Microgrid Assignment

Assigned: 11/17/2021
Due: 12/10/2021 at 11:21 pm

Overview

Microgrid control is complex. Create a model of an islanded microgrid and an optimizing controller for the power generation in the system using a genetic algorithm. The model will be tested by simulating the control of this microgrid model over a 24 hour period of time.

Islanded Microgrid Model and Design Specifications:

- Power generation at 1 hour increments.
- The generation behavior for the next hour based on the previous hour's load data.
- The generation update behavior is the control of power generation contributions from each of the four sources in the microgrid.
- The determination of the new generation distribution across the sources is determined using your genetic algorithm.
- Excess power generation is allowed.
- Power deficit is not allowed.
- Assume snow is not a factor in load differences.
- The user must be able to select the method of offspring generation and selection for the genetic algorithm that is used for the controller.
- Assume that economic and environmental outcomes are equally significant in the generation decision (one is not more important than the other).

Mandated Microgrid Specifications:

- 1 load- Design a time series for this behavior.
    - Power usage for the load must be between 15 and 100 W at all times.
    - The first hour as the initial load demand, thus controlling 22 following hours of power generation
        - The first hour of load in the 24 hours is used as an initial evaluation
        - The last load can not be used since there is nothing to control after, so it should not be calculated

        - During the first hour assume that the exact load is generated
- 4 sources
    - Source 1: Capable of generating 20 W. For each W produced, it costs 0.02$ and produces 0.01 tons of emissions
    - Source 2: Capable of generating 120 W. For each W produced, it costs 0.2$ and produces 0.05 tons of emissions
    - Source 3: Capable of generating 15 W. For each W produced, it costs 0.01$ and produces 0.02 tons of emissions
    - Source 4: Capable of generating 50 W. For each W produced, it costs 0.02$ and produces 0.04 tons of emissions
- User determination of survival approach
- User determination of reproduction approach

Mandated Generator Control Outputs for Implementation:

- The implementation will only produce the following outputs:
    - Plot of load vs power generated
    - Plot of economic factor
    - Plot of environmental factor
    - Plot of run time for each hour
    - Total excess power generated during the 23 hours
    - Total cost over the 23 hours
    - Total emissions produced over the 23 hours
- No other outputs can be generated

Project Requirements

Stage 1: Design Parameter and Input Development

1. Draw a block diagram of how this microgrid may look
2. Create a load time series - It can not be linear or have a slope of zero
    a. This will be a plot that matches up with a vector that will be created in step 3.
    b. Submit the datafile if it is one produced externally, submit the code if created through a function
3. Describe how the load time series was generated
4. Create the chromosome format for the energy sources
5. Define any boundary conditions for each gene
6. Define what it means to optimize the economic factor
7. Define any boundary conditions for the fitness function for the economic factor
8. Define what it means to optimize the environmental factor

9. Define any boundary conditions for the fitness function for the environmental factor
10. Create the boundary function for load needs
11. Select a population size
12. Select a mutation rate
13. Define the crossover point (hint, there are only 3 options to select from here)
14. Define the stopping conditions

Step 2: Function Development

Use the design decisions made in Step 1 to complete these tasks

1. Create a function to initialize the population of chromosomes.
2. Create a function that creates a vector of randomly generated zeros and ones that has the length equal to the population size, the rate at which the value of one is assigned is based on your mutation rate (so the population size times the mutation rate is equal to the number of ones that appear in the vector which are placed at random locations). This will be used to identify which chromosomes to mutate.
3. Create a function that will take in a chromosome and mutate each gene, make sure the boundary conditions are satisfied. Reject all offspring that violate boundary conditions. This function will then return new chromosomes that are added to the population. Note that the population will increase only when a feasible chromosome is generated.
4. Create a function that will create new offspring using crossover. This function will perform one point crossover from 2 parents which are selected randomly. The number of offspring produced will be the population times the mutation rate. The crossover location will take place at the point you defined. Reject all offspring that violate boundary conditions. Add the rest to the population.

