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AA222: Engineering Design Optimization

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Project # 2: Read Me

Description of Algorithms:

1) **Simple1, Simple2, Simple3:**
   The problems Simple1, Simple2, and Simple3 were tackled by combining penalty methods with Hook Jeeves optimization. To assess their performance, a combination of quadratic, mixed and count penalty methods with Hook Jeeves was also tested, with the hyperparameters fine-tuned to suit each problem's design space. Upon a few alterations, an initial step size of $\alpha = 0.1$ seemed to work perfectly with all the simple problems. This step size was scaled down by a decaying a factor, $\gamma = 0.5$. Along with this, the penalties were also tuned for passing the optimization condition.
   Hook Jeeves was particularly effective for these 2D problems as it requires 2n evaluations, making it a reasonable choice. However, this method is not suitable for higher dimensional problems, which limited its use for the secret problems.
2) **Secret1 and Secret2:**
   A combination of the quadratic penalty method and the cross-entropy method was used to optimize these functions. However, tuning the hyper parameters proved to be the biggest challenge. It was observed that the value of ρ and γ also had a significant impact on optimization. To design the normalized population, I ended up using a diagonal covariance matrix and mean of the form:
   $$\Sigma = identity \times sigma\ factor$$
   $$\mu = optimized\ value$$
   Secret1 had a large design space, which required a large covariance to be used for optimization. The size of the design space also made it difficult to manage function evaluations and choose suitable population and elite candidate numbers. One drawback of this method was the use of a random population. Incorporating gradient information would have greatly improved the performance of the optimization. Perhaps, Natural Evolution Strategies could have been a better choice for optimization of these problems.

Comparison of Algorithms:

The following plots were generated to understand the optimization process using different initial conditions. It was observed that due to the constraints, the initial condition had a significant impact on the overall optimization and constraint violation for both the algorithms

