs that can be researched:

$$Minimize \quad C(R_1, ..., R_n) = \sum_{i=1}^{n} a_i C_i(R_i), a_i > 0,$$

subject to

$$R_s \geq R_G,$$
$$0 \leq R_i \leq 1, i = 1, 2, ..., n. \tag{2.1}$$

Let the partial cost function be reasonable and $C_i(R_i)$ satisfies some conditions, Positive, differentiated functions, increasing from $\left[\Rightarrow \frac{dC_i}{dR_i} \geq 0\right]$.

The part costs function of the Euclidean convexity $C_i(R_i)$ analogous to the reality that its derivatives $\frac{dC_i}{dR_i}$ are monotonically increased, i, e. $\frac{d^2C_i}{dR_i^2} \geq 0$. The system reliability restriction is lowered under RG, and the prior plan's objective is to achieve an all-out framework cost base [2].

2.1 Behavior model (cost function).

Let $0 < R_i < 1$ and $a_i, b_i,$ are constants, $i = 1, 2, ..., n.$ are constants. The most notable characteristic of expense is its exponential behavior. The suggestion was made in the form of [6].

$$C_i(R_i) = a_i exp(\frac{b_i}{1 - R_i}), a_i > 0, b_i > 0, i = 1, 2, ..., n. \tag{2.2}$$

The issue with optimization arises :

$$Minimize \quad C(R_1, ..., R_n) = \sum_{i=1}^{n} a_i exp(\frac{b_i}{1 - R_i}), i = 1, 2, ..., n.$$

subject to

$$R_s \geq R_G$$

$$0 \leq R_i \leq 1 \quad , inwhich \quad , i = 1, 2, ..., n.$$

3 The Solution to a Complex Network

A Complex Network shown in Fig.1 has, at a given moment, 90% of in all components of the system, the same key is accreditation. The system reliability goal is 90% at a stated time. Using the probability theorem method, the polynomial reliability of the given system was determined.

$$\begin{aligned} R_S =& R_1R_2 + R_6R_7 + R_2R_3R_4 + R_4R_5R_7 + R_1R_3R_5R_7 + R_2R_3R_5R_6 + R_1R_2R_3R_4R_5R_6 \\ &+ 2R_1R_2R_3R_4R_5R_7 + R_1R_2R_3R_4R_6R_7 + 2R_1R_2R_3R_5R_6R_7 + R_1R_2R_4R_5R_6R_7 \\ &+ R_1R_3R_4R_5R_6R_7 + 2R_2R_3R_4R_5R_6R_7 - R_1R_2R_3R_4 - R_1R_2R_6R_7 - R_4R_5R_6R_7 \\ &- R_1R_2R_3R_5R_6 - R_1R_2R_3R_5R_7 - R_1R_2R_4R_5R_7 - R_2R_3R_4R_5R_6 - R_2R_3R_4R_5R_7 \\ &- R_1R_3R_5R_6R_7 - R_2R_3R_4R_6R_7 - R_1R_3R_4R_5R_7 - R_2R_3R_5R_6R_7 - 3R_1R_2R_3R_4R_5R_6R_7 \end{aligned} \tag{3.3}$$

The issue with optimization then is:

$$Minimize \quad C(R_1, ..., R_n) = \sum_{i=1}^{n} a_i exp(\frac{b_i}{1 - R_i}), i = 1, 2, ..., n.$$

