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A Study on the Female Chest Contour with Elliptic Fourier Analysis ⋆

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Abstract

Elliptic Fourier Analysis(EFA) is an important tool in shape reconstruction. To get the best female subject fitting result, we took the following processes. Firstly, three kinds of sampling methods were taken, including curvature sampling, random sampling and equally spaced sampling. According to our experiment result, equally spaced had the best performance. Secondly, eclectic sampling density was decided by the mean distance and conference. Finally, the number of harmonics used by EFA was decided by the experimental error requirement. The experimental results indicate that the EFA was an powerful and efficient approach in chest shape fitting.

Keywords: Elliptic Fourier Analysis; Sampling Method; Sampling Points; Harmonics

1 Introduction

In 1982, Kuhl [1] used Elliptic Fourier as the main method to describe object silhouette. In other related field, Elliptic Fourier has been taken to describe contour curve and Elliptic Fourier Descriptors (EFD) was treated as an important tool to calculate differences [2-4] between different object curve. For example, Neto J C used EFDs to describe and analyze the shape of plant leaf, and the coefficient of EFDs of plant leaf was taken to identify the type of plant. Martin Friess [5] used Elliptic Fourier to study the form of three dimensional curves and extract characteristic curves from scanned human body.

Human chest size are very important factor for a suitable cloth [6-8], a costume designer designs a virtual [9] or real cloth.

In this paper, EFA was employed as the core approach to implement the whole study. Based on advice from tailors, A facile hypothesis was proposed that the number of sampling points is based on chest girth and maximum distance error and mean error range is 1 mm and 0.5 mm, respectively. Different sampling method leads to different fitting result. As a result, with different

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sampling method, sampling points and harmonics, different approach was taken to reconstruct the fitting curve. At last, sixteen individuals were used to verify the accurate of our fitting.

2 Methodology

2.1 Data Collection

First, the chest circumference was obtained by manual measurement. Then the Kinnect was used to scan a female bust. After the human point cloud data was collected, the OBJ file was imported into GeoMagic Studio 12 [10]. According to the feature points was chosen manually before scanning, the model was cut horizontally and the chest curve was obtained. Last, several different curve was created with various sampling methods.

2.2 Elliptic Fourier Analysis

The coefficients of the Fourier Series were referred to as "Elliptic Fourier Descriptors" (EFDs) [6], which could be implemented to reconstruct the original shape with major features. EFDs was first proposed by [11], it provided robustness to translation, rotation and scale if the EFDs were normalized [12]. Lots of studies used EFDs to research, for example, the characteristics of animals and plants [13-16], anthropology [17], hand-written recognition [18] and aircraft contour description [19].

Suppose there are K discrete sampling points along a closed contour. This contour can be represented by a sequence of x and y coordinates which are ordered by counter-clockwise from an arbitrary starting point. The length from the starting point to the *p-th* point is denoted by t_p, and the perimeter of the whole contour is denoted by T, and $T = t_K$ where K is the total number of the discrete sampling points and Δt_i is the distance between the *(i-1)-th* point and *i-th* point. For each sampling point, the coordinates of *p-th* along x and y directions are:

$$t_p = \sum_{i=1}^{p} \Delta t_i \tag{1}$$

$$x_p = \sum_{i=1}^{p} \Delta x_i \tag{2}$$

$$y_p = \sum_{i=1}^{p} \Delta y_i \tag{3}$$

where Δx_i and Δy_i are the distance from *(i-1)-th* point to the *i-th* point along the x and y axes respectively. Thus, the Elliptic Fourier expansions of x and y coordinate along the contour are

$$x_p = A_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{2n\pi t_p}{T} + b_n \sin \frac{2n\pi t_p}{T} \right) \tag{4}$$

$$y_p = C_0 + \sum_{n=1}^{\infty} \left(c_n \cos \frac{2n\pi t_p}{T} + d_n \sin \frac{2n\pi t_p}{T} \right) \tag{5}$$