Improvement of Genetic Algorithm Using PSO and Euclidean Data Distance

Dong Hwa Kim

Dept. of Instrumentation and Control Eng., Hanbat National University,
16-1 San Duckmyong-Dong Yuseong-Gu, Daejon City, Korea, 305-719.
E-mail: kimdh@hanbat.ac.kr, Hompage: aialab.net
Tel: +82-42-821-1170, Fax: +82-821-1164

kimdh@hanbat.ac.kr

Abstract

When we obtain an optimal solution using GA (Genetic Algorithm), operation such as crossover, reproduction, and mutation procedures is using to generate for the next generations. In this case, it is possible to obtain local solution because chromosomes or individuals which have only a close affinity can convergent. To improve an optimal learning solution of GA, this paper deal with applying PSO (Particle Swarm Optimization) and Euclidian data distance to mutation procedure on GA's differentiation to obtain gobal and local optimal solution together.

Keyword： Genetic algorithm, Particle swarm optimization, Hybrid system, optimal algorithm

I. Introduction

The In the last decade, evolutionary based approaches have received the increasing attention of engineers dealing with problems not amenable to existing design theories: [1]. A typical task of a GA in one of artificial intelligence in this context is to find the best values of a predefined set of free parameters associated to either a process model or a control vector. One of an active area of research in GA is system identification: [2]. A recent and thorough survey of evolutionary algorithms for evaluation of improved learning algorithm, control system engineering can also be found in [3, 4]. The general problem of evolutionary based engineering system design has been tackled in various ways. GA has also been used to optimize nonlinear system strategies. Among them, a large amount of research focused on the design of fuzzy controllers using evolutionary approaches for knowledge about the controlled process in the form of linguistic rules and the fine tuning of fuzzy membership function is often necessary to reach satisfactory results. [7]

In this paper, to improve an optimal learning solution of GA, we apply PSO (Particle Swarm Optimization) and Euclidian data distance to mutation procedure on GA's differentiation. This research can have global and local optimal solution together and faster solution without any local solution through this approach. We use four test functions for proof of this suggested algorithm.

II. Euclidian distance for GA-PSO

A. *Overview of PSO*

The PSO conducts searches using a population of particles which correspond to individuals in GA. A population of particles is randomly generated initially. Each particle represents a potential solution and has a position represented by a position vector. A swarm of particles moves through the problem space, with the moving velocity of each particle represented by a velocity vector. At each time step, a function representing a quality measure is calculated by using the results of crossover and mutation as input. Each particle keeps track of its own best position, which is associated with the best fitness it has achieved so far in a vector. At each time step, by using the individual best position, and global best position, the flexibility of PSO to control the balance between local and global exploration of the problem space helps to overcome premature convergence of elite strategy in GA, and also enhances searching ability. Of course, GA with Euclidean data distance is used for hybrid system with PSO.

B. *Improvement of GA by PSO*

The characteristic of hybrid system of PSO and GA have been studied [3-5]. This paper focuses on hybrid system using GA and PSO based on Euclidean distance. Position and speed vector of PSO is given by

$$v_{f,g}^{(t+1)} = w \cdot v_j^{(t)} + c_1^* rand()^* \left(pbest_{j,g} - k_{j,g}^{(t)}\right) + c_2^* Rand()^* \left(gbest_g - k_{j,g}^{(t)}\right)$$
$$j = 1,2,...,n;\ g = 1,2,...,m;\ k_{j,g}^{(t+1)} = k_{j,g}^{(t)} + v_{j,g}^{(t+1)};\ k_g^{\min} \le k_{j,g}^{(t+1)} \le k_g^{\max} \qquad (1)$$

n : The number of agent in each group, m : The number of member in each group, t : Number of reproduction step, $v_{j,g}^{(t)}$: The speed vector of agent j in reproduction step of t^{th}. $V_g^{\min} \le v_{j,g}^{(t)} \le V_g^{\max}$, $k_{j,g}^{(t)}$: The position vector of agent j in reproduction step of t^{th}, w : Weighting factor, $c1, c2$: Acceleration constant, $rand(), Rand()$: Random value between 0 and 1, $pbest_j$: Optimal position vector of agent j, $gbest$: Optimal position vector of group.

