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Evaluation of Swarm Optimization Techniques using CBSE Reusability Metrics

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Abstract : Component-Based Software Engineering (CBSE) helps users to reuse the components in order to save time and memory space. This paper focused on the evaluation of Swarm Optimization Technique like PSO (Particle Swarm Optimization), ACO (Ant Colony Optimization) and ABC (Artificial Bee Colony) using CBSE reusability metrics. In these techniques, it is difficult to compute the best cost value of each component within time. To calculate the best cost value of Component-Based Software Development (CBSD) within time to enhance the reusability this work use CBSE reusability metrics. CBSE reusability metrics helps in evaluation of swarm optimization techniques by finding the best cost value through MATLAB.

Keywords : CBSE, CBSD, Swarm Optimization Technique, PSO, ACO, ABC.

1. COMPONENT-BASED SOFTWARE ENGINEERING

In most engineering disciplines, systems are designed by composition (building system out of components that have been used in other systems) Software engineering has focused on custom development of components. To achieve better software quality, more quickly, at lower costs CBSE is used. CBSE is a branch of software engineering that depends on component re-usability. It emerged from the failure of object-oriented development to support effective reuse. Single object classes are too detailed and specific. Components are more abstract than object classes and can be considered to be stand-alone service providers. A software component is a software element that conforms to a component model and can be independently deployed and composed without modification according to a composition standard. Thus Component Based Software Reliability (CBSR) is depends on interaction among reusable components. CBS rely on connections of components. If the connectivity of components is complex, then it is difficult to estimate CBSR. The choice of components depends on interfaces between components and re-usability of components. These selected components assist in components integration [1].

2. SWARM OPTIMIZATION TECHNIQES

These techniques rely on the movements of components within a limited area and used to find the optimal solution for a particular target. SOT mainly includes PSO, ACO and ABC. SOT consists of shared links of swarms for finding best arrangement of to achieve goal. The working of PSO, ACO and ABC is described as follows:

2.1. Particle Swarm Optimization (PSO)

Various components move in searching space to achieve target in best manner that includes low cost with high velocity. Each component in PSO updates its parameters based on gross foremost velocity of particles [2].

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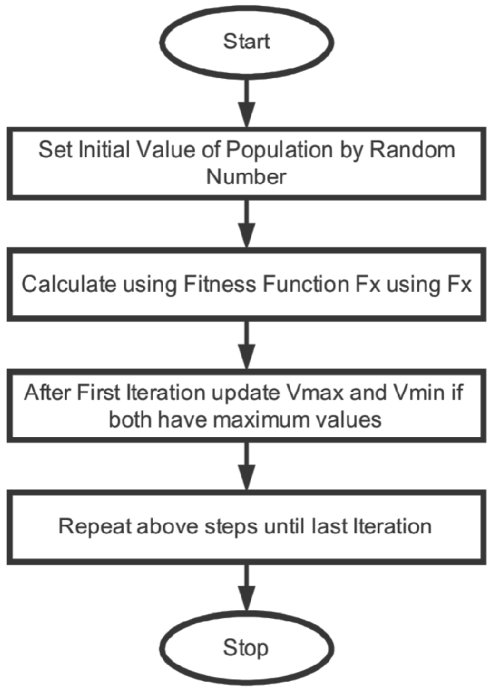

Fig. 1. Working of PSO.

The velocity of components varies in accordance with the searching skill, past experience and information of their neighbors. The overall working depends on fitness function. The fitness function is selected depend on type of requirement. As shown in figure 1, the global best outcome is achieved after executing number of iterations and evaluates those iterations.

2.2. Ant Colony Optimization (ACO)

It includes behavioral activities of ants as shown in figure 2. Ants put down pheromone while moving in their path. This path is assumed as favorable track that will be tracked by other connected ants of colony [3]. The main consistent of ACO are ants, target and pheromones.

