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Comparative Analysis of Meta-Heuristic Algorithms based on their Application Areas in SRGM

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ABSTRACT: Various algorithms based on the natural behaviour of some special kind of animals, are been introduced, which are also known as Meta-heuristic Algorithms. These algorithms are used widely in many areas and they provide various approaches for solving a variety of optimization problems which can't be solved easily by using the conventional methods. The main advantage of using such approaches are that they can perform a variety of continuous searches for the given search space. In this paper, a comparative analysis of four different Meta-heuristic Algorithms, namely, Genetic Algorithm(GA), Cuckoo Search(CS), Particle Swarm Optimization(PSO) and Ant Colony Optimization(ACO) are being studied and presented. This study includes the analysis of Publication Year, Variations, Parameter used, Features & Area of application and the main highlights is on the Specialized Area of these algorithms in SRGM.

KEYWORDS: Optimization, ACO, Cuckoo Search, PSO, GA, Meta-heuristic.

I. INTRODUCTION

To generate the best solution of a complex optimization problem, some Naturally Inspired Algorithms are being introduced. The main advantage of using such Algorithms is that they can perform a variety of continuous searches for the given search space. In this paper, some Algorithms such as PSO, ACO, GA and CS are used. This paper includes a comparative review of these algorithms in tabular form based on their Specialized Area in SRGM.

SRGMs are the statistical models which can be used to make predictions about a Software System's Failure Rate, given the failure history of the system. As the failure intensity decreases, the reliability increases. Meta-heuristic Algorithms are those which are based on the natural behavior of the some special kind of animals. They have tremendous ability to solve various discrete optimization problems. We can use various software reliability models for evaluating and predicting the activities and presentation of the software reliability .Some Approaches such as MLE or LSE which were classical in nature, were applied for parameter estimation of SRGM but were not useful in solving non-linear optimization problems. Due to these obstacles, Meta-Heuristic Algorithms are introduced by some researchers.

In this paper, Section A presents a brief analysis of Optimization Techniques such as PSO and CS. Further Section B explains GA and ACO. Section C explains the comparative analysis of Optimization techniques such as PSO, CS, ACO and GA. Further, Conclusion and Future Work is presented.

II. SOME META-HEURISTIC APPROACHES FOR OPTIMIZATION PROCESS

A. *Particle swarm optimization*

It is a inhabitants dependent optimizing procedure which was created by Dr. Eberhart & Kennedy (1995), & it was motivated by communal activities of bird flocking .It is very much parallel to evolutionary calculation approaches like GA,PSO etc. The initial structure is based on early initialization , with arbitrary inhabitants solutions, further the

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search for optimum value is done by upgrading the values to the next generations. PSO don't use many advance operators like crossover and mutation as there are in GA .In particle swarm optimization techniques the well known particles go from end to end the difficulty space by sub sequencing the existing present best particles, which are also known as potential solutions. The PSO technique is based on the statistical modelling of a variety of combined habits of the alive creatures which show some multifaceted communal behaviours in some ways. In PSO, by the time a element is generating a new circumstance, proper utilization of the cognitivised module of comparative particle and the communal module created by the group is done. With the help of this particle swarm optimization technique can expand the restricted possible solutions into universal best possible answers more efficiently.

Further this algorithm is overstated with the help of the introductory principles of the given parameters that are utilized in the weighing process of the cognitive & communal mechanism including weighing approach of velocity vector. The Best L & Best G concepts are known as the most commonly utilized concepts in the normal particle swarm optimization technique. The achievement of the particle swarm optimization approach in discovering the universal best possible solutions relies prominently on the introductory values of the main parameters such as C1,C2&W of the algorithm which are known as the dimension of the swarm & max possible iterations.

The pseudo code:

```
For each and every particle
{
  Initialization of particle is done.
}

Do till maximum number of iterations is done or least amount of error criteria is found.
{
  For each and every particle
  {
    calculate the Data suitability value
    If the fitness value is better than p Best value
    {
      p Best is set as the current fitness value.
    }
    If p Best is superior than g Best
    {
      place g Best = p Best
    }
  }

  For each and every element
  {
    Compute the speed of each particle
     g Best and velocity is used to revise particle Data
  }
```

B. *Cuckoo Search*

CS is motivated with the ordinary performance of a few spices of birds. Nowadays it is widely used in the area of soft computing and also for solving various optimization problems and for parameter estimation problems in software reliability with great effectiveness and heftiness. Cuckoo search algorithm proves to be more efficient while comparing it with other optimization approaches like 'GA , algorithms & PSO. Cuckoo Search performance to the variation of its fine-tuning parameters, provide a very good, efficient and robust outputs when it is applied to the various problem of parameter estimation of a nonlinear model.

