Hybrid Algorithm as alternative method for optimization, a combination Genetic Algorithm and Particle Swarm Optimization

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Abstract. Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) are both known as a method for optimization. Here in these paper we will combine GA and PSO to create a hybrid algorithm. We compare GA, PSO and Hybrid to solve some optimization problem. These Hybrid Algorithm is an alternative method for optimization.

1. Introduction
There are a lot of Heuristic method that had been develop such as Evolutionary Computation, Simulated Annealing, Tabu Search, Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Ant Colony Optimization, etc. The promising heuristic method to solve optimization problem are GA and PSO as it said on Zhijie Li [1] paper. In this paper we try to make a hybrid method that combine GA and PSO.

2. Genetic Algorithm
Genetic Algorithm (GA)[2], [3] proposed by Golberg as a method of heuristic search that copy of nature selection. At first GA will choses by random a number of individual solution. This number of individual call as a population and became the first generation. Each individual had value of fitness. The higher value of fitness will make the individual became a parent for the next generation. A couple parent will get crossover to create a new offspring of them. This offspring became their kids. Some of this kids had a mutation. This kids became a new individual who will became a new parent for the next-next generation. This will repeated until some generation. GA will stop if the solution found or the generation has reach its maximum.

This is the process of Genetic Algorithm.
- Chromosome representation.
- Construction of first generation of population.
- Bench marking every individual on population.
- If the best value of bench marking solve the problem or the generation has reach its maximum then the process STOP.
- Selection process.
  - Count the Fitness value of each individual.
  - Elitism, Select the best 2 of individual that will became the next generation.
• Crossover. Select 2 individual then marriage those 2 to make 2 kid for the next generation. This process repeated until the number of population fulfilled.
• Mutation. Change the chromosome of population.
• Resorting the best individual of population became the next generation, and GO TO process 3.

3. Particle Swarm Optimization
The Particle Swarm Optimization [4] are inspired by the flocking and schooling patterns of birds or fishes. Particle Swarm Optimization (PSO) was invented by Russell Eberhart and James Kennedy in 1995. Let say we had a random population of bird. The closest bird to food will chirps loudest than other, this bird became the best position of groups. Each bird had an inertia of ability to move. Also each bird had personal best position to the food. So the velocity of each bird is a combination information of 3 thing such as its personal best position, the best position of groups and inertia of ability to move. The next position is sum of the velocity and previous position. This bird will continue to move until the source of food found or this bird died. This is the function of speed:

\[ V^{(i+1)} = \omega V^{(i)} + C_1 r_1 (P_{best} - S^{(i)}) + C_2 r_2 (G_{best} - S^{(i)}) \]  

(1)

And this is the function of position:

\[ S^{(i+1)} = V^{(i+1)} + S^{(i)} \]  

(2)

with:
- \( i \) : iteration numbers.
- \( S \) : particles position
- \( V \) : particles speed
- \( w \) : inertia weight
- \( C_1 \) : cognitive weight
- \( C_2 \) : social weight
- \( P_{best} \) : Best position of particles
- \( G_{best} \) : The Best position of population
- \( r_1, r_2 \) : random numbers between 0 to 1.

4. Hybrid Method
The GA and PSO has own speciality, here are some speciality of it.

Table 1. Formatting sections, subsections and subsubsections.

| Operator                          | Genetic Algorithm | Particle Swarm Optimization |
|-----------------------------------|-------------------|-----------------------------|
| Ability to search global optimum  | High              | Low                         |
| Implementation                    | Hard              | Simple                      |
| Trapped on local optimum          | Sometimes         | Often                       |
| Computer Efficiency               | Lowly Efficient   | Highly Efficient            |
| Speed of Computation              | Slow              | Fast                        |
| Complexity                        | Complex           | Simple                      |
We purpose a hybrid algorithm as a combine from Genetic Algorithm and Particle Swarm Optimization. These are the algorithm:

- **Initialization**: Define system parameters such as number variables, lower and upper bounds on decision variable. Specify parameters such as population size $N_p$ number of generation $N_g$, crossover ratio $r_c$, mutation ratio $r_m$, inertia $I$, Cognitive $C$, Social $S$.

- **Generation of initial population**: Generate $N_p$-th initial population that satisfying boundary constrain. Then compute their fitness for each individual in initial population.

- **Selection**: We choose $0.5N_p$ pairs based on their fitness from the population to became a new parents.

- **Crossover**: We generate $0.5N_p$-th random number then compare it with crossover ratio $r_c$ to choose which parents are can have children. If the parent who cannot had children then this parent become a new individual in next generation. If the parent who can had children then they make 2 children with a combination information of parent, and this children become a new individual in next generation.

- **Mutation**: Some children from crossover process get mutation by mutation ratio $r_m$.

- **Growth**: These part is the PSO part. There are 3 parameter that can guide the children to grow up. First is Inertia $I$ value that can drive the children to change. Second is Cognitive value $C$ that can change the children because of their idol in family. Third is Social value $S$ that can change the children because of the idol in world. The speed of changes is the average of those 3 parameter.

- **Generation of new population**: Compute the fitness of grow up children. Then repeat process Selection (3).

  - This repeat until number of generation $N_g$.

5. Test Project

We chose 3 function to compare GA, PSO and Hybrid. This 3 function was taken from Digalakis[5] paper.

\[
f_1 = 100(x_1^2 - x_2)^2 + (1 - x_1)^2
\]  

\[
f_2 = 200 + \sum_{i=1}^{10}(x_i^2 - 10\cos(2\pi x_i))
\]  

\[
f_3 = 1 + \sum_{i=1}^{10}\left(\frac{x_i^2}{4000}\right) - \prod_{i=1}^{10}\left(\cos\left(\frac{x_i}{\sqrt{i}}\right)\right)
\]

We use the same initial of 30 individual at start until next 20 generation for Genetic Algorithm, Particle Swarm Optimization and Hybrid Method. Here are the result.
5.1. 1st function of Digalakis

\[ f_1 = 100(x_1^2 - x_2)^2 + (1 - x_1)^2 \]

The first function has minimum value at 0. As we can see that the result of GA, PSO and Hybrid are the same, as you can see at Figure 1.

5.2. 2nd function of Digalakis

\[ f_2 = 200 + \sum_{i=1}^{10} (x_i^2 - 10 \cos(2\pi x_i)) \]

Figure 1. The first function test result

Figure 2. The second function test result
The second function has minimum value at 100. As we can see that the result of PSO and Hybrid are the same, as you can see at Figure 2. The GA had not reach the best value.

5.3. 3rd function of Digalakis

\[ f_3 = 1 + \sum_{i=1}^{10} \left( \frac{x_i^2}{4000} \right) - \prod_{i=1}^{10} \cos \left( \frac{x_i}{\sqrt{i}} \right) \]

The third function has minimum value at 11. As we can see that the result of Hybrid are better than PSO. And PSO is better than GA, as you can see at Figure 3.

6. Conclusions

Hybrid Method as an alternative method for optimization problems with better results than GA or PSO.

References

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