



VIRTUAL VEHICLE DIGITAL MOBILITY

A nonlocal approach for modeling the crack initiation in the vicinity of punctual connections

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- Crack initiation - WHY?
- Crack initiation - HOW?
- Implementation in LS-Dyna / Conclusion

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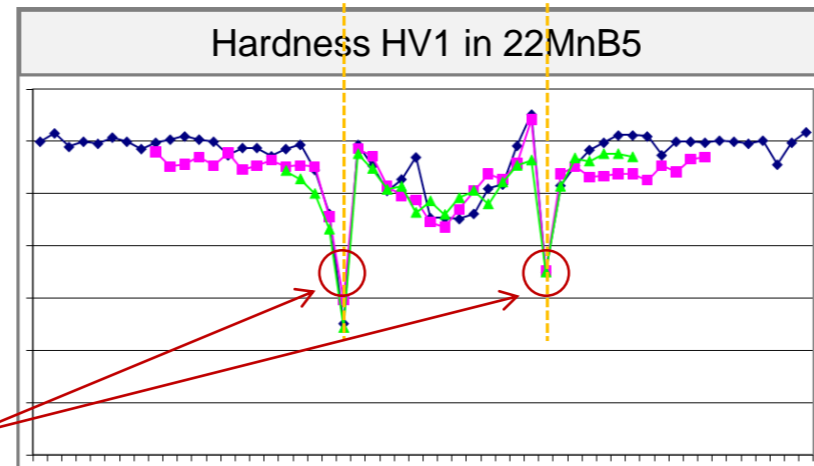
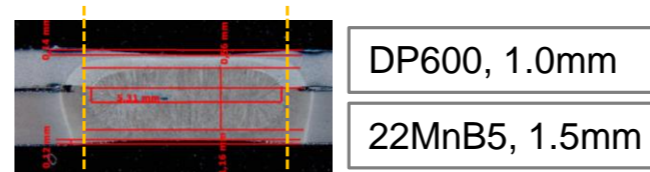
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Problem:

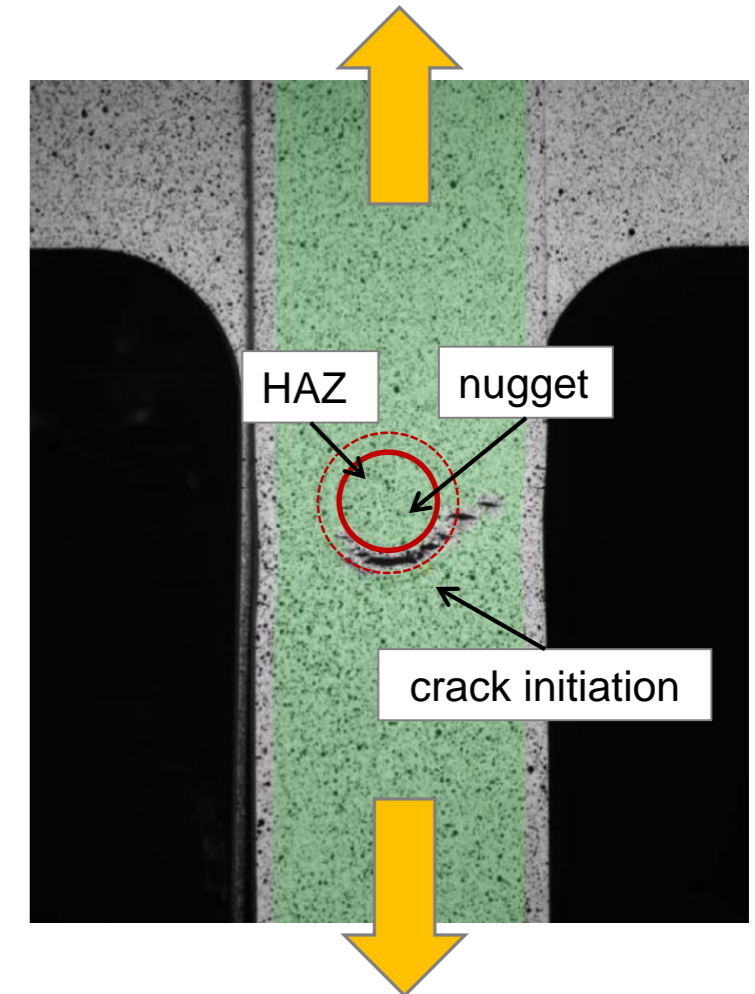
The starting points of cracks are often joints at which stress concentrations occur.

