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A Brief Study on Bio - Organism Behavior Inspired Computing Techniques and Its Applications

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ABSTRACT: Bio-inspired computing techniques are the modern advancement research in artificial intelligence area. Bio-inspired computing is one of the research fields to deal with complex problems with trustworthy results. Bio-inspired Computing techniques are the computational methods and algorithms, were adapted from the behavior and life survival techniques of the various species in the world. It is a multi-disciplinary field strongly based on biology, complexity, computer science, informatics, cognitive science, robotics, and cybernetics. Bio-inspired computational algorithms are always hot research topics in artificial intelligence communities. The goal of this survey is specifically a deep understanding of the Bio- Organism Behavior Inspired Computing techniques and its various Applications.

KEYWORDS: BIO-BIC**,** Organism Behavior, ACO, ABC, Bio- Evolutionary, MCA.

I. INTRODUCTION

All species in the world have its own problem-solving techniques by nature. These intelligent techniques were helped species to lead a successful life and also to overcome the risky situation. Observing and adapting these unique intelligence techniques of the various species are called as Bio-Inspired Computing, to solve the computational complex problems. Nature inspired (BIC) algorithms are metaheuristics is a new era in computation, which are used to resolve optimization problems by mimic the different species of nature [1]. Bio-inspired Computing is the combination of collective intelligence and computational intelligence. BIC is a recent research field in which thoughts and principles from biology are used to propose and execute new and improved computing methods. It is an alternative approach for the Conventional Computing. Even though Conventional Computing is good, it provides bad performance on some situation and incomplete information and pessimistic solutions. Various researchers were proved that BIC able to give optimistic solutions better than Conventional Computing.

II. AN OVERVIEW OF VARIOUS BIC - ALGORITHMS

BIC techniques are grouped into three bases such as Bio-inspired from Organism Behaviors, Organism Structures and Evolutions. BIC is also can be referred as Evolutionary algorithms (EAs). EAs are computational methods inspired by the process and mechanisms of biological evolution [2] .

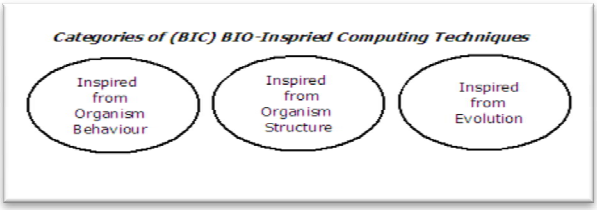

Fig: 1 Categories of BIC

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A. INSPIRED FROM ORGANISM BEHAVIOR:

Each species of this world has its own intellectual behaviours to prevent them from enemies, to get sustain in their community and life. These Intellectual behaviours were observed and incorporated in computing to solve certain complex problems. It is also referred as Swarm Intelligence (SI). The following algorithms are the very few examples of Bio- Inspired Organism Behaviour (Bio-BIC) Algorithms.

- Ant Colony Optimization Algorithm.
- Bee Colony Algorithm
- Shuffled Frog Leaping Algorithm
- Monkey Climbing Algorithm
- Firefly Algorithm
- Cuckoo Search Algorithm
- Fish school Algorithm
- Bacterial foraging Algorithm

B. INSPIRED FROM ORGANISM STRUCTURE

The adaptation of the functionalities of Bio- complex structures for the computation is referred as Bio - Inspired Algorithms from Organism Structures.

- DNA Computing
- Artificial Immune System
- Bio Inspired Neural Networks.
- Membrane Computing

C. INSPIRED FROM BIOLOGICAL AND SOCIAL EVOLUTION

Bio- Evolutionary Inspired Computation is make use of the iterative progress comprising growth , development, reproduction, selection, and survival as seen in a population .

- Invasive Weed Algorithm
- Chemical Genetic Algorithm
- Selfish Gene Algorithm
- Co evolution Algorithm
- Culture Algorithm

III. BIO - ORGANISM BEHAVIOR INSPIRED COMPUTING TECHNIQUES

A. ANT COLONY OPTIMIZATION ALGORITHM

The ant colony optimization algorithm (ACO) is a type of probabilistic methods for solving computational problems to find brilliant paths through graphs. Ant Colony Optimization was established as a new nature-inspired method for the solution of tough combinatorial optimization problems [3].

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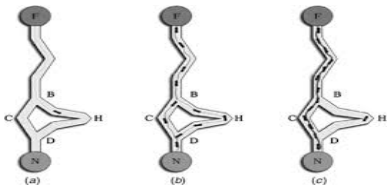

Fig.2 Ant Searching Action

The ACO is inspired by the search actions of real ants and their talent in finding the shortest paths. ACO is a population-based search method for the hard combinatorial optimization problems. Initially this algorithm was proposed based on the behaviour of ant colonies in their search for food[4].The algorithm is inspired by the pheromone trail-laying and guidance behaviour of ant colonies, which the ants are able to find the shortest paths[5].

```
procedure
ACO_MetaHeuristic
    while(not_termination)
      generateSolutions()
      daemonActions()
      pheromoneUpdate()
    end while
  end procedure
```

Table 1. Pseudo code for ACO

B. BEE COLONY ALGORITHM

For the real parameter optimization, Artificial Bee Colony (ABC) algorithm was proposed by Karaboga in 2005. ABC is a newly established optimization algorithm and imitates the intellectual behaviour of bee colony [6] for uncontrolled optimization problems. It is as easy as Particle Swarm Optimization (PSO) and Differential Evolution (DE) algorithms, and uses only general control factors such as colony size and maximum cycle number. ABC as an algorithm for optimization provides a population-based search method in which individuals called foods positions are modified by the artificial bees with time and the bee's aim is to identify the places of food sources with high volume of honey amount and finally the one with the highest Volume of honey.

