Unconstrained 3D Face Reconstruction from Photo Collections

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Abstract:
This thesis presents a novel approach for 3D face reconstruction from unconstrained photo collections. An unconstrained photo collection is a set of face images captured under an unknown and diverse variation of poses, expressions, and illuminations. The output of the proposed algorithm is a true 3D face surface model represented as a watertight triangulated surface with albedo data colloquially referred to as texture information. Reconstructing a 3D understanding of a face based on 2D input is a long-standing computer vision problem. Traditional photometric stereo-based reconstruction techniques work on aligned 2D images and produce a 2.5D depth map reconstruction. We extend face reconstruction to work with a true 3D model, allowing us to enjoy the benefits of using images from all poses, up to and including profiles. To use a 3D model, we propose a novel normal field-based Laplace editing technique which allows us to deform a triangulated mesh to match the observed surface normals. Unlike prior work that require large photo collections, we formulate an approach to adapt to photo collections with few images of potentially poor quality. We achieve this through incorporating prior knowledge about face shape by fitting a 3D Morphable Model to form a personalized template before using a novel analysis-by-synthesis photometric stereo formulation to complete the fine face details. A structural similarity-based quality measure allows evaluation in the absence of ground truth 3D scans. Superior large-scale experimental results are reported on Internet, synthetic, and personal photo collections.