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Composite Layer Technique for use in a Eulerian Shock Physics Code

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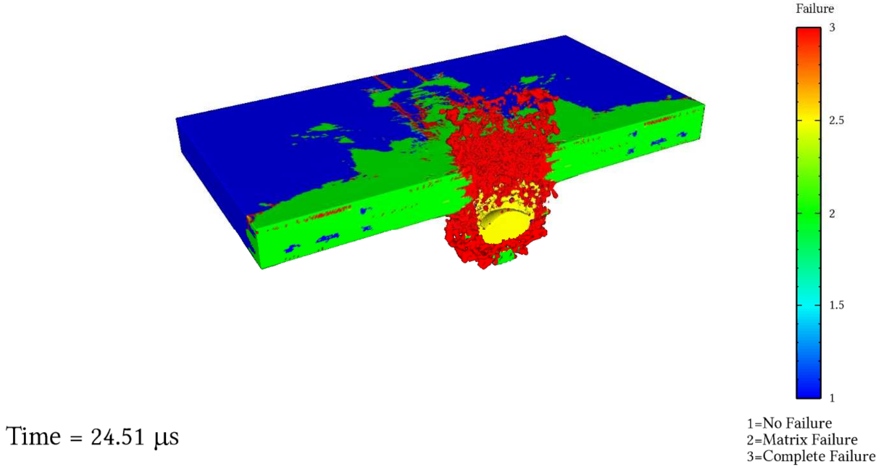
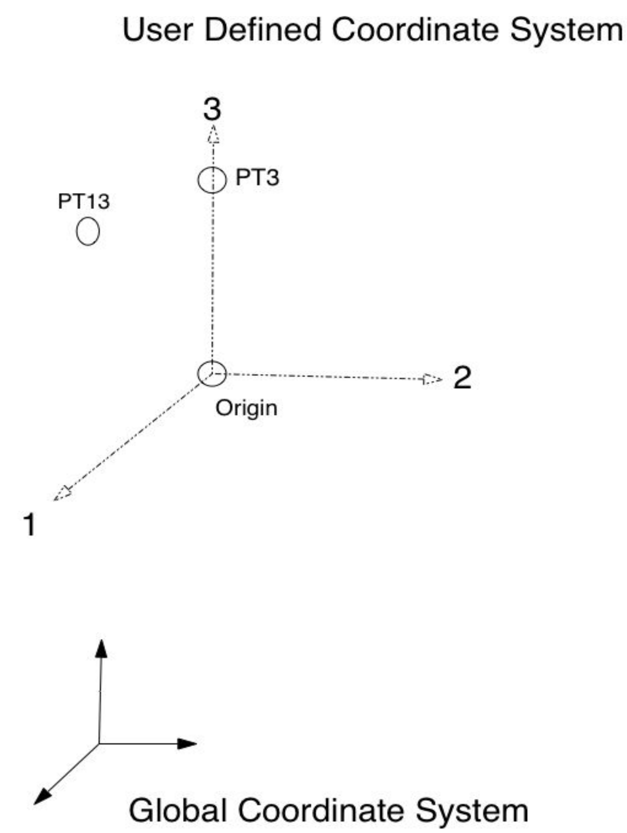
Capability

- Need technique for tracking material orientation in a Eulerian grid
- Large deformation structural mechanics
  - Ballistics
  - Blast on target
  - Penetrators
- Technique must track material orientation as object travels across Eulerian grid
- Developed sub-grid technique to prevent:
  - Smearing of composite layers (lamina) into one large laminate response
  - High grid resolution to capture individual layer response



