As-Stiff-As-Needed surface deformation
Combining ARAP energy with an anisotropic material

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Abstract

The creation of man-made shapes can be seen as the exploration of designers' 'Mental Shape Space', often supported by design reviews. To improve communication during these reviews, we introduce a new physically-based method to intuitively deform man-made shapes. This method is based on As-Rigid-As Possible (ARAP) shape deformation methods, known to offer a direct surface manipulation and to generate visually pleasant shapes, by minimizing local deviations from rigidity. However, the organic behavior of ARAP shape deformations leads to undesired effects, such as surface collapsing or bulging, because of an inappropriate stiffness model over the object. In this paper, we first link the designers' needs to ARAP handle-based variational mesh deformation processes. Then, we study and characterize the ARAP energy and its variants from a structural mechanics point of view. Our insight is indeed that controlling the material stiffness could prevent the undesirable organic effects. We shed light on the fact that, from a mechanical standpoint, none of the ARAP-based methods offers an appropriate stiffness distribution over the object. To improve the stiffness distribution over the surface, and its deformation behavior for man-made shapes, we introduce an appropriate anisotropic (*orthotropic*) material by computing new edge weights in the ARAP formulation. This material is associated with a membrane-like structural behavior to further improve the stiffness distribution. Thanks to these settings, we derive a robust and intuitive deformation which produces an anisotropic mesh deformation. The benefits of our new As-Stiff-As-Needed (ASAN) method are finally illustrated by typical design examples from the automotive industry and other man-made shapes.

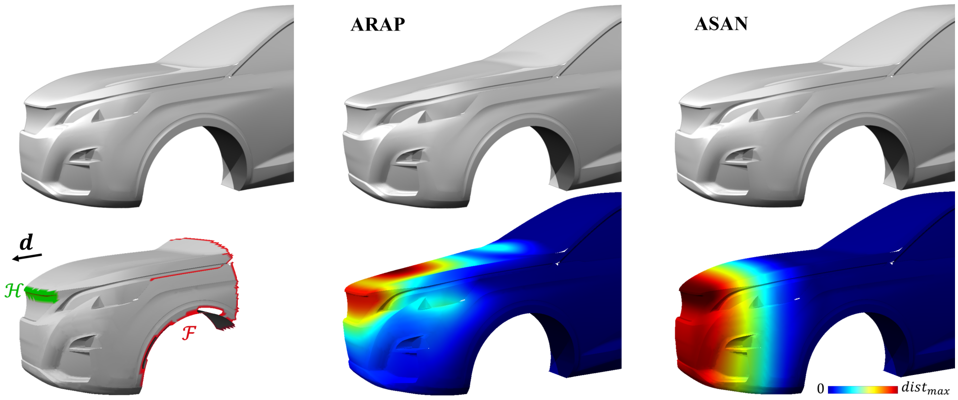

Figure 1: (Graphical Abstract) Our ASAN method offers an intuitive and shape-preserving deformation, appropriate for man-made shapes.