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To solve knapsack problem using bee algorithm

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Abstract

This study aims to solve the knapsack problem using bee algorithm. This study is applied. In recent decades, evolutionary techniques and heuristic search and optimization have been used as a tool in various fields such as science, business and engineering. The scope of application, convenience use and ability to achieve near-optimal solution are the primary reasons of success of these procedures. Bees Algorithm as an optimization method is derived from the behavior of bees so that in this algorithm with reasonably good results and near-optimal flights in backpack question offers0 and 1. In this study, we attempt to use MATLAB software to find the best solutionsin knapsack problem by the number of random flights.

Keywords: Bee Colony Algorithm, Knapsack Problem, Optimization, MATLAB Software

Introduction:

Issues of non-polynomial (NP) refer to problems which their search space is exponentially increased by increasing problem dimensions. These problemsare difficult to solve through mathematical equations and it will be impossible to use these methods by increasing problem dimensions. NP questions are divided to two NP-Hard and NP-Complete groups. NP-Complete mode is related to decision-making issues and NP-Hard mode is more related to optimization issues. In optimization methods based on derivationsuch as gradient, it is tried to reach the optimal solution with movement onerror graph line. . As a result, these methods are inappropriate for solving NP problems because NP problems have many local minima, and these methods primarily will result to achieve one of the closest local minimum to initial random solution. Evolutionary algorithms such as genetic algorithms (GA), particle optimization algorithm (PSO), ant colony optimization algorithm (ACO) and artificial bee colony algorithm (ABC) are population-based algorithms that do not depend on derivative information and have not falling shapes in the local minima and cannot effectively review all the search space. An example of such matters can be seen on issues such as vendor and knapsack that the best solution to solve these problems is to use evolutionary algorithms (Sabet, 2011).

In this paper, a brief description of the Knapsack problem in the first part and the definition of bee algorithm and algorithm steps in the second part areprovided. Part III refers to simulation issue and part IV includesconclusion.

1-Knapsack problem

Knapsack problem has been studied for over a century and the first survey was conducted in 1897 (Lucic, P., & Teodorovic, D., 2003).

Although the first recorded data in this case refers to mathematician works named Tobias Danzig, there already was something as a Knapsack problem among the general public (Gen, M., & Cheng, R.W., 1997).

Knapsack problem takes many forms that one of them is quadratic knapsack problem was first introduced by Gallo, Hamer and Simon in 1960 (Fogel, D.B., 2000).

From the perspective of computer science, the knapsack is noteworthy because:

• It has an algorithm with pseudo-polynomial implementation time using dynamic programming.

• It has an approximation algorithm with polynomial time that uses algorithms with a pseudo-polynomial time as a sub-program.

1-1. Knapsack issue has several types that we refer to some of them:

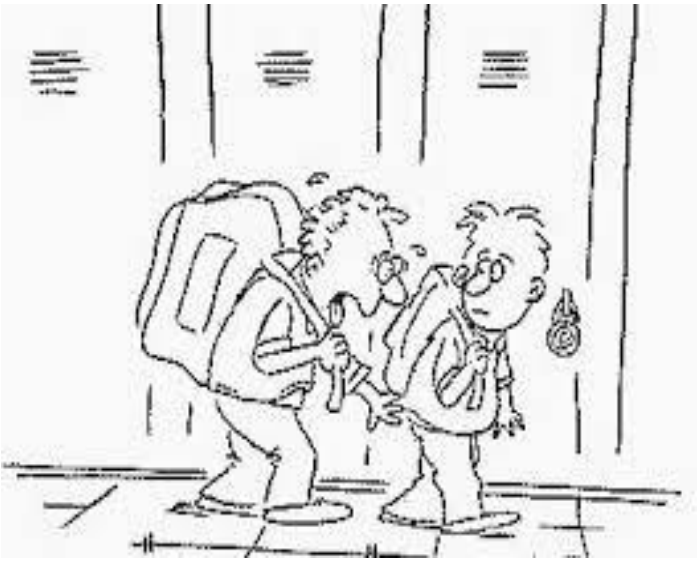
• 0 and 1 knapsack problem: the most famous type of the knapsack is 0 and 1. It means the number of any object is 0 (we don't choose the object) or 1 (the object is selected) (Wikipedia).

