C6 How Accurate is 3D Facial Morphology for Personal Identification?

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After attending this presentation, attendees will be acquainted with the principles of computer-aided personal identification using 3D records of human faces, its technical and methodological imperfections, and novel modifications proposed to currently available algorithms.

This presentation will impact the forensic science community by providing insight into current state-of-the-art forensic facial identification and by introducing novel approaches designed specifically for forensic purposes, developed using the 3D Virtual Model Database of Human Faces.

The increasing accuracy of sensors used for capturing human faces together with advances in computer graphics and vision have had a great impact on the quality of images that are being admitted for forensic examinations. Matching image-based forensic evidence from crime scenes (surveillance videos) with suspects (mug shots, ID photographs) is known to be highly dependent on the image quality, optical distortion, perpetrator's head position, or disguise. Therefore, in many forensic cases, automatic computer-aided systems for facial recognition are of little use as they fail to provide positive (i.e., to identify a person), or negative (i.e., to eliminate a person) results. Currently, new development in 3D technologies has offered solutions to overcome these key limits by allowing 2D-to-3D and 3D-to-3D digital record matching.

Despite that fact that 3D video surveillance systems are being developed and are expected to be widespread in the near future, so far there has not been sufficient scientific evidence on how accurate and reliable it is to utilize 3D records of human faces for the purpose of forensic identification or whether matching 3D digital evidence meets legal requirements that demand the use of quantifiable scientific methods with known error rates. 3D human faces are generally captured by a variety of in-lab equipment — laser- or stereophotogrammetry-based devices, which eventually generate plain or textured photorealistic 3D meshes. Processing and matching two or multiple 3D surface meshes is a challenging task which requires a proper alignment algorithm together with appropriate numerical and visual representations. There are a number of existing algorithms and metrics, such the Iterative Closest Point (ICP) for aligning two surface datasets or Haussdorff distances for quantifying actual distances between two aligned meshes. In addition, surface-based visualization technique is commonly performed using colormaps and scalar fields.

The present research tested the currently available algorithms for matching 3D faces using a dataset sampled from a large database of high-resolution 3D scans — the 3D Virtual Model Database of Human Faces. This study established a stripped version available throughout the project website; the database contains approximately 2,000 scans acquired for a variety of reasons — studies of individual and age-related human variation, growth and development studies, parent-to-offspring resemblance, etc. Specifically, it contains both subadult and adult individuals scanned repeatedly under controlled and semi-controlled conditions as well as those composing a large reference sample of non-matching individuals at a population level.

To improve the matching process, available algorithms were modified by introducing an iterative process of successive improvement of the average face sped up with KD-trees which allows a better alignment of 3D meshes when a multiple comparison is launched. The magnitude of dis/similarity among aligned meshes was expressed by signed and absolute Haussdorff distances (i.e., the greatest of all the distances from a vertex in reference mesh to the vertex in the compared one and further extended to incorporate vertex to polygon and inter-polygon distances).

The results show that all modifications to the tested algorithms proved to be useful for further development of a forensic 3D facial identification system; however, there are a number of other issues of computational and technical nature that need to be addressed in order to acquire high-match scores in same-person comparison. The purpose of this presentation is to present the issues to the forensic community.

Facial Comparison, 3D Surface Data, 3D Database