The **Finite Element mesh** in crash simulation is **too coarse** to represent sufficiently the gradient of local stress field in the vicinity of the joints.

- Use of conventional local **failure criteria on element-level** is highly **mesh dependent**, and ...
- ... locally **detailed remeshing** of the joint geometry is **expensive**.

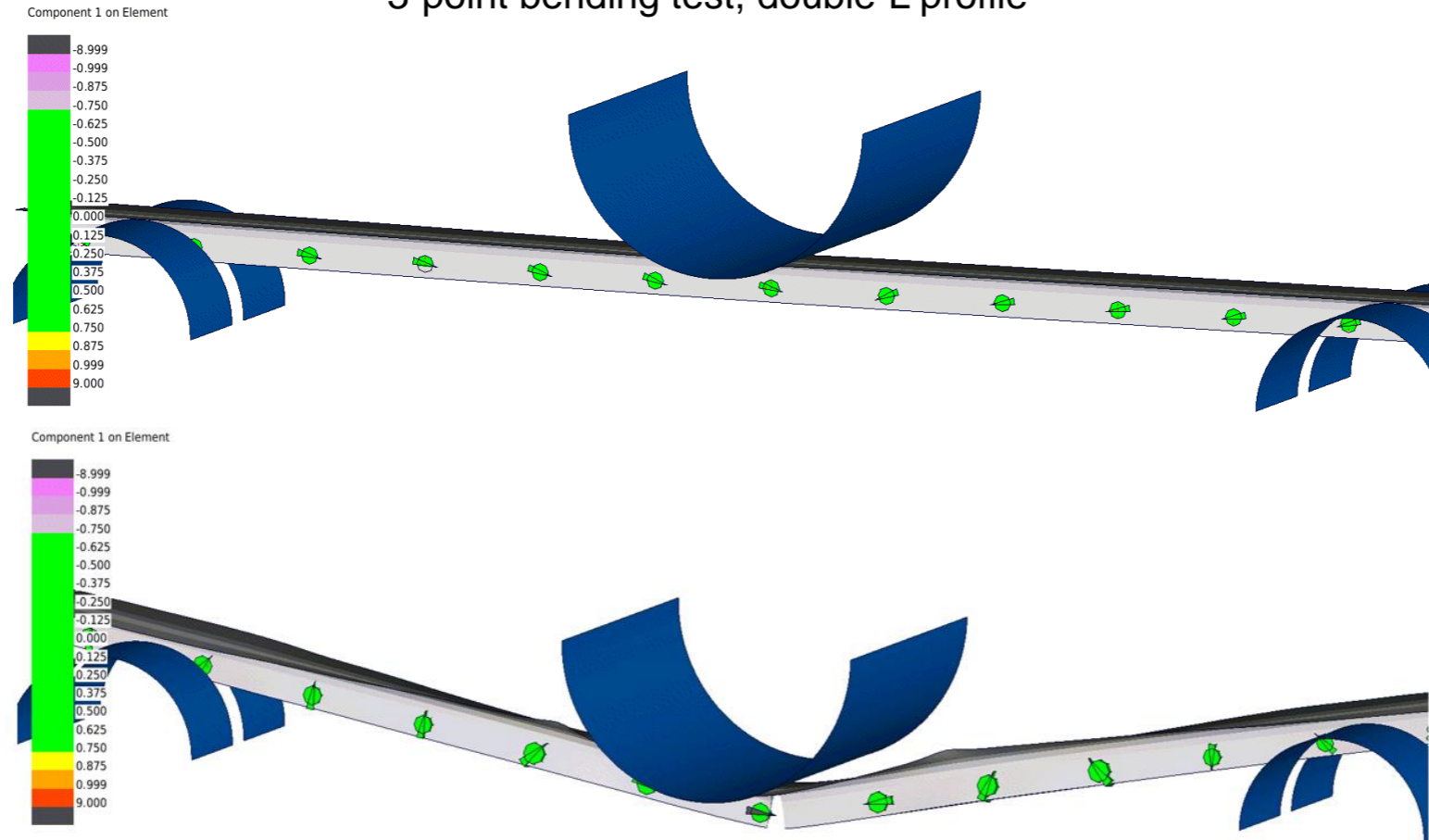


Crack initiation in the softened Heat Affected Zone (HAZ) of a spotweld



Example: Crack initiation in the softened Heat Affected Zone (HAZ) of a spotweld

3-point bending test, double-L profile



Goal: Development of a surrogate model for the effect of zone failure at joints without local re-meshing