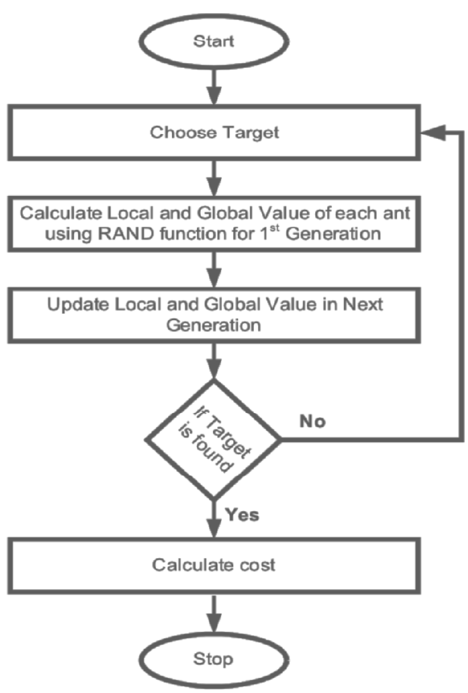

Fig. 2. Working of ACO.

2.3. Artificial Bee Colony (ABC)

ABC consists of three essential components : Food sources, employed and unemployed foragers [4].

Food Sources : A forager bee assess food source with some properties like closeness, richness, quantity, taste to make nectar, difficulty of reach destination.

Employed foragers : These foragers work for specific food. These foragers carry data related to specific food source which is shares among other bees in the hive. The data includes distance, direction and earnings of the food source.

Unemployed foragers : These foragers look after the utilization of food source. Unemployed forager may be a scout or onlooker who checks the environment in random manner for searching food source in accordance with the data provided by the employed foragers.

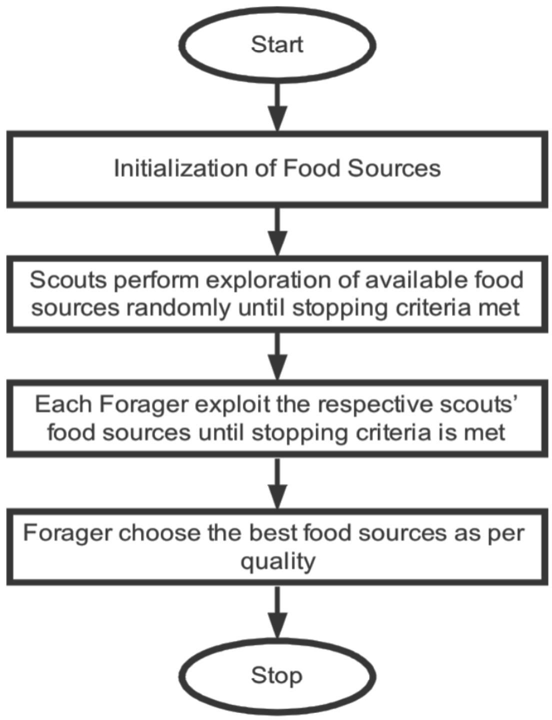

Fig. 3. Working of ABC.

The basis of these algorithms is cooperative working of individuals that makes decision easily and in efficient manner. Many Complex tasks may be solved by sharing of data collection and interaction of individual.

3. RELATED WORK

Nagar and Singh [5], presented student selection process using PSO and ACO. ACO and PSO algorithms were analyzed for SSP. These algorithms provided good optimality results in least amount of time. The comparison of ACO and PSO in support of SSP was also discussed.

Selvi and Umarani [6], focused on analysis of PSO and ACO algorithms with fitness sharing to check performance individual algorithm. The information of individuals must be modified by finding best element from a number of iterations rather than current iteration.

Tyagi and Sharma [7], proposed a model using ACO for estimating CBSR. Heuristic component dependency graphs were used with ACO to estimate CBSR.

Hingrajiya et al. [8], presented an approach for traveling salesman problem based on improved ACO that includes study of evasion of stagnation performance and early convergence using distribution scheme of vibrant heuristic constraint and initial ants modification based on entropy.

Saed and Kadir [9], described performance prediction approach based on PSO for CBSD. Boundary search method with PSO was applied to get efficient solutions. GA was used with case study for validation. QML was used for QoS necessities of the system.

Nian et al. [10], described conventional searching method of independent component analysis rely on gradient algorithm which was unable to solve convergence problem. An improved PSO was applied to independent component analysis. The improved PSO for independent component analysis shows better outcomes that help in increasing convergence speed.

Ropa and Reddy [11], proposed PSO approach to generate other design alternative in periodical design field and ease the design choice through the growth process for CBSS. The computational time was considered and new quality parameters may be taken into account such as availability.

