Third International Symposium on Biological Shape Analysis

Abstract Form

Robust generalized superimposition methods: a comparison using 3D facial images

KATLEEN DANIELS, DIRK VANDERMEULEN, PAUL SUETENS, PETER CLAES

Medical Image Computing, ESAT/PSI, Department of Electrical Engineering, KU Leuven
Medical Imaging Research Center, KU Leuven & UZ Leuven
iMinds-KU Leuven Future Health Department
Herestraat 49 bus 7003, 3000 Leuven, Belgium

katleen.daniels@esat.kuleuven.be, dirk.vandermeulen@esat.kuleuven.be,
paul.suetens@esat.kuleuven.be, peter.claes@esat.kuleuven.be

Abstract. Superimposition is a popular technique to separate scaling, position and orientation differences from true differences in shape represented as landmark configurations. The well-known generalized Procrustes superimposition (GPS), however, is affected by outliers (Pinocchio-effect) and assumes variation of the landmarks to be homoscedastic and uncorrelated, which influences the correctness of the superimposition. This work proposes and investigates two robust superimposition methods, which are generalizations (superimposing more than two landmark configurations) of two ordinary (superimposing two landmark configurations) superimposition methods from recent literature: Outlier Process (from the framework of dysmorphometrics) and Scaled Mixture. In their generalization and in contrast to the GPS, landmarks are not assumed to be homoscedastic. Furthermore, both methods are robust against the Pinocchio-effect. While the Outlier Process Generalization (OPG) explicitly introduces the concept of outliers and assumes the inliers to follow a normal distribution, the Scaled Mixture Generalization (SMG) assumes the displacements of the landmarks to follow a student-t distribution, which is outlier-tolerant. In a first test set-up the methods are tested in their ability to recover a known covariance structure (containing 6 to 20 landmarks), based on perturbed configurations. Additionally, a database of 469 facial images is used, on which 7,150 3D quasi-landmarks are established using an Anthropometric Mask. After generalized superimposition, different quasi-landmarks appear to have a different variance, confirming the importance of a separate displacement distribution per landmark. Both OPG and SMG are able to detect these differences. In a last test set-up, an artificially created Pinocchio, containing large outliers at the nose, is added to the database. This allows the investigation of the outlier detection of the methods. The OPG performs better than the SMG in estimating a known covariance structure and is able to correctly and explicitly delineate the region of atypical facial variation in the face of Pinocchio.