ELISE

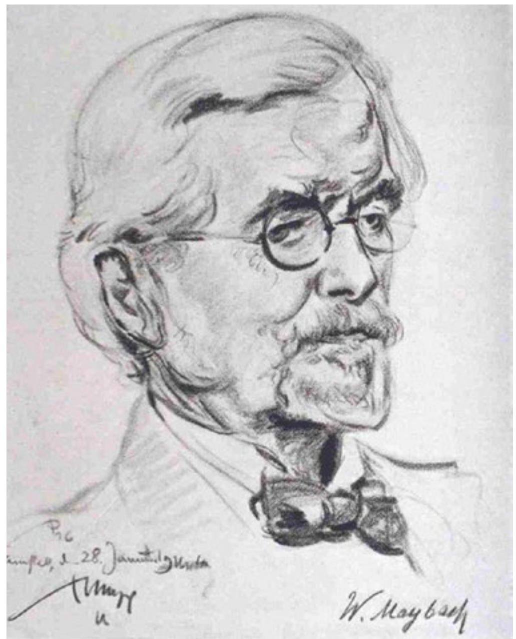
WHITEPAPER

ELISE AUTOMATES PRODUCT DEVELOPMENT

Capture engineering intent in a digital model and implement it automatically

Automation is conquering more and more areas, both in the real world, for example in the form of handling robots, and in the virtual world. Many software packages make it possible to set up workflows that digitally map processes and fire actions such as sending out information via e-mail. It is almost always a matter of shifting recurring activities from humans to machines and thus relieving them. The Bremen-based startup ELISE has developed a solution that has the potential to free designers from routine tasks in product development as well.

Wilhelm Maybach was called the “King of design engineers”. Alone or with just a few employees, he found solutions for automobiles and aircraft engines, some of whose principles are still used today. Maybach, Linde, Benz, Bosch and other superstars of technology created completely new technologies at the end of the 19th to the beginning of the 20th century and founded entire industries.



Wilhelm Maybach

Just as the monarchy has long been out of fashion politically, kings have also not been in demand in design for a long time, but team workers. Regardless of the industry, development work has become much more small-scale, dependent on countless boundary conditions and multidisciplinary with mechanics, electronics, and software. This increases the need for coordination and the accompanying administrative tasks, which take up an ever-greater proportion of the working time of design engineers. And this in turn means that designers have less time for their innovative, creative work.

But just as robots today screw assemblies together and insert and remove components from machines around the clock and without tiring, many routine design tasks can also be transferred to machines. A first step, for example, are requirements management systems, in which all product requirements are collected and compared with the design by the computer. Another approach to design optimization is generative design, in which the designer specifies a design space and the forces that occur, and the computer calculates the optimal geometry.

But these approaches only cover individual areas of engineering design work. How about approaching the task in a much more general way? Every component in a machine has one or more tasks and a number of boundary conditions and specifications. If these were fully understood, the optimum component would automatically result - not only in terms of geometry, but in all aspects. ELISE calls this the “technical DNA”. And if such a component is to be designed again, one only has to retrieve this technical DNA, adjust some parameters and start a new calculation run. The knowledge stored in the DNA is automatically applied to the new product.

Is there any creativity left in the designer’s work? Well, you still need a creative mind that defines the basic mechanisms of the product, divides it into assemblies, then into components, and defines the boundary conditions that each component must fulfill. The subsequent detailing work is then left to the computer. Here, too, human intervention will be necessary to optimize the DNA to the point where a meaningful result emerges. For the next, repetitively similar part, this optimization work will then only be necessary to a much lesser extent. With ELISE’s software, this vision becomes reality.

FROM DIATOMS TO TECHNICAL DNA - THE STORY OF ELISE

The Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (Alfred Wegener Institute, AWI) is known for its research, for example, in the stations in Antarctica or with the icebreaker “Polarstern”, which drifted with the ice through the central Arctic in 2019 and 2020. A central object in AWI’s climate research are unicellular diatoms, whose number and composition in water samples are indicators of different climate phenomena.

The diatoms form complex structures around the individual algae cell. To get to the bottom of these structures and their function, researchers tried to reproduce them three-dimensionally in the CAD model and analyze them using FEM simulation. It quickly became apparent that these bionic structures push conventional CAD systems to their limits. In addition, the researchers wanted to retrace evolution in order to understand nature’s optimization strategies.

