High Detail Marker based 3D Reconstruction by Enforcing Multiview Constraints

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Figure 1: *3D Reconstruction with over 5.000 markers. 1) Camera images; 2) Closeup of detected markers; 3) 3D reconstruction from separate stereo matches without our multiview constraints; 4 and 5) Reconstruction by enforcing multiview constraints using our method*

Abstract

We present a 3D reconstruction method enabling high resolution marker-based capturing of deforming surfaces. In contrast to previous work, we allow all markers to look exactly the same and do not rely on temporal tracking. This implies considerable advantages: markers can be smaller and are easier to apply due to omitted identification; long-range motions normally confusing temporal tracking algorithms become feasible. However, the correct matching of markers between camera views is highly ambiguous in such a scenario. To solve this problem we propose an optimization framework that considers multiview conflicts and local smoothness of the captured surface. An iterative relaxation method based on graph matching is adopted to obtain a consistent, smooth reconstruction for all stereo pairs of a multi-camera system simultanously. Preliminary experiments show excellent and robust results.

Keywords: 3D reconstruction, multiview stereo, motion capture

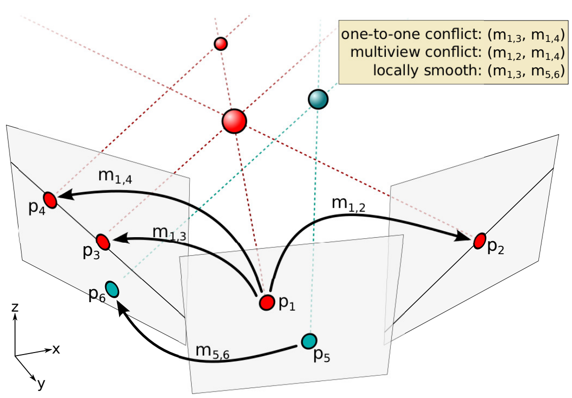

Figure 2: *3 camera views with extracted 2D markers. Correspondences between markers are ambigous (e.g. both $m_{1,3}$ and $m_{1,4}$ might be correct matches for p_1). Considering one-to-one constraints, multiview conflicts, and local smoothness our algorithm removes such ambiguities and finds a consistent 3D reconstruction.*

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1 Our Approach

Given the 2D projections of markers found in multiple camera images, we seek the 3D reconstruction of the markers. To this end, correspondences between projections of markers have to be found. For thousands of identical markers, matching is highly ambiguous even when respecting epipolar constraints. Finding the one-to-one matching between two cameras can be cast as a graph matching problem and solved using approximate methods, which in theory produces locally smooth correspondence fields [Cho et al. 2010]. In a multi-camera setting, solving several stereo reconstructions separately yields the 3D reconstruction. However, we observed that this produces poor results.

We propose to consider interactions between previously separately handled stereo pairs, in the form of multiview constraints. For example, in Fig. 2 the matches $m_{1,2}$ and $m_{1,3}$ belonging to separate pairs of cameras agree on the same triangulated 3D position. In contrast, $m_{1,2}$ and $m_{1,4}$ correspond to distinct triangulated 3D points. The latter case implies a conflict between said matches since p_1 can only be the projection of one of those separate 3D points. In the iterative graph matching procedure, we replace the bi-stochastic normalization (concerning only one-to-one matching constraints) with normalization concerning multi-view constraints and solve for all stereo matches simultaneously. The result is a smooth and consistent 3D reconstruction, Fig. 1 (image 4 & 5).

The proposed algorithm has high potential for further improvements both in reconstruction quality and runtime performance, two issues we would like to tackle in the near future. Being able to easily place thousands of markers without taking special care of marker identification and layout could ease acquisition in interesting application scenarios, such as the capturing of skin and muscle deformation [Park and Hodgins 2006], capturing of garments [White et al. 2007], and marker-based reconstruction of facial animations.

References

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