3D Twins Expression Challenge

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1. Introduction

We describe the 3D Twins Expression Challenge ("3D TEC") problem in the area of 3D face recognition. The supporting dataset contains 3D scans of pairs of identical twins taken with two different facial expressions, neutral and smiling. The dataset is smaller than the FRGC v2 [1] dataset by approximately a factor of ten, but is still more challenging than the FRGC v2 dataset due to it containing twins with different expressions. This challenge problem will help to push the frontiers of 3D face recognition.

Three dimensional face recognition is an active research topic in biometrics [2, 3]. While 2D pictures can be captured quickly, non-intrusively, and easily by widely available cameras, the images are easily affected by variations in pose, lighting conditions, and facial expressions. 3D face recognition is less affected by pose, facial color variations, and illumination changes since the curvature and shape information of the face is available. Since 3D images offer additional information about the face, 3D images combined with 2D images should give better performance than either alone [4].

The best performance in 3D face recognition algorithms has become high enough in large datasets like FRGC v2 that it is difficult to achieve further significant increases in recognition performance. Two problems generally considered to be difficult are variations in expressions and distinguishing between faces of identical twins. We introduce the 3D TEC dataset which consists of 3D scans of 107 pairs of twins taken in a single session, with each subject having a scan of a neutral expression and a smiling expression. The combination of factors related to the facial similarity of identical twins and the variation in facial expression makes this a challenging dataset.

Recently, there have been some twins face recognition studies in biometrics research. Phillips et al. [5] assessed the performance of three of the top algorithms submitted to the Multiple Biometric Evaluation (MBE) 2010 Still Face Track [6] on a dataset of twins acquired at Twins Days [7] in 2009 and 2010. They examined the performance using images acquired in the same day, and also images acquired a year apart (i.e., where the face images acquired in the first year are gallery images and the face images acquired in the second year are probe images). They also examined the performance with varying illumination conditions and expressions. They found that results ranged from around 2.5% Equal Error Rate (EER) for images taken in the same day with controlled lighting and neutral expressions, to around 21% EER for gallery and probe images acquired in different years and in different lighting conditions.

Sun et al. [8] conducted a study on multiple biometric traits of twins. They found no significant difference in performance using non-twins compared to using twins for their iris biometric system. For their fingerprint biometric system, they observed that performance using non-twins was slightly better than using twins. Additionally, using their face biometric system, they could distinguish non-twins much better than twins.

2. The Dataset

The Twins Days 2010 dataset was acquired at the Twins Days Festival in Twinsburg, Ohio [7]. Phillips et al. [5] provides more details about the overall dataset. It contains 266 subject sessions, with the 3D scans in the dataset containing two scans taken using a range scanner: one with a neutral expression and another with a smiling expression. There are 106 sets of identical twins, one set of triplets, and the remainder were non-twins. Three pairs of twins came in for two recording sessions and everyone else only had a single session.

The 3D TEC subset of the Twins Days dataset consists of 3D face scans of 107 pairs of twins (two of the triplets were included as the 107th set of twins) where only the first session for each person was used. To our knowledge, this is the only dataset of 3D face scans in existence that has more

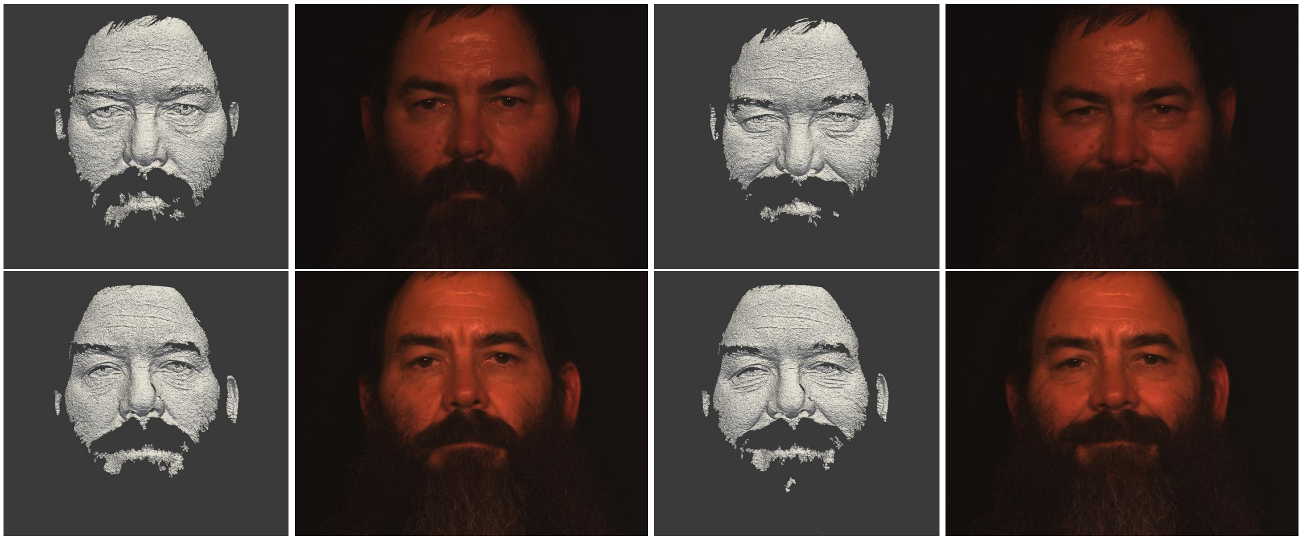

Figure 1: Images of two twins taken in a session. The top row shows the first twin and the bottom row, the second. (The texture images were brightened to increase visibility in this figure.)

than a single pair of twins.