In Bee Colony, an Employee and Onlooker bee fly around in a multidimensional search space and discovers the food sources based on the experience of themselves and with the companion. The Scouts, flies and choose the food sources randomly without using experience. If the new source has the higher amount of nectar, then the new source is memorized and the old will be forgotten by the bees. ABC system includes both the search methods carried out by employee and the onlooker bees (local search methods), and also the global search methods, done by onlookers and scouts.

```
Initialize Population
 repeat
   Place the employed bees on their food sources
    Place the onlooker bees on the food sources depending on their nectar amounts
   Send the scouts to the search area for discovering new food sources
    Memorize the best food source found so far
until requirements are met
```

Table 2. ABC Algorithms steps

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C. SHUFFLED FROG LEAPING ALGORITHM

A Frog-Leaping Algorithm (SFLA) is a meta – heuristic algorithm which is a mimic model of the behaviour of frogs searching for food rest on stones randomly placed in a pool. It was developed by Eusuff and Lansey with efficient global search techniques and also with the strong mathematical foundation.

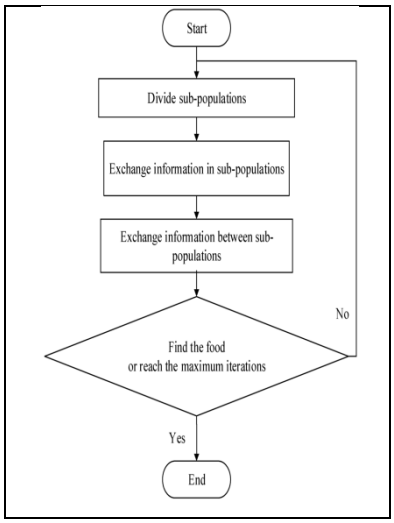

Fig.3. Process flow of SFLA

Initially SFLA generates random population and then ranking will be done for each frogs. Ranked frogs are divided into memeplexes. Memetic evaluations will be done.Then local search and shuffling processes (global relocation) will continue until defined convergence criteria are fulfilled [7].

D. MONKEY CLIMBING ALGORITHM

Monkey Climbing Algorithm (MCA) was developed by Zhao and Tang[8]. It was inspired by the actions of monkeys. The monkey climbs the trees by choosing the best place of the branches of tree. MCA is used to solve global optimization problems. MCA has the following three main processes

- Climb process,
- Watch-jump process,
- Somersault process.

Climb process: It represents the local search of the algorithm. The monkeys climb from some position that is referred as initial positions and selects local optimum position to climb.

Watch-jump process: it is the search process from local optimum to global optimum position. When the monkey reaches the local optimum position, it will look for the new better optimal position. Until the better position found the monkey will stay at the local position.

Somersault process: this process represents the search process for avoiding the local optimum. The monkeys will somersault to new positions at a certain probability and begin a new search [9].

E. FIREFLY ALGORITHM

Firefly algorithm (FA) is a quite simple Bio-inspired search technique, used for global optimization problems . FA becomes more popular in solving a variety of real-world problems [10]–[15]. FA is one of the swarm-based intelligence algorithm. It mimics the flashing behaviour of fireflies. A firefly flashes as a indication to create a center of attention . This behaviour is used for predation or mating. This meta-heuristic algorithm framed by following three rules [16], [17]

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Rule 1: All fireflies are attracted by each other without respect to their sex;
Rule 2: Attractiveness is relatively to its brightness, that is, the less bright one will move towards the brighter one;
Rule 3: If there are no brighter fireflies than a particular firefly, it will move randomly in the space.

F. CUCKOO SEARCH ALGORITHM

Cuckoo search (CSA) was proposed by Yang and Deb in the year 2009, It is has efficient in solving global optimization problems[18]. AT a time a cuckoo bird lays a single egg into a randomly chosen optimum nest. The generation will be ensured only by the optimum nest with great quality eggs. The number of host nests is static and a host can find an alien egg with a probability (Pa) [0, 1], whose presence leads to either throwing away of the egg or abandoning the nest by the host bird [19]. One has to note that each egg in a nest represents a solution and a cuckoo egg represents a new solution where the objective is to replace the weaker fitness solution by a new solution.

