# An Artistic Portrait Caricature Model

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**Abstract.** We present a new model for artistic portrait caricature modeling and rendering. It is composed of a caricature model and a rendering system. The computer portrait caricature is based on an exaggeration of the face features depending on measures realized on the head. A canon provides "golden proportions" to idealize adult male or female head. According to automatic measures realized on a 3D head mesh, the model produces a new deformed mesh. Using the deformed mesh, the renderer produces images in real-time with an hand-like line drawing style.

***Keywords:*** *Mesh deformation, Non-Photorealistic rendering, hand-like line drawing.*

## 1 Introduction

Artistic portrait and moreover caricature are new topics of Non-Photorealistic Rendering[1]. Perkins[2] defines a caricature as a symbol that exaggerates measurements relative to any measure which varies from one person to another.

### 2.1 Craniofacial anthropometry and artistic aesthetic ideals

Craniofacial anthropometry involves measurement of the skull and face. Generally, some particular points of the head are used, measures are realized and compared to anthropometric landmarks[7]. This can be used in medicine to prevent and treat assymmetries for example. Artists use generally a grid system named **canon** and **rules** which provide "golden proportions" to idealize adult male or female head. But they were not intented to represent typical cranonical morphology (some of these do not exist in normal head face). As this paper deals with caricature portrait, we focus on artistic aesthetic ideals. We propose a caricature model based on a canon.

### 2.2 The canon

A canon can be viewed as a set of rules which determinate the proportion of the face. It produces a gird system. In our canon, the head is delimited by a bounding box. Vertically, we compute the distance, named $d_h$, which is equal to 2/7 of the head height. Idealy, starting from the bottom of the bounding box:

- the lower lips is at a distance equal to $\frac{1}{2} \times d_h$,
- the lower part of the nose is at a distance equal to $d_h$,
- the top of the eyes, the bottom of the eyebrows and the top of the ears are at a distance equal to $2 \times d_h$
- the top of the forehead is at a distance equal to $3 \times d_h$.

Horizontally, we compute the distance, named $d_v$, which is equal to 2/5 of the head width. Idealy, starting from the right of the bounding box:

- the left limit of the left eye is at a distance equal to $\frac{1}{2} \times d_v$,
- the right limit of the left eye is at a distance equal to $d_v$,
- the center of the nose is at a distance equal to $\frac{5}{4} \times d_v$,
- the left limit of the right eye is at a distance equal to $\frac{3}{2} \times d_v$,
- the right limit of the right eye is at a distance equal to $2 \times d_v$.

The left part of the figure 1 presents this canon with these "golden proportions". The thick lines are used to represent the integer values of $d_h$ and $d_v$.

### 2.3 The caricature model

Caricature modeling is performed in five steps.

1. A model is loaded[1] and an half-edge data structure is created to maintain the edge adjacency information[8].

[1] Additional Informations concerning front-facing, back-facing and material properties are maintained.

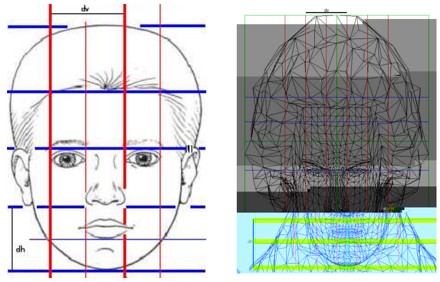

**Fig. 1.** letf: Canon model, right: Canon of the Beethoven's head.

2. Creation of a bounding box around the head of the model. The user specifies the lower limit of the head with an horizontal line[2]. The following steps use this box as a limit.
3. Creation of the **canon**. The user specifies an horizontal line, named $\mathcal{H}$ (top of the eyes), and a vertical line, named $\mathcal{V}$ (left of one eye), and our system computes the canon of the face based on our canon model defined above. The right part of the figure 1 presents the results of this step on the Beethoven's head.
4. Detection and extraction of significant parts of the head. This step is realized automatically using the canon and if available material properties of the model. Note that the material properties simplifies the detection of significant part limits. For all of these significant parts, at least one chain of edges is created with the half-edge data structure. The significant parts are:
   - **eyes** are localized with the canon. At the previous step, the user have specified the upper left corner of the left eye. Based on curvature and material properties if available[3], a closed chain is created for each eye representing the limit of the eye.
   - **eyebrows**: the curvature and material properties are used. A closed chain is created for each eyebrows.
   - **nose**: two chains are created. The first one is a set of segments describing the curvature of the nose bone. The set of segment is composed by vertices with a high Z-value placed horizontally between the eyes and vertically starting between the eyes and finishing with a high Z-value. Note that the expected value for the curvature of the nose bone is a set of segments which have the same vector. The second one is composed by vertices describing the triangle mesh of the nose. In this case curvature is used.
   - **shape of the head**: the shape of head's chain starts from the chin, includes the ears and the top of the forehead excluding the hairs. Chin

[2] To help the user, an orthographic projection is used and only the front-facing polygons are drawn as outlined polygons.