The scans were taken with a Minolta VIVID 910 3D scanner [9] in a controlled light setting, with the subjects posing in front of a black background. For each pair of twins, their neutral and smile images were taken in a 5 to 10 minute window of time.

The Minolta scanner takes a texture image and a range image of 480×640 resolution. The telephoto lens of the Minolta scanner was used since it gives a more detailed scan. The distance of the scanner from the subject was approximately 1.2 m. A scan using the telephoto lens contains 70,000 to 195,000 points for the dataset, with an average of 135,000 points.

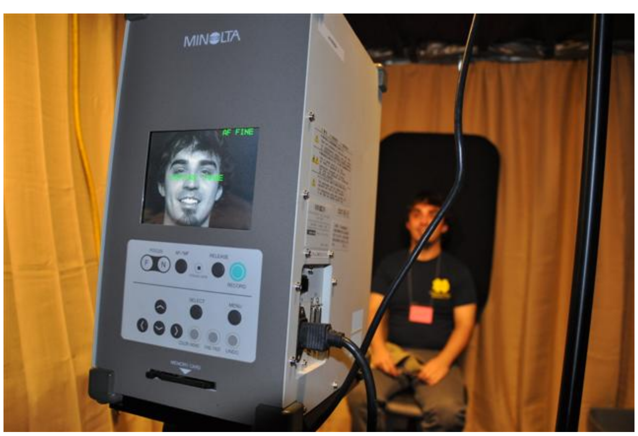

Figure 2: A recording session with the Minolta scanner at Twins Days.

No.	Gallery		Probe	
I	A Smile,	B Smile	A Neutral,	B Neutral
II	A Neutral,	B Neutral	A Smile,	B Smile
III	A Smile,	B Neutral	A Neutral,	B Smile
IV	A Neutral,	B Smile	A Smile,	B Neutral

Table 1: List of experiments performed. "A Smile, B Neutral" means that the set contains all images with Twin A smiling and Twin B neutral.

3. Experimental Design

The experimental design is as follows. For each pair of twins, one person is labeled as Twin A and the other as Twin B. The four verification and identification experiments are run using the gallery and probe sets shown in Table 1.

Experiment I has all of the images with a smiling expression in the gallery and the images with a neutral expression as the probe. Experiment II reverses these roles. This models a scenario where the gallery has one expression and the probe has another expression. In the verification scenario, both the match and non-match pairs of gallery and probe images will have different expressions. In the identification scenario, theoretically the main challenge would be to distinguish between the probe's image in the gallery and his twin's image in the gallery since they look similar.

Experiment III has Twin A smiling and Twin B neutral in the gallery with Twin A neutral and Twin B smiling as the probe. Experiment IV reverses these roles. This models a worst case scenario in which the system does not control for the expressions of the subject in a gallery set of twins. In the verification scenario, the match pairs would have opposite expressions like in Experiments I and II but the non-match pairs which are twins would have the same expression. In the identification scenario, theoretically the main challenge would be to distinguish between the probe's image and his twin's image in the gallery. This is more difficult than Experiments I and II since the probe's expression is different from his image in the gallery but is the same as his twin's image in the gallery.

Algorithms are evaluated by performing verification and identification experiments using each of the four pairs of gallery and probe sets. Performance is evaluated using the following characteristics: True Accept Rate at 0.1% False Accept Rate (TAR at 0.1% FAR), Equal Error Rate, and Rank 1 Recognition Rate. Receiver Operating Characteristic (ROC) curves can also be used to visualize the performance of the face recognition algorithms.

Note that the 3D TEC dataset is "same session" data, meaning that there is essentially no time lapse between the image used for enrollment and the image used for recognition, meaning that any performance estimates from this data are biased to exceed those that can be expected in any practical application.

4. Conclusion

Performance evaluations on the 3D TEC dataset have already been conducted using 3D face recognition algorithms by the Computer Vision Research Lab in University of Notre Dame, Computational Biomedicine Lab in University of Houston, LIRIS in Universite de Lyon, and the Machine Vision Lab in University of the West of England.

The three groups outside of Notre Dame were readily able to complete the license agreement for the dataset (available at [10]), complete the rsync transfer of the dataset, run their algorithms on the dataset, and produce the performance metrics proposed for the challenge. This demonstrates that the basic infrastructure for the challenge has been successfully worked out and is appropriate for use by a broad range of institutions.

The FRGC v2 3D face dataset has been widely used, and various research groups have achieved high performance using it. The best reported performance has become high enough that it is difficult to achieve further significant increases in performance. The 3D TEC dataset presents a challenge, using a substantially smaller dataset.

5. Acknowledgements

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