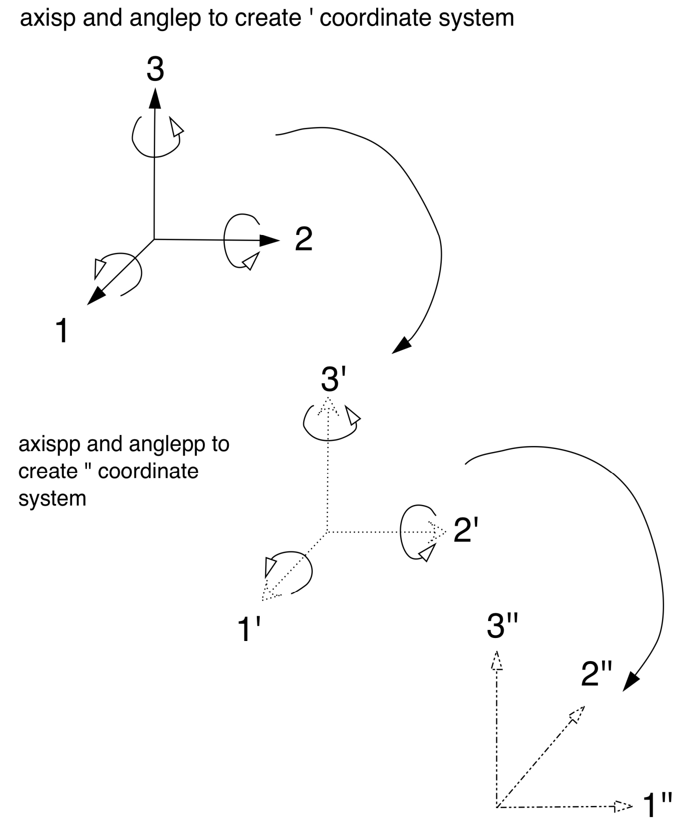
User Defined Coordinate System

- Set user-defined coordinate system in global coordinate system
- Set three points
  - Origin
  - Point locating 3 axis
  - Point locating 1-3 plane
- Using three points construct three unit vectors describing coordinate system



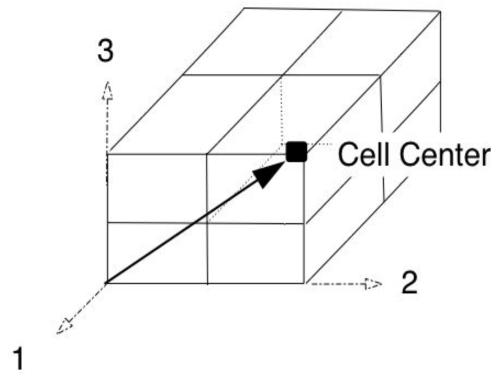
Define Material Orientation

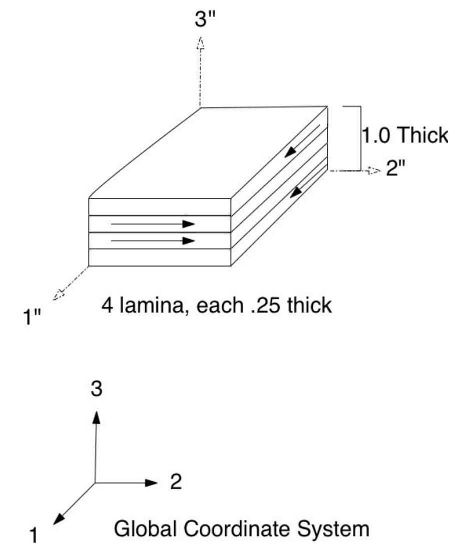
- Allow the user to provide material rotations based on user-defined coordinate system
- The material vector described the local coordinate or material coordinate system the constitutive model will use
- Typically the user defined coordinate system and two rotations will describe any object



Tracking Composite Layers

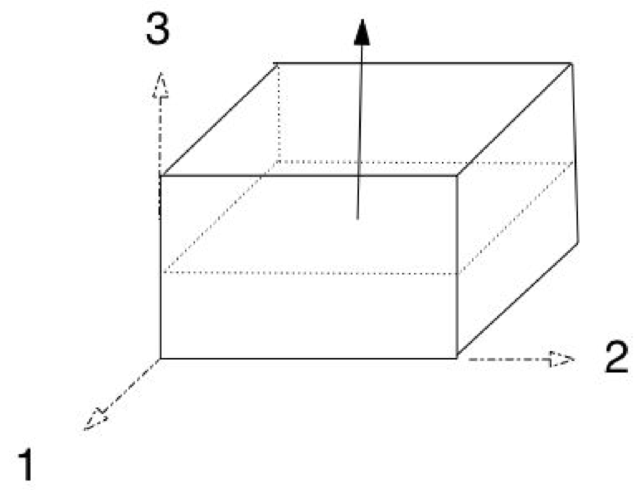
- On initialization save or store the cell center, global position, that a composite object occupies
- Use stored cell center, user defined coordinate system and layer thickness to determine the layer or layers in cell
  - Currently assume constant layer thickness throughout simulation
- Search routine in cell that works through position and layer thickness





