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A Hybrid Simplex Search and Bio-Inspired Algorithm for Faster Convergence

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Abstract. The Bees Algorithm is one of the latest bio-inspired optimisation algorithms. It suffers of slow convergence due to repetitive iteration of the algorithm. In this paper, a hybrid technique is proposed to overcome this issue. A combination of the Nelder-Mead simplex approach is used to exploit the faster convergence of the simplex approach on the Bees Algorithm. Evaluation of effectiveness of the approach is tested on function optimisation problem. The result shows that proposed approach perform faster compare to the original Bees Algorithm technique.

Keywords: Optimization, Simplex, Bio-Inspired Algorithm, Convergence

1. Introduction

The Bees Algorithm (BA) is one of optimisation technique that inspired from nature of the bees food foraging activities. It has been successfully been applied in a few optimisation problem including function optimisation, and parameter optimisation[1]. However, the BA has one important downside, slow convergence.

One simple solution of the above drawback is by identifying and eliminating all unnecessary repetition which is difficult to do it. In addition, from our observation, by doing this, it is not guarantee a better processing time or in some worst case unable to find an optimal solution. Another approach is by introducing a small total number of iteration. Then again, this create another bigger issue, the algorithm did not converge to the optimal solution.

In this paper, we would like to show a combination of the Nelder-Mead (NM) [2], a simplex technique, and the BA can be used for faster processing time. The rest of the paper is organized as followed: Section 2 explains the proposed simplex optimisation using NM approach. In Section 3, describes how the proposed hybrid approach is used and implemented in the BA. A benchmarking to test performance of the proposed approach is detailed in Section 4. Conclusion and future work can be seen in Section 5.

2. The Hybrid Simplex-Bees Method

2.1. The Nelder-Mead Simplex Method

The simplex search method has been known one of the top ten algorithms of the century [3, 4]. Simplex search is initially developed with capability to optimise for linear programming problem. The first simplex algorithm has been introduced by [5] as local search method by introducing a gradient activity on a function of problem to reveal the potential solution route [6]. The NM simplex method is simple to understand and to converge fast on linear problem for fast convergence optimisation problem.

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However, the NM algorithm is sensitive to initial value [7]. For example in function optimisation problem, different initialisation produces different solution. In order to avoid this circumstance, there are two possible to initialise these values. First, a very careful initialisation selection or second using random generated initialisation. The first approach is painstaking for user if they have no idea the nature of the problem. User may choose a wrong initialisation value that this may cause a local minimum problem of the final solution. Therefore, there is no guarantee a global optimum solution is achieved every times. Random generated initialisation alone is also unable to supply a good solution. Though, in this approach is a good initiate with by integrated with a guide. This type of guided technique can be seen in the BA searching method.

The NM method is rescaling operation which depends on local search behaviour of the evaluated function. It starts with initialisation of the each vertex. Later this vertex goes under one of four basic operations with respective coefficient: reflection coefficient, α contradiction coefficient, β expansion coefficient, γ and shrinking coefficient, δ [2], until it converges and for the experiment, the coefficient values have been set 1, 0.5, 2, 0.5 respectively. Fig. 1 illustrates these four main operations of the NM simplex approach.

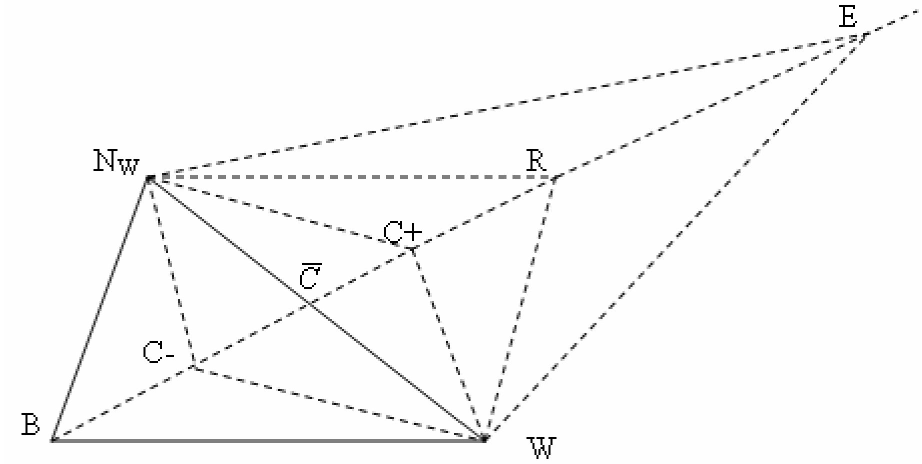

Fig. 1: Different moves from trial condition N_W). B = best position, W= worst position, R = reflection, E = expansion, C+ = positive contraction and C- = negative contraction.

