IEEE 33-Bus Network Reconfiguration with Two-Stage Firefly Algorithm and SNG Visualization

Welcome! This project is a MATLAB implementation for optimizing the configuration of the IEEE 33-bus distribution network. It uses a two-stage Firefly Algorithm (FA) and features a clear visualization of the network's Simplified Network Graph (SNG). The main goal is to reduce power losses and improve voltage profiles by finding the best combination of open and closed switches, while always keeping the network radial.

About the Project

This tool helps power engineers and researchers find the best switch settings for the IEEE 33-bus distribution system. It does this in two steps:

1. It first uses a simplified view of the network (SNG) to quickly find promising solutions.
2. Then, it refines those solutions using the full, detailed network model.

All results-such as power loss, voltage profiles, and switch settings-are displayed in a straightforward way, and the code includes visualizations to help you understand the network structure and optimization progress.

Features

- **Two-Stage Firefly Algorithm:**
    - **Stage 1:** Runs the FA on a simplified network graph for fast, rough optimization.
    - **Stage 2:** Refines the solution on the full network for best results.
- **SNG Visualization:**
    - Plots the simplified network, showing key nodes, edges, and path labels.
- **IEEE 33-Bus Data Built-In:**
    - All standard bus, branch, and tie-switch data included.
- **Radiality Enforcement:**
    - Ensures all solutions keep the network radial (no loops).
- **Performance Reporting:**
    - Shows power loss, minimum voltage, and loss reduction before and after optimization.
- **Voltage Profile Plots:**
    - Visual comparison of voltage profiles for initial and optimized cases.

Getting Started

Prerequisites

- MATLAB

How It Works

1. **Load Data:**
   The script loads all necessary bus, branch, and switch data for the IEEE 33-bus system.
2. **Build and Plot SNG:**
   A simplified network graph is created and plotted, showing major nodes and paths.
3. **Stage 1 Optimization:**
   The Firefly Algorithm searches for good switch settings using the SNG.
4. **Stage 2 Optimization:**
   The best SNG solution is used as a starting point for a more detailed search on the full network.
5. **Results and Visualization:**
   The script prints out the initial and optimized switch settings, power losses, and voltage levels, and plots the voltage profile for all buses.

Usage Example

After running the script, you'll see output like this in the MATLAB command window:

text

========== RESULTS ==========

Initial Configuration:

Open Switches: [33 34 35 36 37]

Power Loss: 210.98 kW

Minimum Voltage: 0.9000 p.u.

Optimal Configuration:

Open Switches: [7 9 14 28 32]

Power Loss: 139.98 kW

Minimum Voltage: 0.9400 p.u.

Loss Reduction: 33.64%

A voltage profile plot will also appear, comparing the base case and optimized case.

Project Structure

- **Main Script:**
  Runs the workflow: data loading, SNG creation, optimization, and results display.
- **Helper Functions:**
  - Data loading (load_33bus_data)
  - SNG creation and plotting (create_SNG)
  - Loop identification (find_fundamental_loops, find_fundamental_loops_SNG)

- Firefly Algorithm operators for both SNG and full network
- Radiality checks
- Load flow evaluation (run_loadflow)
- Utility functions for mapping paths to switches

Customization

- **Algorithm Parameters:**
  - Change num_fireflies, max_iterations, alpha, beta0, or gamma at the top of the script to adjust the optimization.
- **Voltage Limits:**
  - Modify V_min and V_max as needed.
- **Network Data:**
  - Edit the bus and branch data in load_33bus_data() for different scenarios.

Credits

This project was inspired by research on distribution network reconfiguration optimization.
If you use or adapt this code, please consider citing relevant IEEE papers

Fast Optimal Network Reconfiguration With Guided Initialization Based on a Simplified Network Approach | IEEE Journals & Magazine | IEEE Xplore