TEC|MAP: Integrating imperfections
into simulation models

Most finite element simulation models represent the nominal, perfect state of the structure. Nevertheless, in real world most of the structures are not perfect. These imperfections could be based on manufacturing deviations or on defects that grow due to the usage. In any case the effect of these deviations to the performance of the structure should be evaluated.

GUI of the application

Sometimes it might also be interesting to evaluate the effect of a certain imperfection in different areas of the structure as part of a DOE study. Nevertheless, it would be nice to evaluate the effects in a reproduceable way and not dependent on the skill level of the simulation engineer.

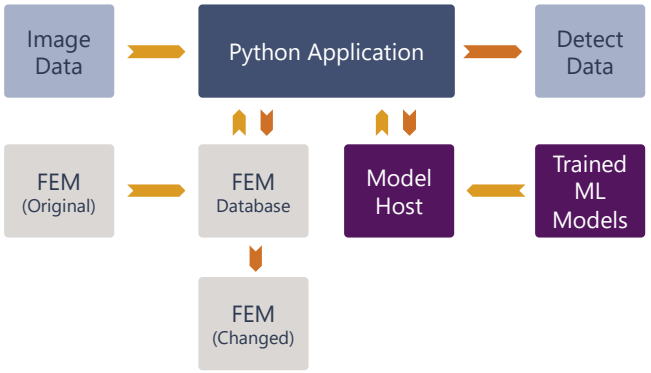
Within a research project TECOSIM developed the process TEC|MAP, which allows the automatic update of finite element simulation models based on image data.

To reach this goal three main modules have been developed:

a) **An application** to show the image data and define the imperfections on the real structure.
b) **A process** to create ML-algorithms that help with the detection of imperfections.
c) **A module** that integrates automatically different types of imperfections into finite element simulation models.

Finding the imperfections

To be able to annotate imperfections on real structures an application was developed that allows the import of image data. Due to the availability of CT-Scan data within the project this is the current image data supported. Nevertheless, the application is not limited to that, and it could be updated to different image data sources (e.g. ultrasonic scan data, photographs) as well.



Data and moduls schematic of the developed application

One advantage of the CT scan data is, that imperfections shown on the images are coupled to their real size and location within the real structure because this is inherent information of the data. Once the imperfection is annotated the application stores where it is located and what size it has. This annotation can be done manually. But it is also possible to use ML-models to support the user with this task. For that reason, a ML-model server was developed that provides the ML-models for the app. This approach was chosen to be able to connect different apps with the same ML models for predictions but also to be able to protect intellectual property rights.

To create new ML-models a tool chain was developed as well that allows the creation of training data, pre-processing of the training data and training the ML-model itself so that it can be applied within the app or any other application (e.g. automatic detection of imperfections on quality control image data). After the imperfections are found and annotated, the real world must be superposed with the simulation world. After this transfer is managed the user can start in selecting how the imperfections should be considered in the simulation model.

Model the imperfections

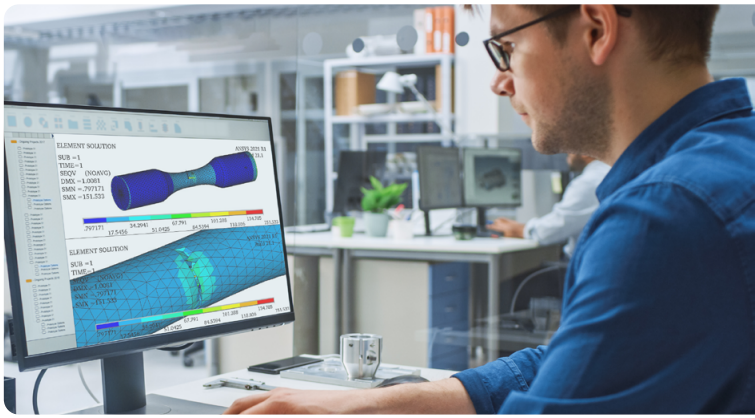
To implement imperfections into simulation models, a FEM database was developed that has routines to import simulation models, to manipulate parts of them in a certain manner and exports the simulation models as well. It was decided to do this in a database structure because most of the features of simulation models are common no matter which solver is used (e.g. nodes, 0D to 3D elements, properties). Therefore, if the handling of a certain imperfection is implemented it can be used for any supported solver.

The handling of the imperfections can be customized depending on the need. But there is no further work on the application necessary because the interface is already implemented. The current implemented imperfections are:

- **Material Change** – suitable for areas of pores or degraded material
- **Delamination** – suitable for areas of failed bonding (available for shell and solid elements)
- **Crack** – suitable for areas that are partly or fully cracked (available for shells and solid elements)

Currently the import and export are available for the solver Ansys Mechanical.

The developed process is designed that it can be used together but also further developed and applied independently. It gives the opportunity to consider complex real-life imperfections in our perfect simulation world.



Effect of crack in simulation model

If you are interested to learn more about this topic, please contact:

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