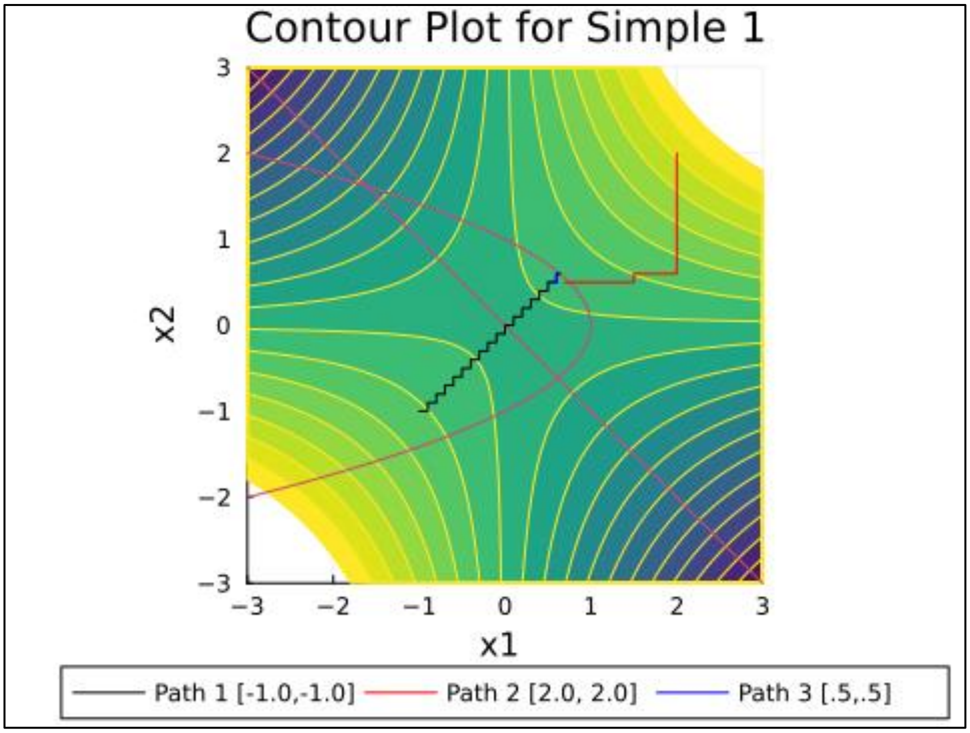

Figure 1: Mixed Penalty with Hooke Jeeves on Simple1

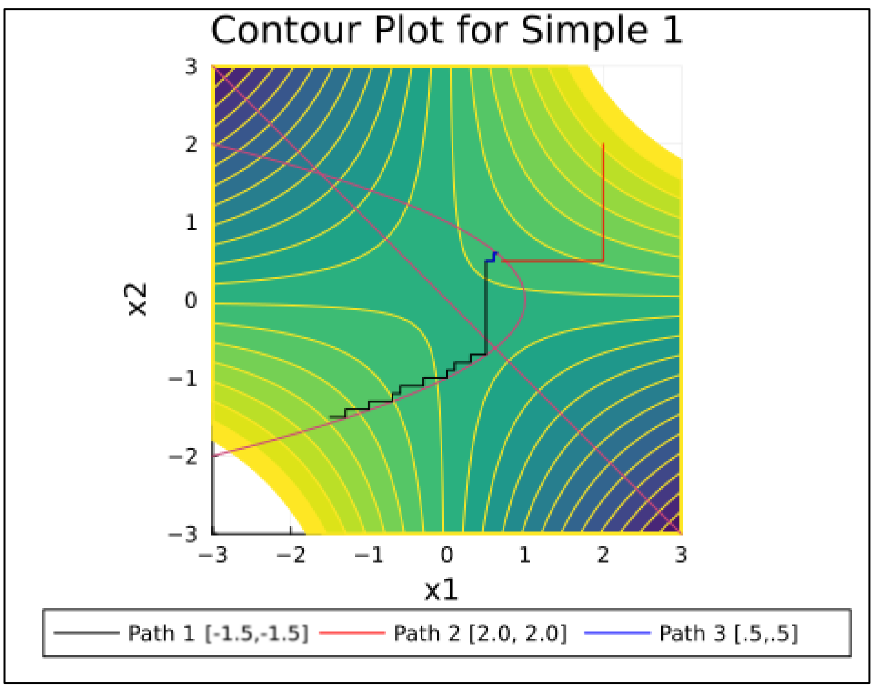