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CS follows three important considerations:

- Each and every cuckoo hatch only a single egg in a time period in ,further it drops that egg into a randomly chosen nest which is of a host bird.
- Further the selected nests which have the collection of best eggs will move further in the next generation.
- The chances that a Cuckoo being noticed by the original host bird is Pa(0,1),and , noticed nests will be not considered and new nest will be built by the host in some different locations.

The pseudo code:
Let's have an Objective Function f(X), X = (x1,x2.....x d)
Preliminary population of n host nests is created;

While (t <Maximum no. of production) or by following the (stopping condition)
Select a cuckoo randomly (i.e., i) and replace its result by applying Levy flights
(Fi)fitness function is generated
[For maximizing ,Fi is proportional f(Xi)],
A nest n (suppose, j) is selected arbitrarily,
If F i > Fj
Substitute J by the fresh solution,
end if
A portion (Pa)of the poorer nests is discarded and fresh ones is created,
Maintain the finest solutions;
Grade the solutions/nests and discover the present best,
Passing the best solution for next generation,
end while

C. *Genetic Algorithm*

GA[1] are the optimization and search algorithms which uses some techniques based on natural evolution to generate optimal solutions for complex optimization problems. The concept of Natural Evolution was first introduced by John Holland in 1970.

- GA has a set of computational models including population based model which uses Genetic Operators to create a new solution in the search space.
- GA has a function optimizer which optimizes non-linear functions using a large number of variables.

GA can also be used as General purpose optimization due to its two features-

- GA's traditional methods use Gradient Information.
- GA's transition scheme is probabilistic.

GA works with encoding of parameters/variables of search problems into a finite length of string as alphabets. The string having candidate solutions of search problems is known as Chromosomes in biological terms. The alphabets are called as Genes. For Example, as in Travelling Salesman Problem, the route denotes a chromosome and the city denotes a gene.

The pseudo code:

Step 1: [START- Initialisation] [4] generate a random number of chromosomes for the search problem i.e. suitable solutions
Step 2: [FITNESS - Evaluation] calculate the fitness of each solution for the problem
Step 3: [NEW POPULATION] generate a new population by using the following below steps in order until a new one is completed

- [SELECTION] process to choose the best fit chromosome from a population. Select the best two chromosomes and named as Parents. Many Selection procedures have been introduced for selection process, including Ranking Selection, Roulette-Wheel Selection etc.

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- [CROSSOVER] crossover or recombine the parts of the two parental solutions to form a better new solution i.e. offspring. This will not result in identical offspring similar to any of its parents.
- [MUTATION] [5] makes changes in a solution/offspring or in individual traits to get better genetic diversity. There are more variations of mutation but includes two or more changes.
- [ACCEPTING] locate/set the position of the new offspring/child into the new population.

Step 4: [REPLACE] replaces the newly generated population from the original parental population to be used to run further algorithm. Many techniques for replacement could be used such as Generation-wise method, Elitist method, Steady-state method etc.
Step 5: [TEST] if the final condition is OK, then Stop and Return the best fitted solution to the current population.
Step 6: [LOOP] repeat steps 2-5 until the terminating condition is met. Hence, the GA performance gives the result which is based on the crossover and mutation operators

D. *Ant Colony Optimization*

ACO [24-27] is a method of solving complex computational problems and was initially proposed by Marco Dorigo in 1992. It is a technique of Bio inspired computing. In this, the behavior of ant colonies and real ants searching of food source is to be used to manage the population and to find the optimal solution via graphs. Ant colony Algorithm is used for optimization purpose. At first, ants are scattered randomly. When one of the ant finds the food source, some walks towards the food by leaving a marker called Pheromone while returning back to their nests which shows the path towards food source. When all other ants follow these Pheromone, they get their destination path with a certain probability. In this way, many ants travel different food source near the colony. The shortest path is to be found when each time they leave markers while bringing food , hence it optimizes the solution. Same approach can be utilized for finding the near -optimal path in traveling Salesman Problem. The route is no longer remains once the food is consumed with no pheromones and slowly deteriorates. Ant colony Algorithm works well with graph with different topologies because colony surrounds among distributed system.

