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What's in a Smile? Initial Analyses of Dynamic Changes in Facial Shape and Appearance †

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Abstract: Single-level principal component analysis (PCA) and multi-level PCA (mPCA) methods are applied here to a set of (2D frontal) facial images from a group of 80 Finnish subjects (34 male; 46 female) with two different facial expressions (smiling and neutral) per subject. Inspection of eigenvalues gives insight into the importance of different factors affecting shapes, including: biological sex, facial expression (neutral versus smiling), and all other variations. Biological sex and facial expression are shown to be reflected in those components at appropriate levels of the mPCA model. Dynamic 3D shape data for all phases of a smile made up a second dataset sampled from 60 adult British subjects (31 male; 29 female). Modes of variation reflected the act of smiling at the correct level of the mPCA model. Seven phases of the dynamic smiles are identified: rest pre-smile, onset 1 (acceleration), onset 2 (deceleration), apex, offset 1 (acceleration), offset 2 (deceleration), and rest post-smile. A clear cycle is observed in standardized scores at an appropriate level for mPCA and in single-level PCA. mPCA can be used to study static shapes and images, as well as dynamic changes in shape. It gave us much insight into the question "what's in a smile?".

Keywords: multilevel principal components analysis; shape and image texture; facial expression

1. Introduction

Human faces are central to our identity and they are important in expressing emotion. The act of smiling is important in this context and the exploration of facial changes and dynamics during the act of smiling [1,2] is an ongoing topic of investigation in fields of research in orthodontics and prosthodontics, both of which aim to improve the function and appearance of dentition. Aesthetics (e.g., of smiles [3]) are therefore an important aspect of these fields. Much research into the "science of a smile" also focuses on the effects of aging and biological sex on the shape and appearance [4,5] and also the dynamics [6–8] of smiling. Recent investigations have been greatly enhanced by the use of three-dimensional (3D) imaging techniques [9–13] that allow both static and dynamic imaging