Figure 2: Quadratic Penalty with Hook Jeeves on Simple 1

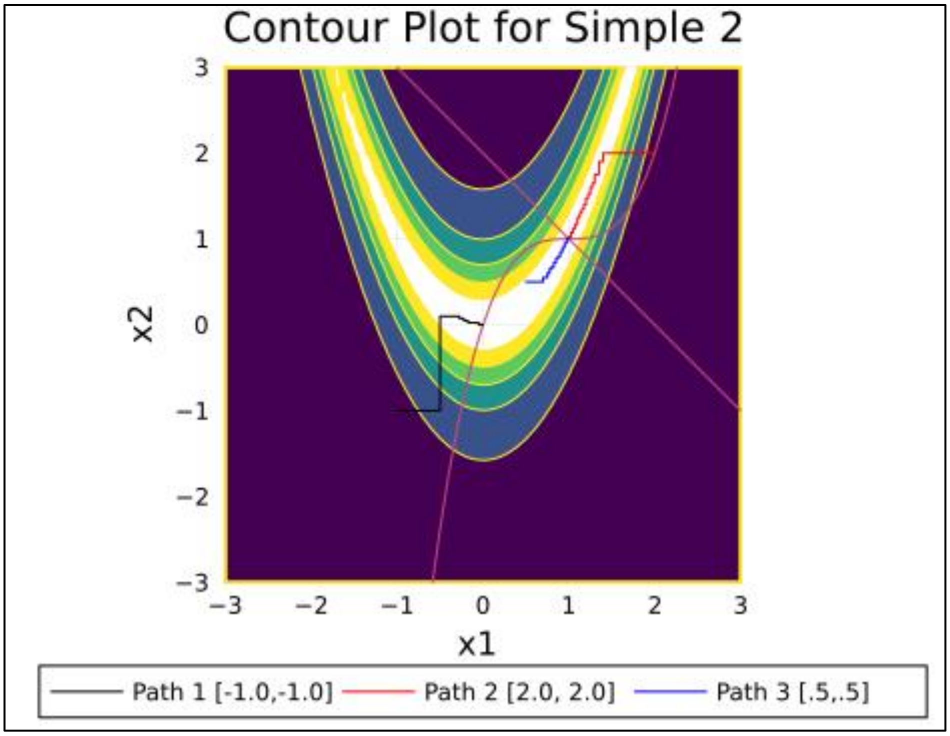

Figure 3: Figure 4: Mixed Penalty with Hooke Jeeves on Simple1

