AVATAR - Automatic Variance and Time of Analysis Reduction

Abstract

- Avatar ¿ accessed through Justine¿ invokes THREEDANT
- Performs 3-dimensional deterministic adjoint calculation
- Mesh independent of MC geometry
- calculates weight windows
- Can be done without user manipulation of data

Introduction

- For problems with complex geometries and with a large problem area, Monte Carlo can be an issue. The desired quantity is OOM smaller than the source. Tally of particles contributing to return signal is small, and unreliable.
- Variance Reduction Techniques
  - Weight windows
    - depend on importance functions.
    - bias the particles towards locations that contribute to the tally.
    - Requires time, experience, and intuition.
  - Solution of Adjoint
    - is recognized as an importance function for the regular forward calculation of NTE.
      - Is computationally expensive to calculate exactly.
    - Less precise calculation provides importance function that can be used to accelerate MC calculation.
      - do this with few energy groups and low angular resolutionn
- AVATAR
  - automatically accelerates MC calculations based on space, energy and angle.
  - User sets up problem using Justine (the GUI)
  - Justine runs Avatar,
    - superimposes a weight window mesh
    - runs THREEDANT in adjoint mode
    - constructs weight windows from adjoint solution
    - runs MCNP
  - User has option to intervene

The Adjoint Flux

- In adjoint calculation, particles emanate from forward detectorsand transport backwards.
- Can be calculated two ways
  - Stochastically with MC
    - provides too much detail and costs just as much as a forward calculation.
  - Determinstically with discrete ordinates transport or diffusion
    - with low resolution gives importances sufficient to speed up calculation.

AVATAR

- Mesh Description
  - Can be in rectangular or cylindrical coordinate system
  - Coarse mesh with fine mesh intervals.
    - Material of each mesh element is material at center of mesh element.
- Automatic Mesh Generation
  - Bounding box in each direction divided into coarse elements.
    - Uniform mesh = dividing boundary box uniformly in each direction
    - Smart mesh = subdividing boundary box into smaller boundary boxes that bound each MCNP cell
      - Justine defaults to smart mesh.
  - Coarse mesh may be subdivided uniformly or logarithmically into fine meshes
    - defuaults to uniform, which is also slightly faster.
  - User can intervene and add or delete mesh lines.
- Determinstic Adjoint Calculation
  - Executed with THREEDANTperforms deterministic discrete-ordinates transport calculation
    - AVATAR executes a lower resolution calculation with threedant.
      - quadrature of S4
      - P2 legendre scattering moment expansion
      - three energy groups
  - Produces a scalar adjoint flux and average current for
    - each mesh element
    - each energy group.
- Weight Windows
  - In each mesh element and each group, the scalar adjoint fluxes are inverted to get lower WW boundary.
    - WW is normalized
    - Regions with high flux = high importance = low weight.

- Angle-Dependent Weight Windows
- Mean Free Path Sampling
  - Particles may arrive in a location where their weights are significantly outside of the local weight window, which increases the variance in particle weights, which increases the tally variance.
  - Avatar protects against this by applying weight windows at least every mean free path that the particles travel.