The steps in detail:

- Interactive adjustment of the cupholder's geometry parameters.
- Simulation to check for stability of the 3D model.
- If the shape cannot withstand the load, CUPstomizer suggests which parameter shall be changed based on a cost function.
- If the geometry is stable enough according to the simulation, it can be 3D printed.

The advantages

CUPstomizer creates a **consistent, virtual model of the object's surface and inner structure**:

- a wide range of geometric changes are possible depending on the parameters of the design to be customized,
- volumetric tiling is intrinsically supported by the representation scheme,
- finite element meshes can be derived automatically.

CUPstomizer performs structural mechanics simulations for medium-sized meshes within fractions of seconds using GPUs.

CUPstomizer creates hints to the user which parameter to change based on optimizing for a cost function.

FRAUNHOFER IGD: THE INTERNATIONAL LEADING INSTITUTE FOR APPLIED RESEARCH IN VISUAL COMPUTING

Competence Center "Interactive Engineering Technologies"
Topics and competencies at a glance:

- Geometry processing
- Real-time visualization
- Interactive simulation

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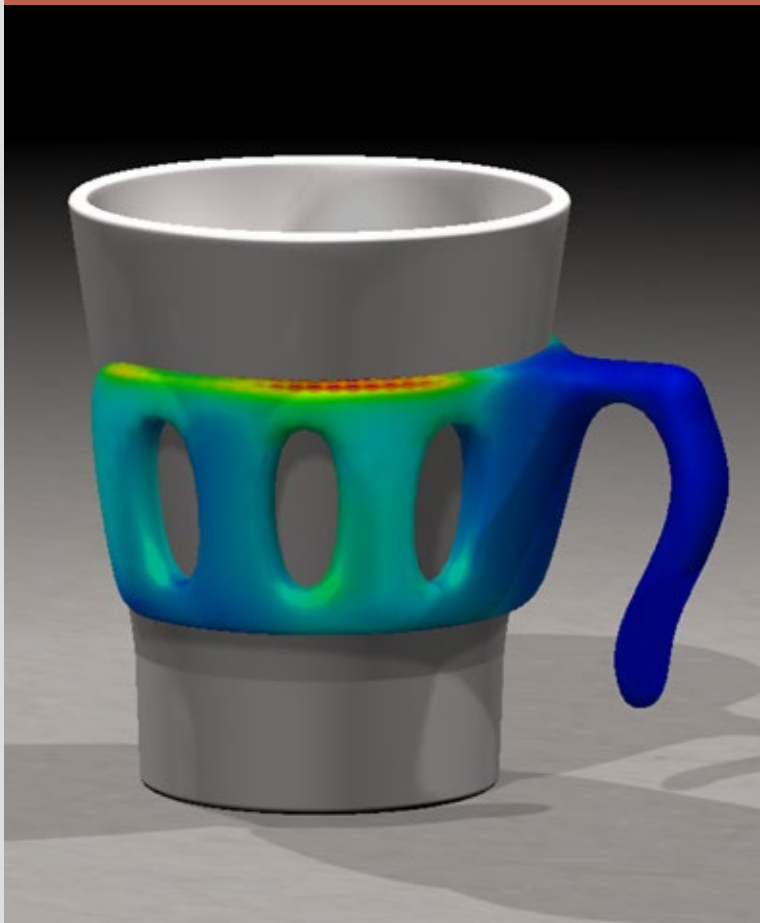
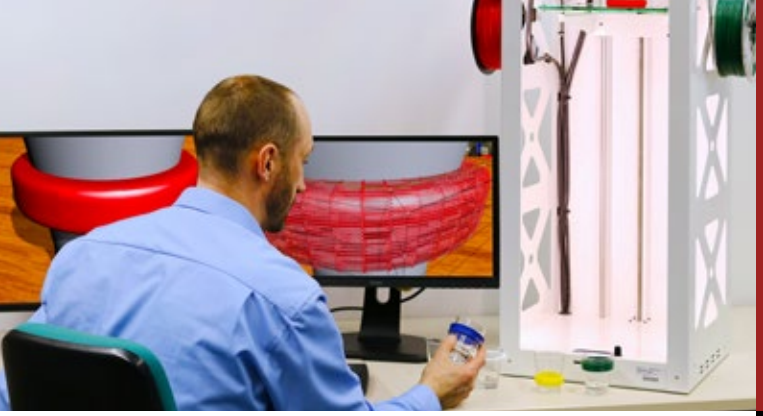
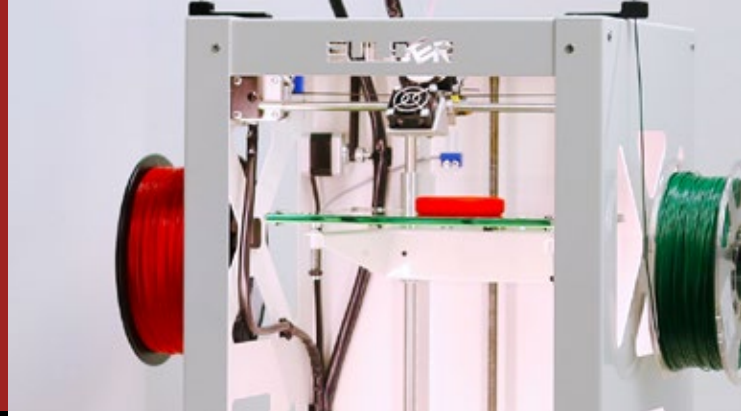
CUPSTOMIZER

INTEGRATED INTERACTIVE DESIGN AND SIMULATION FOR MASS CUSTOMIZED 3D PRINTED OBJECTS







Mass customization and 3D printing centres are a recent trend since a few years. But how to support novice designers and laymen in designing workable objects within some given design space for 3D printed objects?

CUPstomizer is a **prototype solution that integrates parametric modelling, simulation and optimization approaches** to enable the user to vary design parameters and to guide him/her to choose parameters satisfying a goal function of maintaining stability while adding as little as possible material – all in an easy-to-use, interactive 3D application. CUPstomizer illustrates the smooth transition between design and simulation using cup holders for espresso cups.

The idea

Most CAD systems only describe the boundary surface of objects (BRep-NURBS), whereas simulation and 3D printing (additive manufacturing) require volumetric information, in some cases even information about graded materials or properties.

Graded properties can hardly be represented by BRep-NURBS. The transition from typical BRep-NURBS to a model suitable for simulation (e.g. a finite element mesh) is generally tedious and in many cases requires manual intervention.

CUPstomizer features a new kind of volumetric representation in the design stage which can be efficiently transformed into a simulation mesh. We perform computational structural mechanics simulation directly on the graphics processing unit (GPU), using the GPU as a number cruncher (GPGPU) to analyze stability. The fast simulation allows us to perform sensitivity analysis very rapidly to give feedback to the user which parameter to tune in case the chosen configuration does not yield a stable model.

How it works

Typically, 3D printing online shops only check whether the product can be printed in 3D based on the geometry of the model. In contrast, CUPstomizer performs physically-based simulations and only allows for printing 3D shapes that are likely to comply to the pre-defined load case.

To this end, CUPstomizer combines a unique set of features and technologies: subdivision for modeling the geometry, physically-based simulation models using the finite element method based on the subdivision model, GPUs to accelerate the FEM calculations and optimization approaches. More concretely, the internal stresses are computed from external loads, such as gravity and the weight of the cup to be carried. Depending on the magnitude and distribution of the stresses, the stability of the object can be assessed automatically.