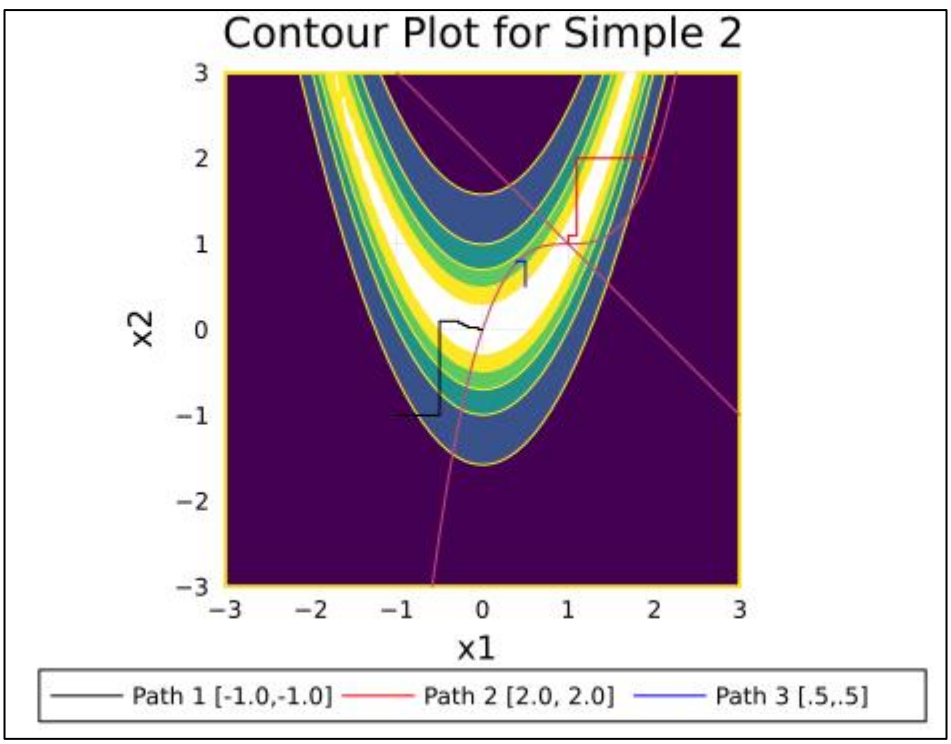

Figure 5: Figure 6: Quadratic Penalty with Hooke Jeeves on Simple1

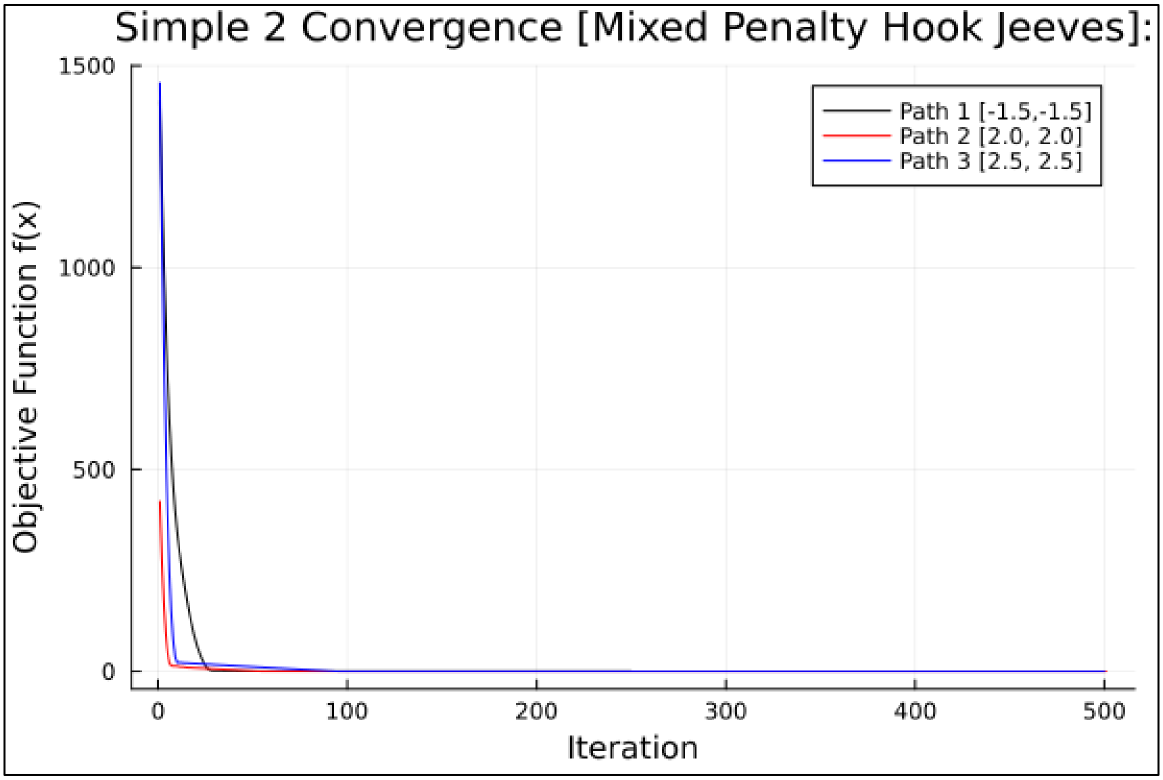

