Camel Herds Algorithm: a New Swarm Intelligent Algorithm to Solve Optimization Problems

Prof. Dr. Ahmed T. Sadiq Al-Obaidi[1], Dr. Hasanen S. Abdullah[2], Zied O. Ahmed[3]
Computer Science Department University of Technology Baghdad, Iraq
[1] drahmaed_tark@yahoo.com, [2] qhasanen@yahoo.com,[3] zied_othman@yahoo.com

Abstract— Swarm Intelligence (SI) is a discipline that deals with artificial and natural systems which study the collective behaviors of social insects or animals. Camel Herds Algorithm (CHA) have been proposed as a new swarm intelligent algorithm in this work. The proposed algorithm depends on the behavior of the camel in the natural wild, taking into consideration that there is a leader for each herd, food and water searching depending on humidity value with neighboring strategy. The Flexible Job Shop Scheduling Problem (FJSP) have been addressed as a case study to confirm the proposed algorithm. The trial result showed that the CHA is a good strategy to find the optimal solution in problem space.

Keywords— Flexible job shop scheduling; makspan

I. Introduction

Swarm intelligence, bio stirred computation in general, has been a matter of concern in the last years, and many Swarm intelligence based optimization algorithms have grew huge admiration. There are many motives for such attention, and two main motives are maybe that these Swarm intelligences based algorithms are dynamic, and that they are very effective in addressing nonlinear design problems with real-world applications. Bio stimulated computation has invaded into almost all areas of sciences, engineering, and industries, from data mining to optimization, from computational intelligence to business planning, and from Bioinformatics to industrial applications. In fact, it is perhaps one of the most active and popular research subjects with wide multidisciplinary connections [1].

The camel is a vital form of the desert ecosystem, where plants, food and energy are found. As the camel considerable local importance, one can make a case for intensifying research on this animal. The areas of behavior, physiology, reproduction and socioeconomic importance of camels have been identified as being most significant where further information is urgently required. Despite its importance, basic scientific information is sparse, especially on behavior [2].

Scheduling is a decision-making method that is used on a regular base in various industrial facilities. It deals with the distribution of resources for jobs and each task has a giving period and its goal is to optimize one or more goals [3].

This paper provides the optimal solution for a flexible job shop scheduling problem, through proposing a novel approach inspired by the camel's behavior in the wild. This new approach produces sequences of jobs on a set of machines that minimize the value of makespan function.

The rest of the paper work is arranged as follows: Some related works are revised in section 2, section 3 presents a brief description of camel behavior, the proposed algorithm is presented in section 4. Section 5 includes applying the case study and experimental outcomes, finally, there are some closing remarks that are presented in section 6.

II. Related Work

This paper present a new approach inspired from camel life, hence, there is no similar related work, instead of we present the asymptotic studies.

In [4] [2016], Cuckoo improved a search algorithm to resolve flexible job scheduling problem and compared it with the basic Cuckoo

Search algorithm on HUdataset, the improvement was done through two ways first based on current based neighbor generation, the second based on a frequented Levy flight.

In [5] [2010], a new approach offered to solve flexible job scheduling problem and compared it with another search algorithm. They proposed a modification of the Climbing Discrepancy Search approach for addressing this problem, and also presented different neighborhood structures associated with the appointment and sequencing problems.

In [6] [2009], a particle swarm optimization (PSO) algorithm and a Tabu search (TS) algorithm are joint to addressing the multi objective FJSP with numerous conflicting and incommensurable purposes. PSO contains two types of search (local and global) structures which both own high search effectiveness. And, TS is a meta-heuristic which is aimed for searching a near optimal solution of combinatorial optimization problems.

The Ref. [7] [2011] offers a hybrid Pareto-based discrete simulated bee colony algorithm for answering the multi objective flexible job shop scheduling problem. In the hybrid algorithm, every solution will find a match to a food source, which is composed of two constituents, i.e., the routing constituent and the scheduling constituent.

III. Camel Behavior

A. Social Behavior

In their natural environment, Arabian camels live a lot of their time grazing and looking for food. Their normal eating behavior is to walk and browse over a large range in the cooler parts of the day (diurnal – dawn/dusk). While young camels (4-5 years) devote extra time than older camels browsing during the daytime. In the hottest times of the day, camels will sit on the sand to keep their body temperature constant to bound water loss and energy usage. This behavior is how they can survive on a daily and weekly basis without food and water. Camels will not experience any type of torpor or hibernation period [8].