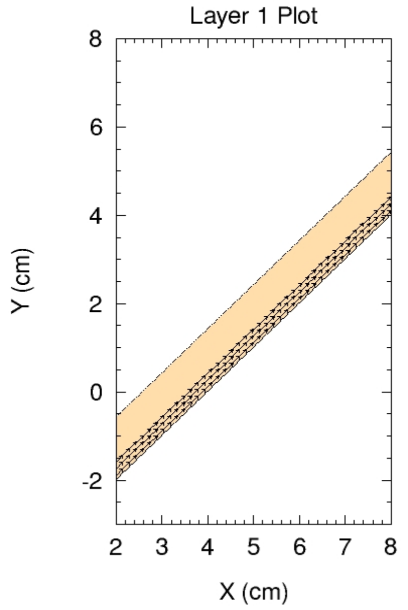
Volume Fractions

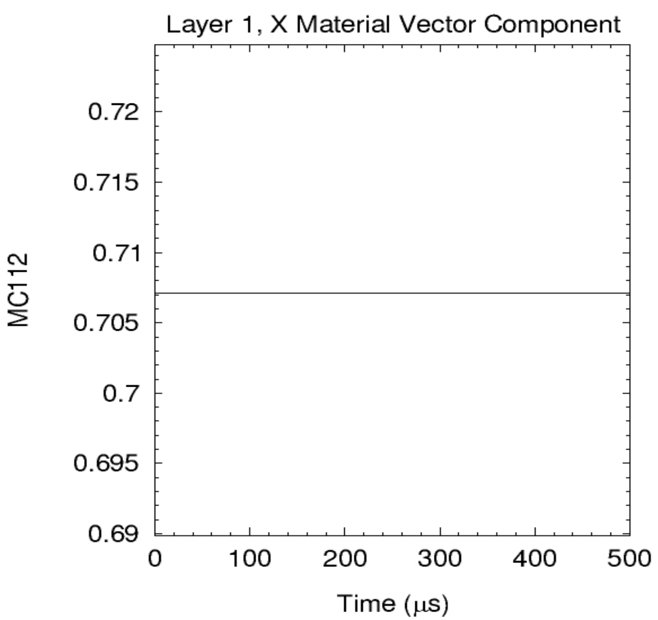
- Compute normal (through thickness) vector based on material motion and orientation
- Use thickness and layer count to cut up cell and determine the volume a layer occupies
- Volume fraction weight layer material state variables
  - Store the material layer state variables
  - Compute the overall cell response

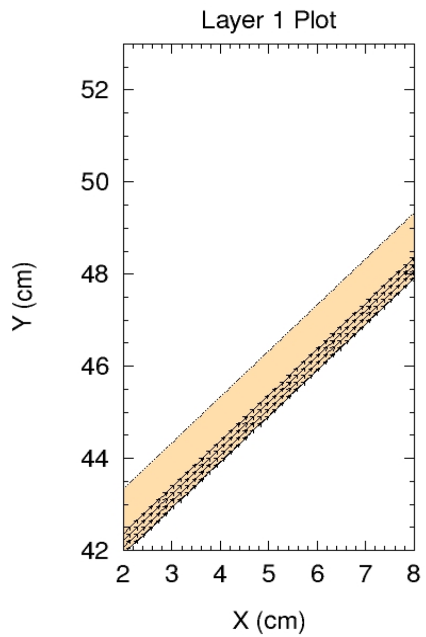


Example 1

- Advection test of material vectors
- Oblique plate orientated at 45°
  - Layup of $[0,90]_s$
  - 1 cm thick, each layer 0.25 cm
- Plate traveling at 1 km/s
- Results after traveling 0.5 m
- Grid cells 0.05 cm