Singhal et al. [12], compared basic working principle and applicability of GA, PSO ACO and BCO. These optimization techniques may be used to find the suitability to certain applications. These techniques may be combined to solve many problems and help in minimizing limitation.

Gupta and Sharma [13], used additional operators such as mutation and crossover of GA in traditional ABC algorithm for resolve the job scheduling difficulty. In future, different types of crossover and mutation operators may be applied in ABC algorithm.

Hashni and Amudha [14], presented comparative study of consultant guided search , ACO, and BCO techniques. Consultant guided search is hybrid Meta heuristic technique that integrates new ideas found in ACO and BCO. The paper focused on relative study of ACO, BCO and CGS.

Chikhalikar and Darade [15], emphasized on ACO and BCO with their variants. The comparison of these two techniques was also described. It was observed that the ACO is suitable for less search space and BCO is suitable for larger search spaces.

Jasser and Sarminim [16], compared experimental study between ACO and Enhanced BCO. MATLAB was used for implementation. The comparison was based on parameters like time consumed, outcome quality and difficulty of algorithm to examine effectiveness and performance. In this research, 30 cities were analysis for experimental study of ACO and BC.

Basir and Ahmad [17], surveyed biologically inspired techniques: ACO, PSO, Artificial Fish Swarm Algorithms, ABC, Firefly Algorithms and Bat Algorithms and their applicability in feature selections and reductions. Optimality may be categorized in two ways: to select best kind of problems and finding the best algorithm for efficient solutions.

Uma et al. [18], used GA, PSO and ACO for fractal image compression in support of design of robust image compression which decreases seek field for discover the self resemblance in given image.

Serbencu and ?erbencu [19], compared effectiveness of differential ant-stigmergy algorithm and PSO. The performance comparison of DASA and PSO is implemented using a set of six test functions well known for their difficulty.

Vilovic et al. [20], optimized the location of base station through neural network data model of wireless local area network. It was found that the use of PSO was better than ACO.

Toader [21], presented job shop scheduling using ACO and PSO that helps in solving the confliction of resources clash and reduce the make-span and total completion time.

Gigras et al. [22], proposed a Robotic path planning with hybrid approach of ACO-PSO is used to find optimal path for robot with avoiding the collision with barrier found in its path. Simulation results of hybrid approach gives collision free path and better results as compared to the traditional heuristic approach.

Basu [23], presented an ABC optimization technique for solving multi area economic dispatch problem. The parameters multiple fuels included multiple fuel, valve-point loading, transmission losses and prohibited operating zones. The usefulness of algorithm was verified on different small and large test systems.

4. COMPARISON OF PSO, ACO AND ABC

Table 1 shows the comparison of PSO, ACO and ABC with the parameters like path, enrollment methods, navigation method, adaptability, time consumption, steps requirement for computing result etc. [12] and [24].

Table 1. Comparison of PSO, ACO and ABC.

Parameter	*PSO*	*ACO*	*ABC*
Movement	Particles moving in search space for the best solution	Activities of ant colonies.	Activities of bee colonies
Section of Path	Global best value from the each particle is assumed to be best solution.	Based on quantity of Pheromone on track. The path with highest quantity is selected.	Waggle dance (WD) provides both quality and direction of food.
Enrollment Methods	Indirect. The fitness function us used to calculate velocity of each particle and find maximum and minimum velocity after few iteration.	Indirect. Ants use pheromone in their path as per type and quantity of food.	Direct. WD provides distance and direction towards target with quality and quantity
Navigation Method	Walking randomly towards target and obtain all details related to path.	Walking randomly and put down Pheromone in the path.	Walking randomly and obtain details in the path.
Adaptability	Less adaptive in nature.	More adaptive in nature.	Less adaptive in nature.
Computational Time	More as compared to ABC.	More as compared to ABC.	Less as compared ACO.
Steps requirement for Computing result	Requires more Steps than ABC.	Requires more Steps than ABC.	Require less iteration to collect all food at hand.
Scalability	Less scalable.	More scalable.	More scalable.
Advantages	(*i*) Easy to find solution due to less calculation as compared to other methods. (*ii*) There is choice of fitness function selection for minimizing and maximizing a function.	(*i*) robustness (*ii*) distributed computation avoids premature convergence (*i*) Natural parallelism. (*ii*) Quick finding of good quality result. (*iii*) ACO may be applied where many components having random behavior.	Team job: Scout and hunter bees work jointly for getting wealthy food.Learning: It takes lots of knowledge of WD occurrence for a bee to turn into a scout bee. Exploration and Exploitation: enquires memory based searching.
Disadvantages	(*i*) Less accuracy due to different direction and different motion of particles. (*ii*) PSO may not successfully work where contact scattering of particles motion is requires (*iii*) PSO may cause problem in non-coordinate environment	Early convergence and identify design parameters are problems	Map of WD to the outcome of any trouble is a complex task.Pre-knowledge of various factors
Applications	telecommunications, data mining, combinatorial optimization, power systems, signal processing, constrained problems etc.	Scheduling problems, Assignmentproblems, vehicle routing, TSP, image processing, network model problem	Job shop, Flow Shop and Open shopplanning problems, TSP, spam detection, data mining etc.