The pseudo code:

Step 1: Initialising the pheromone parameters
Step 2: Find out Maximum ways where ants can move/ travel.
Step 3: Start Iteration
Step 4: Using the distribution strategy, the node is selected randomly and each ant is placed at a given node
Step 5: While p=1 to n, do the following steps

- each ant is to be routed in different paths
- repeat the above step (a) till all the nodes are visited one by one.
- choose a node say, q to be visited next
- use local updating rule
- repeat loop until ant p has done the tour
- End while loop

Step 6: Apply sub local search i.e. sub tour
Step 7: Use Global Updating rule
Step 8: Measure the Entropy value for the current pheromone
Step 9: Update heuristic parameter
Step10: End

III. LITERATURE REVIEW

A Particle Swarm Optimization is a concept in terms of its precursors, which provide a brief review of various steps of the development from social simulation to optimizer was proposed . James Kennedy and Russell Eberhart in 1995 [24]. A new structure of the particle swarm optimizer was proposed that checks about the changes in the pattern that affect the number of iterations which is required to meet an error criterion, and also the regularity with which models set endlessly in the region of a non global optimum. Later on three other versions were tested like GBEST ,in which

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each and every particle have the knowledge about the best evaluation of the group and further two other variations of LBEST were evaluated in which one with a neighbourhood of 6 and other in 2.The result explain that original GBEST version performs best in terms of median no of iteration and LBEST with a neighbourhood of 2 is more opposed to local minima . James Kennedy and Russell Eberhart in 1995 [25] Van den Bergh and A. P. Engel Brecht GCPSO is therefore said to guarantee convergence to a local minimize and used it for solving a particular problem A new hierarchical version of (PSO) meta heuristic method which was called H-PSO was proposed , in which the arrangement of the particles was done dynamically in a hierarchy , which was used to define the neighbourhood architecture. Further the particle can move up or down and it depends on there finding of best solution ,this helps in generating new and good particles that can move upwards in the hierarchy by influencing the swarm .Stefan Janson and Martin Middendorf in 2005 [26]. A opposition based PSO(OPSO was presents to speed up the meeting of PSO and for avoiding early meeting on multi-modal functions. Later on a method was also proposed which employs resistance based learning for each particle and also applies lively Cauchy change on the best particle. Hui Wang, Yong Liu, Sanyou Zeng , Hui Li and Changhe Li in 2007 [27].The Cuckoo Search optimization algo are use to solve various optimization problems in the area of optimization engineering. It helps to find various optimal solution ,and it is used in the problems of spring design and many more problems .A discrete Cuckoo Search optimization algorithm is used for solving the problem of nurse scheduling and solving the problems .Travelling salesman problem and a quantum-based CS was creating for solving Knapsack problems ,used for generating various independent test paths for structural testing of a software product and also for test data generation. A evaluation of the cuckoo search optimization algorithm with various other optimization algorithm such as Particle swarm optimization, Differential evolution and Artificial bee colony algorithm illustrates that CS and DE are more robust in nature as compared to PSO and ABC optimization algorithm[28].A study that includes evaluation of structure based optimization problems assure that Cuckoo Search gives much better results in comparison to other optimization algorithms[29]. Recent studies illustrates that search problems can do better than other algorithms in milling area , also in industrialized scheduling, and many other areas and Cuckoo search optimization algorithm can also be used to solve boundary value problems.

Sivaraj, R. et.al [31] proposed the boosting performance of genetic algorithm through Selective initialization The main success of genetic algorithm depend upon the individual chosen in the initial population and size of population. If the poor individual is select in the initial population, it will result in longer execution time and weaker optimal solution. Bramlette, M.F. [30] proposed a general approach to improve the initialization procedure of GA in 1991. The initial population is built by taking the best of n randomly chosen individuals. Ramsey, C.L. suggest case based Initialization approach by including strategies in initial population of genetic algorithm [30]. The success of all approach relies on expertise of user in finding best individual in search space in 1993. Louis Sushil J.& Johnson, Judy proposed a research paper on robustness of case initialized genetic algorithms. They investigate the robustness of case initialized genetic algorithm (CIGAR) system with respect to problem indexing.

