CAE GEOMETRY: ENGINEERING MODELS BUILT TO SUPPORT FUTURE SIMULATION

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ABSTRACT

To perform any kind of engineering analysis requires a discretisation of the target problem: typically a mesh. This discretisation serves as a model of the world, but of course meshes are not all created equal. The accuracy and convergence of an analysis depends crucially on how efficiently and faithfully the mesh is able to capture the solution for the analysis in question. For example, structural FEA simulations are much more efficient if thin shell parts are meshed using 2D shell elements, or solid hexahedral elements aligned with the shell, in the same way that CFD simulations can be vastly improved by using hexahedral elements aligned with the flow. However, in both cases some parts of the domain may not admit a hexahedral mesh with well-shaped elements, and in some regions the required solution may have no dominant direction.

Among our customers that are pushing the limits of what is possible through simulation, it is therefore accepted that domain partitioning is increasingly important, both to identify features of a model, such as thin shell parts, and to impart engineering knowledge, such as the direction of fluid flow. If meshing is performed without first making this kind of partitioning, it is impossible to generate meshes that give the best possible results with the shortest possible runtime. To perform some of the largest CAE simulations in the world, aiming to produce such a mesh is not merely an efficiency saving, but a feasibility requirement.

However, the “B-rep” boundary representation used by CAD models is ill-suited to making these kinds of partitions. By splitting a model up into multiple boundary surfaces, B-reps make it difficult to answer even conceptually simple questions, such as the thickness of a part or the offset shell of a body. Through a series of industrial research projects, TranscenData has developed algorithms and geometry representations that allow a CAD system to reason about a whole model, not just its constituent parts. However, building these coherent models can expose the shortcomings in a B-rep that are hidden by CAD systems, such as unwanted gaps, singularities and oscillating curvatures. As CAE becomes more ambitious, we anticipate that the deficiencies in today’s CAD models will be increasingly limiting.

In this talk, we present the concept of “CAE geometry”, a term we use to describe geometry that is coherent and rich enough to support the domain partitioning required for cutting-edge simulation. We will demonstrate that models of this calibre make it possible to perform automated domain partitioning for a range of engineering analyses. We will discuss the tools we use to repair and idealise CAD models so that they are suitable for CAE, and the geometry representations that we see as increasingly important for expressing the smooth, geometrically watertight models that CAE requires. The talk will conclude with a survey of current research directions in geometry representation, along with the challenges and possibilities that those representations present for CAE.

SUGGESTED THEMES

CAD, Geometry, Representations, Partitioning