The value of position vector and speed vector is determined by acceleration constant $c1, c2$. If these values are large, each agent moves to target position with high speed and abruptly variation. If vice versa, agents wander about target place. As weighting factor w is for the searching balance of agent, the value for optimal searching is given by

$$w = w_{\max} - \frac{w_{\max} - w_{\min}}{iter_{\max}} \times iter\ , \qquad (2)$$

where $w_{\max}$: Max mum value of w (0.9), $w_{\min}$: Minimum value of w (0.4), $iter_{\max}$: The number of iterative number, $iter$: The number of iterative at present.

The speed vector is limited by $V_g^{\min} \leq v_{j,g}^{(t)} \leq V_g^{\max}$. In this paper, the value of speed vector for each agent is limited with 1/2 to avoid abrupt variation of position vector. Computing process for each step is as the following step.

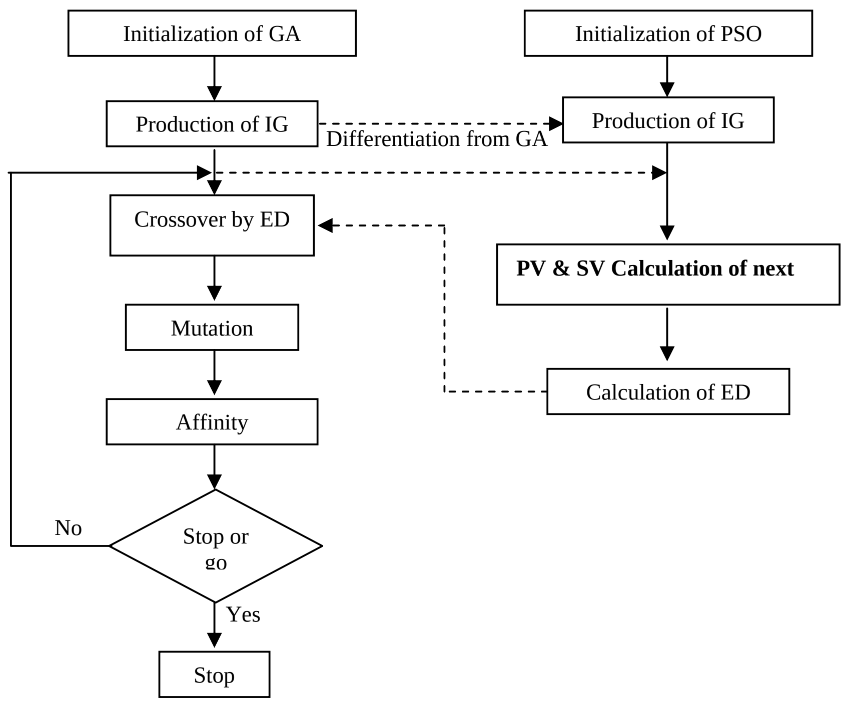

Fig. 1. Calculation procedure of GA-PSO algorithm.