TABLE 1. META-HEURISTIC ALGORITHMS

ALGORITHM	YEAR	AUTHOR
Genetic Algorithm	1960-1970	J. Holland
Evolutionary Algorithm	1960	Rachenberg & Swefel
Evolutionary Programming	1960	Fogel
Tabu Search	1980	Glover
Stimulated Annealing	1983	Kirkpatrick
Ant Colony Optimization	1992	Dorgio
Genetic Programming	1992	Koza
Particle Swarm Optimization	1995	Kennedy & Eberhart
Differential Solution	1996/1997	Storn &Price
Harmony Search	2001	Geem
Honey Bee Algorithm	2004	Nakrani & Tovey
Firefly Algorithm	2008	Yang
Cuckoo Search	2009	Yang & Deb

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TABLE 2. COMPARISON OF VARIOUS OPTIMIZATION TECHNIQUES

OPTIMIZATION TECHNIQUES	PUBLICATION YEAR	VARIATIONS	BASED ON FOLLOWING PARAMETERS	FEATURES	AREA OF APPLICATION
PARTICLE SWARM OPTIMIZATION (PSO)	Dr. Eberhart and Dr. Kennedy in (1995)	**BASIC VARIANTS** Velocity clamping Constriction Synchronous asynchronous **MODIFIED VARIATIONS-** Single solution of PSO Niching with PSO Constrained optimization using PSO Multi-objective optimization, Fully Informed PSO	Number of particles Dimension of particle Range of particle V max. Learning factors Stop criteria Global version vs. local version	Applied in Scientific Research and Engineering. No overlapping &mutation calculation Fast searching speed. Simple Calculations Adopts the real number coding that is directly decided by the solution.	Manufacturing scheduling Nurse scheduling problem In the area of Data Mining, Design, Combinatorial Optimization. Used to solve Unconstrained, Single Objective Optimization problems
ANT COLONY OPTIMZATION (ACO)	Marco Dorigo (1992)	Elitist As (EAS) Rank Based As(RAS) Max-Min Ant System(MMAS) Ant Colony System(ACS) Hyper Cube Framework(HC) Continous Orhtogonal Ant Colony(COAC) Recursive Ant Colony Optimization	Weight of pheromone concentration. Importance of heuristic information. Pheromone Evaporation Rate . Quantity of pheromone. Initial pheromone value Number of Ants in the colony. Stopping Criterion.	Inherent Parallelism Positive Feedback accounts for rapid discovery of good solutions Efficient for Traveling Salesman Problem and similar problems Used in dynamic applications (adapts to changes such as new distances, etc). Easy to diagnose solutions of TSP for small number of nodes guarantees for convergence.	Used to solve TSP problem by generating near-optimal solutions. Use in network transportation and routing systems Scheduling problems Distributed information retrieval Data mining Graph colouring
CUCKOO SEARCH	Xin-she Yang and Suash Deb (2009)	Modified Cuckoo Search Multiobjective cuckoo search (MOCS) Hybridization, hybridized with other swarm-based algorithms such as PSO.	No of Nest. Discovery Rate of Alien Solution. Levy Exponent Maximum Iteration. Number of dimensions. Lower &Upper Bounds	Simple implementation. Less number of Parameter in comparison to PSO, GA &ACO.	. Job Scheduling . To locate the best possible server in Distributed systems Clustering.
GENETIC ALGORITHM	R A Fisher(1958)	Red Coded GA. Binary Coded GA. Micro GA. Improved GA.	Population Size. Mutation Probability. Crossover Probability.	Transition scheme is Probabilistic. Easily transferred to existing Simulations and Models. Clears up all complex Optimisation Problems with	Excellent in Searching through a large and Complex search Space. Image Processing Linguistic Analysis

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		Differential Evolution GA	Number of Generations. Probability Of Selection. Generation Gap.	their many Solutions. Easy to understand. Non-differential, Non-dimensional, Non-continuous and Non-parametric Problems can be easily resolved due to Non-dependence of GA techniques on the Error Surface.	(NLP). Neural Network. Software Engineering.

IV. CONCLUSION

In this paper, optimization techniques such as Particle Swarm Optimization, Ant Colony Optimization, Cuckoo Search and Genetic Algorithm have been analyzed based on some specialized area of their applications in Software Reliability Growth Models. The algorithms studied in this paper are mainly used for Parameter Estimation in SRGMs and it is a common specialized area of these algorithms used in reliability growth models. A study and review from various research papers from various authors is done which conclude that these algorithms have tremendous ability to solve various discrete optimization problems. In future, study and evaluations of more such algorithms using different domains can be done effectively.

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23. A Comparison Of Parameter Best Estimation Method For Software Reliability Models Latha Shanmugam1 and Dr. Lilly Florence 2 1Research Scholar, Anna University, Tamil Nadu lathashanmugam4@gmail.com 2Professor, Adiyamaan College of Engineering, Hosur, lilly_swamy@yahoo.com