5. RESULT & ANALYSIS

Cost value of any optimization technique depends on number of factors like number of iterations, fitness functions, total number of interaction and delay between objects. These factors are used to calculate cost of a various optimization techniques. The cost is computed by using mathematical equation [25]:

$$C_s = C_{nr} - C_r \tag{1}$$

Where C_s present saving cost or mean cost, C_{nr} is cost of developing software with no reuse, C_r is the cost of developing software with reuse. The saving cost C_s can be calculated using line of code, function used repeatedly and the function those are not used repeatedly.

Table 2 presents number of line of code, function used repeatedly and the function those are not used repeatedly. Line of code depicts total number of lines used in code. It includes duplicates statements and functions that are multiple times used. When reusability is applied then duplicates lines are excluded and same statement and functions reused at multiple times without detailed code.

Table 2. LOC and Function used in optimization techniques using MATLAB.

Optimization Techniques	*Line of Code*	*Function used repeatedly*	*Function not used repeatedly*
PSO	132	7	4
ACO	121	8	5
ABC	152	8	4

Table 3 shows parameters used for evaluation of PSO, ACO and ABC with the help of reusability metric as shown in equation 1. The number of iteration may be increase or decrease as per analysis requirement.

Table 3. Simulation Parameters

No. of Iteration	***200***
Optimization techniques	PSO, ACO and ABC
Simulation time	30000 seconds
Fitness Function used	$Y = x_1^2 - 3x_2 + 10$ Where $0 <= x_1, x_2 <= 8$
Operating System	Windows 7
Platform	Matrix Laboratory 2009 v2

5.1. Best cost value of ABC algorithm

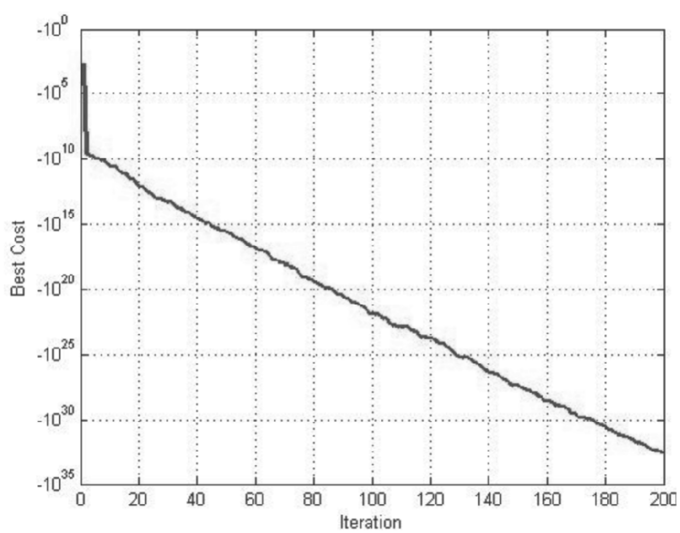

Fig. 4. Best cost value of ABC algorithm with iteration

Figure 4 illustrates analysis of enhanced ABC algorithm with multiple iterations. As shown above, as increase in iteration, the cost of ABC decreases.

