Deformable 3D Reconstruction with an Object Database

Pablo F. Alcantarilla
pablofdezalc@gmail.com
Adrien Bartoli
adrien.bartoli@gmail.com

ISIT-UMR6284 CNRS
Université d'Auvergne
Clermont-Ferrand, France

Deformable 3D reconstruction from 2D images requires prior knowledge on the scene structure. Template-free methods [1, 2, 5, 6, 9, 14] use *generic* prior knowledge such as piecewise smoothness but require multiple images with significant baseline. Template-based methods [4, 10, 13] require only one image but handle only one object for which they need specific prior knowledge, namely a 3D template.

In this paper, we propose a novel method that alleviates the strong assumptions of both the template-free and template-based methods: our method uses multiple templates to achieve deformable 3D reconstruction from only one image and for multiple objects. It uses object recognition to automatically discover what objects are visible in the input image and to select the appropriate templates for deformable 3D reconstruction. The object database is built offline. Crucially, this database does not only contain appearance descriptors as in existing object recognition frameworks [7, 8, 11], but also material properties to facilitate deformable 3D reconstruction.

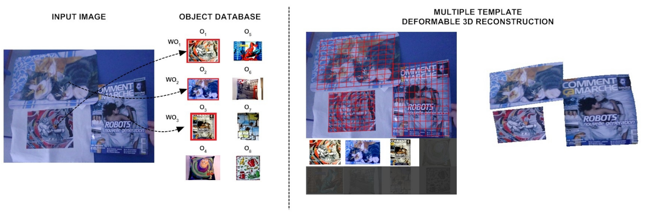

Figure 1: Given an input image, we first perform object recognition to detect database objects in the input image. Then, we compute 2D image warps that model the deformation of each particular object between the input image and a 2D parameterization of the 3D template. Finally, using the estimated warps we perform template-based isometric surface reconstruction. The detected objects from the database are highlighted, whereas non-detected objects are depicted in a darker color.

At runtime we use object recognition to automatically discover what objects are visible in the current input image and to select the appropriate templates for deformable 3D reconstruction. For this purpose, we perform wide-baseline image matching between the stored templates in the database and the input image that contains the deforming surfaces. We use an outlier rejection method [12] to obtain a set of clean-up matches between each detected template and present objects in the 2D input image. For those objects that have a number of clean-up matches higher than a defined threshold, we compute an image warp [3] that encodes the particular deformation of an object in the image. Finally, given the estimated warps we perform deformable 3D reconstruction for the detected objects [4].

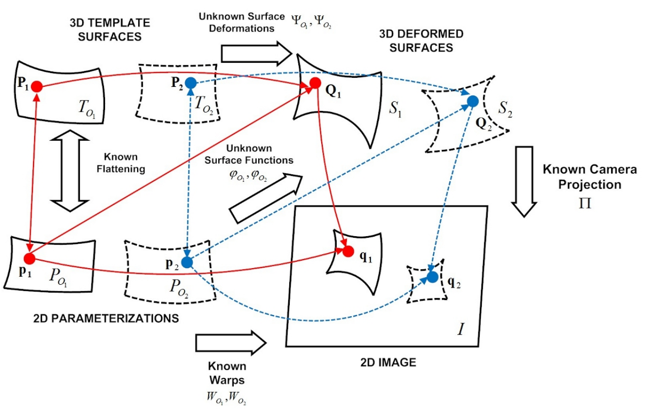

Figure 2: Geometric modeling of monocular multiple-template based reconstruction.

Our approach is the first to use an object database to aid deformable 3D reconstruction. In terms of genericity, it lies between existing template-based and template-free methods, as it assumes that strong priors on the world can be modeled but is not object-specific. We show successful deformable 3D reconstruction results of multiple objects from a single image. The objects in the database are made of different materials such as paper, cloth and plastic, and the database contains both developable and non-developable objects. Our work opens a whole new area of approaches that can benefit from using strong priors encoded in a versatile object database.

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