• Society–unit knapsack problem :(SUKP) by Kellerer et al., (Gen, M., &Cheng, R.W., 1997). The aim is to find the subset of members thatits total weight does not exceed than the knapsack mass and have the maximum value.

• Knapsack problem with maximum density: w0 is initial weight and we will enhance the density of the selected objects as long as are not inconsistent with capacity constraints(Gen, M., & Cheng, R.W., 1997).

One of the important issues and, more importantly, decision making optimization is knapsack problem. Especially when the issue of time and investment in one field isof the critical factors and is very important, accurate and efficient problem solving stylewill be helpful in knapsack problem. On the other hand, we are faced with this problem to dedicate resources with limited financial and items such as composition, computational complexity theory, cryptography and applied mathematics. Different algorithms have been proposed to solve knapsack problem but most of the time when they reflected (Ghorbanpour &Akbari Nasab, 2013).The knapsack problem has been one of the important optimization problems and has many applications in real issues.High usage of it and it also appears as part of complex

optimization problems, has caused that knapsack problem has had of great concern and a great variety of it has been examined (Nojavan, 2008). In this study, the knapsack has a special and stable capacity in terms of volume and weight that is effective on problem conditions. To collect contents, which have further superior quality, are prioritized that it is called weight in mentioned problem rather than volume were selected based on the quality (weight).



2- Bees Algorithm

Bee optimization algorithm is a social smart search algorithm to solve optimization problems that first was introduced by Darwish Karabvga in 2005 (Chang, T.S., & Tiwari, M.K., 2007). This algorithm simulates the behavior of groups of bees are searching for food in nature. The algorithm is able to optimize problems with one or more targets.

A colony of bees can be distributed in various directions to exploit food sources. Bees' colony consists of three sections in nature includingfood sources, worker bees and non-working wasps(Shams Kia, 2012).

First step: in nature, a group of bees can fly to remote locations and simultaneously use food sources in different directions. This group is developed by sending forager bees toward more appropriate resources. In this process, high-nectar flowers will host more bees and less- nectar flowers will host fewer bees. Inspector bee initiated the search process in a group.Inspector bee randomly moves from one flowerbed to other flowerbed, and then learns from them, returns to the hive and starts to exchange information such as direction and their hive distance to flowerbed.

Second step: worker bee's duty is to search for new food sources. Watchful bee takes the responsibility of evaluating the solutions obtained by the worker bees. In each repetition of the algorithm, a number of worker bees have found the best solution,are become the scout bees by watchful bees.To scout bees, recruitment process is carried out which means that a number of worker beeswill be assigned by each scout bees to search near a food source for that scout bee. This process continues until finding the optimal solution.

Third step: every scout bee chooses a source linked to its solution quality.

Fourth step: to determine a source should be abandoned and allocation of worker bees as a scout to search for new food sources.

Fifth step: To refresh the memory

Sixth step: to check counter (frequencies)

2-1.In brief, reasons for choosing artificial bee colony algorithm to solve knapsack problem are:

1. Due to the good performance of the genetic algorithm to solve knapsack problem that is provided by Ghorbanpour and Akbari Nasab, bees' algorithm optimization algorithms such as genetic algorithms belonging to optimization algorithm are based on population and can have a pleasant performance.
2. Lack of bee algorithm usage in knapsack problem optimization (new applications)
3. Bees algorithm compared to other algorithms used to solve the knapsack problem is relatively new. (new)
4. Simple logic used in the ABC (easy implementation)

2-2.Selection probability offood source:

$$pi = \frac{F(\theta i)}{\sum_{k=1}^{s} F(\theta k)} \qquad (1)$$

In order that sentinelbees choose a food source site:
Pi: selection probability of i-th site
S: the number of available solutions
($F\Theta_k$): Total amount of other positionssuitability
K: the competence offood source corresponding to i-th bee
($F\Theta_i$): to send search-keeping bees (Calculate the cost function)

$$f(xi) = \begin{cases} \frac{1}{1+f(xi)}, & f(xi) \geq 0 \\ 1 + |f(xi)|, & f(xi) < 0 \end{cases} \qquad (2)$$

$f(x_i)$ The amount of response cost function

2-3. Selection of new food source

$Vij = Xij + \phi ij(Xij - Xkj)$ (3)

xi=(i=1, ……., SN): Solutions are randomly generated, where SN is the number of food sources. For each worker bee which total number of them is equal to half of the total number of food sources.

