Evolutionary Computing -2020 Assignment #3: evolutionary strategy

Shiraz University | Due Date: 5/Feb

Problem statement

System reliability optimization is very important in real world applications. To design a highly reliable system, there are two main approaches: 1) Add redundant components 2) Increases the component reliability.

For financial reasons, it has to establish a balance between reliability and other resources during designing a highly reliable system. In this project we ask you to design an Evolution Strategy (ES) based approach to reach this goal.

Well-known benchmarks

The notations used in this project are listed in table (1):

Table 1: Notations

Notation	*Description*
m	*number of subsystems in the system.*
n_i	*the number of components in ith subsystem. 1≤ i ≤ m.*
n	*n= [n_1,…, n_m], the vector of the number of components in*
r_i	*system.the reliability of each component in ith subsystem.*
r	*= [r_1,…, r_m], the vector of component reliabilities.*
w_i	*the weight of each component in ith subsystem.*
c_i	*the cost of each component in ith subsystem.*
v_i	*the volume of each component in ith subsystem.*
R_i	*the reliability of the ith subsystem.* $R_i = 1 - (1 - r_i)^{n_i}$.
R_s	*the reliability of the system.*
C	*the upper limit on the cost of the entire system.*
W	*the upper limit on the weight of the entire system.*
V	*the upper limit on the volume of the entire system.*

The reliability–redundancy allocation problem can be modeled in general form as follow:

$$\text{Max} \quad R_s = f(r_i, n_i). \tag{1}$$
$$\text{subject to} \quad g(r_i, n_i) \le predefinedValue$$

Where f (.) is the objective function (fitness function) for the overall system and $g(.)$ is the set of constraint functions (e.g., constraints are on system weight, volume and cost). For more information, see:

P. Wu, L. Gao, D. Zou, and S. Li, "An improved particle swarm optimization algorithm for reliability problems," ISA Trans., vol. 50, no. 1, pp. 71–81, 2011.

1.1. Complex (bridge) system (*P1*): Figure 1 represent a complex system that consists of five subsystems. The objective function for complex system is:

$$Max\ f(r.nc) = R_1R_2 + R_3R_4 + R_1R_4R_5 + R_2R_3R_5 - R_1R_2R_3R_4 - R_1R_2R_3R_5 - R_1R_2R_4R_5 - R_1R_3R_4R_5 - R_2R_3R_4R_5 + 2R_1R_2R_3R_4R_5 \tag{2}$$

subject to:

$$g_1(\mathbf{r},\mathbf{n}) = \sum_{i=1}^{m} w_i v_i^2 n_i^2 - V \le 0$$

$$g_2(\mathbf{r},\mathbf{n}) = \sum_{i=1}^{m} \alpha_i \left(-\frac{1000}{\ln(r_i)}\right)^{\beta_i} [n_i + \exp(0.25 n_i)] - C \le 0$$

$$g_3(\mathbf{r},\mathbf{n}) = \sum_{i=1}^{m} w_i n_i \exp(0.25 n_i) - W \le 0$$

$$0 \le r_i \le 1, \quad n_i \in Z^+, \ 1 \le i \le m.$$

1.2. **Series system (*P2*):** Figure 2 represents a series system consisting of five subsystems. The objective function for series system is:

$$Max\ f(r.n) = \prod_{i=1}^{m} R_i = \prod_{i=1}^{5} (1 - (1 - r_i)^{n_i}) \tag{6}$$

subject to: $g_1(r.n)\ .\ g_2(r.n),\ g_3(r.n)$.

Parameter used for complex (bridge) system (P1) and series system (P2) are listed in table (2):

Table 2. Parameter used for complex and series system

i	$10^5\alpha_i$	β_i	$w_i v_i^2$	w_i	V	C	W
1	2.330	1.5	1	7	110	175	200
2	1.450	1.5	2	8	110	175	200
3	0.541	1.5	3	8	110	175	200
4	8.050	1.5	4	6	110	175	200
5	1.950	1.5	2	9	110	175	200

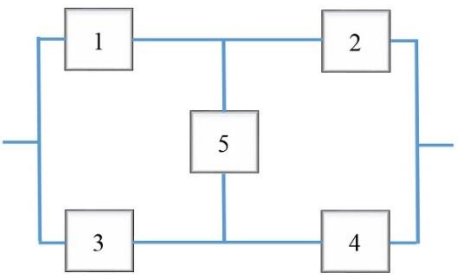

Figure 1. Complex (bridge) system (P1)

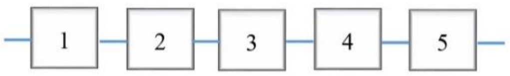

Figure 2. series system (P2)

Notes:

- Your implementation should be functional.
- You should write a complete report for the results you get.
- Allowed programming languages: MATLAB – python.
- Feel free to change the model parameters.
- Any sign of cheating would be result in the zero grade for the assignment.
- Your codes should be self-commented.
- Send you codes in a ZIP file named "LASTNAME - FIRSTNAME.zip"