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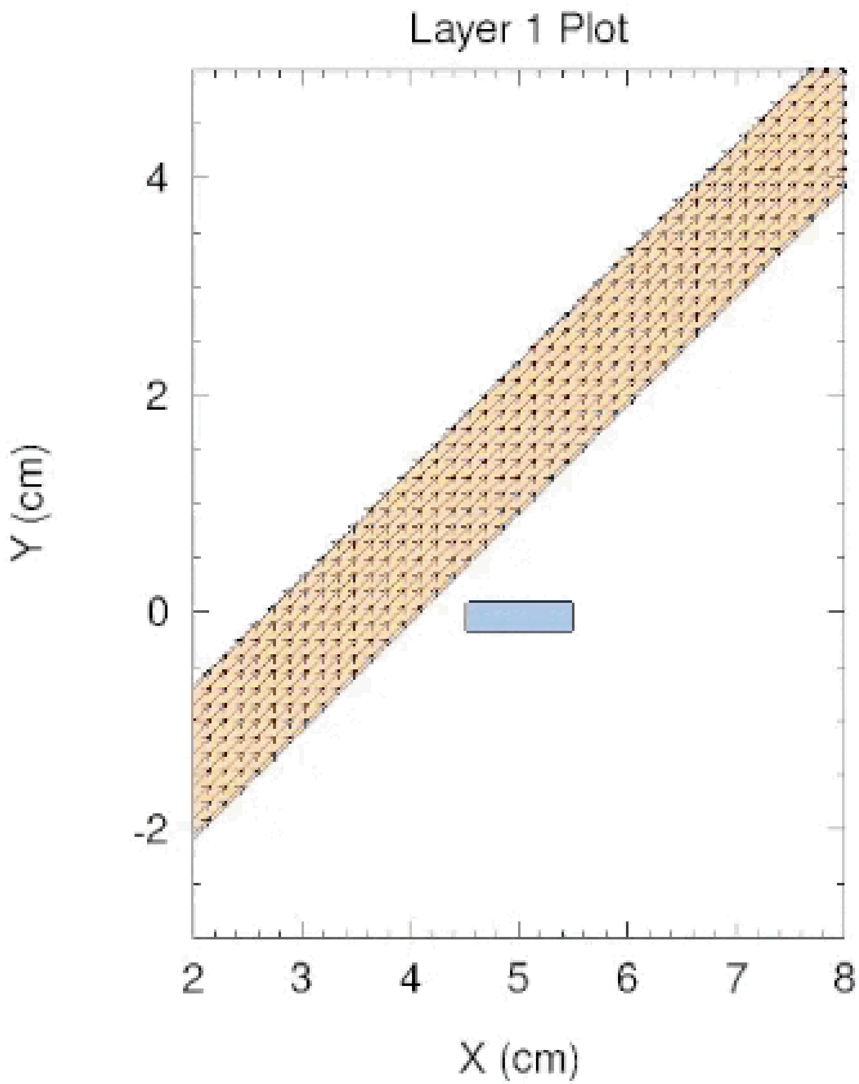
Example 2

- Application test for material vectors
- Oblique plate orientated at 45°
  - Layup of $[0,90]_s$
  - 1 cm thick, each layer 0.25 cm
- Impactor traveling at 1 km/s
  - Steel disk
- Grid cells 0.05 cm



Conclusion and Future Work

- Technique developed for tracking direction composite materials in a Eulerian grid
- Robust technique for solving directional composite material
  - Technique tested on 1000's of processors
  - No issues in parallel processor scaling
- May be used with continuous or separate layer strain fields
- Current assumptions
  - Constant through thickness dimension
  - Continuous strain field in each layer
- Future work
  - Adapt composite methods to the Material Point Method (MPM)
  - Separate velocity fields in each layer