Name(s)
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Project Number
38092

Project Title
Running on Water: Developing Novel AI/Optimization Techniques to Accelerate Research on Real-time Hydrogen Production

Abstract

Objectives/Goals
This project is a continuation of a four-year effort to generate hydrogen in real time to power automobiles, including last year's addition of a computer model of my physical system and an artificial intelligence (AI) to optimize the design based on user input priorities. This year, my objective was to create a faster and more accurate program that returns designs that better meet the user's priorities, accounts for more possibilities and how the design will be used, and converges faster to an optimized solution.

My objective was to improve my hydrogen production model & AI for greater application, accuracy, efficiency and speed, to find the optimum solution based on input priorities.

Methods/Materials
Hydrogen Production simulation: I updated my model to more accurately characterize the electrocatalytic (cathode, anode, solution) properties.
System optimization: I added an operating cost term to the Cost function, to better evaluate the time-based cost of maintenance and operations. The Cost function was also updated to better represent how well the AI is meeting the user's expectations, for more accurate and intuitive assessment by the user.
Novel AI algorithms: I developed new AI techniques and incorporated them into my evolutionary algorithm from last year:
1. #Food" based incentivization, to efficiently search the Design Space by allocating more resources to #organisms# with the most potential in each generation
2. Third order gradient descent line search, to improve speed by taking intelligent next steps

Results
Updating the cost function to include operating cost encouraged more efficient designs which took into account time based factors as well. In addition, the results of the model, when compared to previous data, were more accurate. Finally, my novel AI techniques consistently produced better designs (lower relative Cost) and converged to the best design approximately 6 times faster than a standard evolutionary AI algorithm.

Conclusions/Discussion
In addition to technical specifications, it is critical to consider realistic factors such as the cost over time of maintenance and operations. The successful changes to the AI algorithm demonstrate the importance of having the right algorithm to generate accurate, relevant results quickly. The novel third order line search and food-based population system I developed could be valuable additions to the arsenal of existing AI

Summary Statement
I developed two novel AI techniques and updated my computer model of a hydrogen production system, resulting in faster convergence to better designs.

Help Received
Assistant Prof. Kochenderfer of the Aero-Astro / Computer Science Departments gave me early access to his textbook "Algorithms for Optimization", which provided a comprehensive overview of the most current optimization techniques. These techniques served as a foundation from which I built my own