A Prototype for coupling DRAGON & DONJON to MORET5

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Introduction

Criticality Monte Carlo: Iterative Process
- Initial guess
- Convergence stage

Loosely coupled systems, high dominance ratio
- Difficulty in converging

Coupling Deterministic and Monte Carlo Methods
- Adjoint flux deterministic calculation
- Automated Initialization
- Modification of fission sites selection
- Splitting / Russian Roulette Strategies

Two tests cases
Test Cases

- **Case 1**: from NEA report

- **Case 2**

- **Sn calculation**

- **Diffusion calculation**
Automated Initialization

- According to the deterministic adjoint flux

\[ n_i = \frac{\int \int \phi^*_\text{det}(r,E)\chi(r,E)dEdr}{\int \int \phi^*_\text{det}(r,E)\chi(r,E)dEdr} \]

- Start on a density close to the fundamental mode
- Avoid inappropriate guess by the user
- Reduce the transient to few batches
Initialization : Firsts results

Case 1 : Asymmetric case
Initialization: first results

Case 2: Core

<table>
<thead>
<tr>
<th>Volume</th>
<th>Initial guess</th>
<th>Mean</th>
<th>Calculated σ</th>
<th>Real σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside the core</td>
<td>Uniform</td>
<td>1.11e-2</td>
<td>2.49e-4</td>
<td>1.73e-3</td>
</tr>
<tr>
<td></td>
<td>$\Phi^*\chi$</td>
<td>1.05e-2</td>
<td>2.26e-4</td>
<td>1.28e-3</td>
</tr>
<tr>
<td>Near the reflector</td>
<td>Uniform</td>
<td>1.9e-3</td>
<td>9.86e-5</td>
<td>6.84e-4</td>
</tr>
<tr>
<td></td>
<td>$\Phi^*\chi$</td>
<td>2.16e-3</td>
<td>1.02e-4</td>
<td>5.47e-4</td>
</tr>
</tbody>
</table>

- Important reduction of the transient
- Variance reduction due to considering only active batches
Selection of Fission Sites

**Analog density**

\[ f_n(i) = \frac{\sum_i V_i \int \nu \Sigma_f \phi_{mc}^{n-1}}{\sum_i \int \nu \Sigma_f \phi_{mc}^{n-1}} \]

**Modified density**

\[ f_n(i) = \frac{\phi_{det}^*(i) \int \nu \Sigma_f \phi_{mc}^{n-1}}{\sum_i \phi_{det}^*(i) \int \nu \Sigma_f \phi_{mc}^{n-1}} \]

**Analog weight**

\[ w_n(i) \]

**Modified weight**

\[ w_n^*(i) = w_n(i) \frac{\sum_i \phi_{det}^*(i) \int \nu \Sigma_f \phi_{mc}^{n-1}}{\phi_{det}^*(i) \int \nu \Sigma_f \phi_{mc}^{n-1}} \]

Reduce variability due to Monte Carlo Sampling
Selection of fission sites: first results

- **Case 1: symmetric case**
  - Real standard deviation reduced by 15% (production rate in one volume)
  - Figure of Merit could be improved with an optimization of the coupling
  - Deterministic mesh is different from MC volumes (more dense)

- **Case 1: asymmetric case**
  - No acceleration of fission source convergence observed

- **Case 2**
  - No reduction of standard deviation observed (production rate in 2 vol.)
  - Deterministic mesh is the same as MC volumes
  - Origin of non-reduction?
    - Diffusion instead of transport?
    - Same volumes for diffusion and MC calculations?
Modification of random walk

Splitting and Russian Roulette Strategies
- Based on an adjoint flux criteria
- Splitting when moving towards a more “important” region
- Roulette when moving towards a less “important” region

Case 1: symmetric case (DRAGON calculation)
- Increase of standard deviation for every quantity
- For one neutron - More roulette than splitting - increase variance
- Not a good criteria

Case 1: asymmetric case (DRAGON calculation)
- No acceleration observed for source convergence
 Modification of random walk

Case 2 : Core
- Real standard deviation reduced by 15%
- For one neutron - More splitting than roulette - decrease variance
- Origin of this decrease?
  - Mesh is wide in regard to mean free path?
- However strategy is time consuming
- Variance reduction does not compensate computation time

Look at a different criteria for splitting / Roulette
Conclusions

Initialization
- Reduce transient
- Automated the initial guess
- Reduce convergence constraint on deterministic calculation

Modification of fission sites selection
- Variance reduction for case 1
- Investigate non-reduction for case 2 (diffusion? Deterministic mesh?)
- Improve the coupling

Splitting & roulette strategies
- Try other criteria
  - Deterministic?
  - Complete Monte Carlo?