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GENERATING ASSEMBLY MODELS FOR ADAPTIVE SIMULATIONS

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Abstract. Companies, especially in the aircraft and automotive industries are increasingly interested in setting up numerical simulations throughout a product development process. Because of the inherent complexity of their products, simulations are not only targeting isolated components but there is now a strong interest at studying the behavior of one or more subsystems of these products [1, 2]. The corresponding requirement is the setting of rather complex FE models that cannot be currently handled within the time scale prescribed by an industrial product development project.

The purpose of the proposed contribution is to describe how FE simulation models can be derived from assembly CAD models and how adaptive simulations can take place with these large scale models. Consequently, the contribution focuses on the major steps of simulation model preparation and its interactions with an adaptive simulation process. The target addressed falls into the scope of the national research project, ROMMA [3], and, if all the connections between the steps are not completed yet, the paper will report the current progress in each of them.

In a first place, studying the content and structure of an assembly model, as available in a Product Data Management System (PDMS), reveals that product assemblies or Digital Mock-Ups (DMUs) reduce to a set of components located in 3D space without geometric relationships between them. Complementarily, simulation models for assemblies strongly need geometric interfaces between components to be able to set up boundary conditions

between them and/or meshing constraints, e.g. conformal mesh requirements.

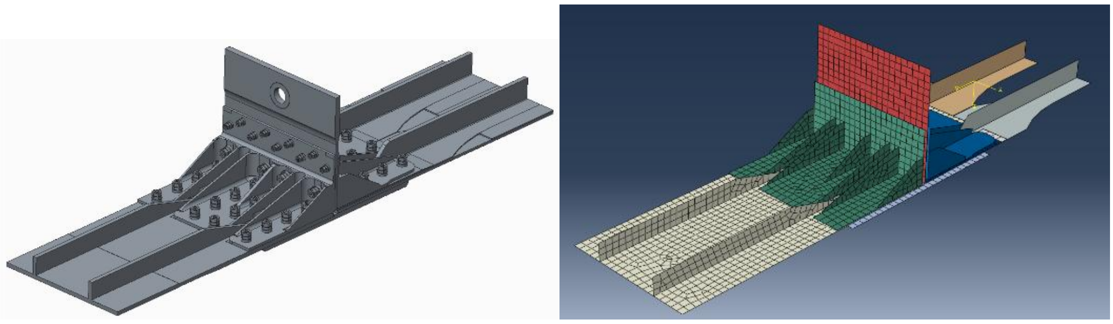
Another observation derived from this analysis is the prominence of component functions as a means for specifying component simplifications/idealizations. This leads to a first step of the assembly processing scheme:

- Identification of geometric interfaces between components;

- Assignment of functional designations to components. Currently, functional information is automatically added to some categories of components using a qualitative reasoning process.

As a result, components are structured geometrically, i.e. key geometric interfaces are located on the boundary of each component and in its neighborhood, as well as from a functional standpoint, i.e. functional designations of components fit into a taxonomy and set constraints over technological data describing the interfaces involved in their definitions [4].

Because assembly models can lead to highly complex simulation models when it focuses on car and/or aircraft models, idealizations of components are key issues of simulation model preparation since dimensional reductions is a means to generate efficient simulation models. To this end component segmentation has been set up to analyze component morphology and produce robust idealization algorithms (see Figure 1). These idealization algorithms take also into account meshing constraints, i.e. locations of stiffeners interact with the shape and size of FEs and choosing ‘internal’ or ‘external’ stiffener positions rather than mid-surface can improve the FE mesh quality.



(a) (b)

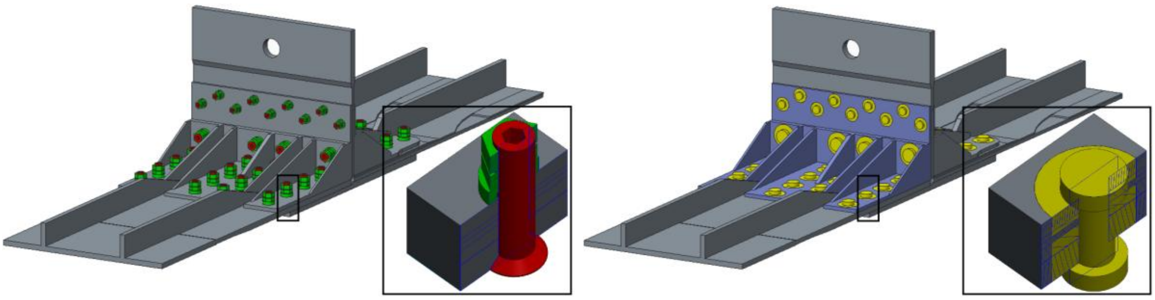
Figure 1: (a) CAD model of an assembly, (b) model demonstrating the results obtained after component segmentations, an idealization process and a mesh generation. For illustration purposes some components have been idealized but not meshed, others have been idealized and meshed.

This result is a first step to connect with large scale simulation models as needed for COFAST software [5] to address simulation objectives at a rather global level.

The iterative scheme that is used in COFAST, is derived from the LATIN method. The main principle is to separate the equations in order to avoid solving simultaneously a global and a nonlinear problem. The procedure searches for solutions that alternatively satisfy the global linear equations (kinematic admissibility and equilibrium on a substructure) and then, the local equations (interface equations). This leads to a decoupling of the problem. Because very few iterations of the LATIN method generate a solution over the whole time interval, the initialization overacts on the whole time interval. The solution obtained with this procedure ends up with a very low computation cost and can be parallelized to obtain a very good approximation of the solution.

Functional information becomes also important to set up simulation models dedicated to local analyses. Figure 2 illustrates how functional information can be used to simplify bolts and derive control areas around these bolts that are used to precisely monitor the mesh generation process so that meshing strategies can be efficiently set up when processing complex assemblies.

Functional information derived from the DMU is of qualitative type, e.g. cylindrical fittings are not quantified but classified as ‘tight fit’ or ‘loose fit’. However, this information acts as a template that can be used when setting up the simulation parameters required at interfaces between components. Because components interfaces are clearly identified and can be categorized from a mechanical point of view, the simulation model preparation is strengthened: the number and type of parameters needed at various interfaces can be unambiguously identified, thus avoiding inconsistencies that could arise when setting up complex simulation models.



(a) (b)

Figure 2: (a) CAD model of an assembly after the identification of functional designations of components (colors indicate the differences of functional designations), (b) model demonstrating the use of functional designations to simplify bolts and set up control volumes around them to adapt the model to the simulation objectives.

Additionally, the precise location of interfaces becomes helpful for setting up input for a posteriori error estimators. Indeed, the estimator used here is based on the constitutive error relation concept. A pillar of the method is to construct admissible fields. The knowledge of interfaces between substructures is then of primary importance. Nevertheless, in order to simplify a generic construction has been built when some data are missing [6]. When available, the precise location of the interfaces and more generally all the knowledge about the mechanical loading can be integrated in the generic method developed and improves the quality of the computed error estimation. The first results obtained in the framework of linear elasticity have to be extended to the framework of contact with and without friction. The final objective is to obtain a tool that make possible to design a robust simulation of assemblies through an adaptive process.

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