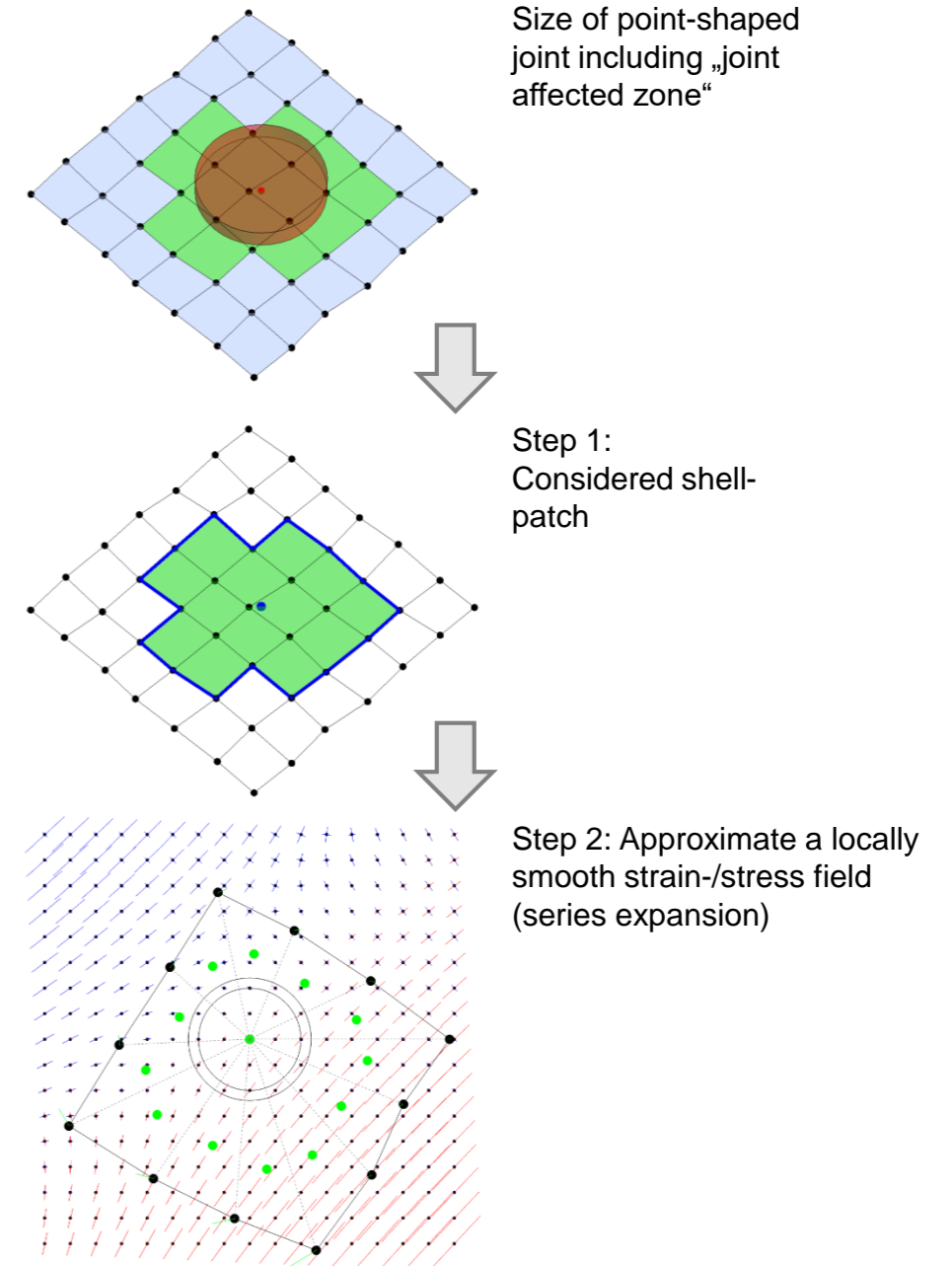
“Non-Local Approach”:

