Present State of Swarm Intelligence and Future Directions

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INTRODUCTION

The field of Artificial Intelligence is based on research activities for simulating human-thinking and behaviors, thanks to advanced mathematical approaches. In this field, there are many different kinds of interest areas in which researchers perform different studies to obtain effective solutions for especially real-world based problems. At this point, Swarm Intelligence is one of the most remarkable interest areas, which attract researchers' attention. The research scope of Swarm Intelligence is associated with problem solution approaches, which employ collective behavior of natural or artificial self-organized systems. In this context, different types of algorithms have been designed and developed by researchers in order to provide alternative solutions for the problems.

Regarding to the research activities in Swarm Intelligence, it has been a trend to design and develop new algorithms aiming to ensure better solution ways for certain problems. In order to achieve this, researchers has spent their time on examining natural dynamics of different swarms and tried to design some mathematical algorithms to provide similar models of natural dynamics while obtaining general solution frameworks. It is important that the nature has a great, inspiring role on creating new algorithmic structures to combine both mathematics and physical events, which we witness in the real life.

When the present literature is examined, it can be seen that some widely used Swarm Intelligence algorithms like Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC) and Artificial Immune Systems (AIS) have important popularity to be used among different problems. In addition to these algorithms, there are also many different algorithms, which have been already introduced in the related literature. These algorithms are generally based on natural dynamics and may include some additional working mechanisms based on evolutionary approaches or models, which have been introduced before. Anyone, who wants to understand present state of the literature and have ideas on future directions, should examine general approaches of the algorithms and learn working mechanisms employed in them.

The primary mission of this article is to figure out present state of the literature on Swarm Intelligence, and express some ideas about future directions. For this aim, it has been organized as a study, which explains basics of well-known and widely-used algorithms on Swarm Intelligence, and discusses about some comparative aspects; making it better to understand more about the present state. After explaining basics of the algorithms, the article employs some sections to introduce some recent comparative studies, in order to enable readers to have ideas on which algorithms are better than others. In this way, it is aimed to show more about present status and have some preliminary ideas before talking about potential works in the future. As general, the article supports the idea of last sentence in previous paragraph; and makes it easier for people, who are interested in Swarm Intelligence, to understand present state of the literature and have ideas on future directions.

BACKGROUND

In order to discuss about present state of Swarm Intelligence and have an objective idea about the future, basics of the related algorithms covered in this article should be explained first. Because the term of Swarm Intelligence has been expressed indirectly at the beginning, background section of this article is devoted to the algorithms.

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Particle Swarm Optimization (PSO) Algorithm

Particle Swarm Optimization (PSO) algorithm is an optimization approach, which simulates social behavior related to the actions and movement of organisms in a bird flock or fish school (Kennedy, 1997; Kennedy & Eberhart, 1995; Shi & Eberhart, 1998).

As default, PSO employs a population (swarm) of candidate solutions (particles) formed for the specific problem. At this point, the 'particles' move in the 'search space' by taking into account some mathematical equations. Particle movements are affected by their own best known position within the search space as well as the entire swarm's best known position (Kennedy, & Eberhart, 1995; Kennedy, 1997; Shi, & Eberhart, 1998; Particle Swarm Optimization, n.d.). Calculated positions are used in new iterations to determine new movements while searching for the best solution of the problem. All process is repeated in a cycle until an appropriate solution is found.

Figure 1 shows general PSO mechanism (Corne, 2012).

In the Figure 1, green dots point the particles, which are near to the optimal solutions whereas the blue ones are not just near yet. Optimal solutions are visualized with some hills – peaks. The figure is also a reference for typical working mechanism of many Swarm Intelligence based optimization algorithms.

Algorithm of the PSO is shown in Figure 2 (Karaboga & Akay, 2009).

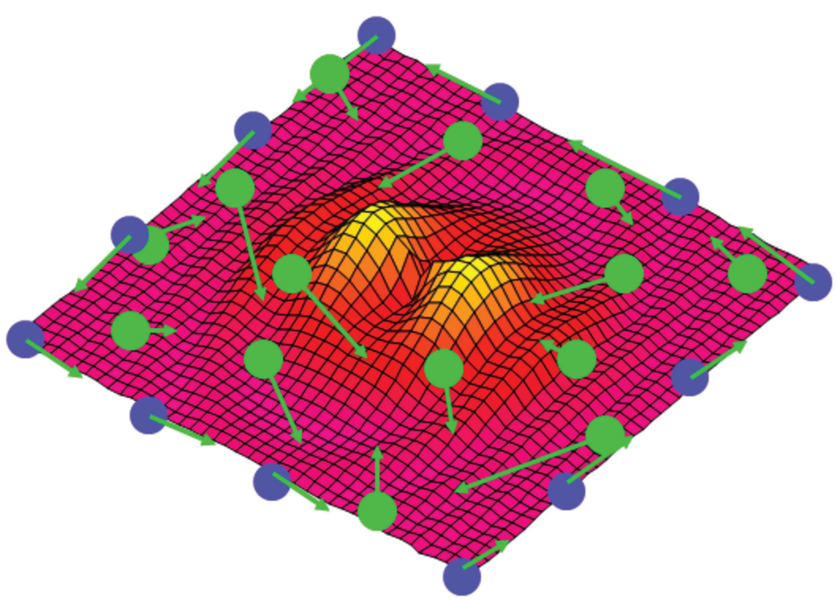
More about mathematical details of the PSO can be found at Kennedy and Eberhart (1995) and Shi and Eberhart (1998).

Ant Colony Optimization (ACO) Algorithm

Ant Colony Optimization (ACO) algorithm was first introduced by Dorigo in his Doctorate thesis (Colorni, Dorigo, & Maniezzo, 1991; Dorigo, 1992). As general, the algorithm is based on a searching operation for the most optimal path in some kind of solution space. At this point, the 'graph' data model is used for defining the solution space.

Briefly, ACO can be evaluated as a simple simulation for behaviors of ants seeking a path between the colony and a food source. Because of this, natural aspects of ant behavior should be known in order to understand the algorithm structure better. According to the natural behavior, ants start to wander randomly and when an ant finds a food source, it returns back to the colony while laying down the 'pheromone' trails. If other ants find such a path, they start to follow

Figure 1. General PSO mechanism (Corne, 2012)



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