

# A New Metaheuristic Bat-Inspired Algorithm

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**Abstract.** Metaheuristic algorithms such as particle swarm optimization, firefly algorithm and harmony search are now becoming powerful methods for solving many tough optimization problems. In this paper, we propose a new metaheuristic method, the Bat Algorithm, based on the echolocation behaviour of bats. We also intend to combine the advantages of existing algorithms into the new bat algorithm. After a detailed formulation and explanation of its implementation, we will then compare the proposed algorithm with other existing algorithms, including genetic algorithms and particle swarm optimization. Simulations show that the proposed algorithm seems much superior to other algorithms, and further studies are also discussed.

## 1 Introduction

Metaheuristic algorithms such as particle swarm optimization and simulated annealing are now becoming powerful methods for solving many tough optimization problems [3-7,11]. The vast majority of heuristic and metaheuristic algorithms have been derived from the behaviour of biological systems and/or physical systems in nature. For example, particle swarm optimization was developed based on the swarm behaviour of birds and fish [6, 7], while simulated annealing was based on the annealing process of metals [8].

New algorithms are also emerging recently, including harmony search and the firefly algorithm. The former was inspired by the improvising process of composing a piece of music [4], while the latter was formulated based on the flashing behaviour of fireflies [13]. Each of these algorithms has certain advantages and disadvantages.

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For example, simulating annealing can almost guarantee to find the optimal solution if the cooling process is slow enough and the simulation is running long enough; however, the fine adjustment in parameters does affect the convergence rate of the optimization process. A natural question is whether it is possible to combine major advantages of these algorithms and try to develop a potentially better algorithm? This paper is such an attempt to address this issue.

In this paper, we intend to propose a new metaheuristic method, namely, the Bat Algorithm (BA), based on the echolocation behaviour of bats. The capability of echolocation of microbats is fascinating as these bats can find their prey and discriminate different types of insects even in complete darkness. We will first formulate the bat algorithm by idealizing the echolocation behaviour of bats. We then describe how it works and make comparison with other existing algorithms. Finally, we will discuss some implications for further studies.

## **2 Echolocation of Bats**

### ***2.1 Behaviour of Microbats***

Bats are fascinating animals. They are the only mammals with wings and they also have advanced capability of echolocation. It is estimated that there are about 996 different species which account for up to 20% of all mammal species [1, 2]. Their size ranges from the tiny bumblebee bat (of about 1.5 to 2g) to the giant bats with wingspan of about 2 m and weight up to about 1 kg. Microbats typically have forearm length of about 2.2 to 11cm. Most bats use echolocation to a certain degree; among all the species, microbats are a famous example as microbats use echolocation extensively while megabats do not [11, 12].

Most microbats are insectivores. Microbats use a type of sonar, called, echolocation, to detect prey, avoid obstacles, and locate their roosting crevices in the dark. These bats emit a very loud sound pulse and listen for the echo that bounces back from the surrounding objects. Their pulses vary in properties and can be correlated with their hunting strategies, depending on the species. Most bats use short, frequency-modulated signals to sweep through about an octave, while others more often use constant-frequency signals for echolocation. Their signal bandwidth varies depends on the species, and often increased by using more harmonics.

### ***2.2 Acoustics of Echolocation***

Though each pulse only lasts a few thousandths of a second (up to about 8 to 10 ms), however, it has a constant frequency which is usually in the region of 25kHz to 150 kHz. The typical range of frequencies for most bat species are in the region between 25kHz and 100kHz, though some species can emit higher frequencies up to 150 kHz. Each ultrasonic burst may last typically 5 to 20 ms, and microbats emit