φij isa random number uniformly distributed in the interval [1,1] that controls the location of neighbor food sources around xij , K is solution indicator that is randomly selected from colonies (K = int (rand * SN) + 1), j = 1,. . ., D and D is dimensions of the problem.

2-4. If a source finishes or quality of a food source is inappropriate, worker bees abandon it and become a scout and randomly search on the scope of the problem by following formula:

$Xij = xjmin + (xjmax - xjmin) * rand$ (4)

Methodology

Library method and prestigious internet resources were used to collect data and necessary information for study. In the library method, we referred to libraries and information centers of Persian and Latin books and articles that are used for the completion of the investigation. Information analysis is based on table and graphs that has been done by MATLAB software.

3. Simulation and Analysis

Knapsack "hive": We require a primary space named the hive in designed problem. The primary space should have conditions such as fixed and limited volume. In definition, this space should arise circumstances that the number of hive population is appropriate.

The contents of knapsack "nutrition": content should be placed in a knapsack is examined that both value and volume is maximum. There are also limitations in defining the terms of this component. These limitations such as the radius of the territory, local abundance of logic, the diversity of the target, the target value should be considered.

The collectors "bees": bees take responsibility to choose and collect the contents of target in this task. Bees carry out this task with specific technique and method. Thissearch method has a great impact on how things are done there. In optimization problems, these techniques are known search patterns that are concisely defined in previous chapters.

The number of duty repetitions "repetition loop": on this problem based on the fewer number of bees to target resources, the number of stages in which work should be done is more than one stage that causes

to develop a component namedthe number of repetition loop.

In order to evaluate the performance of the proposed optimization methods, simulation was performed using MATLAB software.

ABC algorithm parameters values are:

Food sources = 50, run average = 30, the number of loop = 5000, the number of bees = 100

Sometimes the simulation result won't be the same as the actual results. But trying to feel the realization side of the simulation is done in the form of problem designation.

Simulation is done based on the following algorithm in MATLAB and required parameters values are expressed in the problem. The creation of the required parameters in software has been determined in the following manner:

% parameters setting
1 >> Determine the number of number of variable
2 >> Determine the number of lower bound
3 >> Determine the number of upper bound
4 >> Determine the number of number of bee
5 >> Determine the number of number of food
6 >> Determine the number of max of iteration
7 >> Determine the number of loop iterations
8 >> Determine the limitation of researches

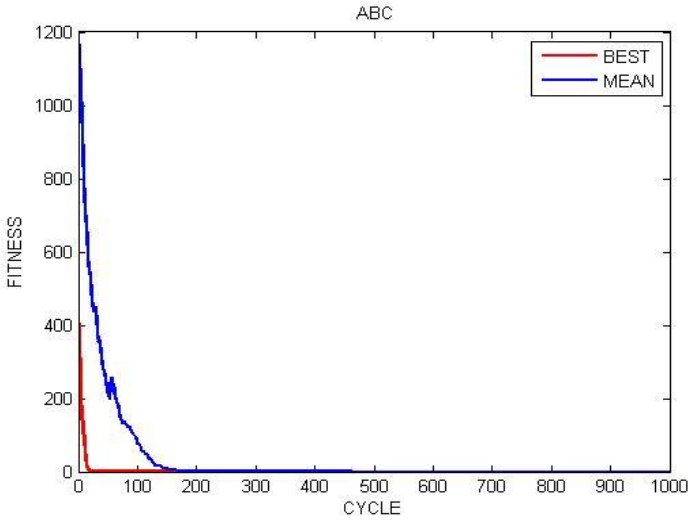
Processes, that are going to be applied on the data to achieve the desired result, will be as follows. These processes, taking into account the bee algorithm in the improvement of expected result of problem, are applied which the three main stages are carried out. The first step is to send the worker bees to search in assumed flowerbed of problem.