It became clear that no system on the market met these two requirements - modeling of complex organic shapes and iterative optimization through simulation. The later founders of ELISE, Dr. Moritz Maier, Sebastian Möller and Daniel Siegel, therefore for over a decade developed the foundations of the ELISE software based on the technology of algorithmic modeling. ELISE GmbH was founded on August 1, 2018, and the company was able to raise three million euros in its seed round in November 2019 from investors such as Cherry Ventures, Venture Stars and BMWi Ventures. Today, ELISE employs over 40 people at its location in Bremen.

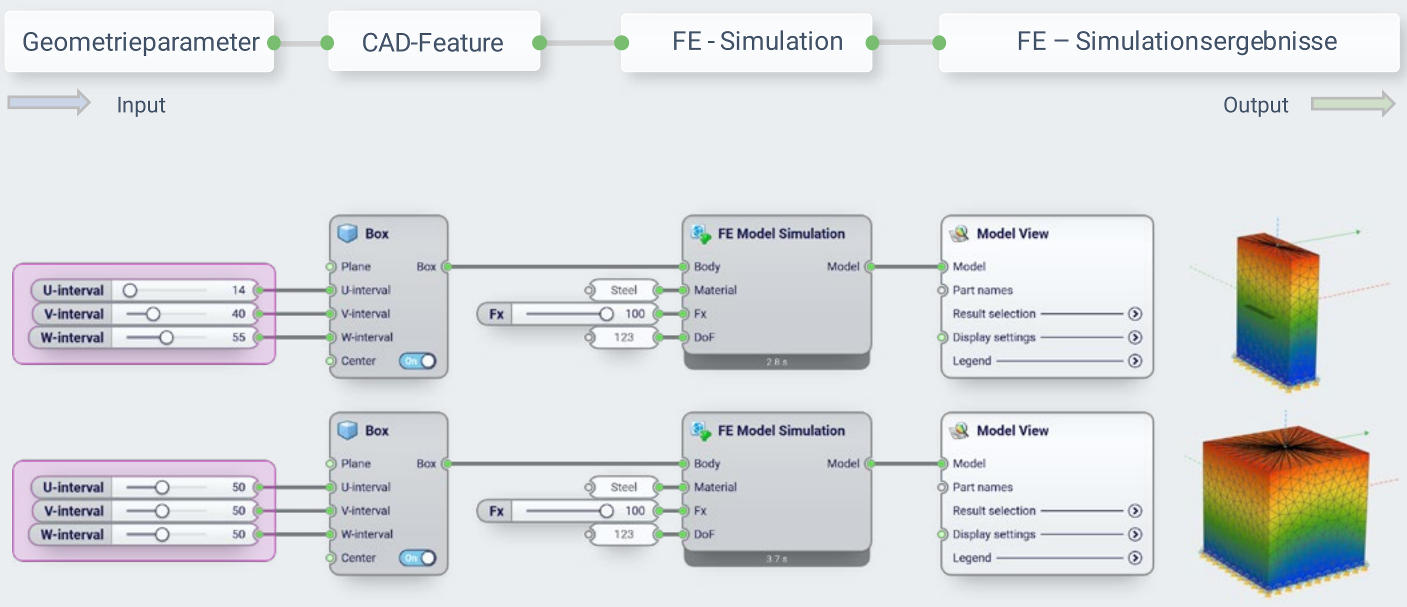


Figure 1: Control of CAD features via geometry parameters and interface to FEM solvers in ELISE

PROGRAMMING INSTEAD OF MODELING - THE INNOVATIVE ELISE APPROACH

The idea of algorithmic modeling is not new; it is used, e.g. in architecture it is used to develop recurring geometries that can be described mathematically. Instead of describing the geometry directly, this philosophy uses function blocks, called components, with input and output interfaces. Input and output flow in and out of these blocks from other blocks. In ELISE, these blocks are represented visually and the user connects inputs and outputs of different components with "cables" that transport the values and data.

As shown in **Figure 1**, a cuboid can be created by connecting the inputs for X, Y and Z edge length to sliders or components that provide the desired numerical values. If always a cube is to be created, all three inputs can also be connected to a single slider, so that the edge lengths are always the same.

