Overview of tools for meshing defects

code_aster, salome_meca course material
GNU FDL license (http://www.gnu.org/copyleft/fdl.html)
Outline

1. Introduction
2. The tools for meshing defects
3. Advice
Outline

1. Introduction
2. The tools for meshing defects
3. Advice
Different types of defects

- **Surface Defect**
  - Cracks

- **Volume Defect**
  - Interfaces: inclusion, bi-material interface, etc.
  - Voids: Thickness reduction, porosity, hole, scratch, etc.

**Objective:** Model a defect in a FEM structure to evaluate its harmfulness
Outline

1. Introduction
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3. Advice
Plugin for CT specimens

- **To launch it**
  - `salome_meca` / Tools / Plugins / salome_meca / Eprouvette CT

- **Functionalities**
  - Produces a mesh of a 2D/3D Compact Tension (CT) specimen
  - Different types of crack (sharp crack, U-notch, CZM…)
  - Different types of mesh (free, regular, radial…)

- **Training**
  - On demand

- **Support**
  - Robin Degeilh (R&D/ERMES)

- **Documentation**
  - Help button of the GUI
MORSE (ex-OMA): thickness reduction in pipes & elbows

To launch it
- `salome_meca / OMA (Module)`

Functionalities
- Produces a mesh with thickness reduction
- Scope: straight pipe, elbow
- From a formatted list of thicknesses at given points
- Typical use of the mesh: limit load analysis (with code_aster)

Training
- On demand

Support
- David Haboussa (R&D/ERMES)

Documentation
- [SU1.03.01] Notice d'utilisation de l'outil-métier tube et coude avec sous-épaisseur

For 2020
Bloc Fissure: Generic crack

**To launch it**
- salome_meca / Mesh (Module) / Mesh / SMESH plugins /
  - Add a crack in a mesh (blocFissure plugin) → for any type of structure

**Functionalities**
- Need a ruled sane mesh with only hexahedrons
- Produces a mesh of a structure with a crack
- Radial mesh around the crack tip / front (torus)

**Training**
- On demand

**Support**
- Robin Degeilh (R&D/ERMES)

**Documentation**
- Note EDF R&D 6125-1716-2016-01295-FR, Définition du périmètre d'utilisation de l’outil métier d’insertion de fissure « blocFissure » dans Salome

Also for any type of crack
Bloc Fissure: Cracked elbows generator

To launch it
- **salome_meca** / Mesh (Module) / Mesh / SMESH plugins /
  - Meshed Pipe with a crack (blocFissure plugin) → only for elbows

Functionalities
- Produces a mesh of a structure with a crack
- Radial mesh around the crack tip / front (torus)

Training
- On demand

Support
- Robin Degeilh (R&D/ERMES)

Documentation
- Note EDF R&D 6125-1716-2016-01295-FR, Définition du périmètre d'utilisation de l'outil métier d'insertion de fissure « blocFissure » dans Salome
Zcracks

- To launch it
  - `salome_meca` or `Salome / Mesh (Module) / Mesh / SMESH plugins / Run Zcracks`

- Functionalities
  - Produces a mesh of a structure with a defect (sane mesh needed)
  - Free mesh around the defect

- Training
  - Itech: `code_aster / Salome_meca - Module 2: Advanced training`

- Support
  - Samuel Geniaut (R&D ERMES)

- Documentation
  - `Code-aster.org / formation / Code_aster salome_meca - Module 2: Advanced training: Tool for crack and defect insertion in a mesh - Zcracks -`
X-FEM

To launch it
- Specific operators in `code_aster`
  - `DEFI_FISS_XFEM`, `MODI.MODELE_XFEM`,
  - `RAFF_XFEM`,
  - `POST_MAIL_XFEM`, `POST_CHAM_XFEM`...

