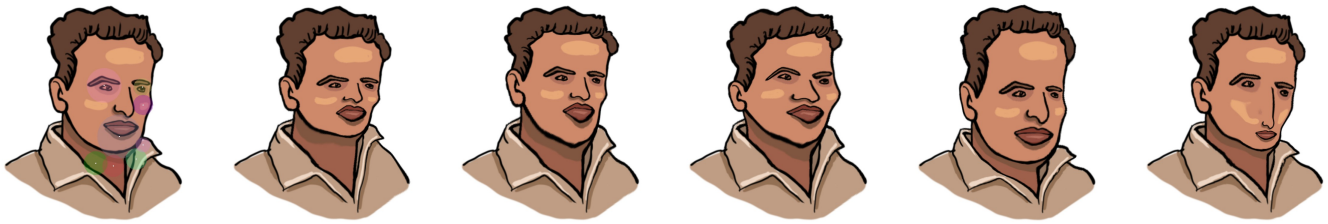
Caricature Creation with Conformal Mapping in Complex Domain

Ergun Akleman
Departments of Visualization & Computer Science and Engineering, Texas A&M University
College Station, Texas, USA
ergun.akleman@gmail.com

Bekir Tevfik Akgun
Department of Computer Engineering, Istanbul Okan University
Istanbul, Turkey
akgunbt@gmail.com



(a) Original Image (b) Exaggeration 1 (c) Exaggeration 2 (d) Exaggeration 3 (e) Exaggeration 4 (f) Exaggeration 5

Figure 1: *We can obtain significantly exaggerated facial features without getting grotesque results since we guarantee to preserve angles with maps defined in complex domain.*

ABSTRACT

Caricature is an art form of exaggeration of features [Akleman 1997; Akleman et al. 2000; Akleman and Reisch 2004; Brennan 1985; Klare et al. 2012; Liang et al. 2002]. An important property of feature exaggeration is that it is not deformation. By deforming features we can obtain funny looking portraits, however the resulting features will not look exaggerated. In this work, we present an approach for extreme exaggeration of facial features to obtain caricature effect. Our approach is based on the well-known conformal property of maps in complex domains. Namely, any map in a complex domain is angle preserving, which is crucial for caricature generation. Without angle preservation, the maps can result in deformations that look funny or grotesque, but not caricature. We have developed a particular mapping in a complex domain and show that we can obtain a wide variety of faces starting from any illustration (or photograph) of a human face.

CCS CONCEPTS

• **Computing methodologies** → **Non-Photorealistic Rendering**.

KEYWORDS

Caricature, Conformal Mapping, Angle Preserving Transformations, Non-Photorealistic Rendering, Image Processing

SIGGRAPH '21 Posters, August 09-13, 2021, Virtual Event, USA

ACM ISBN 978-1-4503-8371-4/21/08.
https://doi.org/10.1145/3450618.3469149

ACM Reference Format:
Ergun Akleman and Bekir Tevfik Akgun. 2021. Caricature Creation with Conformal Mapping in Complex Domain. In *Special Interest Group on Computer Graphics and Interactive Techniques Conference Posters (SIGGRAPH '21 Posters), August 09-13, 2021.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3450618.3469149

