Artificial Bee Colony (ABC) algorithm for the job-shop scheduling problem

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1 Introduction

Artificial bee colony algorithm simulating the intelligent foraging behavior of honey bee swarms is one of the most popular swarm based optimization algorithms. It has been introduced by Karaboga in 2005 [1] and applied in several fields to solve different problems up to date.

The objective of this work, is to adapt the metaheuristics of the bee colony optimization (the Artificial Bee Colony (ABC) algorithm) for solving the Job shop Scheduling Problem (JSP) which is known as one of the most difficult scheduling problems. The JSP is an optimization problem that can be described in terms of a set of n jobs, each with one or more operations. The operations of a job have to be processed in a specified sequence on a specific set of m machines. The time required for all operations to complete their processes is called the makespan (Cmax). The objective of JSP aims to minimize the makespan value. The characteristics of the JSP class them as an NP-hard problem and as an important practical problem in the fields of production management and combinatorial optimization.

ABC algorithm has only one tuning parameter (the size of the population) and has the advantage of having a very fast convergence to the solution because it stresses the balance between global exploration and local exploitation. ABC algorithm is tested on 5 benchmarks problems taken from the Operations Research Library (OR- Library) [3] and the results obtained are compared to the best known solutions (BKS) for the instances reported by Jain and Meeran [4].

2 Artificial bee colony algorithm (ABC)

2.1 A real bee colony :

In a real bee colony, some tasks are performed by specialized individuals. These specialized bees try to maximize the nectar amount stored in the hive using efficient division of labour and self-organization. a honey bee colony which the consists of three kinds of bees: employed bees, onlooker bees and scout bees. Half of the colony consists of employed bees, and the other half includes onlooker bees. Employed bees are responsible for exploiting the nectar sources explored before and giving information to the waiting bees (onlooker bees) in the hive about the quality of the food source sites which they are exploiting. Onlooker bees wait in the hive and decide on a food source to exploit based on the information shared by the employed bees. Scouts either randomly search the environment in order to find a new food source depending on an internal motivation or based on possible external clues.

2.2 The ABC algorithm

ABC algorithm takes concepts from the foraging process in a real bee colony to discover good solutions in an optimization problem. Essential components in ABC algorithm are defined as follows : **Food Source** represents a feasible solution in an optimization problem. **Fitness Value** represents the *profitability* of a food source. For simplicity, it is represented as a single quantity associated with an objective function of a feasible solution. **Bee Agents** is a set of computational agents. They are categorized into three groups : employed bees, onlooker bees, and scout bees. Each solution in the search space consists of a set of optimization parameters, which represent a foodsource's *location*. The number of employed bees is equal to the number of food sources.

A pseudo-code of main body of ABC algorithm [2] :

Step 1 : Initial_Solutions
While (criterion) : **Step 2** : Update_Feasible_Solutions (Employed bees)
Step 3 : Select_Feasible_Solutions (Onlooker bees)
Step 4 : Update_Feasible_Solutions (Onlooker bees)
Step 5 : Avoid_Sub-Optimal_Solutions (Scout bee)
Step 6 Memorize the best solution achieved so far
End while , End.

2.3 The adaptation of ABC algorithm to the JSP :

For a job shop of n jobs and m machines, the goal is to find the job operation scheduling list that minimizes the makespan value. This operation scheduling list is represented as a food source (a vector x) in the ABC algorithm. Each dimension in a food source (x) represents one operation of a job. Each food source (x) contains n×m dimensions corresponding to n×m operations. At the The implementation of the ABC algorithm the randomly chosen solution or the updated solution must be repaired in order to have an admissible scheduling list. Each dimension in the operation scheduling list of the old food source is selected to produce the new position with the probability of 0.5.The fitness of each food source $f(x)$ is determined by the inverse of its makespan value ($Cmax(x)$), which is calculated during the selection of feasible solutions.

3 Experimental study and discussion :

The performance of the ABC algorithm is evaluated by testing them on 5 benchmark problems taken from the OR-Library [3]. One referred as *ft06* (n×m=6×6) and the others referred as : *la01-la02-la03-la05* (n×m=10×5). We compare our results, donne by the **Table**1, with the best known solution 'BKS' guived for the instance reported by Jain and Meeran [4].

Instance	***ft06***	***La01***	***La02***	***La03***	***La05***
Size (n×m)	6×6	10×5	10×5	10×5	10×5
ABC Cmax	53*	666	655	597	593
BKS Cmax	55	666	655	597	593

Table 1 : The Makespan values obtained with ABC Algorithm for different instances.

It is clearly seen on the **Table** 1 that the ABC algorithm can find the best known solution (BKS) for the four benchmarck problems gived by Lawrence (*la01-la02-la03-la05*), and moreover, for the instance *ft06* the result (Cmax=53) is better than the best known solution donne in the literature [4].

4 Conclusion

This paper investigated the adaptation of the Artificial bee colony algorithm (ABC) for solving the Job shop Scheduling Problem with the criterion to minimize the maximum completion time (makespan). ABC algorithm has only one tuning parameter (the size of the population) and has the advantage of having a very fast convergence to the solution because it stresses the balance between global exploration and local exploitation. The numerical simulation results based on well-known benchmarks and comparisons with the best known solutions existing in the literature demonstrate the effectiveness of the ABC algorithm.

References

[1] D. Karaboga, (2005) An idea based on honey bee swarm for numerical optimization, Technical report TR06, Erciyes University, Engineering Faculty, Computer Engineering Department.

[2] D. Karaboga, C.Ozturk, N. Karaboga, B. Gorkemli, (2012) Artificial bee colony programming for symbolic regression. Information Sciences 209 1–15.

[3] J.E.Beasley,(1990).Or-library : distributing test problems by electronic mail.J. Oper. Res. Soc.14,1069–1072.

[4] A.S. Jain, S. Meeran, (1999). Deterministic job-shop scheduling : Past, present and future. Eur. J. Oper. Res. 113, 390–434.