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Measuring Fluctuating Asymmetry in Human Faces Using High-Density 3D Surface Scans

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Abstract : Fluctuating asymmetry (FA) has been studied for many years as an indicator of developmental stability or 'genetic quality' based on the assumption that perfect symmetry is ideally the expected outcome for a bilateral organism. Further studies have also investigated the possible link between FA and attractiveness or levels of masculinity or femininity. These hypotheses have been mostly examined using 2D images, and the structure of interest is usually presented using a limited number of landmarks. Such methods have the downside of simplifying and reducing the dimensionality of the structure, which will in return increase the error of the analysis. In an attempt to reach more conclusive and accurate results, in this study we have used high-resolution 3D scans of human faces and have developed an algorithm to measure and localize FA, taking a spatially-dense approach. A symmetric spatially dense anthropometric mask with paired vertices is non-rigidly mapped on target faces using an Iterative Closest Point (ICP) registration algorithm. A set of 19 manually indicated landmarks were used to examine the precision of our mapping step. The protocol's accuracy in measurement and localizing FA is assessed using simulated faces with known amounts of asymmetry added to them. The results of validation of our approach show that the algorithm is perfectly capable of locating and measuring FA in 3D simulated faces. With the use of such algorithm, the additional captured information on asymmetry can be used to improve the studies of FA as an indicator of fitness or attractiveness. This algorithm can especially be of great benefit in studies of high number of subjects due to its automated and time-efficient nature. Additionally, taking a spatially dense approach provides us with information about the locality of FA, which is impossible to obtain using conventional methods. It also enables us to analyze the asymmetry of a morphological structures in a multivariate manner; This can be achieved by using methods such as Principal Components Analysis (PCA) or Factor Analysis, which can be a step towards understanding the underlying processes of asymmetry. This method can also be used in combination with genome wide association studies to help unravel the genetic bases of FA. To conclude, we introduced an algorithm to study and analyze asymmetry in human faces, with the possibility of extending the application to other morphological structures, in an automated, accurate and multi-variate framework.

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