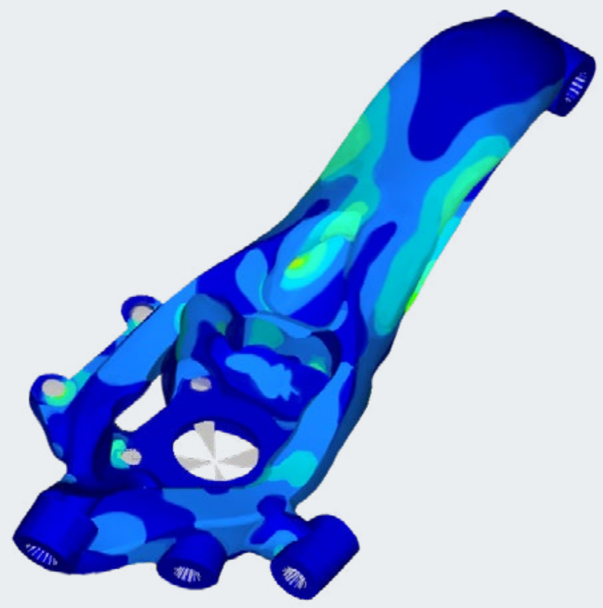
The resulting cuboid geometry can now be passed into a component that controls a FEM solver. Thus, by changing the sliders, the initial geometry for a FEM calculation can be changed as desired.

Since the selection of components in ELISE goes far beyond pure geometry, all requirements for a component can be defined in the software - this is the technical DNA mentioned above. The network of components and inputs describes all requirements for the component as well as the interdependencies of all values.

A FEM solver returns result values, for example, a strength, which itself can be used as an input variable for the geometry. Likewise, instead of fixed input variables, value ranges can also be specified to allow optimization. Thus, the original goal of an evolutionary optimization can be achieved.

ELISE is constantly expanding its range of components and cooperates with partners in this area. These include software providers whose solutions can be "remotely controlled" via ELISE on the one hand, and research and development partners who contribute algorithms that are integrated into ELISE components on the other. And last but not least, many ELISE users and third-party providers develop their own components, which they make available to other users.

The software already offers components that calculate the cost of a part, so that, for example, the cheapest solution can be calculated with maximum strength. The company is currently working on components that calculate the sustainability of a component. In this way, the ecological footprint of a design can be included in the optimization even at an early development stage.



The software already offers components that calculate the cost of a part, so that, for example, the cheapest solution can be calculated with maximum strength.

Once such a workflow has been created, it can be fed with new values or slightly modified to create a successor design or variant. For example, once the requirements for the A-pillar of a car have been defined, this definition can be reused in ELISE for the successor model by simply adjusting the pervious design's values.Or a component is exchanged, for example to create a round beam instead of a rectangular one. The system then calculates a new optimum and the matching geometry based on these values.

Compared to conventional optimization systems, ELISE goes one step further, because the computational model directly controls the solver, builds the geometry itself and can thus act much more flexibly. Conventional optimizers, for example, work with a manually created geometry and with manual pre-processing to set the optimization parameters. ELISE can insert completely new parameters or generate completely different geometries inside of a fully automated workflow.

THE ENGINEER AS A PROGRAMMER - AN EXAMPLE OF AN OPTIMIZATION WITH ELISE

Figure 2 shows a workflow for the automatic design of a steering knuckle for a car. The basic geometry - or the design space - comes from a CAD model that is read in via so-called import components (highlighted in blue). These components process native CAD data from various systems such as Catia, NX or Creo, but also STL or Step models.

In the blue-marked components, further data of the technical component specification are loaded, for example the force vectors with node ID - the force application point -, name, X/Y/Z parameters and the amount of each force. These can be ideally stored in an Excel table, whereby it is also possible to store several parameter sets. These can then be specifically selected using further input components in order to calculate different load cases. The material data also usually comes from Excel files.

In the gray-marked section of **Figure 2**, generative features are used to enable automatic creation of the steering knuckle. This is followed by a meshing component that controls Altair Hypermesh in the background. The component offers all the functionalities that Hypermesh also offers, so the user does not miss out on any settings. The inputs of most settings are assigned with default values, so that the system works even if you do not control all values yourself. Thus, simple as well as complex scenarios can be created with the same component.

Mesh, material values and forces are now brought together and supplied to a FEM solver, in this example Optistruct, also from Altair. ELISE also offers components for other systems, such as Abaqus or ANSYS.