Camels generally live in a herd, called a ‘caravan’. They can be kept in three different types of ways: an all-male bachelor group, some all-female group and young are kept until five years if it is a male, and if it is a female, it will be led by one leading male. At bare minimum housing, a pair of camels together is recommended. An Arabian camels' home range is determined by how far it will travel to search for food and water. This range can be wherever up to 100 km radius [8].

Camels do not walk individually, but in a community (herd) and each herd leads an older male and the rest of the herd follow them. When they march, the leader does not change, and the older camel continues to lead the herd. The camel has the ability to find out the road without human intervention, and he could find out the water places in desert through the sense of smell, they can count camel to go to the whereabouts of the water by the humidity in the atmosphere, though this hypothesis has not been scientifically proven.

In the process searching for food, the leader of the herd deliver the members of the herd to the place where there's food, when you reach the herd members in multiple directions spreads to search for food was up to long distances. Some of them get food places nearby to get him to places far away, the search process and the deployment of a herd come as result of the nature of herbs distributed in the desert grasses and plants do not accumulate in one place in the desert, but are spread over large areas, so the herd is spread over large distances to get food and then return to the same place that launched him (any place that led them her herd leader),and when completed or not getting a sufficient amount of food, the leader of the flock leads them to another place may find a greater quantity of food.

B. Camel Intelligence

Some people believe that camels are ignorant. Such beliefs come through reading fiction stories written by people who have no experience with camel behavior, they only describe the camel as unintelligent animal. On the contrary, camels are very intelligent animals compared with cattle, sheep and goats, yet they are less intelligent than horses and dogs. Camels have good sense of direction and can return back home even after a long journey. Also, camels are devoted to the place where they have been raised. Pregnant camels tend to return to the place where they first gave birth for future calving, therefore, they can be left unguarded during the last stages of their pregnancy. Also, camels can be trained to learn things [9].

Camels are used for military purposes and can be well-trained to lay down on the ground when there is an enemy attack. Also, certain camel herders can be trained to dance to music, to smoke, and even to eat sweet things from the hand of the trainers. In India, a camel has been trained to lift his foreleg to shake hands with the trainer, to move in zigzag pattern through the desert, and also to do acrobatics. Animals of less intelligence could never be trained to do such things [9].

IV. Camel Herds Algorithm (CHA)

As it is presented earlier, the camels are gathered in herds, and each herd has one leader. The leader searches for water in the desert depending on the humidity in the air. The camels can smell the humidity in air and wherever they find water in the desert there's food also. These properties are employed in the proposed algorithm to find the optimal solution for problems.

The algorithm start with identify the number of herds, each herd produce one solution. The herds have number of camels, the algorithm choose one of there and make it a leader for herd. The leader leads the other camels in the herd to find the solution in the space problem. Each leader starts from different points on space problem, this approaches gives diversity to find the solutions.

After initializing the parameters, the algorithm launches the herds in the space problem. The leader starts with its start state, spread out the other camel to find the neighbors. The leader examines each neighbor that given from camels, and fumbles high humidity through the best neighbor's function that depend on humidity factor.

Xi' = Xi * (1\Hum)
Xi+1=: (XLed – Xi') \ dis(XLed, Xi')...........(1)

The best neighbor is saved, and the leader lead the herd to it and start over again. This process continue until reaches the solution. When each herd finishes its own action, the algorithm produces a number of solutions for the problem. The algorithm is shown in the figure 1.

CHA Algorithm

```
Input: n no. of camel, Hc no. of herds, max_Hum
For each herd (HcK) Do    // identify the leader of herd LHc and full its tabu list with starting state
            Select one of HcK as a leader LHcK using selection method
            Select starting state and insert to the tabu list for LHcK
Next
Repeat
      For each HcK Do */ k=:1 to no. of Hc /*
            a:= 1
            initialize (Hum)
            For Y=1 to length(LHck)
                  For each solution Do
                  Generate random neighbors (d) of LHcK // where d is the
no. of camel in the herd except the leader
                  For z:=1 to d Do
                        NCz= NCz *  1\Hum
                        NCZ=: LHck - NCZ \ dis(LHck,NCz)
                  End for
                  LHcK[Y] [a+1] =: LHcK [Y] [a]+ Best Neighbors (NCz)
                  Insert the best neighbor to the path LHcK[Y] [a+1]
                  End for
            Update Hum
            End for
      End for
Until reach the goal or max Humidity
Print shortest tower found for tabu list LHc
```

Figure 1: Camel Algorithm pseudocode.

