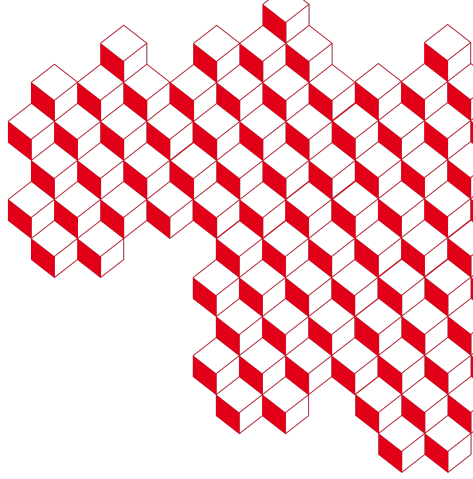

MEDCOUPLING Projection methods

08-03-2024

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Outline

Agenda

Interpolation, extrapolation or projection?

Spatial Discretization & Nature Of A Field

Functionalities

Agenda

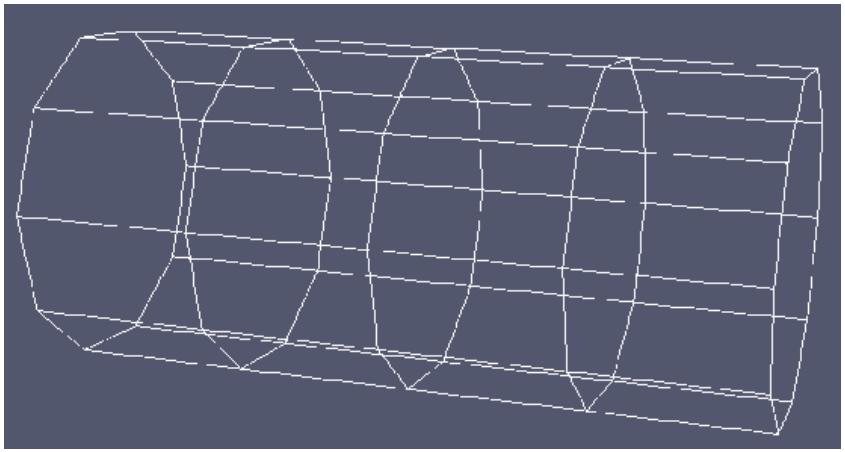
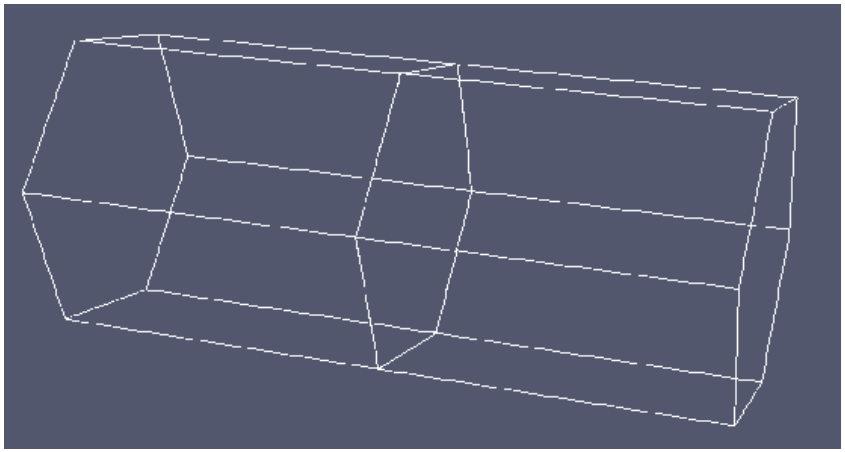
Interpolation, extrapolation or projection?

Spatial discretization and nature of a field

What MEDCoupling can do for you

Outline

Illustration

Code A	Code B
	

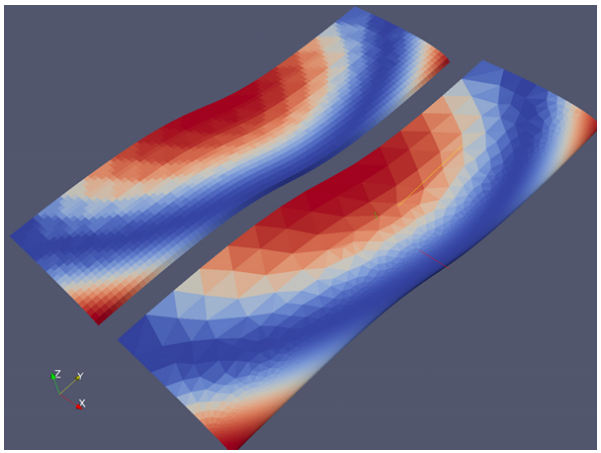


Figure 1: Interpolation

Introduction: A typical use case: code coupling

Different numerical codes might use

- Different numerical schemes
  - E.g. temperature on nodes in code A and on elements in code B
- Different spatial discretization
  - Meshed with hexahedrons in code A, and with tetrahedrons in code B
- Different dimensions
  - A heat flux on a 2D surface for code A and a 3D source term for code B

How do you “transfer” information from one to the other?

