

# Evolutionary Computation Applied to 3D Image Reconstruction

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**Abstract**— We apply a simple algorithm for evolutionary computation to the problem of approximating a human facial 3D image by a triangular mesh under the condition that the number of data points is restricted. The essential point of this problem is to locate the data points in such a way that the resulting triangular mesh approximates the facial surface as good as possible. Selection and reproduction of the data points, based on the approximation error, are shown to be effective for solving this problem even in its simplest algorithmic implementation. We also argue that such evolutionary computation might be useful in other engineering fields.

**Keywords**— image reconstruction, evolutionary computation, Delaunay triangulation, polygonal approximation, computer graphics

## I. INTRODUCTION AND SUMMARY

The primary aim of this work is to show that an evolutionary algorithm can be applied to a practical problem. The problem is to approximate a human facial 3D image by polygons (triangles) using a limited number of data points. The whole data set is given in a regular grid structure. We focus on how to capture the fundamental features of the facial surface — curved parts of nose, eyes, lip and so on as well as smooth cheek, forehead and so forth — while avoiding unnecessary usage of the entire data for the best but trivial representation. This is of practical importance for feature detection, data compression, not to mention computer graphics image processing. Moreover face recognition has recently attracted much attention from engineers as well as psychologists recently.

We show that an evolutionary algorithm can be applied successfully to solve the problem. The population consists of a fixed and a limited number of data points chosen among the whole set. Decimation and birth of points in the population, according to the approximation error that each point has in its spatial relation to some neighboring points, are iteratively done over generations. The population changes its configuration, being subject to selection and reproduction, even if we start with a random distribution. Better and better approximations of the facial surface emerge quickly.

The basic algorithm is not sophisticated and leaves room for improvement and modification so

as to be more adaptive to this specific facial image. We also note that there already exist several different kinds of polygonal mesh refinement in computer graphics [1][2][3][4]. Nevertheless, since the essence of the above problem is to approximate a surface in 3D by relocating a limited number of points, the basic idea would be applicable to other fields such as topographical engineering. There are few studies that use evolutionary computation to solve this kind of problem. We shall briefly argue on this in the last section.

In II, we describe some features of the human face 3D image data in order to clarify which part is important and which part is dispensable in the data. We also formulate the approximation and interpolation problem. In III, we give an evolutionary algorithm which is based on the errors in Delaunay triangulation. Results are shown together with some statistics. In IV, we conclude with discussion and future prospects.

## II. PROBLEM FORMULATION

We employ as our data source a digitally scanned 3D image of a plaster bust surface. The data is given in a cylindrical grid structure as follows. Let  $(\rho, \theta, \zeta)$  be the standard cylindrical coordinate system, where  $\rho = 0$  axis runs vertically through the middle of the head. The whole set of data points, each representing a point on the surface by a triplet  $(\rho, \theta, \zeta)$ , constitutes a mesh like latitudes and longitudes on a model globe. One small unit of mesh has such resolution that  $d\rho = 2\pi/256$  rad and  $d\zeta = 2.4$  mm. In order to focus on the facial features, we take a portion of its face out of the bust. The resulting data set consists of  $N \cong 97 \times 86 = 8342$  data points.

Fig. 1 shows that the face has curved portions like the eyes' hollows, the ridge of the nose, the tiny valley of the lips, the wavy hair etc. as well as smooth parts of the forehead, the cheeks etc., all of them constituting the prominent features of the face. On the other hand, of course the plaster face has no extremely fine features such as eyelash, which we discard in this work.

Now our problem is to approximate the facial surface by doing interpolation based on a polygonal mesh while avoiding unnecessary location of points

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