A Comparison of PSO and the Genetic Algorithm

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The Idea

- Test the claim that PSO is as effective as GA but also more efficient.
- Two experiments (effectiveness and efficiency)
- Three well-known benchmark problems
- Two design-space problems

Benchmark Problems

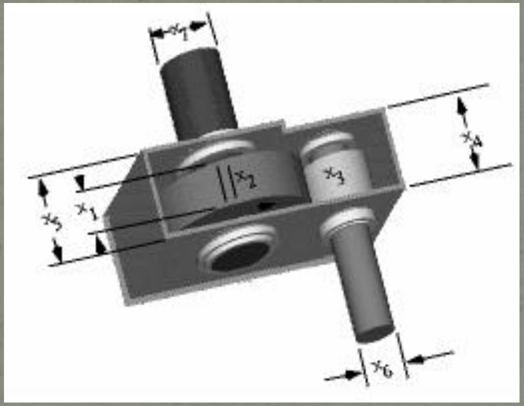
- The Banana (Rosenbrock) Function
- Minimize $f(x) = 100(z - y^2)^2 + (1 - y)^2$
- y and z in [-5,5]
- Known global minimum at (1,1) with value 0.

Benchmark Problems

- The Eggcrate Function
- Minimize $f(x) = y^2 + z^2 + 25((\sin y)^2 + (\sin z)^2)$
- y and z in [-2pi, 2pi]
- Known global minimum at (0,0) with optimal value 0

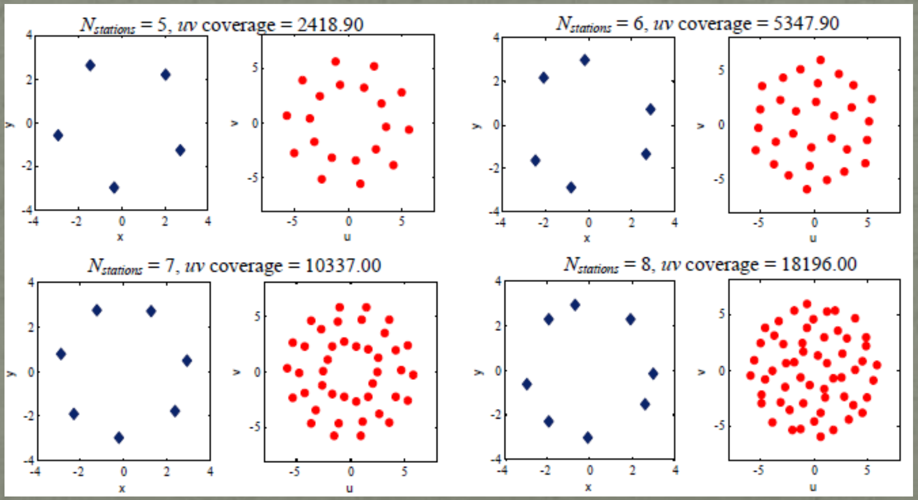
Benchmark Problems

- Golinski's Speed Reducer (i.e. a simple gearbox)
- 11 constraints, 7 variables
- Minimize weight



Space Systems

- Telescope Array Configuration
- Maximize coverage of the sky using a distributed small telescope array
- Known global solution: place all stations on the perimeter of a circle



Space Systems

- Communication Satellite Reliability-Based Design
- Design payload and bus subsystems for geosynchronous satellite with a given payload requirement
- Minimize spacecraft overall launch mass
- 6 functional constraints, 27 <u>discrete</u> variables

Results

	Effectiveness Test, $t_{critical} = 2.0$ Calculated t-value		Efficiency Test, $t_{critical} = 2.5$ Calculated t-value
	PSO	GA	
1- Banana Function	8404.05	-2.49	1.9980
2- Eggcrate Function	312420.20	5214.34	7.2743
3- Telescope Array (5 Stations)	∞	∞	19.2995
4- Telescope Array (6 Stations)	∞	∞	16.8674
5- Telescope Array (7 Stations)	∞	∞	20.9451
6- Telescope Array (8 Stations)	∞	∞	23.7893
7- Golinski's Speed Reducer	-0.39	1251.28	10.3079
8- Satellite Design	-2.13	6.47	19.6993