5.2. Best cost value of PSO algorithm

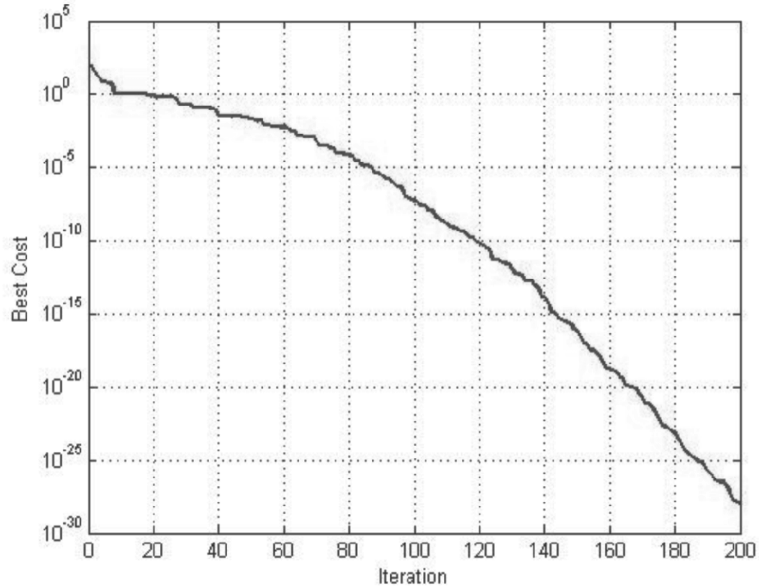

Fig. 5. Best cost value of PSO algorithm with iteration

Figure 5 illustrates analysis of enhanced PSO algorithm with multiple iterations. As shown above as increase in iteration, the cost of PSO decreases. In PSO cost value is higher than ABC technique.

5.3. Best cost value of ACO algorithm

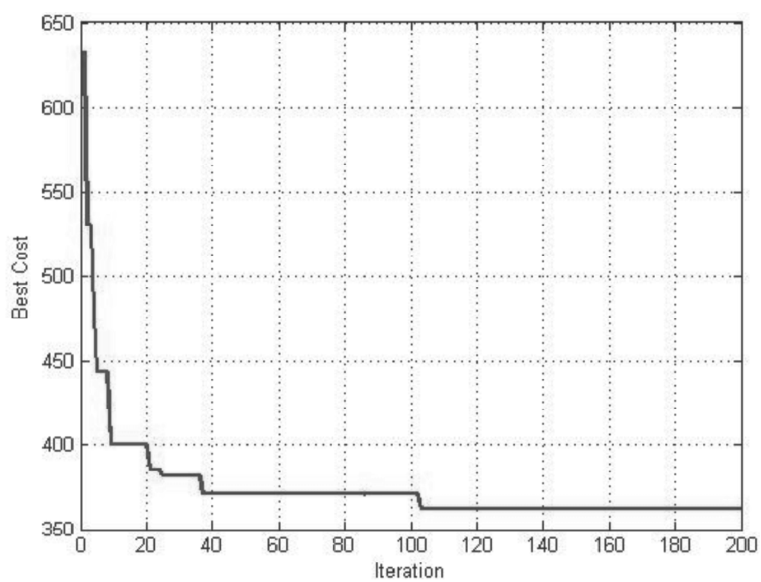

Fig. 6. Best cost value of ACO algorithm with iteration.

Figure 6 illustrates analysis of enhanced ACO algorithm with multiple iterations. As shown above, as increase in iteration, the cost of ACO decreases. The cost value is low in case of ACO in perspective of ABC and PSO.

The best cost presents the mean cost as mentioned in reusabilty metric that is estimated using line of code and functions used in program for a number of iteration as shown in table 3. The output results shows that the reusabilty factor is more used in ACO as compared PSO and ABC. The graphs presents output that show the relation between cost and iteration. The number of iteration may be varied as per analysis requirement.

6. CONCLUSION

In this paper different swarm optimization techniques like ACO, ABC and PSO are presented with their working. The comparative analysis of these techniques has been discussed. The calculated cost value represents the reusability of components and integrity of components among PSO, ACO and ABC. The outcome shows that ACO have better reusability of component integrity than PSO and ABC techniques.

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