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NON-RIGID REGISTRATION-BASED DATA-DRIVEN 3D FACIAL ACTION UNIT DETECTION

Automated analysis of facial expressions has been an active area of study due to its potential applications not only for intelligent human-computer interfaces but also for human facial behavior research. To advance automatic expression analysis, this thesis proposes and empirically proves two hypotheses: (i) 3D face data is a better data modality than conventional 2D camera images, not only for being much less disturbed by illumination and head pose effects but also for capturing true facial surface information. (ii) It is possible to perform detailed face registration without resorting to any face modeling. This means that data-driven methods in automatic expression analysis can compensate for the confounding effects like pose and physiognomy differences, and can process facial features more effectively, without suffering the drawbacks of model-driven analysis.

Our study is based upon Facial Action Coding System (FACS) as this paradigm is widely accepted to be capable of describing practically all types of human facial expressions and enables their systematic evaluations. Coding with FACS is done with Action Units (AUs) that are closely related with muscular activations. To validate the first hypothesis we develop person-independent detectors and intensity estimators of AUs, which use 2D maps of 3D facial surfaces. This approach enables us to compare 2D luminance modality with the 3D surface geometry data modality under the same set of algorithms. In addition, our detectors and estimators are free from biases of model-driven techniques to guarantee a fair assessment of the two modalities. For the second hypothesis, we first investigate non-rigid registration on 2D facial surface curvature maps. Our non-rigid registration algorithm is capable of handling large deformations and yet it is computationally efficient. To realize our second hypothesis we explore and develop AU detectors using this algorithm. Our work is the first example of detailed registration in data-driven expression analysis and surpasses the performance of state-of-the-art AU detectors.

PUBLICATIONS

Journal Papers

- 1) **A. Savran**, B. Sankur, M. T. Bilge, "Regression-based Intensity Estimation of Facial Action Units", *Image and Vision Computing*, invited paper, in review.
- 2) **A. Savran**, B. Sankur, M. T. Bilge, "Comparative Evaluation of 3D versus 2D Modality for Automatic Detection of Facial Action Units", *Pattern Recognition*, in press, 2011.

In Refereed International Conferences

- 1) **A. Savran**, B. Sankur, M. T. Bilge, "Estimation of Facial Action Intensities on 2D and 3D Data", *EUSIPCO*, Barcelona, Spain, 2011.
- 2) **A. Savran**, B. Sankur, M. T. Bilge, "Facial action unit detection: 3D versus 2D modality", *IEEE CVPR'10 Workshop on Human Communicative Behavior Analysis*, San Francisco, California, USA, 2010
- 3) **Savran, A.**, Sankur, B, "Automatic Detection of Facial Actions from 3D Data", *IEEE ICCV Workshop on Human Computer Interaction*, Japan, 2009

- 4) **Savran, A.**, Sankur, B., "Non-Rigid Registration of 3D Surfaces by Deformable 2D Triangular Meshes", *In Proc. IEEE CVPR Workshop on Non-Rigid Shape Analysis and Deformable Image Alignment*, Alaska, USA, 2008
- 5) **Savran, A.**, Alyüz, N., Dibekliolu, H., Çeliktutan, O., Gökberk, B., Akarun, L., Sankur, B.: Bosphorus Database for 3D Face Analysis. *In: First European Workshop on Biometrics and Identity Management Workshop (BioID 2008)*
- 6) Alyüz, N., Gökberk, B., Dibekliolu, H., **Savran, A.** Akarun, L., Sankur, B., *3D Face Recognition Benchmarks on the Bosphorus Database with Focus on Facial Expressions. In: First European Workshop on Biometrics and Identity Management Workshop(BioID 2008)*

In Refereed National Conferences

- 1) **A. Savran**, B. Sankur, "Detecting 3D Facial Action Units via Non-rigid Registration", IEEE Signal Processing and Communications Applications (SIU), Antalya, Turkey, April 2011.
- 2) M. Motro, **A. Savran**, B. C. Gönül, I. Oktay, Z. Güzel, N. Erverdi, B. Çakırer, B. Sankur, "3D Stereophotogrammetric Surface Registration and Cephalometric Assessment of Orthognathic Surgery", ACBID'10, Antalya, Turkey, May 2010.
- 3) **A. Savran**, B. Sankur, "Detecting Action Units On 3D Faces", IEEE Signal Processing and Communications Applications (SIU), Diyarbakır, Turkey, April 2010. (IEEE Second Best Student Paper Award, Alper Atalay Third Best Student Paper Award)
- 4) **A. Savran**, B. Sankur, "Elastic Registration of Noisy and Expression 3D Faces", IEEE Signal Processing and Communications Applications (SIU), Antalya, Turkey, April 2009.
- 5) **A. Savran**, B. Sankur, "A Comprehensive 3D Facial Expression Database and Its Elastic Registration", IEEE Signal Processing and Communications Applications (SIU), Didim, Turkey, April 2008.

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