Shape Optimization for Digital Fabrication

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If a digital 3D object is to be produced physically, not only its geometric but also its physical properties need to be controlled during design. Compared to traditional fabrication techniques, devices like 3D printers provide a lot of flexibility with respect to the outer shape of an object but also with respect to its inner structure. We exploit this flexibility by generating, for a given outer surface, an inner offset surface with varying thickness. By adjusting the local thickness of this offset, we can move mass to different parts of the model which allows us to control physical properties like center of gravity, inertia tensor and buoyancy but also structural strength and natural frequencies. In this talk I present a generic numerical procedure that enables the efficient solution of the involved optimization problem. The key ingredients are: effective order reduction, optimal local pre-conditioning, and constraint elimination by parameter mapping. We show a number of results that have been computed by the method. The generic procedure can easily be adapted to the control of other physical properties as well.