# From images or voxels to FEM models. Application to the meshing of 3D interlock composite structures

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## ABSTRACT

3D interlock composites are complex structures composed of thousands of fibers impregnated with resin. The difficulties of creating a mesh of these weaves are known: multiple yarn contacts, interpenetration, no spurious space should be added at the interface, variation of cross-section. A number of approaches proposes to create an idealized geometry as realistic as possible which does not necessarily enable mesh generation. The main difficulty is to transform interpenetrations into conforming contact zones and allow an unstructured tetrahedron mesh generation of the extremely complex shape of the resin. 3D images such as tomography shows this complex arrangements. A 3D model can be easily converted into a voxel representation which is already a FE-model with conforming meshes at the interface between yarns. The number of voxels can be adjusted to the desired accuracy. One of the main shortcoming of this representation is indeed the jagged effect of the surface model which can seriously alter the accuracy of the finite element analysis especially overestimated stresses due to the singularities at sharp edges and corners. We propose here an iterative surface smoothing technique inspired from subdivision surface modelling. Non-connex volumes are identified and the process is applied on each component while maintaining the interface. A line smoothing technique derived from the surface smoothing is applied at the interface between two yarns and resin. The smoothing technique can be constrained in order to keep some features such as planar faces or imposed points. Sharp edges and edges are removed altogether with an undesired terrace-like effect of the voxel model. Nodes are relocated at the end of the process in order to compensate the shrinking of the volume. The surface of deformed voxels is thereafter split into triangles. Hexahedra (voxels) are quite deformed during the process and the splitting must be optimized in order to allow a tetrahedron remeshing. A typology of the deformed voxels associated with remeshing configurations into tetrahedra is proposed. In a few cases, a local remeshing using a 3D mesh generator is performed. The technique proved to be robust and efficient even with highly complex shapes and numerous volumes.

## References

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