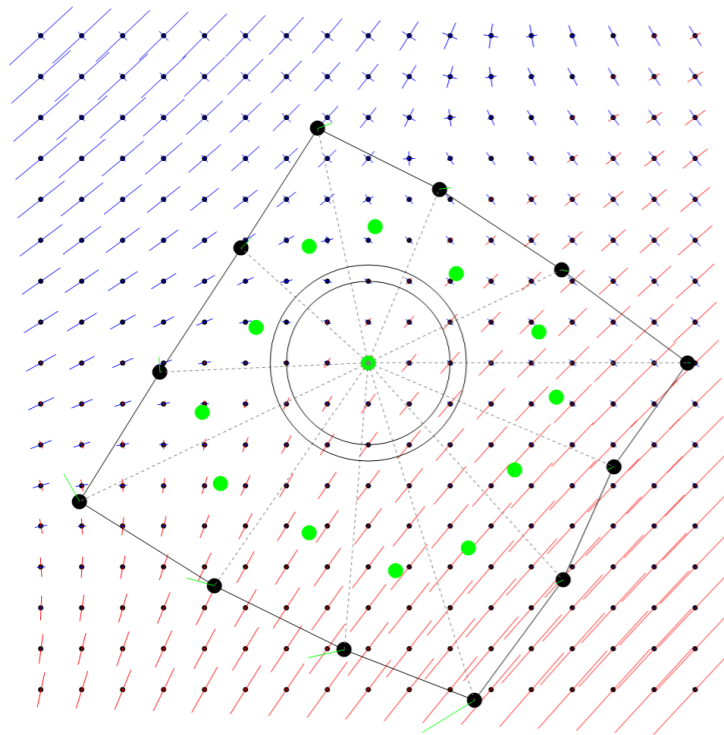
Surrogate model for crack initiation at joints:

- Considers not only the “isolated” stress states in single shell elements ...
- ... but the “collective” stress within a suitable shell-patch around the joint

Goal:

- Get access to the relevant data of the local deformation state
- Reduce significantly mesh dependency ...
- ... without the need of local remeshing





Locally smooth strain field

Step 2: Taylor series expansion of the local 2d strain field around the link center (origin) up to first order term

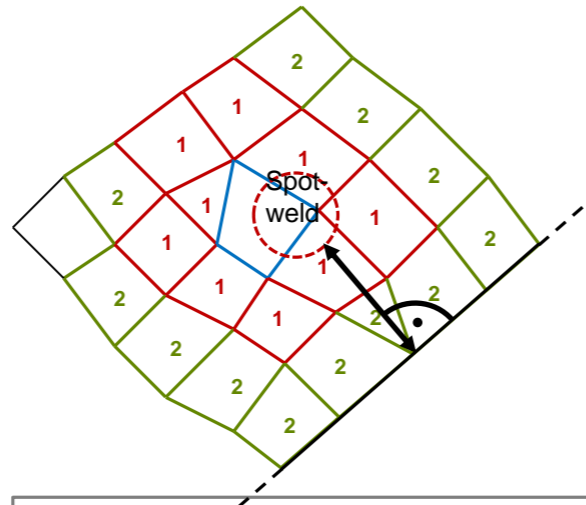
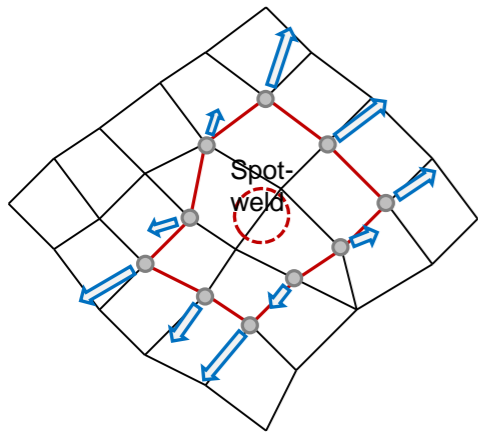
- Based on a best fit with respect to the polygon nodes displacements
- Considers the locally dominant circular symmetry
- Smooths the local strain information of the considered shell patch
- Considers only the relevant orders of field expansion (0th and 1st order)



Solving a 12-dimensional linear equation system

Model Parameters

- Used parameters for the surrogate model**
- Spotweld nugget diameter
 - (Appropriately deduced) local in-plane strain field around the joint (series expansion up to 1st order)
 - Distance from the spotweld to the flange edge
 - Sheet thickness, sheet material properties: hardening curve (power law param.)