Results

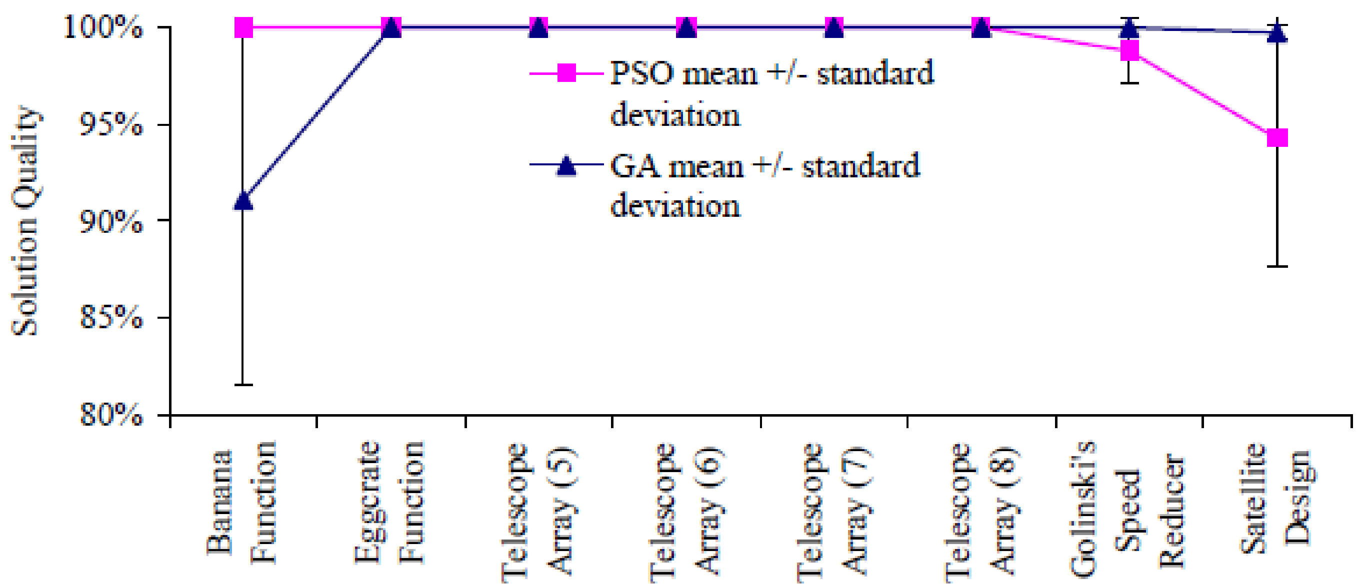


Figure 4. The mean quality of the solutions obtained by PSO and the GA using 10 run samples for eight test problems.