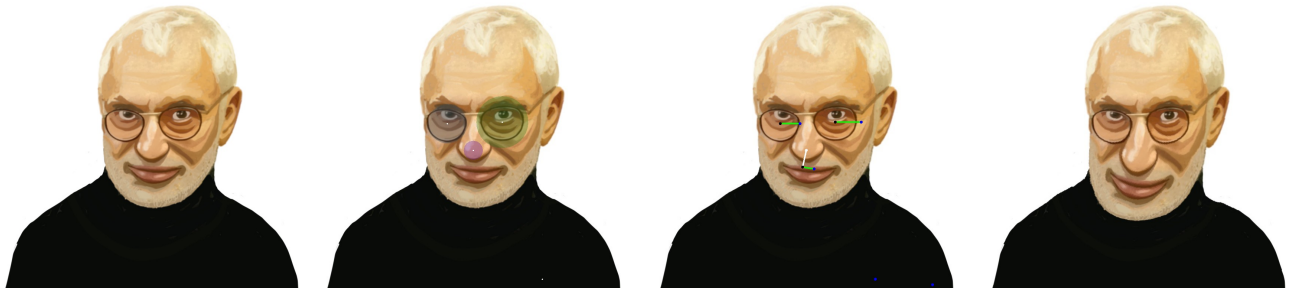
1 EXTENDED ABSTRACT

An important problem with caricature generation is that using some deformation tool, users need to be very careful to control results [Akleman 1997; Akleman and Reisch 2004; Brennan 1985]. There is, therefore, a need for a simple exaggeration tool that can guarantee to obtain acceptable deformation. In this work, we propose that conformal maps are suitable for caricature generation since they can preserve angles. The good news is that any analytical mapping in complex domain is naturally conformal. Such complex domain transformations has been used by mathematician to obtain droste effect that is inspired by a drawing of Maurits Cornelis Escher, called "Print Gallery" [de Smit et al. 2005; Leys 2007]. Unfortunately, these are creatively designed maps that are useful for specific purposes. Complex domain is also used in Computer Graphics to obtain controlled deformation [Weber et al. 2011; Weber and Gotsman 2010]. In this work, we have developed a new method to obtain controllable conformal maps in complex domain. Our goal is to obtain a kind of the control a caricaturist wants such as making the nose bigger or making the lips smaller without deforming local regions.Our results suggest that it is possible to easily obtain a large variety of faces from any given drawing or photographs.

A transformation in complex space can be represented as

$$z' = F(z)$$

where z' and z are complex numbers and F is an analytical function. An important property of these type of transformations is that



(a) Original Image (b) Circle Control Regions (c) Manipulating control regions (d) Transforming circles

Figure 2: *We can obtain significantly exaggerated facial features without getting grotesque results since we guarantee to preserve angles with maps defined in complex domain. By moving, resizing and rotating circle control regions, we can convert one face into a completely different face. This is useful in the sense that we can obtain wide variety of characters from the same illustration or photograph.*

they naturally preserve angles. Note that since the function F is analytical function, we can simply extend it to Taylor series around any given complex number z_0, the first two terms gives us an affine approximation as follows:

$$F(z) \approx F(z_0) + \frac{dF(z_0)}{dz}(z - z_0)$$

Note that function and its derivative at z_0 are also complex numbers. Let $a = F(z_0)$ and $b = \frac{dF(z_0)}{dz}$ denote the two complex numbers then it becomes easier to see affine equation as follows:

$$F(z) \approx a + b(z - z_0)$$

where a is translation and b is rotation and scaling around z_0. Note that since b is a complex number it can be rewritten as $b = re^{i\theta}$ where r is uniform scaling and θ is amount of rotation. The key idea here r does only provide uniform scaling in every direction. That is the reason that angle is preserved with transformations that are given by analytical functions on complex space. This is useful information, for practical purposes we should be able to design our transformations for simple interface.

Let a set of local transformations are given as an affine function in complex space as follows

$$F_n(z) = a_n + b_n(z - z_n).$$

For the design of analytical function, our goal is to construct a function that behaves like $F_n(z)$ in a region that is close proximity of z_n. In computer graphics, we have already many Barycentric algebra based solutions to this problem as a weighted average of control functions $F_n(z)$ as follows:

$$F(z) = \sum_{n=0}^{N} w_n(z) F_n(z)$$

where $w_n(z) \geq 0$ for all z and $\sum_{n=0}^{N} w_n(z) = 1$. It is easy to design these weights using always positive functions. In this case, we compute weights using a form of Gaussian function as follows

$$W_n(z) = e^{D(z)}$$

where

$$D_n(z) = 1 - \frac{(z - z_n)(z - z_n)^*}{r_n^2}.$$

Then $w_n(z)$ computed as follows:

$$w_n(z) = \frac{w_n(z)}{\sum_{n=0}^{N} w_n(z)}$$

In this formula, z_n and r_n defines the center and radius of a circular region of influence for the transformation n. Note that the resulting function is derivative continuous everywhere.

This particular type of analytical functions provides a simple interface. We simple draw a set of circles and we resize and rotate them to define local affine transformations (See Figures 1 and 2). Only a few number of circles are sufficient to control obtain desired results. Because of angle preserving property, most results turn out to be acceptable. Note that in practice we use inverse transformation, however, the inverse transformation is not the inverse of the forward transformation. It is simple designed in the form of $z = F(z')$, using the same method of function design.

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