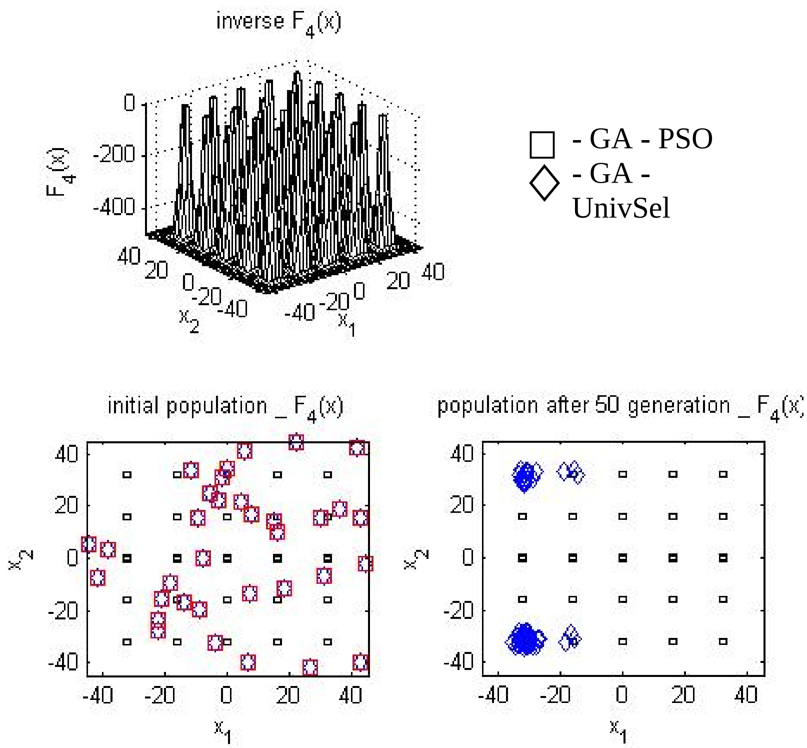

Fig. 2 (a). Fox hole.

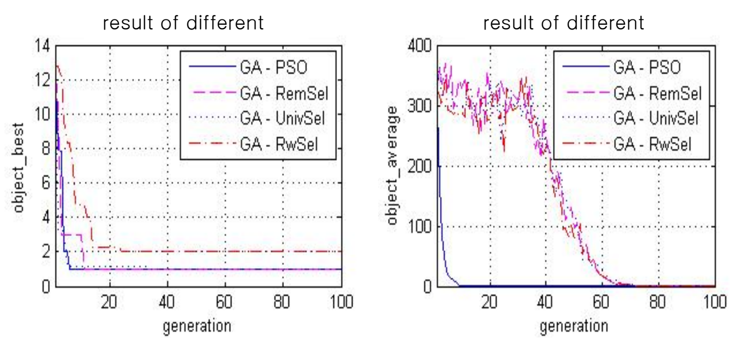

Fig. 2(b). Fox hole.

[Step 1] Initialize each variables of GA; [Step 2] Initialize each variables of PSO.; [Step 3] Calculate affinity of each agent for condition of optimal solution of GA. At this point, optimal position condition of PSO is introduced into GA; [Step 4] Arrange the group of PSO and agent in GA; [Step 5] Update position vector $pbest$ and speed vector $gbest$; [Step 6] Operate crossover in GA using Euclidian distance and position vector PSO; [Step 7] Operate mutation in GA; [Step 8] If condition of GA is satisfied with target condition (the number of iteration and target value), processing for reproduction stops. In this paper, at first time, position of individual on data set is calculated by Euclidean distance based method and then mutation and crossover is performed to improve running speed on optimal process. Therefore, it is able to obtain global optimal solution because all data effect solution. Fig. 2 represents relationship between objective function and generation to the number of particle in PSO.

III. Simulation and Discussion

In this section, test function, Fox hole

$$F_4 = \left(0.002 + \sum_{j=1}^{25} \left(j + \sum_{i=1}^{2} (x_i - a_{ij})^6 \right)^{-1} \right)^{-1}$$

is applied to the proposed system.

Fig. 2 and Table 1 are for the results of Fox hole function. These illustrate the proposed system is the faster stability, when GA – PSO, GA – RemSel, GA – UnivSel, and GA – RwSel vary.

IV. Conclusion

Generally, the GA uses three basic operators (reproduction, crossover, and mutation) to manipulate the genetic composition of a population. Reproduction is a process by which the most highly rated individuals in the current generation are reproduced in the new generation.

