# General Human Traits Oriented Generic Elastic Model for 3D Face Reconstruction

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We propose a *Simplified Generic Elastic Model (S-GEM)* which intends to construct a 3D face from a given 2D face image by making use of a set of general human traits viz., *Gender, Ethnicity and Age (GEA)*. We hypothesise that the variations inherent on the depth information for individuals are significantly mitigated by narrowing down the target information via a selection of specific GEA traits. In this paper, we propose a 3D reconstruction method to retain the robustness of the PCA-based models and in the meantime to provide control over the depth values of 2D facial feature points. We formulate the reconstruction of the 3D face model of a given 2D face image as a posterior estimation of the PC coefficients $\Phi$ given the observations of the 2D facial feature points $x_f$. The depth value $Z$ of the 2D feature points is expressed as the hidden information. The posterior probability is represented as the marginal distribution of $P(\Phi|\boldsymbol{x}_f)$ integrated over $Z$ as shown below:

$$P(\Phi|\boldsymbol{x}_f,\Delta) \propto \sum_{Z_f} P(\Delta|\boldsymbol{x}_f,Z_f)\cdot P(\boldsymbol{x}_f,Z_f|\Phi)\cdot P(\Phi) \tag{1}$$

where $\boldsymbol{x}_f$ represents the $x$ and $y$ coordinates of the 2D input feature points, $\Delta$ represents the corresponding GEA group and $Z_f$ represents the hidden $Z$ values of the 2D input feature points. Also, $\boldsymbol{x}_f$ and $\Delta$ are the observed variables in this representation. Based on the Bayesian theory, $P(\Delta|\boldsymbol{x}_f,Z_f)$ can be written as,

$$P(\Delta|\boldsymbol{x}_f,Z_f) = \frac{P(\boldsymbol{x}_f,Z_f|\Delta)P(\Delta)}{\sum P(\boldsymbol{x}_f,Z_f|\Delta)P(\Delta)} \tag{2}$$

$P(\boldsymbol{x}_f,Z_f|\Delta)$ is defined using simplified mixture model. The proposed S-GEM method was compared with the PCA-TR method [1] and a method of utilising the Z-coordinates of the model mean-face feature points (we name it M-GEM). M-GEM is chosen for comparisons as it is based on the same principle of the popular GEM model[2], i.e., using the model mean face depth value to represent any individual face depth. The results in Figure 1 shows that the proposed S-GEM method has produced the least MSE out of the three methods in terms of the full 3D face shapes. Figure 2 shows the outputs of the newly reconstructed 3D face models using proposed S-GEM.

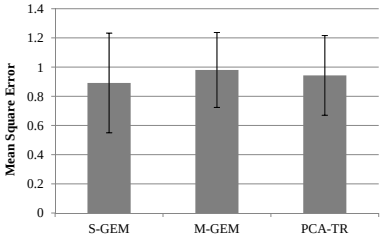


Figure 1: Empirical test of the proposed method (S-GEM), M-GEM and PCA-TR.

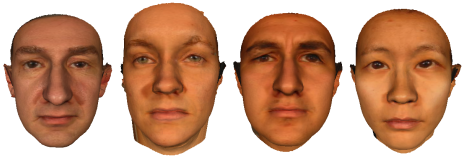

Figure 2: Outputs of the newly reconstructed 3D face models using proposed S-GEM.

[1] AY Maghari, Ibrahim Venkat, Iman Yi Liao, and Bahari Belaton. PCA-Based Reconstruction of 3D Face Shapes using Tikhonov Regularization. International Journal of Advances in Soft Computing and its Applications , 5(2):1-15, 2013.
[10] Jingu Heo. 3D Generic Elastic Models for 2D Pose Synthesis and Face Recognition, 2009.