subject to

$$R_s \geq R_G$$

$$0 \leq R_i \leq 1 \quad , in which \quad , i = 1, 2, ..., n.$$

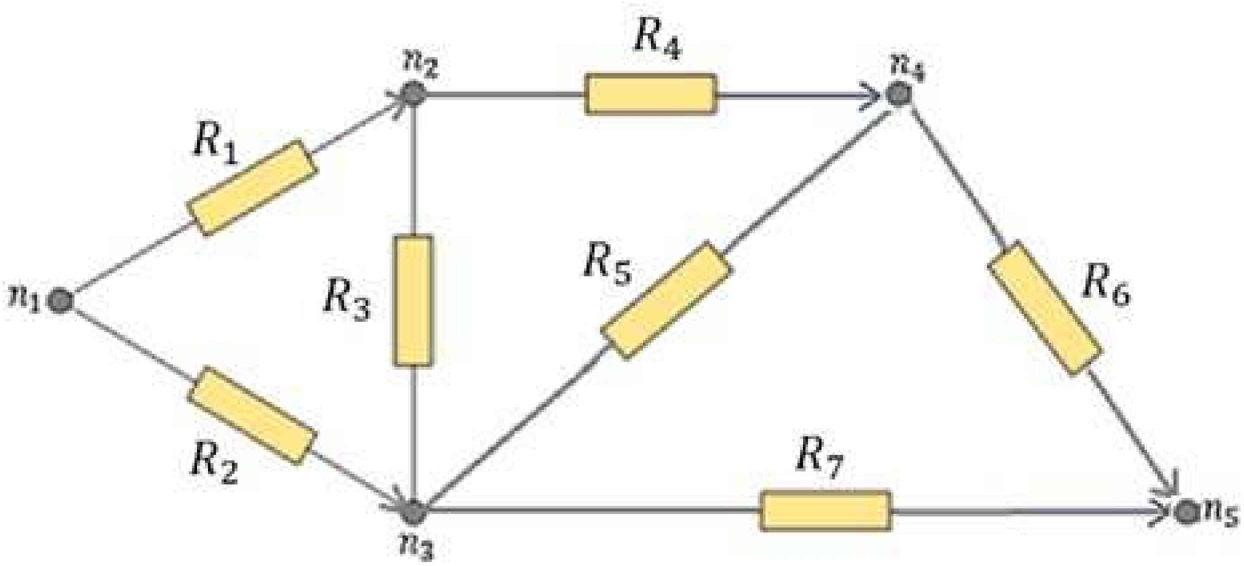

Figure 1: Complex network

4 Optimal of reliability allocation

By applying the GA to the system, the results of the reliability allocation were published in [2]. Also, when applying the algorithm the PSO, the results were in the allocation of reliability of the system as shown in the following table

Table 1: Summary Table of Complex Network components for optimum reliability allocation of GA and PSO

Components	Genetic Algorithm	Particle Swarm Optimization
R_1	0.99	0.98
R_2	0.92	0.91
R_3	0.93	0.67
R_4	0.92	0.91
R_5	0.94	0.8
R_6	0.94	0.8
R_7	0.99	0.98

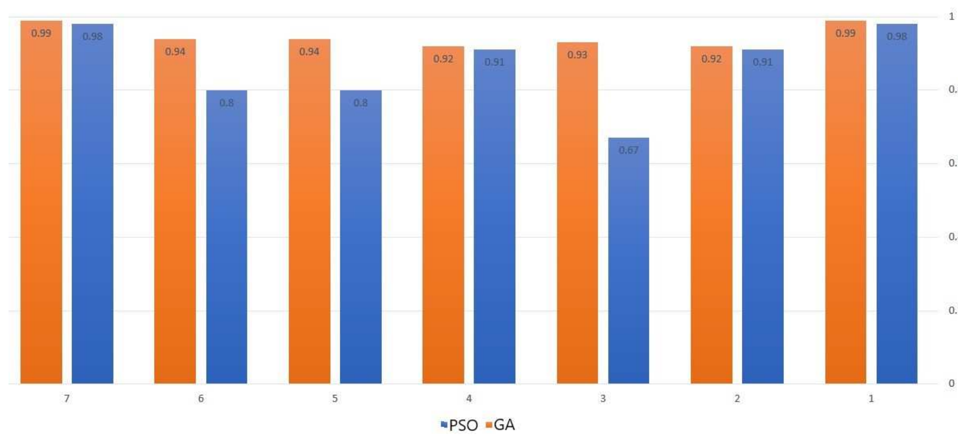

Figure 2: Allocation of reliability based on GA and PSO behavior models.

5 Discussion of the results

The results of the allocation of reliability through the Genetic Algorithm were the best solution for the allocation of each component of the system and each according to its location in the system and the results of the R_1 equal to the equal toR_7 and its value was (0.99), the R_5 is equal to the R6 and its value (0.94), the value of the R_3 is equal (0.93). then, R_2 is equal to the R4 and its value (0.92). The results of the allocation of the particle swarm optimization by (iteration 1000 times) the values of the R_1 and R_7 components were equal (0.98), the value of R_2 and R_4 were equal (0.91), R_3 value of was equal (0.67), and the values of component R_5 and R_6 were equal and their values equal (0.8).

6 Conclusion

In this paper, we addressed the network reliability optimization difficulty by distributing each reliability component. Using GA and PSO, the topic of an exponential behavior model (cost function) and active limits was investigated as a nonlinear programming problem.

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