- I need to provide code B with the temperature computed by code A
- Solution A: ad-hoc solution. For each pair (code A, code B), write a mapper
- Solution B: use generic projection methods thanks to MEDCoupling

Projection, Interpolation?

Normally

- *Interpolation*: computing a function's value at a given point inside a domain where the function's values are known at discrete points
- *Extrapolation*: computing a function's value outside a domain, but in relationship with points where the function's values are known: hazardous!
- *Projection*: from linear algebra, expression of a function (a vector) into a new basis of a (another) vector space (often with a smaller dimension)

In MEDCoupling, we do not take sides

- *Prepare* the operation (given the two meshes)
- *Transfer* one or several fields

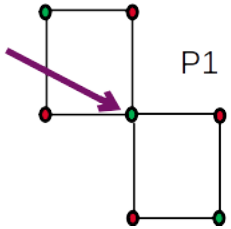
Notes

- Two meshes are overlapping if they cover the same spatial domain
- Temporal interpolation is not covered!

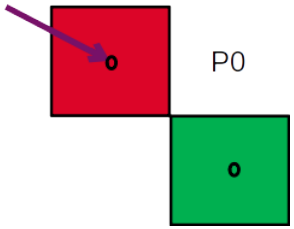
Outline

Spatial discretization of a Field

- A field can be supported by:
  - The nodes (or vertices) of the mesh: ON_NODES also called P1



  - The cells (or elements) of the mesh: ON_CELLS also called P0



  - By more complex reference locations:
    - Gauss Points (ON_GAUSS_PT, ON_GAUSS_NE),
    - Kriging points (ON_NODES_KR)
- Obviously the projection methods will differ according to the localization
- Generally P0-P0 projection is the best supported option
- Not all combinations are possible

Supported configurations

- Mesh combination (U: unstructured, C: cartesian, E: extruded)
  - U - U
  - U - C
  - C - U
  - C - C
  - E - E
- Dimensions
  - 1D
  - 2D curve, full 2D
  - 3D surface, full 3D
- Spatial discretization
  - P0 - P0
  - P1 - P0
  - P0 - P1
  - P1 - P1
  - P1 - P0Bary
  - PG - PG

Field Nature (1/2)

Physical quantities can be

- Extensive: mass, power . . . quantity that scales with the volume of a cell
- Intensive: density, temperature . . . quantity that do not scale with the volume

Two methods available

- Governing the behavior in case of non-overlapping meshes
- “Maximum” value preserved in the result
- “Integral” value preserved in the result

Summary

- See detailed formula in the documentation

/	Intensive	Extensive
Conservation	`IntensiveConservation`	`ExtensiveConservation`
Maximum	`IntensiveMaximum`	`ExtensiveMaximum`

Field Nature (2/2)

Non-overlapping meshes

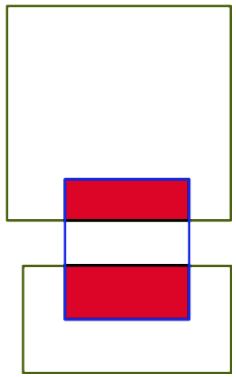


Figure 2: Blue mesh A and green mesh B

For a projection from B to A

- Should the full volume (here surface) of the cell from mesh A be taken into account?
- Or only the volume covering both mesh A and mesh B?
- Depends on the nature of the physical quantity you're handling

Outline

Projection Methods (1/2)

To project one field onto a new target mesh

1. Prepare (required only once, the weight matrix is internally computed):
   - From the source mesh and the target mesh only
   - Ratios of the volumes between source cells and target cells
   - `Wij`: how much from source cell (i) will contribute to target cell (j)
   - API: `prepare(source, target, method)`
2. The source field must have a valid nature set!
   - API: `setNature()` on the field
3. Transfer (can be done several times):
   - A field on the source mesh can be transferred to the target mesh
   - API: `transfer(srcField, tgtField, defaultValue)`
   - Default value covers non-overlapping cases

A Trivial python example

- Transfer a field on cells onto a new field on cells

```
import medcoupling as mc
remap = mc.MEDCouplingRemapper()
remap.setPrecision(1.e-12)
remap.prepare(srcMesh,trgMesh,"P0P0")  # cells to cells
srcField.setNature(mc.IntensiveConservation)  # field nature
trgField = remap.transferField(srcField,1e+300)
```

- `srcField` is a `MEDCouplingFieldDouble`
- `srcMesh` and `trgMesh` are `MEDCouplingMesh`-s