

# Cuttlefish Algorithm – A Novel Bio-Inspired Optimization Algorithm

Adel Sabry Eesa, Adnan Mohsin Abdulazeez Brifiani, Zeynep Orman

**Abstract**— In this paper, a new meta-heuristic bio-inspired optimization algorithm, called Cuttlefish Algorithm (CFA) is presented. The algorithm mimics the mechanism of color changing behavior used by the cuttlefish to solve numerical global optimization problems. The patterns and colors seen in cuttlefish are produced by reflected light from different layers of cells including (chromatophores, leucophores and iridophores) stacked together, and it is the combination of certain cells at once that allows cuttlefish to possess such a large array of patterns and colors. The proposed algorithm considers two main processes: reflection and visibility. Reflection process is proposed to simulate the light reflection mechanism used by these three layers, while the visibility is proposed to simulate the visibility of matching pattern used by the cuttlefish. These two processes are used as a search strategy to find the global optimal solution. Efficiency of this algorithm is also tested with some other popular biology inspired optimization algorithms such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO) and Bees Algorithm (BA) that have been previously proposed in the literature. Simulations and obtained results indicate that the proposed CFA is superior to other algorithms.

**Index term**— Cuttlefish algorithm, Reflection, Visibility, Optimization, Chromatophores, Iridophores, Leucophores, Test functions.

## 1 INTRODUCTION

**G**LOBAL optimization is a field with applications in many areas of science, engineering, economics, and others, where mathematical modeling is used. Without loss of generality, the optimization maybe defined as the search for a vector  $x_0$  in a possible solution set  $X$  minimizing a target function  $f$  so that  $\forall x \in U \subseteq X: f(x) \geq f(x_0)$ . For  $U = X$ ,  $x_0$  is called a global optimum, otherwise it is called a local optimum of  $f$  in  $X$  [29]. Global optimization algorithms are usually broadly divided into deterministic and meta-heuristic [10]. Deterministic algorithms tend to use gradient technique and find greater use in solving unimodal problems. While meta-heuristic models tend to learn as they run, and tend to be more intelligent and adaptive. Meta-heuristic methods are usually faster in locating a global optimum than deterministic ones. The components of any meta-heuristic algorithms are intensification and diversification, or exploitation and exploration [29]. Diversification means to generate diverse solutions so as to explore the search space on a global scale, while intensification means to focus the search in a local region knowing that a current good solution is found in this region. A good balance between intensification and diversification should be found during the selection of the best solutions to improve the rate of algorithm convergence. The selection of the best ensures that solutions will converge to the optimum, while diversification via randomization allows the search to escape from local optima and, at the same time, increases the diversity of solutions. A good combination of these two major components will usually ensure that global optimality is achievable.

Most of meta-heuristic algorithms are nature-inspired such as Ant Colony Optimization ACO, Particle Swarm Optimization PSO, Bees Algorithm BA, etc. that have previously been proposed by researchers. Some of these

studies [1] have been inspired by animal behaviors for developing optimization techniques. For example, ACO algorithm proposed by Dorigo et al. [2], is inspired by the research on the behavior of ant colonies. BA proposed by D.T. Pham et al. [3], is inspired by the food foraging behavior of honey bees. PSO algorithm proposed by Kennedy and Eberhart [4], models the social behavior of bird flocking or fish schooling.

Recently, new meta-heuristic approaches are presented by several researchers. For example, collective animal behavior CAB algorithm proposed by Erik Cuevas et al. [5] is inspired from a group of animals which interact with each other that is based on the biological laws of collective motion. A gravitational search algorithm GSA, proposed by Esmat Rashedi et al. [6] is based on the law of gravity and mass interactions. Bumble bees mating optimization BEMO algorithm presented in Yannis Marinakis et al. [7] simulates the mating behavior of the bumble bees. Parliamentary optimization algorithm POA, proposed by Ali Borji [8] is motivated from human social behaviors in political environments. Bat Algorithm BA proposed by Xin-She Yang [9] is based on the echolocation behavior of bats. Firefly algorithm FA proposed by Xin-She Yang [11] is based on flashing characteristics of fireflies.

In this paper, a new meta-heuristic optimization algorithm that is inspired based on the mechanism of color changing behavior of cuttlefish is presented to find the optimal solution in numerical optimization problems. The patterns and colors seen in cuttlefish are produced by reflected light from different layers of cells stacked together, and it is the combination of certain cells at once that allows cuttlefish to possess such a large array of patterns and colors. The proposed algorithm mimics the light reflection process through the combination of these layers, and the visibility of matching pattern process used by cuttlefish to match its

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## **Table of Contents Cuttlefish Algorithm A Novel Bio Inspired Optimization**

1. Understanding the eBook Cuttlefish Algorithm A Novel Bio Inspired Optimization
  - The Rise of Digital Reading Cuttlefish Algorithm A Novel Bio Inspired Optimization
  - Advantages of eBooks Over Traditional Books
2. Identifying Cuttlefish Algorithm A Novel Bio Inspired Optimization
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Cuttlefish Algorithm A Novel Bio Inspired Optimization
  - User-Friendly Interface
4. Exploring eBook Recommendations from Cuttlefish Algorithm A Novel Bio Inspired Optimization
  - Personalized Recommendations
  - Cuttlefish Algorithm A Novel Bio Inspired Optimization User Reviews and Ratings
  - Cuttlefish Algorithm A Novel Bio Inspired Optimization and Bestseller Lists
5. Accessing Cuttlefish Algorithm A Novel Bio Inspired Optimization Free and Paid eBooks
  - Cuttlefish Algorithm A Novel Bio Inspired Optimization Public Domain eBooks
  - Cuttlefish Algorithm A Novel Bio Inspired Optimization eBook Subscription Services
  - Cuttlefish Algorithm A Novel Bio Inspired Optimization Budget-Friendly Options
6. Navigating Cuttlefish Algorithm A Novel Bio Inspired Optimization eBook Formats

- ePub, PDF, MOBI, and More
  - Cuttlefish Algorithm A Novel Bio Inspired Optimization Compatibility with Devices
  - Cuttlefish Algorithm A Novel Bio Inspired Optimization Enhanced eBook Features
7. Enhancing Your Reading Experience
    - Adjustable Fonts and Text Sizes of Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Highlighting and Note-Taking Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Interactive Elements Cuttlefish Algorithm A Novel Bio Inspired Optimization
  8. Staying Engaged with Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Joining Online Reading Communities
    - Participating in Virtual Book Clubs
    - Following Authors and Publishers Cuttlefish Algorithm A Novel Bio Inspired Optimization
  9. Balancing eBooks and Physical Books Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Benefits of a Digital Library
    - Creating a Diverse Reading Collection Cuttlefish Algorithm A Novel Bio Inspired Optimization
  10. Overcoming Reading Challenges
    - Dealing with Digital Eye Strain
    - Minimizing Distractions
    - Managing Screen Time
  11. Cultivating a Reading Routine Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Setting Reading Goals Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Carving Out Dedicated Reading Time
  12. Sourcing Reliable Information of Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Fact-Checking eBook Content of Cuttlefish Algorithm A Novel Bio Inspired Optimization
    - Distinguishing Credible Sources
  13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development
    - Exploring Educational eBooks
  14. Embracing eBook Trends
    - Integration of Multimedia Elements
    - Interactive and Gamified eBooks

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