Table 1. Comparison to Fox function.

	x1	x2	Optimal value of objective function (1.0e-005*)	Average value of objective function
GA - PSO	3.5844	-1.8481	0.0002	0.0285
GA - RemSel	3.0000	2.0000	0.0003	1.1161e-005
GA - UnivSel	2.9998	2.0002	0.1121	2.1361e-005
GA - RwSel	3.0000	2.0000	0.0003	1.0902e-005

The crossover operator produces two offsprings (new candidate solutions) by recombining the information from two parents. In this paper, GA Euclidian based distance conception and PSO are introduced into enhancement of optimal learning of the conventional. By Euclidian distance, total data set can have an effect on mutation or crossover of GA. Therefore, GA can provide for the exact optimal solution, while it can avoid local optimal. On the other hand, this paper deals with applying PSO (Particle Swarm Optimization) to have a faster convergence. A candidate solution for a specific problem in GA is called an individual or a chromosome and consists of a linear list of genes. Each individual represents a point in the search space, and hence a possible solution to the problem. A population consists of a finite number of individuals. Each individual is decided by an evaluating mechanism to obtain its fitness value. Based on this fitness value and undergoing GA-PSO operators with Euclidian distance, a new population is generated iteratively with each successive population referred to as a generation. In case of PSO, it can have the faster convergence and function to limit data. The GA-PSO system proposed in this paper can have a superiously optimal solution function to local optimal and total optimal method.

References

[1] J. C. Ports, T. D. Giddens and S. B. Yadav, "The Development and Evaluation of an Improved Genetic Algorithm Based on Migration and Artificial Selection, "*IEEE Trans. Syst., Man, Cybern*. , 1994, Vol.24, No.1,pp.73-86.

[2] J. Kennedy and R. Eberhart, "Particle swarm optimization" in *Proc. IEEE int. Conf. Neural Networks*, 1995, vol. IV, Perth, Australia, pp. 1942-1948.

[3] Angeline, P.J., "Using Selection to Improve Particle Swarm Optimization", *IEEE int. Conf.* , 1998, pp. 84-89.

[4] Chia-Feng Juang, "A Hybrid of Genetic Algorithm and Particle Swarm Optimization for Recurrent Network Design", *Systems, Man and Cybernetics, Part B, IEEE Trans*. , 2004 Vol. 34, pp. 997-1006.

[5] Shi. X. H., Lu. Y. H, Zhou. C. G., Lee. H. P,Lin. W.Z, Liang. Y.C.,"Hybrid Evolutionary Algorithms Based on PSO and GA", *Evol. Comp. 2003. CEC '03*., 2003,Vol. 4, pp. 2393-2399.

[6] Dong Hwa Kim, "Comparison of PID Controller Tuning of Power Plant Using Immune and genetic algorithm. Measurements and Applications," *Ligano, Switzerland*, 29-31 July 2003.

[7] Dong Hwa Kim, "Robust PID controller tuning using multiobjective optimization based on clonal selection of immune algorithm," *Proc. Int. Conf. Knowledge-based intelligent information and engineering systems. Springer-Verlag*. ,2004 , pp. 50-56.

Author's biography

Name: Dong Hwa Kim

Affiliation: Hanbat National University

Address: San 16-1, Duckmyong Yuseong Daejon Seoul, Korea. 305-719

Brief Biographical History:

1977-1993: KAERI

1985-1986: AECL in Canada

2000. 3-2001.3: University of Alberta in Canada

1993.3- : Hanbat National University in Korea

Main Works:

Intelligent control, Immune algorithm based control, Evolutionary algorithm.

Membeship in Society:

SICE(The Society of Instrument and Control Engineers), IEEE, RSJ(The Robotic Society of Japan), ISA, IEEJ(The Institute of Electrical Engineers of Japan. KIEE(Korea Institute of Electrical Engineers), INNS(International Neural Network Society), SOFT(Journal of Japan for Fuzzy Theory and Intelligent Informatics).