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Mechanical Design Based on the Pelican Optimization Algorithm

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INTRODUCTION & AIM

The Pelican Optimization Algorithm (POA) [1] is a meta-heuristic optimization algorithm, distinguished by its excellent ability to balance global exploration and local exploitation. This unique advantage enables it to effectively tackle complex multi-objective and multi-constraint optimization problems in mechanical design [2], where traditional algorithms often struggle with precision and efficiency. Thus, exploring POA's application value in this field is of great significance for advancing mechanical design optimization. This study applies the POA to mechanical design parameter optimization, taking advantage of its bionic mechanism that simulates pelicans' natural hunting behavior. To verify its performance, POA is employed to solve three mechanical design optimization tasks: minimizing the self-weight of tension/compression springs, reducing the volume of rolling bearings, and lowering the manufacturing cost of reducers, with parameter optimization conducted by leveraging POA's balanced exploration–exploitation capability. Comparative experimental tests show that the mechanical design solutions obtained by POA outperform those generated by other conventional meta-heuristic algorithms. Specifically, in terms of core objective function values, including the self-weight of springs, volume of rolling bearings, and production cost of reducers, POA achieves more optimal results, demonstrating its superior optimization performance. The application of POA effectively enhances the precision and efficiency of mechanical design parameter optimization. This study confirms the feasibility, superiority, and practical applicability of POA in solving engineering optimization problems, providing a reliable new optimization tool for related mechanical design scenarios.

METHOD

This study takes POA as the core method, which simulates pelicans' foraging behavior to achieve dynamic balance between global search and local optimization and has specific position update formulas. It includes five implementation steps: initialization, evaluation and selection, predation behavior simulation, population update, and iteration and convergence. For mechanical design [3], the study establishes a general mathematical optimization model with objective functions and constraints, and formulates the design process for applying POA to mechanical design problems. Experiments carry out on a Windows 10 platform with an Intel i5 processor and 16 GB RAM, set the population size to 50 and the maximum iteration count to 1000, and optimize the self-weight of springs, volume of rolling bearings, and production cost of reducers by defining corresponding variables, objective functions and engineering constraints.

RESULTS & DISCUSSION

POA outperforms seven algorithms including FLA, CoatiOA RIME, GA, PSO, DE, ES in the three mechanical component optimization experiments, and all optimization results fully meet the corresponding engineering constraints. In tension/compression spring design, POA reduces the weight by 0.1%-0.5% compared with other algorithms. For rolling bearing design, POA cuts down the volume by 0.28%-0.45% against most algorithms. In reducer design, POA lowers the manufacturing cost by 0.5%-0.7% than other algorithms. The excellent performance of POA comes from its fine-grained search for continuous and discrete variables, adaptive adjustment of exploration-exploitation strategies and strong ability to avoid local optima, which enables it to balance various engineering constraints effectively and exhibit superior robustness in solving complex mechanical optimization problems with mixed variables.

CONCLUSION

This study systematically explores the application of the POA in mechanical application design, and verifies the algorithm's effectiveness and robustness through theoretical analysis and experimental validation. The results prove that POA has outstanding performance in handling complex multi-constraint mechanical design problems, and can effectively improve the precision and efficiency of mechanical design parameter optimization while satisfying all engineering constraints.

FUTURE WORK / REFERENCES

The research verifies POA's performance for high-dimensional problems, expands its application to more mechanical design fields, and develops specialized modules to boost its engineering applicability in practice.

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