Constrained Optical Flow: an efficient system for nonrigid 3D tracking

Tim K. Marks, J. Cooper Roddey, John Hershey, and Javier R. Movellan
University of California San Diego

May 2, 2003

Brand and Bhotika [2001] recently proposed a fast and reliable method (flexible flow) for joint tracking of rigid 3D pose and nonnrigid deformation parameters of moving human faces. We show that the coupled translation, rotation, and deformation parameters can be estimated simultaneously using a Gauss-Newton approach to a non-linear regression problem. Expressing the flexible flow algorithm in this manner leads to more principled estimators for the parameters, and opens new avenues for improving and extending the system using common regression techniques, such as robust, ridge, and kernel regression.

Each iteration of the flexible flow approach involves a linear optical flow estimation followed by a linear motion estimation. Brand and Bhotika [2001] take great care to obtain not only the point estimates but also the Gaussian uncertainties from optical flow, and to propagate these uncertainties through the motion estimation equations. In our formulation, the optical flow and the motion estimation are unified into a single linear regression problem that can be solved more directly. The resulting constrained optical flow algorithm is more efficient than the original flexible flow algorithm, and renders unnecessary the careful propagation of uncertainties. Furthermore, each Gauss-Newton iteration produces estimates that are guaranteed to be at least as good as those of the original flexible flow system under the assumptions of the model. We verify this theoretical result by applying the algorithm to simulated data.

We present ongoing theoretical and empirical work evaluating three different extensions of the flexible flow algorithm. To get ground truth information, we performed simulations on synthetic 3D face data using the morphable model of [Blanz and Vetter 1999], which models the variation in a population of laser-scanned human heads.