2.2. The Bees Algorithm

Nature is always a beneficial example to human. Natures for long time have been replica of solution for many complexes and hard solve problems including optimisation, searching and sorting. This idea also can be noticed in the BA. The BA starts by initialising a predefined number of bees for future good solution. A number of bees later added to the “elite” area. “Elite” is areas where the top bees produce top possible solution space. Again, the number of top solution is predefined in initialisation stage of the algorithm. The ideas of sending more of these bees to these “elite” areas is mainly because there are possibilities that these extra bees in “elite” sites can provide better solution compare to the original one. The total number of bees is been assigned vary depends on earlier initialisation. Fig.2 shows the general pseudo-code of the BA.

The way of the BA works is by assigning a number of bees, *n* to a number potential areas of solution, *m* (also known as site). The same intensive and repetitive computational method is delegated to each of these bees. Each bee does this repetitive local search neighbourhood procedure until the best possible answer is reached. The BA focuses only on one of the bees that produce the best possible answer (or in this case the best optimal value). The site that provides the optimal answer from this bee is now known as ‘*elite’* site. A few numbers of new scout bees is assigned to this *elite* site with the intention of the new better answer will be produce of the new scout bees. Therefore, each of these new scout bees (with the old bees) continues with the similar procedure as the previous one. The process continues until the best solution is met or exceed predefined the total number of iteration.

```
Initialise parameters.
Step 1. Initialise population.
Step 2. Evaluate fitness of the population.
Do
       Step 3. Select elite bees and neighbourhood search.
       Step 4. Select other sites for neighbourhood search.
       Step 5. Recruit bees around selected sites and evaluate fitness.
       Step 6. Select fittest bee’s site from each site.
       Step 7. Assign remaining bees to search randomly and evaluate their
                fitness.
While stopping criterion not met.
```

Fig. 2: A typical pseudo-code of the Bees Algorithm.

These new appointed bees perform similar process as the first foraging best bee. Repetition of unnecessary similar process causes an additional computational time in generating solution. The situation is worsening for large dimension of evaluation’s problem. From the observation, medium size data such as 4 by 1000, sometimes requires more than two full days to produce a best solution. A proper action is needed to overcome or reduced this long processing time of the BA. This make the BA is very slow to converge to reach an optimal solution. Nevertheless, the BA is an algorithm that able to give best global solution using random generated initialisation.

2.3. The Proposed Hybrid Approach

The NM simplex method requires $N+1$ vertex points of N number of evaluated variables. In this circumstance, modification for Bees Algorithm is needed to accommodate simplex algorithm. To adjust this simplex method, each bee represents vertex point. Initialisation of total number of bees, n of Bees Algorithm depends on user initialisation. Sufficient space is required to able to attract to a new points of better solution for function evaluation. In this case, total number of bees, n must greater than total number of evaluated variable, N where $N < n$.

Implementation of the NM structure, Yen at el. [6] and Fan & Zahara [7] has suggested that the total number of space that is needed is $3N+1$ where $N+1$ is for the simplex method operation and $2N$ for other possible solution in the future, and again N is total number of variable to be evaluated. For Bees Algorithm, total number of $2N$ must applied condition where $n > 3N + 1$. Fig. 3 shows the overall structure of the hybrid Bees-Nelder-Mead Algorithm. Since Bees Algorithm requires number of “elite” bees, e this is replaced by $N + 1$ bees.

3. Benchmarking

Evaluation of the effectiveness of the proposed hybrid technique, we have used two functions namely Beale and Rosenbrock function. Both functions have been chosen purposely with different dimension and complexity. The Beale function is slightly simpler than the Rosenbrock function and has smaller problem dimension. Table 1 shows mathematical representation of both functions.