[3] Note that for some models, eyes are composed by edges incident to only one polygon and so the detection is very easy.

is at the bottom of the canon and a vertical symmetry is used to find other parts. Materials properties can also be used to find the limit with the hair.

At the end of this step, the user can verify and modify the detection realized if needed. Eyes, nose and shape of the head are often well detected. Some problems remains for eyebrows chains.

5. Measure computation and generation of a new triangle mesh: using the chains generated above and the canon, we compute measures on the head. These are the nose curvature and size, the eyes size and tilt, the fronthead size, the height of the hair and the eyebrows. We deform the triangle mesh according to the measures and the expected values of the canon. The deformation is weighted by a user-specified value. The order of the deformations is the hair, the forehead, the width of the head, the eyes and the nose[4]. This assures that there is not discontinuity on the new 3D mesh. The number of vertices and edges is constant. The figure 2 presents the results of this step on the Beethoven's head (left to right: global view (original, distorted), focus on nose (original, distorted)[5].

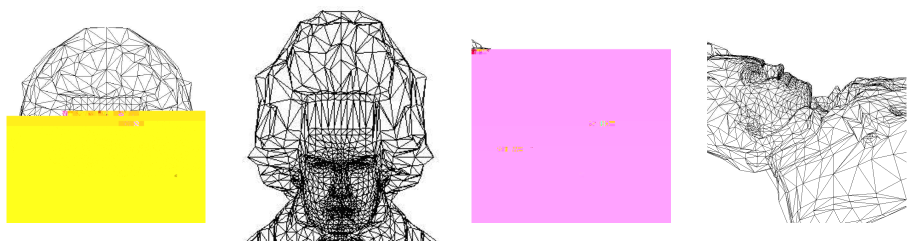

**Fig. 2.** Original and distorted Beethoven's head and nose.

## 3 Rendering

The rendering process produces images in real-time in NPR style using hand-like line-drawing. Our method is based on the Sousa et al. method[9]. The main steps of the algorithm are:

1. extraction of additional feature lines. We search the *silhouette edges* (**SE**), the *border edges* (**BE**) and the *creases* (**CE**). The creases are edges which

[4] There are two deformations for the nose: one for the curvature and the other for sub-mesh of the nose.

[5] Note that for Beethoven's nose, two vertices do not follow the curvature (starting from the top of the nose, the second one is above the expected curvature and the next to

separate two front-facing triangles whose normal vectors make an angle $\theta$. The limits of $\theta$ are given by the user and can be changed dynamically.

2. creation of graphs. Three graphs, one for each kind of edge, are created. They maintain an adjacency list represented by an array of vertices (see[9] for details).
3. generation of list of chains: a chain corresponds to a path in the graph (**SE**, **BE**, **CE**) starting from a source (vertex with indegree equal 0) and finishing at a skin (vertex with outdegree equal 0). Contrary to Sousa, the sources are sorted by lowest *indegree* and highest *outdegree* and we build all chains for a graph composed at least by two vertices (possible chains with less than two vertices are not considered). Note that when a vertex is selected, its indegree and outdegree are updated. This permits to obtain the same chains at any time. This process is iterated until no valid chain remains in the graph.
4. creation of B-splines: at this step we have obtained chains from graphs and we add chains extracted for significant parts of the head (eyes, eyebrows, nose...). Vertices of chains are considered as control points of a B-Spline then rendered. The thickness of the B-Splines depends on two parameters:
   - the kind of edges: B-Spline of silhouette and border have globally a thickness greater than creases and the chains created during the caricature process have the same thickness.
   - the measure of curvature: for each control point of the B-Spline, we compute the thickness of the curve depending on the curvature (a high curvature increases the thickness).

The triangle mesh is drawn with the background color and the curves mei.1797d(is)Tj(9.59478 0 Td(r)display 1
lines) the back face culling is used to display only the lines of the visible t
The images have been produced on a Pentium IV.59478 0 86 0 Td (2,4
model.

## 4 Conclusion

We have presented a model to desi
is the first working directly on 3D
It produces distortions of a 3D tria

**Fig. 3.** Different view of the Beethoven's head with different values for creases rendered with our system.

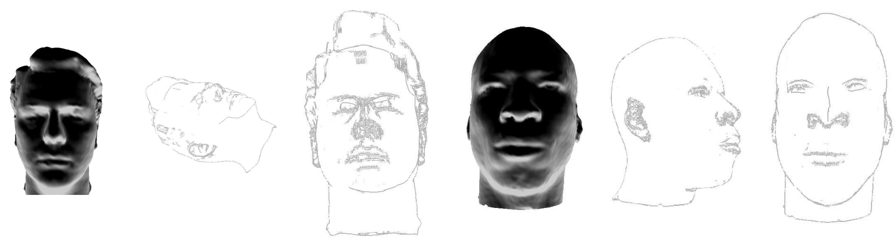

**Fig. 4.** Two other examples: Original mesh, images produced by our rendering system with different deformation ratios and creases values.

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