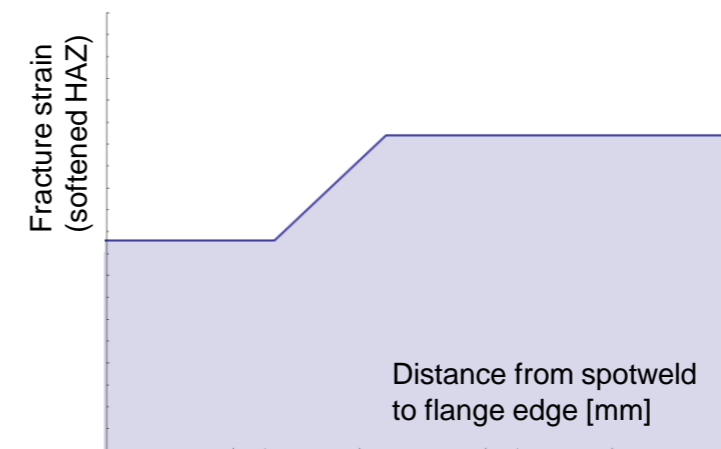
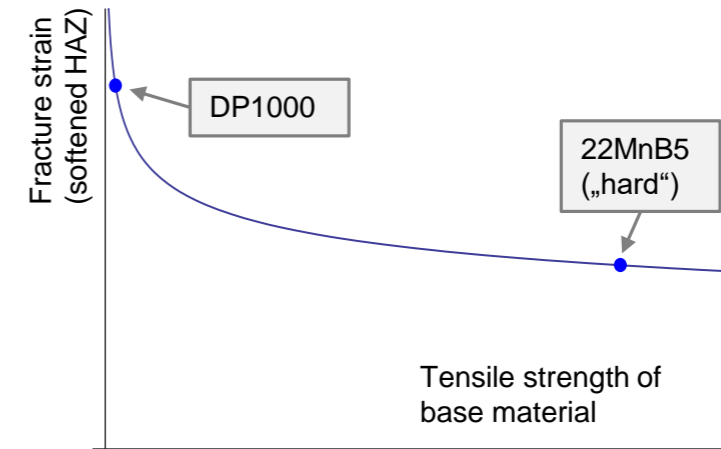


The **in-plane strain information** are suitable deduced from the nodal displacements (⇨) of a closed polygon loop.

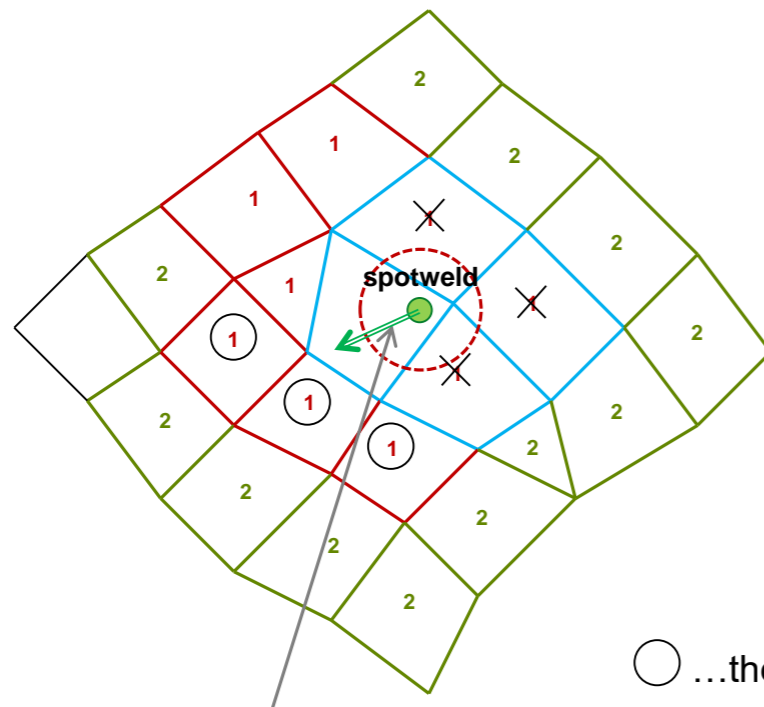
Distance from the spotweld joint to the flange edge

Model Approach

- Local **“Fracture Strain”** in dependence of
- Material strength of the base material
 - Distance from spotweld to flange edge



Shell elimination in case of crack initiation



Direction/Position of highest loading in the HAZ

- Criterion for shell selection:**
- The shells are as close to the joint as possible,
 - but they are not ,linked' with the area of the 'Joint Element'
 - so that 'Joint Element' is *not* automatically eliminated
 - The direction of the 'initial crack' is normal to the direction of highest loading

○ ...these shells are selected for elimination (under the directive of a given ,initial crack length' (user-parameter))

- Development of a (*mesh-independent*) surrogate model for the effect of zone failure at joints without local remeshing
- Implementation in LS-Dyna:
 - The automatic determination of the shell-patches (MPP-capable),
 - the analysis of current loading states,
 - the evaluation of surrogate model for crack initiation,
 - and occasionally the elimination of suitable shell elementsare accomplished via the User-Routines **uctrl1**, **uweldfail** und **loadud**.

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