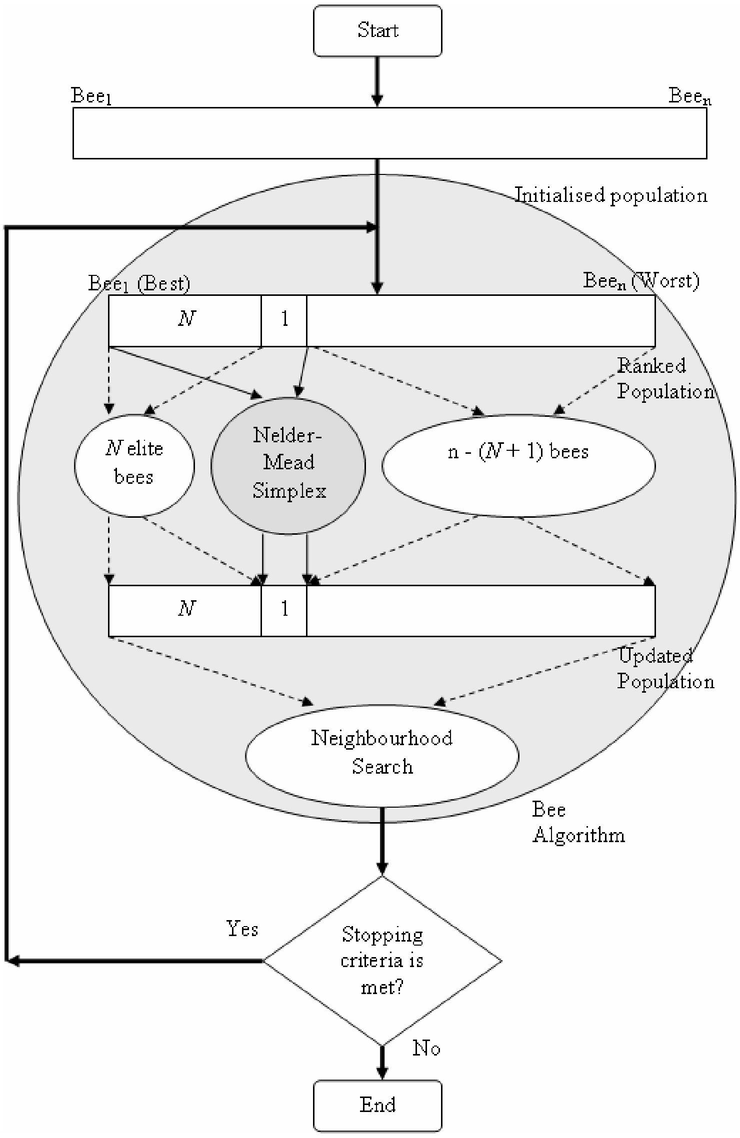

Fig. 3: General framework of the hybrid NM-Bees Algorithm.

Table 1: Mathematical representation of Booth and Martin & Gaddy functions.

Function Name	***Dimension***	***Mathematical Representation***
Beale function	2	$f(x) = \sum_{i=1}^{3} (y_i - x_1(1 - x_2^i))^2$ where $y_1 = 1.5,\ y_2 = 2.25,\ y_3 = 2.625$
Rosenbrock function	4	$f(x, y) = 100 \times (x^2 - y)^2 + (1 - x)^2$

Table 2: Obtained fitness value of both Beale and Rosenbrock function**.**

Iteration	Beale		Rosenbrock	
	Bee	***NM-Bee***	***Bee***	***NM-Bee***
0	1.71e-8	2.87e-5	1.231	0.064
10	3.26e-9	0	1.15e-4	0
20	3.26e-9	0	9.95e-5	0

30	4.39e-10	0	3.04e-6	0
40	4.39e-10	0	3.04e-6	0
50	4.39e-10	0	3.04e-6	0
60	4.39e-10	0	3.04e-6	0
70	1.77e-10	0	3.04e-6	0
80	5.81e-11	0	3.04e-6	0
90	5.81e-11	0	3.04e-6	0
100	5.81e-11	0	3.04e-6	0
110	2.31e-12	0	3.04e-6	0

Table 2 shows comparison value of the both functions, Beale and Rosenbrock, tested on both original Bees Algorithm and with the hybrid approach. It shows that the hybrid converge significantly faster than the original algorithm. Both functions convergence in 10 iterations compare to the original bee that may takes longer time to converge. In the table also shows that the Bees Algorithm seems like stucks in Rosenbrock function after 30 iterations. This can be explained that this function is difficult function compare to the simple Beale function.

4. Summary and Future Work

In this paper, a hybrid technique has been applied in the Bees Algorithm as a result of the Bee Algorithm takes long time to converge. The situation becomes worse especially on high dimension problem. To overcome this problem, a NM simplex method has been introduced. NM is known as a method that can search converge faster. However, NM search method is very sensitive to initial values where in this case, so the global optimum is not guaranteed. In contrary, the Bees Algorithm uses global search approach but slow in convergence rate and initial value problem is not an issue. The Bees Algorithm requires much computational effort in neighbourhood search. This hybrid technique is used and combined advantages of both algorithms' search method. The results show that the proposed approached has improved the computational time of Bees Algorithm significantly.

The proposed hybrid method shows its ability by performing at the best level by combining the two approaches. However, the hybrid approached is still needs some programming adjustments to handle bigger problem dimension.

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