V. Camel Herds Algorithm to solve FJSP

The FJSP under study is solved by choosing an operation through assigning a resource for the designated operation, to set up its start time, and so on until scheduling all the operations. To decrease the makespan, we only study two types of variables: operation selection and resource assignment. The start time of each operation will be set up at the earliest possible value.

We denote X for the operation selection variables vector and A for the resource allocation variables vector. Thus, Xj corresponds to the jth operation in the sequence Aj and its assignment value(

$$\forall\, j=1\ldots No.\, with\, No\, the\, total\, number\, of\, operations$$

.

The range of variable Xj is {Op1,1, Op1,2 ,..., Op1,n1, Op2,1,..., OpN,1,..., OpN,nN} matches with the choice of the operation to be scheduled. The values taken by the Xj variables have to be all unmatched. The Aj range is {Mc1,..., Mcm}. Furthermore, the precedence constraints between two successive operations of the same job and precedence constraints that may link each operation with other jobs operations are taken into consideration. The search technique first studies an operation selection variable to select an operation, then it studies a resource assignment variable to allocate the selected operation to a resource.

The projected algorithm has been paralleled with four different approaches: Climbing Depth-bound Discrepancy Search (CDDS) [5], Tabu Search (TS) [5], hybrid Genetic Algorithm (hGA) [5], and Cuckoo Search (CS) [4]. These approaches test different samples of the dataset (HUdata) that have a set of 129 problems [10]. The problems were acquired from three problems by [11] and 40 problems by [12] (la01 to la40). [10] produced three sets of test problems: Edata, Rdata and Vdata. The first set comprises the problems with the minimum amount of flexibility 1.15 while the average flexibility equals 2 in Rdata and m/2 in Vdata (ranges between 2.50 and 7.50), in which the number of machines are matching.

The proposed Camel algorithm was coded in MATLAB R2013b and applied on Intel Core i7 2.70 GHz personal computer with 4GB RAM. The result of computational study on HUdata are summarized in Table 1. The first, second, and third columns symbolize the name and size of the problem, in that order. The total number of the best solutions given by each algorithm is briefed in the following columns. The Mean Relative Error (MRE) is calculated as follows:

$$MRE=\frac{(Cmax-LB)}{LB} \quad . ... (2)$$

TABLE 1.

PERFORMANCE COMPRESSION BETWEEN THE PROPOSED CAMEL ALGORITHM AND (CDDS, TS, HGA, CS) ON HUDATA (NUMBER OF HERDS ARE 5, AND NUMBER OF CAMELS FOR EACH HERD IS 4)

Data	*Instances*	*Nxm*	*MRE*				
			CDDS	*TS*	*hGA*	*CS*	*CHA*
Edata (*flex.* = 1.15)	mt06	6x6	0.00	0.00	0.00	0.018	**0.00**
	mt10	10x10	0.05	0.10	0.10	0.36	**0.14**
	la01–la05	10x5	0.73	0.00	0.00	0.21	**0.39**
	la06–la10	15x5	0.19	0.00	0.00	0.19	**0.57**
Rdata (*flex.* = 2)	mt06	6x6	0.34	0.34	0.34	0.17	**0.04**
	mt10	10x10	0.47	0.36	0.34	0.57	**0.19**
	la01–la05	10x5	0.28	0.24	0.07	0.28	**0.22**
	la06–la10	15x5	0.19	0.08	0.00	0.22	**0.37**
Vdata (*flex.* ∈ [2.50,7.50])	mt06	6x6	0.00	0.00	0.00	0.17	**0.00**
	mt10	10x10	0.00	0.00	0.00	0.52	**0.03**
	la01–la05	10x5	0.23	0.11	0.00	0.28	**0.18**
	la06–la10	15x5	0.00	0.03	0.00	0.24	**0.32**
Average MRE			0.20	0.10	0.07	0.26	**0.20**

The difference between CDDC, TS, hGA, CS, and the proposed algorithm to finding better makespan was clearly shown in Figure 2.

