D16 Accurate Forensic Video Superimposition Through Computational 2-D to 3-D Multi-View Registration (Towards Computational Techniques for ImageShape Based Cranial/Facial Comparison)

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The goal of this presentation is to build a rigorous mathematical formulation for scientific computational methods of Shape-to-Image comparisons, for shapes approximating human head/face; provide accurate Forensic Video Superimposition through Computational 2-D to 3-D MultiView Registration; and to provide mathematical analysis of the sources and estimates of errors.

This presentation will impact the forensic community and/or humanity by providing new computational methods for Image-Shape based Cranial/Facial comparisons, which can be used in the forensic process of Virtual Superimposition, with the critical shape (head/ skull) anglesposition parameters estimated automatically, thus introducing the smallest possible error. In addition, this method enables comparison between individuals head/face captured on a video sequence, to a database of prior scanned 3-D head/face shapes for known individuals, thus enabling a Virtual Line-up comparison. Mathematical analysis of the sources and effect of error in 2-D to 3-D registration process, may help to establish the boundaries for the acceptance-rejection identification decisions.

Video Superimposition techniques are used by forensic scientists to assist in identification of unknown skulls, through comparison with antemortem photographs of individuals. The critical variables that determine accuracy of this comparison process are geometrical quantities: orientation, scale, and comparison features. There is no statistical or mathematical theory that estimates accuracy and error of the above experimental procedure. In fact it is not known if some features (landmarks) are more stable than other to be used in the matching process. If several photographic views are available, or a recorded video sequence of the individual in question exists, the straight forward and profile views are considered more reliable, since the oblique views are 'difficult to match'. Analysis of the superposition consists in estimating resulting concordance of anthropometric features and regions of the re-projected skull-tophoto blended image. Here, again, there are no rigorous criteria for estimating the degree of match. Rather, a qualitative comparison ranking is practiced to state the degree of similarity or dissimilarity between the shape of the skull and the photographic image examined. Thus the superimposition technique is mostly used as a non-quantitative exclusionary tool, and not for positive identification or rejection.

Recent advances in 3-D scanning technology introduced portable, and reasonably accurate 3-D laser scanning cameras that can be used to extract 3-D shape of objects, including skulls and human heads/ faces. This also opens a possibility to compare photographs and face/head shapes for living subjects, where the solid 3-D model will be used instead of the human skull. A mathematical matching procedure can be formulated to 'match' a single view, or a sequence of views, to the scanned model.

The author proposes to reformulate the problem of Video Superimposition as a 2-D to 3-D Registration task where single or multiple views of the same individual are registered to a set of a prior known solid head/face models. This registration process shall be invariant to orientation and scale, thus resolving this above-mentioned basic problem of manual Video Superposition. If only a single view is available, and if the comparison features to be matched are reduced to a set of 2-D and 3-D points, we apply relatively straightforward least-square algorithm. If a sequence of views (as in video) is available, we describe results of a novel multi-frame *coupled* algorithm that yields optimal mapping of all the available views (e.g. from video frames) onto the 3-D model.

The above registration process may yield optimal match (minimal optimization error) for several 3-D candidates' models. The question however remains: does the examined 3-D model "fit or misfit' the image view (or the sequence of image views)? The outcome of this will determine if possible identification or exclusion of the subject is obtained. To have some progress in this last question, a study of structure is proposed, rather than size of the error function. The proposed method will enable search/ comparison of the head/face images of individuals with respect to a database of 3-D face/head scans, thus making images of humans as useful as fingerprints databases are.

Image to 3-D Shape Registration, Virtual Line-Up, Automatic Computational Superimposition

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