Functionalities
- Cracks, interface between materials, voids...
- Propagation of cracks
- But: Limited scope of compatibility with `code_aster` functionalities

Training
- On demand

Support
- Samuel Geniaut (R&D ERMES)

Not a software
- Allow computations only on a sound mesh
- No explicit representation of cracks
- Enrichment of Finite Elements for discontinuous fields

Documentation
- [U2.05.02] Operating Instructions for the X-FEM mode
To launch it
- In salome_meca or Salome
- Create sane geometry with partition to describe defect in GEOM or Shaper
- Mesh geometry with fine mesh around crack front or zone of interest in SMESH
- Create physical discontinuity in SMESH Modification / Transformation / Duplicate Nodes or/and Elements

Functionalities
- Can model anything but need to create the CAD from scratch
- Graphical mode and script mode

Training
- Itech: Salome module 2 (GEOM+SMESH) and module 7 (SHAPER)

Support
- TMA Salome: 01 78 19 32 97 - tma.edf@opencascade.com

Documentation
- Salome documentation: https://salome.der.edf.fr/documentation
Outline

1. Introduction
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## Generic tools for cracks (sane mesh available)

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<th>Bloc Fissure</th>
<th>Zcracks</th>
<th>X-FEM</th>
<th>CAD + Mesh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Free mesh</td>
</tr>
<tr>
<td>Robustness of tool</td>
<td>O</td>
<td>O → ●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Ease of use (Ergonomics)</td>
<td>O</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Speed of use</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>O</td>
</tr>
<tr>
<td>Quality of results</td>
<td>●</td>
<td>O → ● ?</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Genericity (functional scope)</td>
<td>O</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Performance of computations</td>
<td>●</td>
<td>O → ● ?</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Under Quality insurance</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Is LGPL (license free)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- **O**: High
- **●**: Moderate
- **O**: Low
- →: planned future evolutions
- → ?: potential future evolutions
End of presentation

Is something missing or unclear in this document? Or feeling happy to have read such a clear tutorial?

Please, we welcome any feedbacks about code_aster training materials. Do not hesitate to share with us your comments on the code_aster forum dedicated thread.
Appendix
Different ways for modeling a crack

<table>
<thead>
<tr>
<th>Approach / method</th>
<th>Crack modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard approach (G, K)</td>
<td>“standard” crack</td>
</tr>
<tr>
<td>Energetic approach (Gp)</td>
<td>U-notch</td>
</tr>
<tr>
<td>Cohesive Zones (CZM)</td>
<td>Specific elements</td>
</tr>
<tr>
<td>Local approaches (Beremin, Bordet)</td>
<td>Crack or U-notch</td>
</tr>
<tr>
<td>Damage models (Rousselier, GTN)</td>
<td>No explicit crack</td>
</tr>
</tbody>
</table>

$\delta$ Small or null

« standard » crack

U-notch
Overview of the tools

**salome_meca: a toolbox**
- Plugin for CT specimens
- MORSE: thickness reduction in pipes
- Bloc Fissure
- Zcracks
- X-FEM
- Shaper (CAD) + Smesh (mesh)

**Different categorizations**
- Types of defects: surface / volume defect
- Explicit / implicit representation of the defect
- General tool / skill module

**And several others**
- Compatibility with code_aster operators
- Functional scope (structure + defect)
- Quality of results
- Robustness
- Performances of computation
- Ergonomics
- License
- …
J'enlèverais cette slide

DEGEILH Robin; 30/07/2019
Explicit vs. Implicit representation

(From an intrinsic point of view, not linked to a development level)

Explicit crack representation (FEM)
- Pros: all functionalities available
- Limit: a fine discretization around the crack front is required, which can be very costly for free meshes

Implicit crack representation / Space-discretization enrichment
- Limit: the functionalities of standard Finite elements are not automatic
- Pros: optimal convergence of finite elements
- Limit: question on the compatibility with the massively
- Pros: mutualization with the management of bi-materials, voids…
**Documentation**

- **Plugin for CT specimens**
  - Help button of the GUI

- **MORSE**
  - [SU1.03.01] Notice d'utilisation de l'outil-métier tube et coude avec sous-épaisseur

- **Bloc Fissure**
  - Note EDF R&D 6125-1716-2016-01295-FR, Définition du périmètre d'utilisation de l'outil métier d'insertion de fissure « blocFissure » dans Salome

- **Zcracks**
  - code_aster / Salome_meca - Module 2: Advanced training: [20-Tool for crack and defect insertion in a mesh - Zcracks -](#)

- **X-FEM**
  - [U2.05.02] Operating Instructions for the X-FEM model