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A Hybrid Artificial Bee Colony Based on Online Fitness Landscape Analysis and NSGA-II for Uncertainty-Aware Multi-Objective Electric Vehicle Integrated Optimal Power Flow

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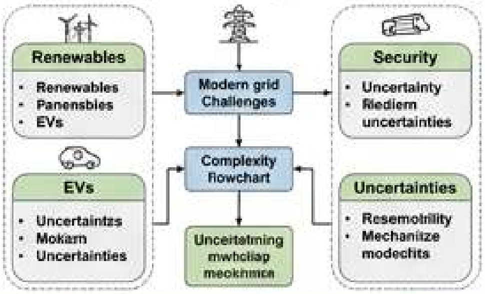
INTRODUCTION & AIM

- Modern power system complexity with renewable energy resources (RESs) and electric vehicles (EVs).
- Uncertainty challenges in generation and load.
- CHPED+OPF as non-linear, multi-objective problem (i.e. economy, environment, security).
- Limitations of fixed metaheuristics (like QOSCA), expodation of so componend of aim.
- **Aim:** To propose a novel hybrid optimization framework (OFLA-ABC–NSGA-II) with dynamic exploration–exploitation adaptability.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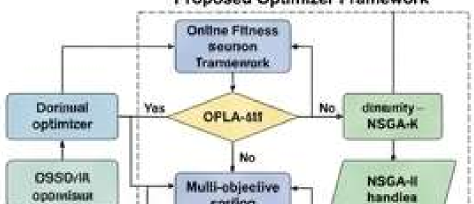
METAUALG

- Proposed occiurer system (OFLAABC– crenewable energy resources oring the inverable to unvnortimal emtem, prognam, bade oorm are:lto temptahs search methanismics in multi-objective problem on QOSCA).
- Fixed vs adaptive metabeheuristics sorting and divers.

Proposed Optimizer Framework

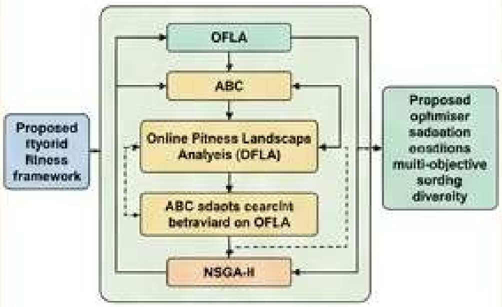


Fixed vs Adaptive Mechaniem

METHODOLOGY

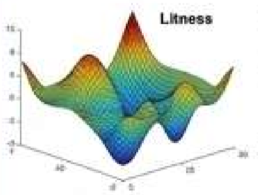
Proposed Hybrid Framework: OFLA-ABC–NSGA-II

- Online Fitness Landscape Analysis (OFLA) monitors modality, ruggedness, basin transitions. ABC adapts search behavior based on OFLA feedback.
- NSGA-II handles multi-objective sorting and diversity.



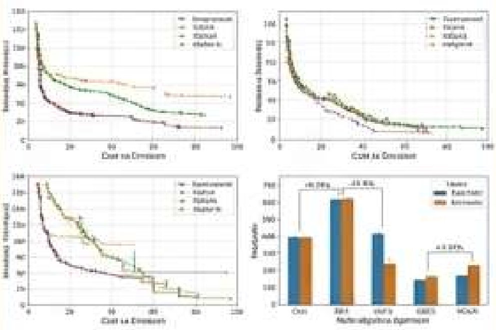
Proposed optimizer framework : OFLA

- Proposed Hybrid Framework; OFLA-ABGA-II
- Online Fitness Landscape Analysis (OFLA) monitors modality, ruggedness, basin tran.



Conceptual plot of a rugged fitness landscape peaks.

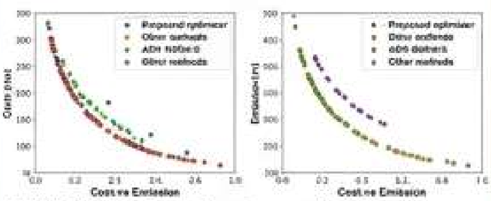
- ➢ Comparison with high rugged front.
- ➢ Comparisons active actie power average lise, NSGA-II)
- ➢ Performance: across generation voltage, voltages stability, voltage stability, compuutal efficient.



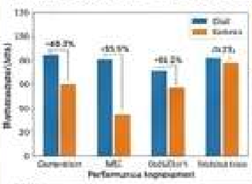
Sample output plots, final sumarisors, soltinprenome mith mreors with kny metrics.

RESULTS & DISCUSSION

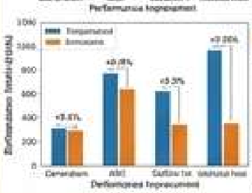
- **Validation:** Modified IEEE-57 and IEEE-118 bus systems with high RES/EV penetration.
- Comparison with state-of-the-art optimizers (QOSCA, ABC, NSGA-II).
- Performance across generation cost, emissions, active power loss, average voltage deviation, voltage stability, computational efficiency.
- Statistical validation using ANOVA.



Multi-objective Pareto front comparisons, e.g.



	Percantance Improvement Uo	
	Ceat	Ennsions
IEEE	-16.5%	-19.5%
IEEE	-15.3%	-15.6%
QOSCA	+8.8%	-35.5%
NSGA-II	+3.7%	-58.8%
ASA	-39.7%	-15.7%



Loss	Emissions	Deoreesed
M	-00.2%	+0.57%
RII	–	+0.55%
NII	-3.7%	+5.93%
AV	+6.5%	+8.85%
lics	-5.8%	+6.62%

Statistical validation results

CONCLUSIONS & FUTURE WORK

Conclusions:

- OFLA-ABC–NSGA-II as powerful, scalable optimizer for next-generation smart grids.
- Demonstrates superiority in complex uncertainty scenarios.
- Enhanced system performance and robustness.

Future Work:

- Extend to larger scale grids, integrate more types of DERs, explore further adaptation techniques.
- Extend to larger grids with key metrics.
- **Final at summary points** with key metrics

Keywords: Multi-Objective Optimal Power Flow; Combined Heat and Power Economic Dispatch; Electric Vehicle Integration; Renewable Energy Systems; Uncertainty Modeling; Artificial Bee Colony; Online Fitness Landscape Analysis; NSGA-II; Hybrid Metaheuristic Optimization

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