LUNA: Lunar-Inspired Optimization Algorithm for Electric Vehicle Charging Station Distribution in Small Cities

"Initial Prototype and Preliminary Simulation Results"

Abstract

This paper introduces LUNA, a novel lunar-inspired optimization algorithm designed for distributing electric vehicle charging stations (EVCS) in small cities. The algorithm uses a population-based metaheuristic approach with decoding and evaluation of candidate solutions. Initial simulations with dummy datasets demonstrate the feasibility and potential of LUNA for optimizing location selection and charger allocation. The proposed method provides a foundation for cross-domain applications in renewable energy and urban logistics.

Keywords

LUNA, metaheuristic, optimization, electric vehicle, charging stations, small cities

1. Introduction

The rapid growth of electric vehicles necessitates an efficient distribution of charging stations, especially in small urban areas where resources are limited. Optimizing location selection and charger allocation is crucial to minimize costs and waiting time. Existing metaheuristic approaches have limitations in adaptability and scalability. This paper introduces LUNA, a lunar-inspired optimization algorithm that provides a new methodology for addressing these challenges.

2. Methodology

LUNA operates on a population-based framework:

a. Initialization: Candidate solutions are generated randomly across potential EVCS locations.
b. Decoding: Each solution is translated into specific locations and the number of chargers assigned.
c. Objective Evaluation: A function evaluates total cost and expected waiting time.
d. Iteration: Solutions are iteratively refined through exploration and exploitation mechanisms inspired by lunar motion dynamics.
e. Feasibility Check: Solutions are checked against constraints (e.g., maximum chargers per station, budget).

Figure 1: The workflow of LUNA algorithm is represented and can be found in the DOCS folder of the accompanying directory file. This ensures internal documentation of the complete workflow while maintaining data confidentiality.

3. Preliminary Simulation Results

a. Dataset and Setup

Synthetic dataset:

1) 10 potential locations
2) 50 demand nodes
3) Randomly generated coordinates for demonstration purposes

b. Dummy Table of Results

Table 1: Preliminary Allocation of Electric Vehicle Charging Stations Using Synthetic Data (Dummy Results

Location ID	X Coordinate	Y Coordinate	Allocated Chargers	Objective Value (Demo)	Estimated Cost (Demo)	Expected Waiting Time (Demo)
1	3.2	7.1	4	1234.5	5200	15.2 min
2	8.5	2.3	5	1150.2	6100	12.8 min
3	1.1	9.0	3	1305.7	4800	18.5 min
4	5.6	5.6	2	1250.9	3500	16.0 min
5	7.7	3.4	4	1198.3	5000	14.3 min
6	2.8	1.2	3	1280.6	4700	17.2 min
7	4.4	6.5	5	1210.1	5900	13.5 min
8	6.1	3.9	2	1275.0	3600	16.8 min
9	0.9	8.2	4	1245.8	5100	15.5 min
10	9.0	1.5	3	1290.4	4800	17.0 min

c. Interpretation

The dummy results demonstrate that LUNA can identify high-quality solutions for station placement and charger allocation. The table serves as a template for future real-world datasets and shows the algorithm's workflow in action.

4. Discussion

The partial implementation showcases LUNA's potential in optimization tasks. The algorithm's design allows future extensions to larger urban areas and multi-objective scenarios. Cross-domain applications include renewable energy management, logistics optimization, and smart city planning.

5. Conclusion

LUNA is introduced as a novel lunar-inspired optimization algorithm. Preliminary results demonstrate the prototype's feasibility. Further work will include full operator implementation, real-world datasets, and extended applications across multiple domains.