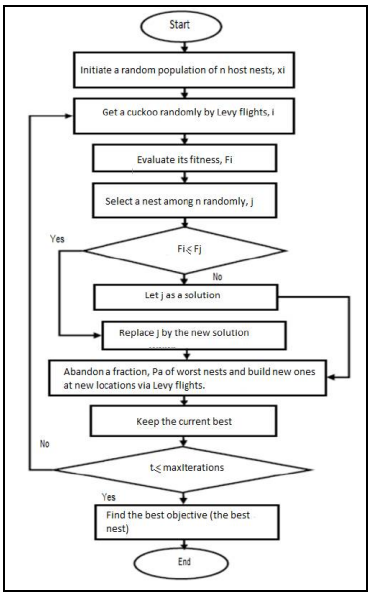

Fig.4. Process flow of CSA

G. FISH SCHOOL SEARCH

(FSS) is a computational intelligence technique proposed invented and by Bastos-Filho and Lima-Neto in the year 2007. FSS was conceived to solve search problems, which is based on the social behavior of schools of fish[20]. It is an uni-model optimization algorithm. FSS is inspired from a collective behavior of fish schools.

1.	Initialize user parameters
2.	Initialize fishes positions randomly
3.	while Stopping condition is not met do
4.	Calculate fitness for each fish
5.	Run individual operator movement
6.	Calculate fitness for each fish
7.	Run feeding operator
8.	Run collective-instinctive movement operator
9.	Run collective-volitive movement operator
10.	end while

Table 3. FSS- Pseudo Code

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H. BACTERIAL FORAGING ALGORITHM.

In 2002, Passino [21] proposed the Bacteria Foraging Optimization Algorithm (BFOA) , inspired by the group foraging behavior of bacteria such as E.coli and M.xanthus. Specifically, the BFOA is inspired by the chemotaxis behavior of bacteria that will recognize chemical gradients in the surroundings and move toward or away from specific pointer. BFOA has advantages, such as parallel distributed processing, insensitivity to initial value, and global optimization. The foraging strategy of E. coli bacteria is governed by four processes [22],

- ✓ Chemotaxis,
- ✓ Reproduction,
- ✓ Elimination
- ✓ Dispersal, and swarming.

IV. APPLICATIONS OF BIO INSPIRED COMPUTING

Inspired from Organism Behaviour			
S.No	Name of the Algorithm	Observation	Applications
1	Ant Colony Optimization	ACO	Scheduling problem Vehicle routing problem Assignment problem Set problem Image processing Device sizing problem in nano- electronics physical design Connection-oriented network routing Connectionless network routing Data mining Discounted cash flows in project scheduling Distributed information retrieval Grid workflow scheduling problem Intelligent testing system System identification Protein folding Power electronic circuit design bankruptcy prediction
2	Artificial Bee Colony	ABC	Biological simulation Genetic Algorithm Improvement Continuous Optimization Travelling Salesman Problem(TSP) Stochastic Vehicle Routing Ride-Matching Problem Dynamic Allocation of Internet Service Telecommunication Network Routing Job Shop Scheduling Neural Network Dynamic Resource Data Mining –Clustering Integrated Partitioning/Scheduling

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3	Shuffled Frog Leaping Algorithm	SFLA	Color Image segmentation Grid Task scheduling Optimal viewpoint selection for volume rendering Fuzzy controller design Optimal Reactive Power Flow A Web Document classification Mobile robot path planning classification rule mining Job-shop scheduling Multicast Routing Optimization
4	Monkey Climbing Algorithm	MCA	Multidimensional Assignment Problem Mobile robot control. Global numerical Optimization. Power System Optimization. Cluster Analysis Discrete Optimization.
5	Firefly Algorithm	FA	Dispatch Problems Job Scheduling Price Forecasting Network Analysis Travelling Salesman Problem
6	Cuckoo Search	CS	Multilevel Image Threshold Selection Edge Detection Optimizing Job Scheduling Optimizing Sensor Node Energy Speaker recognition Optimizing Neural Network Weights Web Document Clustering
7	Fish School Search	FSS	Function optimization Parameter estimation Combinatorial optimization Least squares support vector machine
8	Bacterial foraging Algorithm	BFOA	Optimizing Job Scheduling Web Document Clustering Vehicle routing problem Assignment problem Set problem Image processing

V. SURVEY FINDINGS

This survey clearly stated that the Bio - Organism Behavior Inspired Computing Techniques are applied in various computer science research fields such as Data mining, Image processing, Wired and Wireless Networks, Cloud Computing , Grid Computing, Intelligence System, and also in Neural Networks. Bio - Organism Behavior Inspired Computing Techniques are also used in non computer research areas such as Mathematic, Electrical and Electronics, Economics and also in the medical fields.

VI. CONCLUSIONS

New revolution in computer science is created with help on bio inspired techniques. A number of Bio organism behavior methods have been proposed to solve and optimize the difficult computation in various research fields of

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computer science. This paper provides an overview of Bio organism behaviour techniques including Ant Colony Optimization Algorithm, Bee Colony Algorithm, Shuffled Frog Leaping Algorithm, Monkey Climbing Algorithm, Firefly Algorithm, Cuckoo Search Algorithm, Fish school Algorithm, Bacterial foraging Algorithm and is applications. Bio-BIC is most powerful algorithm for scheduling and optimization problems in various research fields.

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