Figure 7: Simple 2 Convergence Plot using Algorithm 1

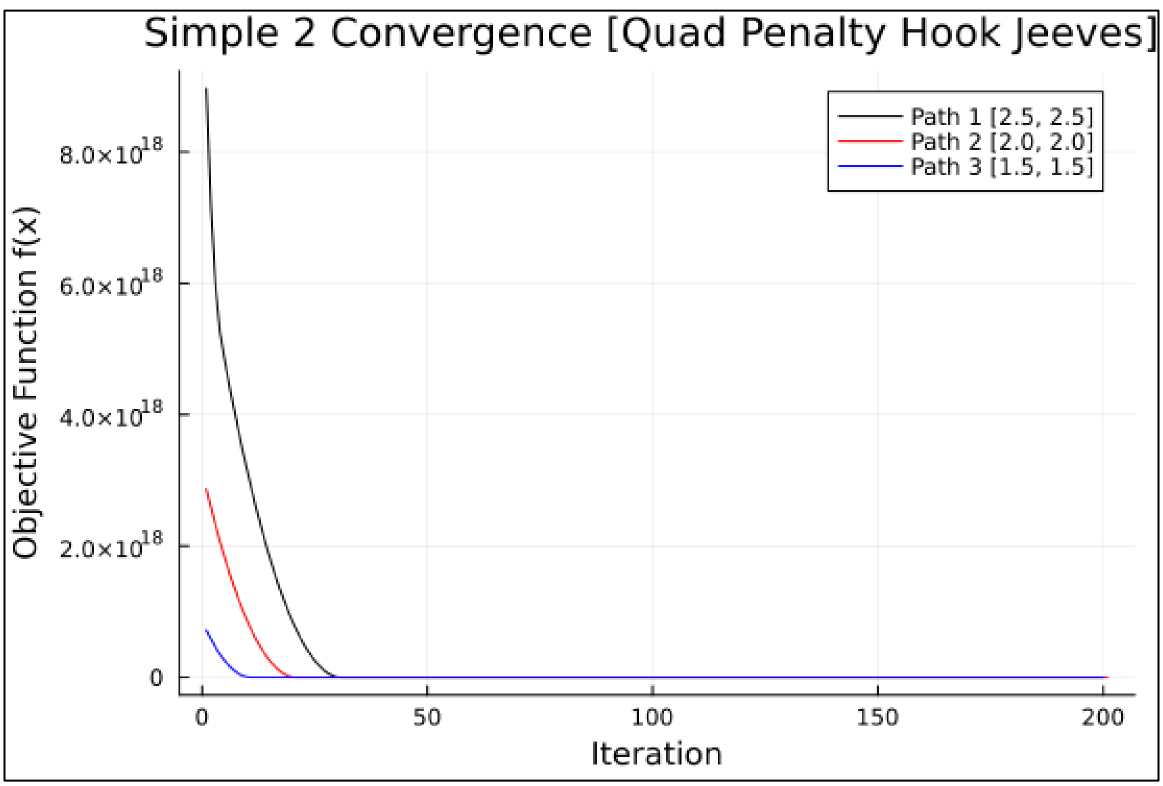

Figure 8: Simple 2 Convergence Plot using Algorithm 2

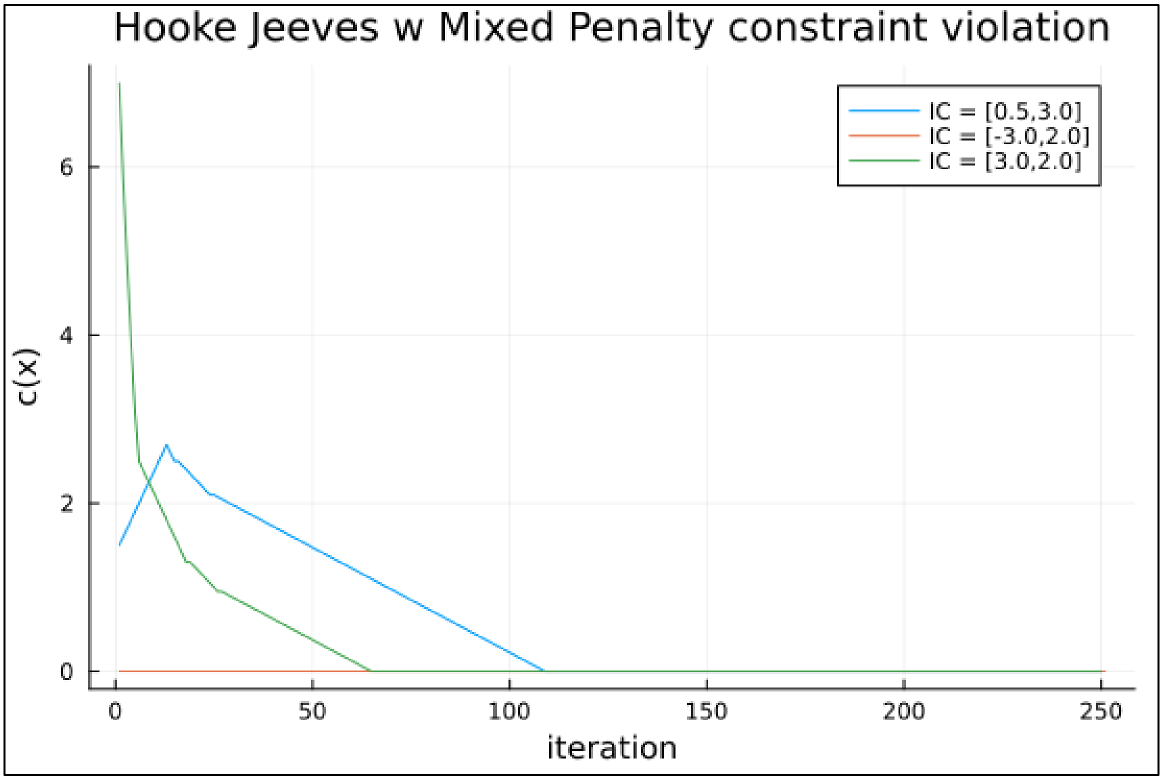

