# Improved Automatic Caricature by Feature Normalization and Exaggeration

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## 1 Introduction

This sketch presents an improved formalization of automatic caricature that extends a standard approach to account for the population variance of facial features. Caricature is generally considered a rendering that emphasizes the distinctive features of a particular face. A formalization of this idea, which we term "Exaggerating the Difference from the Mean" (EDFM), is widely accepted among caricaturists [Redman 1984] and was first implemented in a groundbreaking computer program by [Brennan 1985]. Brennan's "Caricature generator" program produced caricatures by manually defining a polyline drawing with topology corresponding to a frontal, mean, face-shape drawing, and then displacing the vertices by a constant factor away from the mean shape. Many psychological studies have applied the "Caricature Generator" or EDFM idea to investigate caricature-related issues in face perception [Rhodes 1997].

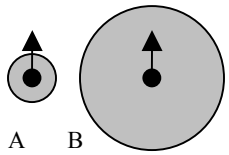


Figure 1: features A and B are moved the same distance from their means, but when their distribution is considered, A is distinctive whereas B is not.

However, the EDFM method may not produce the best caricatures. As shown in Fig 1, the distinctiveness of a displaced feature not only depends on its distance from the mean, but also its variance (shown as circles in the figure). For example, the width of the mouth is much more widely distributed than the width of eyes. Thus, a mouth 2cm wider than the mean may still look normal, whereas eyes 2cm wider than the mean will be very distinctive. In the EDFM method, however, both the mouth and eye width will be emphasized by a same factor because their DFMs (Difference-From-Mean) are the same.

This sketch describes a method to produce caricatures based on both feature DFMs and feature variance.

## 2 Method

Three-hundred frontal faces from the FERET database were selected as training examples to learn a "face space"; on each face, 94 points were hand-labeled to represent the shape. A 188x300 shape matrix $S$ is constructed, a column of which consists of $x$ and $y$ coordinates of a training shape. Non-negative matrix factorization [Lee and Seung 1999] is applied to the $S$ to learn the face space dimensions:

$$S = F * E$$

Each dimension consists of a basis vector $\boldsymbol{f}_i$ (the $i$-th column of matrix $F$) and its distribution (expectation $m_i$ and standard deviation $\sigma_i$ of the $i$-th row in matrix $E$). Each dimension represents an abstract facial feature.

Now given a new face photograph, the shape $\boldsymbol{s}$ can be automatically located with an Active Appearance Model in some cases (frontal face, simple lighting). If the AAM fails, the shape points are manually placed, which takes several minutes at most. The shape $\boldsymbol{s}$ is then represented in the face space as a non-negative linear combination of the basis vectors and a residual:

$$\vec{s} = \sum_i e_i \cdot \vec{f}_i + \vec{r} = \sum_i (m_i + \delta_i) \cdot \vec{f}_i + \vec{r}$$

The shape is exaggerated by scaling the DFM by a factor $k$ on the dimensions where $|\delta_i| = |e_i - m_i|$ is larger than $2 \cdot \sigma_i$:

$$\vec{s}' = \sum_i (m_i + t_i \cdot \delta_i) \cdot \vec{f}_i + 0.5 \cdot k \cdot \vec{r}$$

We set $t_i$=1 if $|\delta_i| < 2 \cdot \sigma_i$ and $t_i$=$k$ if $|\delta_i| \geq 2 \cdot \sigma_i$. The residual $\boldsymbol{r}$ may consist of distinctive features that cannot be represented in the face space and/or noise; thus, $\boldsymbol{r}$ is also exaggerated, but with a reduced scale.

A photo-realistic caricature is produced by image warping from original shape $\boldsymbol{s}$ to the exaggerated shape $\boldsymbol{s}'$. Further applying Non-Photorealistic Rendering techniques generates a stylized line-drawing caricature. Some results are shown in Fig 2.

Figure 2: results. Left, original faces; middle, photorealistic caricatures; right, stylized caricatures.

## References

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