Group 3-13

3D Reconstruction of Non-Rigid Objects

Keisuke Kinoshita* and Shigeru Akamatsu* **
*ATR Human Information Science Laboratories, ** Hosei University

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We proposed a method to compute the shape of non-rigid 3D objects such as faces from stereo camera. A pair of cameras are used to capture images from different viewpoints. The cameras are pre-calibrated and the corresponding points are searched and determined incorporating shape smoothness and motion smoothness. From the corresponding points, object's 3D shape as well as their motion are estimated.

3D Reconstruction with smoothness constraints

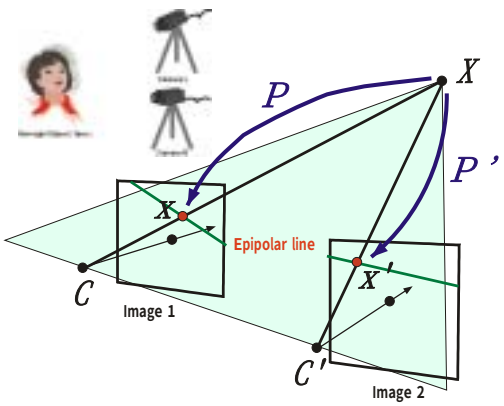

Fig.1 Stereo camera and epipolar constraint. A point on an image corresponds to a line on the other image. This constraint can be represented in a simple form of x'Fx=0. F is calculated from points on the images or by camera calibration procedure using a 3D jig.

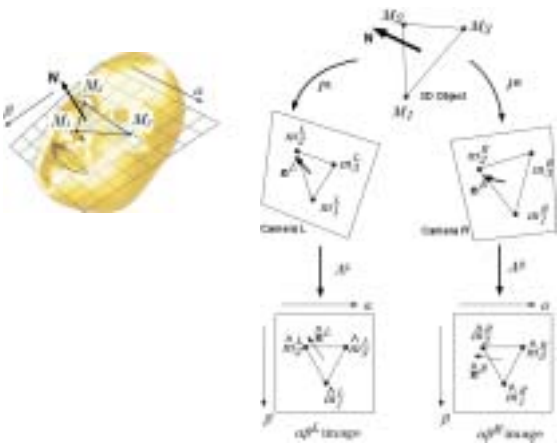

Fig.2 Parameterization of facial structure. Two eyes and nose are used as reference points for 2D affine transformations. The two images are normalized such that the reference points are transformed to the same coordinates. The corresponding points are searched along the epipolar lines.

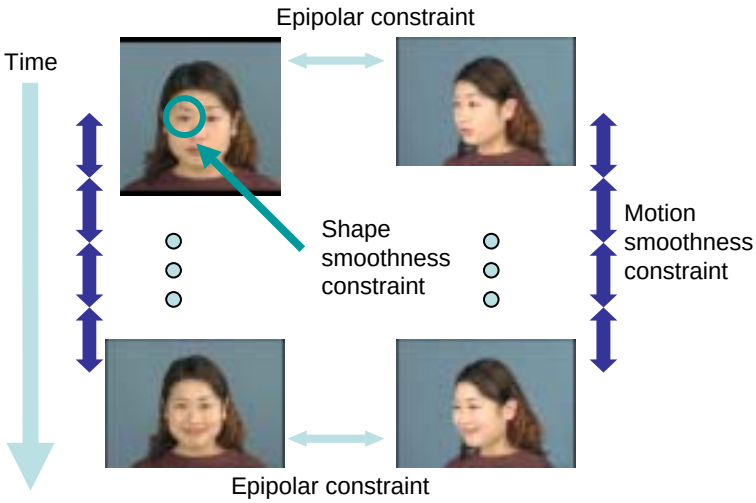

Fig.3 Three constraints are used to obtain more accurate corresponding points as well as the 3D shape. Using cross correlation alone for corresponding point search does not give sufficiently good results due to noise, viewpoint and light source dependencies to image intensities. We combined shape smoothness of the face and the motion smoothness together with the epipolar constraints, in other words, spatial, temporal and geometric constraints, to obtain more accurate 3D shape information.

Experiments

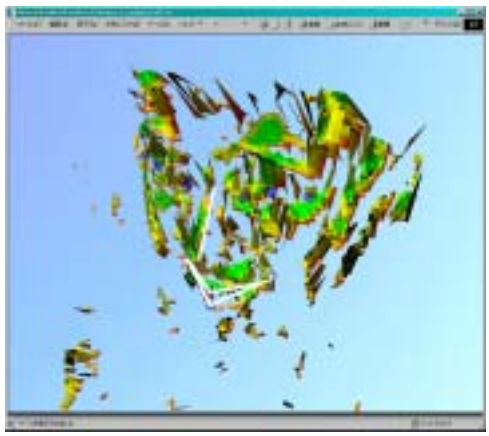

Fig.4 Reconstructed 3D facial structure. Once the corresponding points are determined, their 3D positions are calculated by triangulation using calibrated camera parameters. The uncertainties of their positions are estimated as well. Some regions are missing since the corresponding points are not obtained due to less texture information on the face: cheeks, forehead, etc.

Basic algorithms

Camera calibration: Compute camera parameters such as position, orientation and focal length of the lens, using geometric relation of 3D-2D projection.

Computation of fundamental matrix: From minimum eight corresponding points, fundamental matrix F is linearly calculated. F is 3x3 matrix with rank 2.