ELISE provides very sophisticated functions for reconstructing geometries after a topology optimization, which make it possible to smooth the "humpy" geometries often resulting from topology optimizations. In this way, solid models are created from the optimized geometry, which in turn can be further processed in the CAD system. If desired, special functions ensure that, for example, inner edges become round and outer edges become angular, as is often desired in the technical field.

At the end of the workflow (green-marked area in **Figure 2**), ELISE shows the found shape and - depending on the output component - the results of the simulation with deformations and colored areas. The exciting thing about the component system is that it is independent of the geometry. So, for example, instead of the steering knuckle, you can enter the geometry of a wishbone, adjust the forces accordingly, and run through the same optimization routine. This flexibility is reflected in the concept of technical DNA - the basic system remains the same, the environmental parameters change. In many cases, 70 to 80 percent of the DNA - which represents engineering knowledge - can be reused, even when it comes to completely different components.

ELISE offers components that meet specific requirements for certain manufacturing technologies, such as support structures and a build plate for 3D printing. The company is working with a number of partners to develop additional components, including Materialise with its eStage software for generating support structures for 3D printing, and Hexagon/MSC with HxGN Emendate for generative design. Other partners include Fraunhofer IAPT with LBM Cost for 3D printing cost calculation and iPoint with Umberto for calculating the CO_2 footprint of the design.

MAP ENGINEERING KNOWLEDGE, AVOID ROUTINE WORK - THE ELISE PRINCIPLE

If you take a closer look at how products were created in Maybach's time, it quickly becomes clear that there were no lone geniuses at work back then either; instead, engineers defined the rough lines of a design and the actual design was implemented by armies of technical draftsmen at the drawing board. With the introduction of computer-aided development tools, this way of working changed and in many cases the designer remained in charge of the complete design until the very end.

With ELISE, the term "computer aided design" finally gains its true meaning: the user defines the boundary conditions and objectives of the design, and the computer works out the details. In this way, designers arer relieved of routine work such as the exact geometric design and concentrate - again - on their creative tasks.

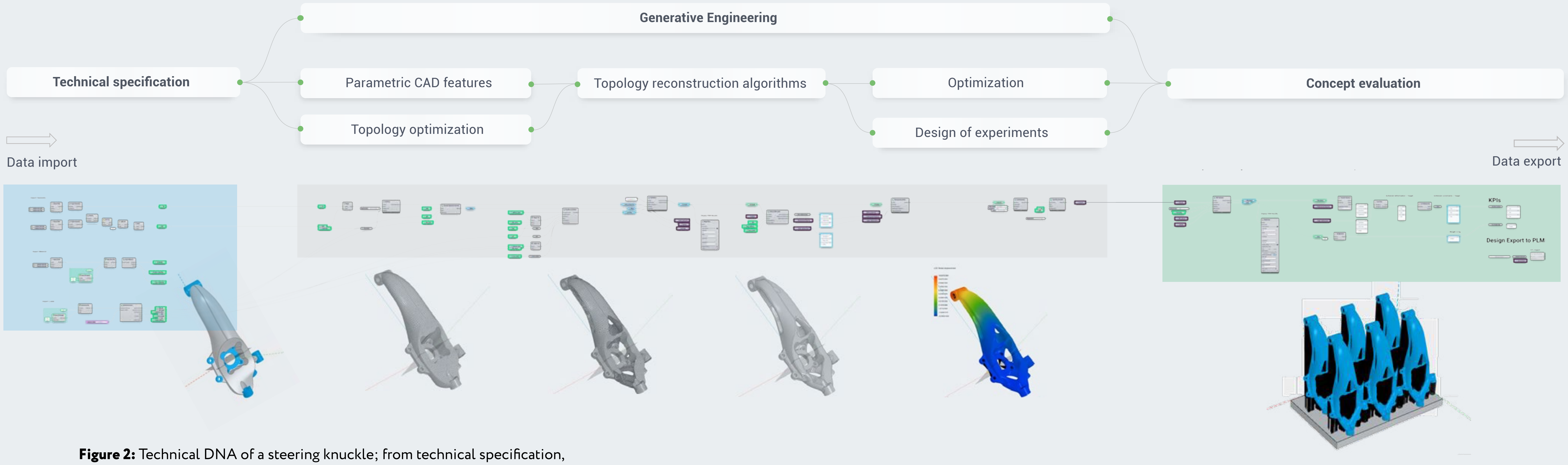


Figure 2: Technical DNA of a steering knuckle; from technical specification, generative feeatures to concept evaluation

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