D26 Novel Method for 3-D Biometric Face/Head Total and Partial Comparison Through Scanner-Invariant Slicing

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The goal of this presentation is to present new theory and algorithm for 3D based face/head comparison.

This presentation will impact the forensic science community and/or humanity by extending the understanding of the state of the art 3D based techniques for biometric identification and comparison.

The classical techniques to compare 3-D surface-shapes are either exploit numerical, e.g., least-square, matching of surface shapes[1], or the 3- D data is matched through registration of "landmarks," which are "meaningful loci that can be unambiguously defined and repeatedly located with a high degree of accuracy and precision."[2] These methods may be classified as a "local" 3-D registration techniques, since they are based on point-to-point comparison cumulative metrics. Most recently a new class of 'global' 3D shape comparison methods was pioneered in[3], which is based on comparison of coordinate-system invariant geodesic curves that connect pairs of surface points. The main advantage of this method is that under surface deformations which are area-preserving, the minimal length geodesics do not change. Thus it opens up a possibility to 'expression- invariant' face matching, as long as there is no shortening or stretching of the facial surface (as in opening and closing the mouth).

Neither of the above techniques is invariant with respect to the corresponding 3-D scanning method and machine which is used in collecting the 3-D data. It is well known that the scanning apparatus is capable of introducing 3-D shape variations that are at least affine in nature. For example surface areas can get stretched and skewed. Therefore it is desirable to have a method that does not depend on the chosen 'extrinsic' coordinate system and is at least affine-invariant. Similarly, there is a need for a 'partial' comparison method that is able to identify matching shape parts, even if the rest of the shape is missing or distorted.

In this presentation, the theory for and demonstrate implementation of the new method for the matching and partial comparison of 3-D biometric Face/Head scanned data is proposed. The main idea is to "dissect" the 3-D shape of Face/Head 3-D scan into "invariant" slices. If such coordinates invariant slicing can be performed, the resulting "slice-curves" turn out to be also invariant, i.e., independent from affine transformations due to the scanner, and are independent of the selected coordinate system, which may vary for each scan, and each scanner. Then using affine-invariant methods of curve comparison, a matching criterion can be established for a whole or a part of the 3-D shape. The original affine-invariant 3-D surface-shape registration method was proposed by authors in.[4,5] It is based on a fundamental principle that geometric tangency is preserved by affine transformations, e.g., by zooming and skewing. Once the slicing curves are determined, the tangency condition can be used again on the 2-D "sub- manifolds" of curves. This results in parsing the 'slicing' curves into affine- invariant line-elements, which then can be coded and compared.

The traditional 3-D face matching methods will fail when very little 3-D complexity is present in the shape. Initially, the computational performance and stability of our method on the 3-D scanned database of "doll-heads" with affine variation of scanning parameters will be demonstrated. The significance of the doll-head bench mark data is that the examined shapes have very few significant 3-D features and no macro- textural information, unlike human faces which sometimes are easier to distinguish just by correlating local shape information. Several comparison examples with human Face/Head 3-D scans are also presented.

Furthermore, the 3D data are exploited to numerical matching of two surface shapes. The difference of two shapes are also visualized.

References:

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3D Shapes, Shape Comparison, Scanner Invariant Slicing

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