    Note: the population will increase only when a feasible chromosome is generated.
5. Create a function to evaluate the fitness function for the economic factor.
6. Create a function to evaluate the fitness function for the environmental factor.
7. Create a function that produces a vector containing the overall fitness function for each chromosome.
8. Create two functions that will take in the new population and reduce it down to the desired population size, thus creating the new generation.
    a. Function 1: Random Selection
    b. Function 2: Elitism
9. Create a function to determine if the stopping conditions are met.
10. Create a function that stores the selected chromosome based on the best fitness function at that point in time into a vector.
11. Create a function that will plot both the load and the power generation as a function of time.
12. Create a function that will plot the economic factor as a function of time.
13. Create a function that will plot the environmental factor as a function of time.

14. Create a function that will plot the time it takes to determine the next generation distribution for each calculation time.
15. Create a function that will produce an output of the total amount of excess energy generated, total cost, and total environmental impact that occurs over the 23 hour period that you are controlling the power generation of the microgrid for.

Step 3: Design Implementation Plan

1. Using the content developed in steps 1 and 2, create a flowchart to represent the implementation. The design must include all the necessary initialization tasks and all the functions developed in step 2.

In this step, the flowchart can get rather large. Abstraction to make module blocks that group together other blocks can be used. If using abstraction, the flowcharts for each of the blocks created must be made.

The flow chart must be created with electronic software.

Step 4: Implementation

Note: The program must function during grading and produce all the results as presented in the submission.

1. Create a program to implement this system
2. Use the elements defined in step 1 guide implementing the design parameters and inputs
3. Use the functions designed in step 2 following the plan developed in step 3
4. Incorporate the ability to determine the run time of generation determination at each time step (each hour calculation)

Step 5: Analysis

1. Compare the results of the design using each combination of reproduction and selection that is possible
2. In this comparison, look at all four factors of performance
    a. Excess power
    b. Cost
    c. Environmental impact
    d. Calculation time

3. Explain a speculation on what factors make one selection approach better than the other if they are different or why they have the same outcome if they are the same.

Step 6: Recommendation

1. Based on the analysis, make a recommendation of how to improve the design of the generation controller for this microgrid
2. This was a prototype and did not consider the safety of the implementation. Identify 2 concerns that need to be addressed for societal/ethical safety and explain why each one should be considered in the future revisions of the design.

Submission:

- Step 1, 3, 5, and 6 will be answered in a worksheet style document and submitted as a **PDF** on UB Learns. Non-PDF files will not be graded
  - Step 1 question 2 will have an extra file submitted for it
- All code will be submitted for parts 2 and 4
  - The will be tested with the expectation that it can be run from start to end to control the generation of power
  - If there are additional files that are used for inputs (such as the load), it must also be included
  - Everything must be properly commented
  - Non-Matlab files will not be accepted
- Report presenting the project in IEEE conference paper format and saved as a PDF. Non-PDF files will not be graded

Grading: (out of 230 Points)

- Step 1:Graded on “worksheet”
  - 2 points per task/question (14 tasks)
  - Question 2 data: 5 points
- Step 2: Graded with code submission
  - 16 functions
    - 2 points per function
      - This is evaluated on the logic of the function, not if it works
    - Comments: 0.5 points per function
- Step 3: Graded on “worksheet”
  - Flowchart appearance: 5 points
  - Initialization process defined: 5 points
  - Functions included: 1 point per function (16 functions)
  - Correct flow to implement the genetic algorithm: 10 points

- Correct flow to control the generation using the genetic algorithm: 10 points
- Correct flow to create the necessary outputs: 5 points
- Flowchart represents the complete system: 5 points

- Step 4: Graded with code submission
  - Header: 4 Points
  - Comments: 5 points
  - Functions incorporated to main function: 0.5 per function (16 functions)
  - Run time extraction: 5 point
- Step 5: Graded with “worksheet”

  If your code doesn’t run, these points are forfeited.
  - Question 1: 16 points
    - 4 different configurations with 4 data considerations for analysis each- 1 point per data point analysis per configuration
  - Question 2: 5 points
  - Question 3: 5 points
- Step 6: Graded with “worksheet”
  - Question 1: 5 points
  - Question 2: 5 Points
- Presentation of work for steps 1, 3, 5, and 6:
  - Combine the appropriate answers into a well structured conference paper style presentation of the work. Use the IEEE Conference template to accomplish this. https://www.ieee.org/conferences/publishing/templates.html
  - Language: 5 points
  - Appearance: 5 points
  - Structure and layout of content: 5 points
  - Content: 20 points
  - Introduction: 4 points
  - Conclusion: 4 points