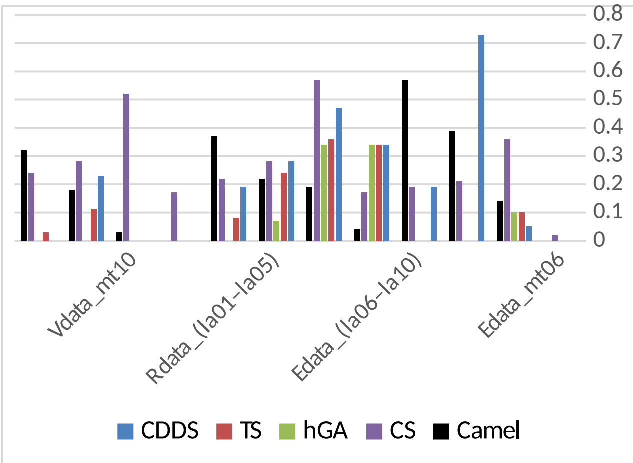

Figure 2. Difference between strategies

VI. CONCLUSIONS

Our approach - based on the camel behavior in the wild, comprises two types of variations, operation selection and resource assignment. Flexible Job Shop Scheduling Problem that aim to reduce makspan value and this have been solved using the proposed CHA. The proposed algorithm gives a good diversity solution through the camel strategy based on neighbor, which depend on the leader of the herd with humidity ratio in the desert. This new algorithm tries to propose introductory elements to open new horizons for the reader. No doubt new algorithm will expand the area of finding the optimal solution in the problem space.

REFERENCES

[1] Xin-She Yang, Zhihua Cui and Renbin Xiao; "Swarm Intelligence and Bio-Inspired Computation Theory and Applications"; Elsevier, First edition 2013

[2] MANSOUR A. AL-HAZIM and PAUL F. BRAIN; "A Preliminary Study on the Behaviour of the Dromedary (Camels dromedarius) in the Mid-western Region of Saudi Arabia"; J. K. A. U.: Sci, vol. 5, pp. 71-76 (1413 A.H/ 1993 A.D.)

[3] M. L. Pinedo, “Scheduling: Theory, Algorithms, and Systems”, 3rd ed., Springer-Verlag, 2008.

[4] Dr. Ahmed T. Sadiq Al-Obaidi and Samer Alaa Hussein; "Two Improved Cuckoo Search Algorithm to solve Flexible Job Shop Scheduling Problem"; International

Journal on Perceptive and Cognitive Computing; Vol 2, No 2 (2016).

[5] Abir Ben Hmida, Mohamed Haouari, Marie-Jos_e Huguet and Pierre Lopez ; "Discrepancy Search for the Flexible Job Shop Scheduling Problem"; HAL Id: hal-00461981 Submitted on 8 Mar 2010

[6] Guohui Zhang, Xinyu Shao; "An Effective Hybrid Particle Swarm Optimization Algorithm for Multi-objective Flexible Job-Shop Scheduling Problem"; Computers & Industrial Engineering, Volume 56, Issue 4, May 2009, Pages 1309–1318.

[7] Jun-Qing Li, Quan-Ke Pan and Kai-Zhou Gao; "Pareto-based Discrete Artificial Bee Colony Algorithm for Multi-objective Flexible Job Shop Scheduling Problems"; The International Journal of Advanced Manufacturing Technology, August 2011, Volume 55, Issue 9, pp 1159–1169.

[8] Graeme Phipps, Jacki Salkeld and Brad Walker; "Arabian Camel Camelus dromedaries Camel idea: Mammalia"; Western Sydney Institute of TAFE, Richmond; Date of Preparation: 29/07/08

[9] Falah K. Al-Ani; "Camel Management and Diseases"; Dar Ammar Book Publisher 2004.

[10] Hurink E., Jurisch B. and Thole M.; “Tabu search for the job shop scheduling problem with multi-purpose machines”. Operations Research-Spektrum, 15:205–215; 1994.

[11] Fisher H. and Thompson G.L.; “Probabilistic learning combinations of local job shop scheduling rules”. In Industrial Scheduling, J.F. Muth and G.L. Thompson (Eds), Englewood Cliffs, NJ: Prentice-Hall. p.225–251; 1993.

[12] Lawrence S.; “Supplement to resource constrained project scheduling: an experimental investigation of heuristic scheduling techniques”. GSIA, Carnegie Mellon University, Pittsburgh, PA.; 1984.