Turn That Frown Upside Down: Analysis and Detection of Facial Expressions using Geometric Morphometrics

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Introduction

Facial expressions are a universal form of body language. Slight changes in the mouth or eyes can indicate how a person is feeling. The goal of this project was to detect these changes using Geometric Morphometrics.

Geometric Morphometrics is the statistical analysis of the geometry of organisms. Such statistical analysis was used to determine the differences between faces making happy versus unhappy expressions.

Methods

1. 2d Data Landmarks

Using tpsDig2, 14 landmarks were created for each face specimen to be used for analysis. The inner and outer corners of the eyes, the ends and arch of the eyebrows, the center edge of the top and bottom lip, and the outer corners of the mouth were used as landmarks.

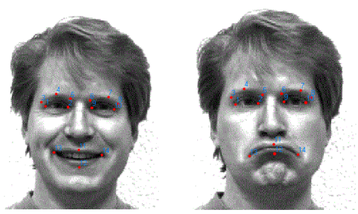

Fig. 1 Data Landmarks shown on a "happy" trial face and an "unhappy" trial face.

2. Generalized Procrustes Analysis

After reading in the 2d landmark data into R, a Generalized Procrustes Analysis was performed. GPA translates, scales, and rotates specimens using least-squares criterion until corresponding points align as closely as possible. The resulting coordinates represent the shape of each specimen.

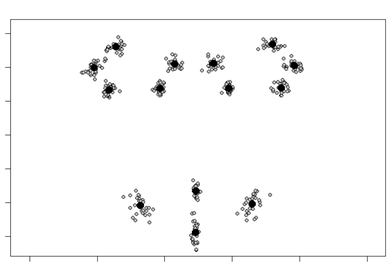

Fig. 2 Coordinates of each specimen after Generalized Procrustes Analysis.

3. Procrustes ANOVA

The Procrustes ANOVA function assesses statistical hypotheses describing patterns of shape variation. The shape variation in this case was attributed to a pre-determined factor, "happy" or "unhappy" for each specimen. The results indicated this was significant to shape variation.

	df	SS	MS	Rsq	F	P.val
faces_emotion	1	0.040987	0.040987	0.22388	8.0769	0.01
Residuals	28	0.142088	0.005075			
Total	29	0.183075	0.006313			

Fig. 3 Results from Procrustes ANOVA. P-value of 0.01 indicates significance.

4. Pairwise Group Comparisons

After significant shape variation by a grouping factor has been identified, a pairwise comparison is done. This test calculates Euclidean distances from group means, also known as Least Squares group means. This data is used to determine which group the unknown face is closest to.

Fig. 4 Results from Pairwise Comparison. Distance from Unknown to "Happy" is shorter than the distance to "Unhappy".

$Obs.dist

	Happy	Unhappy	Unknown
Happy	0.0000000	0.0739252	0.1095096
Unhappy	0.0739252	0.0000000	0.1133530
Unknown	0.1095096	0.1133530	0.0000000

5. Principal Components Analysis

Performs a PCA of shape variation and plots the 2d tangent space of Procrustes-aligned specimens. Deformation grids of the specimens at the ends of the range of variability are displayed. Specimens from different groups are plotted using specific colors.

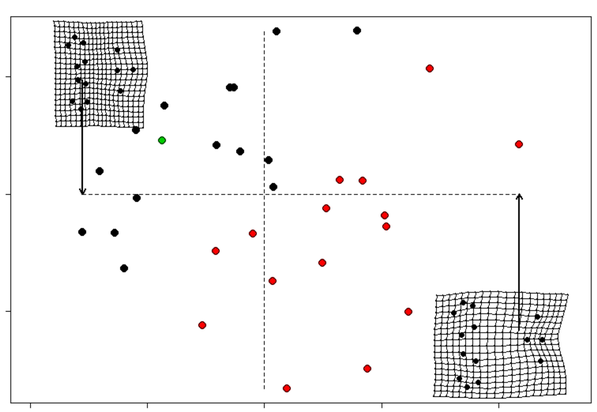

Fig. 5 2d tangent space of Procrustes-aligned specimens with deformation grids. "Happy" faces are plotted in black, "unhappy" faces are plotted in red, and the "unknown" face is plotted in green.

The average PC1 and PC2 values are calculated for the "happy" and "unhappy" Procrustes-aligned specimens. Then, the Euclidean distance between the unknown face and the average values for each expression are compared to determine which group the unknown face is closest to.

Conclusions

The unknown face is determined as "happy" or "unhappy" after analysis from the Pairwise Group Comparisons and Principal Components Analysis.

Fig. 6 Test face was detected as "happy" after analysis

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Based on the Pairwise comparison, the unknown face is happy
Based on the Principal Components Analysis, the unknown face is happy
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Of the 15 test faces used, 100% of them were detected as the correct facial expression for both tests. Test faces were used from different databases than the trial faces, so scaling was necessary for accurate results.

These techniques can be used to detect changes in expressions for a series of purposes, such as customer service and product review.

Acknowledgements and Citations

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