Available online at www.sciencedirect.com
ScienceDirect
Journal of the Franklin Institute 344 (2007) 362–376
Journal of The Franklin Institute
www.elsevier.com/locate/jfranklin

Swarm intelligence based classifiers ☆

Seyed-Hamid Zahiri[a,*], Seyed-Alireza Seyedin[a,b]

[a]*Department of Electrical Engineering, Faculty of Engineering, Birjand University, P.O. Box. 97175-376, Birjand, Iran*
[b]*Department of Electrical Engineering, Faculty of Engineering, Ferdowsi University of Masshad, Mashhad, Iran*

Received 14 January 2005; accepted 21 December 2005

Abstract

A proposed *particle swarm classifier* has been integrated with the concept of *intelligently controlling the search process of PSO* to develop an efficient swarm intelligence based classifier, which is called intelligent particle swarm classifier (IPS-classifier). This classifier is described to find the decision hyperplanes to classify patterns of different classes in the feature space. An intelligent fuzzy controller is designed to improve the performance and efficiency of the proposed classifier by adapting three important parameters of PSO (*inertia weight*, *cognitive parameter* and *social parameter*). Three pattern recognition problems with different feature vector dimensions are used to demonstrate the effectiveness of the introduced classifier: Iris data classification, Wine data classification and radar targets classification from backscattered signals. The experimental results show that the performance of the IPS-classifier is comparable to or better than the *k*-nearest neighbor (*k*-NN) and multi-layer perceptron (MLP) classifiers, which are two conventional classifiers.

Keywords: Decision hyperplanes; Fuzzy controller; Particle swarm optimization; Pattern recognition

1. Introduction

Particle swarm optimization (PSO) is a swarm intelligence technique developed by Kennedy and Eberhart in 1995 [1]. In fact, natural flocking and swarm behavior of birds

☆This paper is an extended version of the paper entitled "Intelligent Particle Swarm Classifiers", which has been presented in the *First International Conference on Modeling, Simulation and Applied Optimization* (*ICMSAO/05*) and has been selected for the special issue of Journal of the Franklin Institute.

*Corresponding author. Tel.: +985612227044; fax: +985612223925.
E-mail addresses: shzahiri@yahoo.com (S.-H. Zahiri), seyedin@ferdowsi.um.ac.ir (S.-A. Seyedin).

0016-0032/$30.00
doi:10.1016/j.jfranklin.2005.12.006

and insects inspired him to PSO. This technique has been used in several optimization and engineering problems (e.g. [2,3]). In pattern recognition problems some particle swarm clustering techniques have been proposed (e.g. [4,5]), but a swarm intelligence based classifier using PSO directly to obtain the decision functions in the feature space has not been implemented in the recent researches. In this paper an *intelligent particle swarm classifier* (*IPS-classifier*) is developed, integrating the concept of *intelligently controlling the search process of* PSO with a proposed *particle swarm classifier* (*PS-classifier*), which is designed to find the decision hyperplanes in the feature space.

An IPS-classifier has an additional intelligent controller to adapt the important parameters of PSO to increase its efficiency and means steering the swarm to an appropriate trajectory to find a better solution. Simulation results indicate that convergence to better hyperplanes with a lower number of iterations can be achieved using this technique. In fact, the IPS-classifier searches the solution space and chooses hyperplanes in such manner that the misclassified training points are minimized.

PSO is a simple and powerful search technique in high dimensional spaces, therefore IPS-classifier has the potentiality to successfully classify different classes in *high dimensional* feature spaces by achieving the separate hyperplanes, with a little priori information.

Any intelligent controller may be utilized to increase the efficiency of the classifier. In this article a fuzzy structure has been chosen and the IPS-classifier using this controller is called *fuzzy controlled particle swarm classifier* (*FCPS-classifier*).

The fuzzy controller rules have been extracted from a linguistic description from previous researches on study the effects of the PSO parameters on its search process (e.g. [6–8]).

Two common benchmark problems and a special problem in pattern recognition are considered to compare the proposed and the other methods with each other. The Iris data and the Wine data classification are common problems in pattern recognition researches with low and medium feature space dimensions and automatic target recognition for continuous wave radars is a special pattern recognition problem with high feature space dimensions. The performance of an IPS-classifier is compared with k-NN and MLP classifiers to show that the average recognition scores of designed IPS-classifier are better than or comparable to the traditional classifiers. To show the effectiveness of the intelligent fuzzy controller in the search process and correctly steering the swarm toward the solution, some meaningful figures are included.

In this paper, Section 2 explains a particle swarm classifier (PS-classifier). Intelligent particle swarm classifier is described in the next Section. Section 4 considers implementation of the classifier and experimental results on the three aforesaid pattern recognition problems. Finally, conclusion and discussion is presented in Section 5.

2. Fundamentals of a particle swarm classifier

2.1. PSO algorithm

In the basic PSO technique proposed by Kennedy and Eberhart [1], great number of particles moves around in a multi-dimensional space and each particle memorizes its position vector and velocity vector as well as the time at which the particle has acquired the best fitness. Furthermore, related particles can share data at the best-fitness time.