% employing bees to search

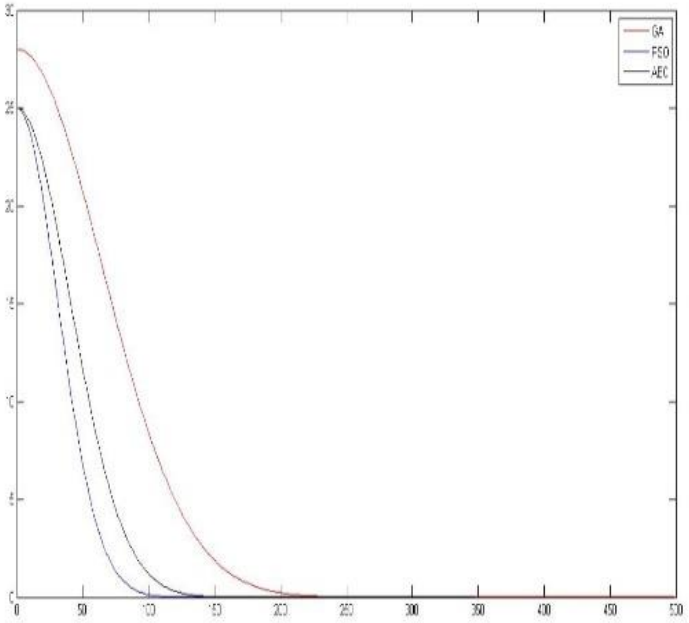
12 >> for loop of employing bees >randomizing search >a suitable loop of while till achieving
13 >> randomizing search dimension as width
14 >> randomizing search dimension as depth
15 >> searching & finding foods as new
16 >> determining max & min capacitance of Knapsack
17 >> determining of food value
18 >> conditional loop to determining of food value
% unlooker bees
19 >> are comparing which food has more value ... & Also compute how much food is required.
20 >> for loop for declaring new food for colony
... In each loop
>determining & comparing food cost and value
32 >> fit food in colony via food value
33 >> conditional loop to compare new food with last foods
% scout bees
34 >> are keeping colony safe from unexpected raids
35 >> a conditional loop for saving food that can be better ... than of last> BEST (cycle) is that founded better than other
36 >> MEAN (cycle) is that average duty cycle of colony
37 >> Displaying o best & mean cycle of all cycle of operations.
at last results are declaring in plots & charts

1. Optimization rate

Food distribution / Bees number	5-15	15-45	45-75	75-100	100-150	>150=
10 50	24% 58%	21% 42%	19% 38%	16% 21%	12% 17%	<10% <15%
50 100	56% 71%	46% 59%	42% 51%	39% 47%	31% 41%	<25% <35%
100 150	70% 84%	61% 71%	54% 65%	49% 56%	41% 47%	<30% <35%
150 200	86% 91%	85% 90%	82% 88%	79% 87%	77% 87%	<70% <85%



1. Time distribution graph of bee algorithm



2. Difference graph of processing dimensions times by problem scattering

According to the outputs of the simulated program and compared with the performance and results of other performed procedures, it can be concluded that bee algorithm with intended conditions solution with problem is a convenient and efficientsolution in terms of time and processing.

4- Conclusion

In the aforementioned algorithm, because there is only one mother to generate children that is Queen and the Queen bee launches to mate withmale bees near colonies to breed and this process requires to have an ever-changing amount and this upward procedure helps to increase colony population and better and more useful search that creates a more complete search results in the detection and collection.With regard to the use and determining fewer variables by this algorithm, it makes less use of memory resources which increases the speed of processing and analyzing the less data than other existing algorithms.

The mentioned algorithm was compared with two other evolutionary algorithms so that the speed of processing and data analysis is more in the artificial bee colony algorithm,but processing and analysis speed is low because of the extent of the problem space due to much parents and children in genetic algorithm. We also concluded in pso evolutionary algorithm that pso algorithm is more efficient in fewer numbers of repetition loops, but when the number of repetition loop increases the ABC algorithm gives better results. In the mentioned knapsack project, we have taken into account knapsack with a capacity thatequals 20. Now we have a number of objects to place in knapsackwith defined volume and weight. It outlines how to distribute and place these objects and volumes. Repetition loopsdebate about how to play in three-dimensional space.

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