Figure 9: Constraint Violation for Algorithm 1

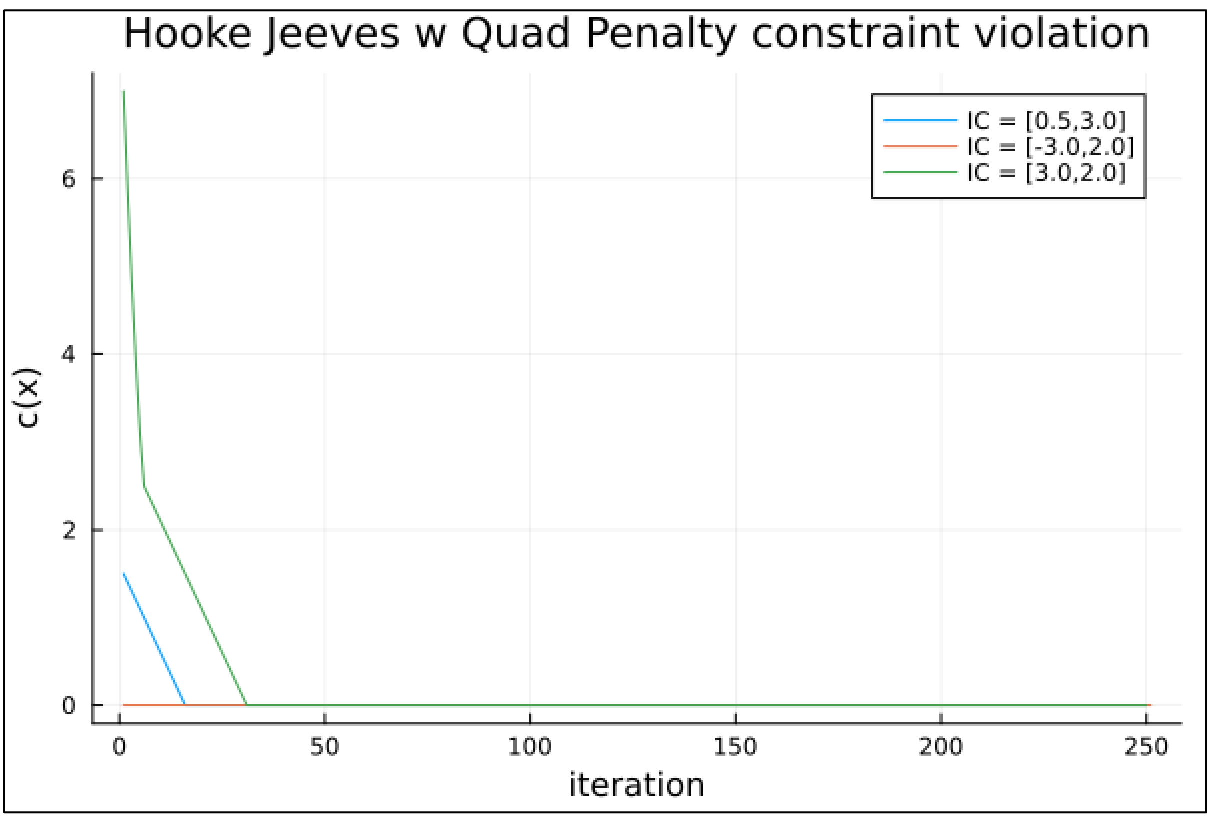

Figure 10: Constraint Violation for Algorithm 2