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Golden Drop Algorithm: A Water Wave and Golden Ratio inspired novel metaheuristic for global optimization

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ABSTRACT

Metaheuristic methods are approximate solution techniques that are widely used to solve complex optimization problems. Drawing inspiration from nature, physics, or human behavior, researchers have developed a diverse range of metaheuristic algorithms, either population-based or single-solution-based, with varying neighborhood structures and memory usage. Due to the diversity and complexity of optimization problems in different domains, no single algorithm can be universally effective for all types of problems. This study proposes a novel metaheuristic algorithm, the Golden Drop Algorithm (GDA), which is simple, efficient, and easy to implement. GDA is a physics-inspired method that simulates the propagation of circular waves formed by raindrops falling into water, with wave expansion governed by the golden ratio. The algorithm was evaluated using the Congress on Evolutionary Computation (CEC) 2017 benchmark functions and was compared with three well-known metaheuristics: Genetic Algorithm (GA), Grey Wolf Optimizer (GWO), and Particle Swarm Optimization (PSO). The results demonstrate that GDA is not only straightforward and computationally efficient, but also capable of producing competitive and feasible solutions. In 50 % of the CEC 2017 benchmark functions, GDA ranked first, while in 32 % of the functions, it secured second place. In addition, its performance was validated through three benchmark engineering design problems: welded beam design, pressure vessel design, and compression spring design, highlighting its robustness and effectiveness in solving constrained nonlinear optimization tasks.

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Izvirni znanstveni članek

Algoritem zlate kaplje: nova metahevristična metoda za globalno optimiranje, navdihnjena z vodnimi valovi in zlatim rezom

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POVZETEK

Metahevristične metode so približni postopki za reševanje zahtevnih optimizacijskih problemov. Raziskovalci so na podlagi navdiha iz narave, fizike in človeškega vedenja razvili številne metahevristične algoritme, populacijske in enorešitvene, z raznolikimi strukturami sosedstva ter različnimi stopnjami uporabe spomina. Zaradi raznolikosti in kompleksnosti optimizacijskih problemov na različnih področjih noben algoritem ni univerzalno učinkovit za vse vrste problemov. V tem prispevku je predstavljen nov metahevristični algoritem, imenovan algoritem zlate kaplje (angl. Golden Drop Algorithm, GDA), ki je preprost, učinkovit in enostaven za implementacijo. GDA je fizikalno navdihnjena metoda, ki simulira širjenje krožnih valov, nastalih ob padcu dežnih kapelj na vodno površino, pri čemer je razširjanje valov vodeno z zlatim rezom. Algoritem je bil ovrednoten z uporabo referenčnih testnih funkcij CEC 2017 (Congress on Evolutionary Computation) ter primerjan s tremi uveljavljenimi metahevristikami: genetskim algoritmom (GA), optimizatorjem sivega volka (GWO) in optimizacijo z rojem delcev (PSO). Rezultati kažejo, da je GDA konceptualno preprost in računsko učinkovit ter sposoben zagotavljati konkurenčne in dopustne rešitve. Pri 50 % referenčnih funkcij CEC 2017 se je GDA uvrstil na prvo mesto, pri 32 % funkcij pa na drugo mesto. Poleg tega je bila njegova učinkovitost potrjena še na treh referenčnih inženirskih optimizacijskih problemih: zasnovi varjenega nosilca, zasnovi tlačne posode in zasnovi tlačne vzmeti, kar potrjuje njegovo robustnost in učinkovitost pri reševanju omejenih nelinearnih optimizacijskih nalog.

PODATKI O ČLANKU

Ključne besede:
Metahevristično optimiranje;
Fizikalno navdihnjene metahevristike;
Vodni valovi;
Zlati rez;
Referenčne funkcije CEC 2017;
Inženirski optimizacijski problemi

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