Results

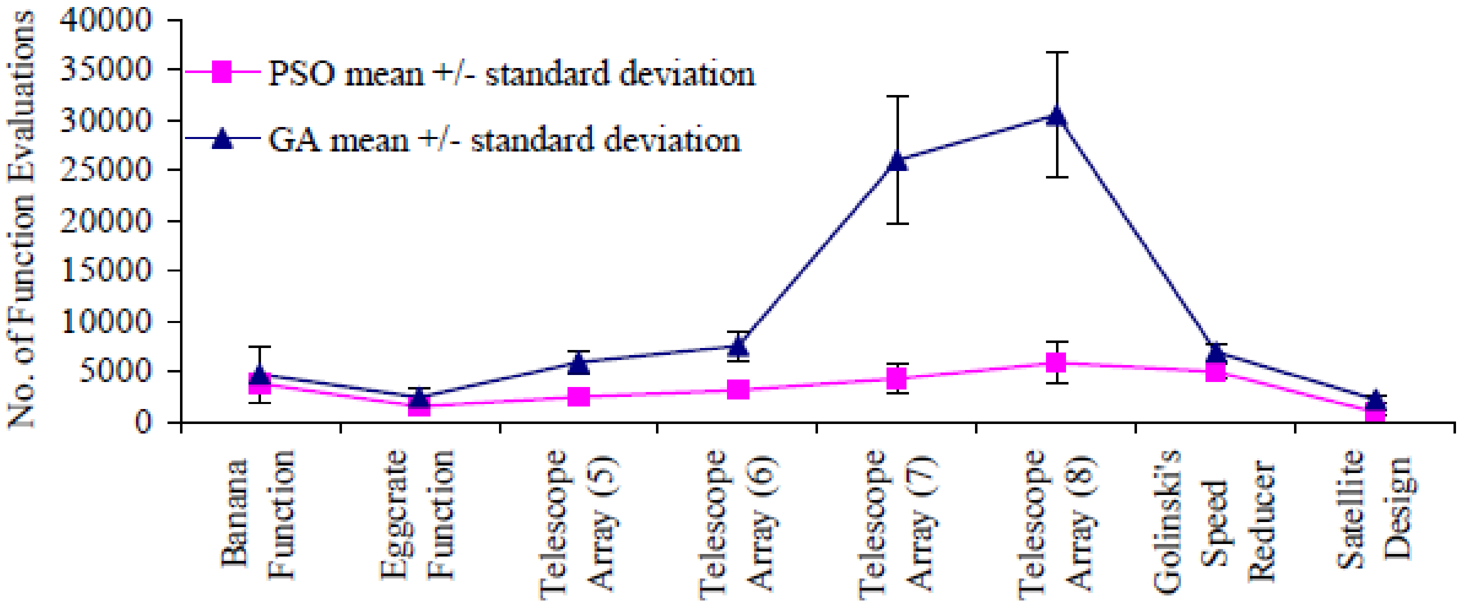


Figure 5. The mean computational effort of the solutions obtained by PSO and the GA using 10 run samples for eight test problems.

Results

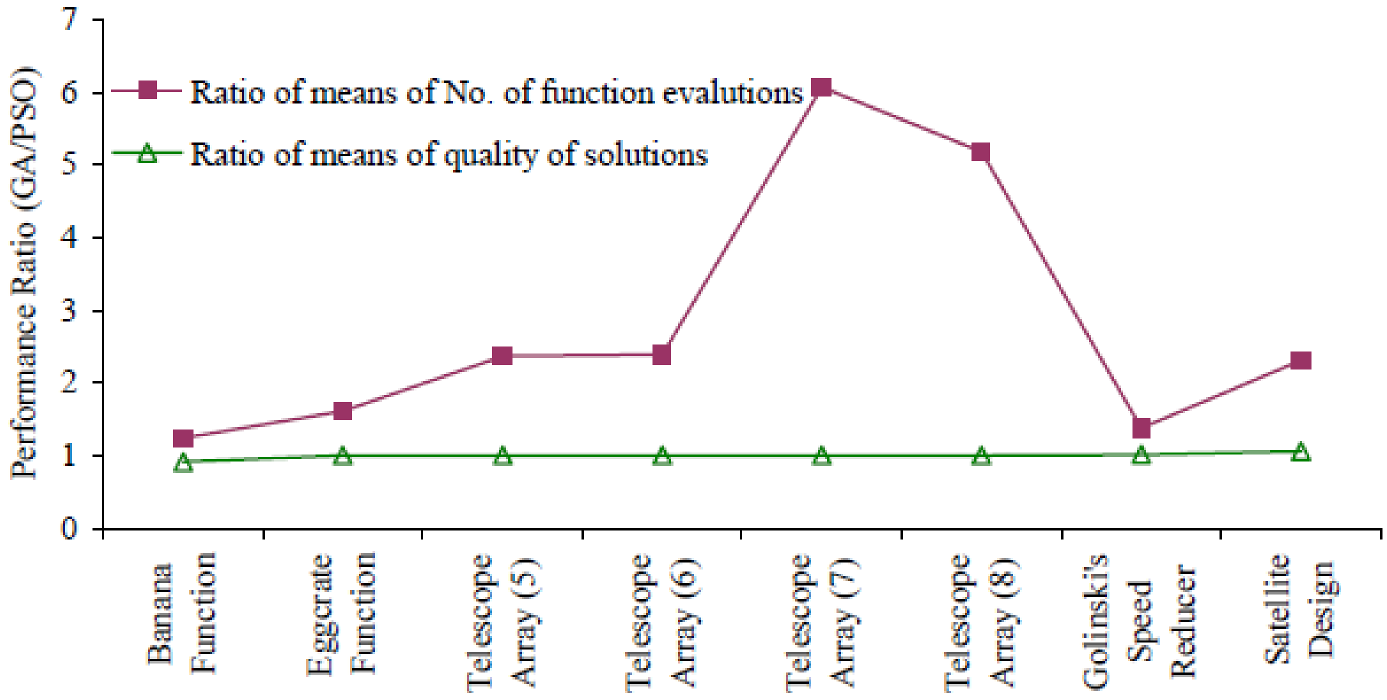


Figure 6. Comparison of ratios of solution quality and computational effort of PSO and the GA.

Conclusions

- PSO and GA produce solutions of equal quality (99% confidence level).
- PSO significantly outperforms GA when solving unconstrained nonlinear problems with continuous variables.
- PSO has a slight performance lead on GA when solving constrained nonlinear problems with continuous or discrete variables.