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Accuracy and comfort analysis of digital shoe design

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Abstract

In this paper, we select the typical female bridge of the nose bridge as the experimental object, and discuss the dimensional accuracy of the digital shoe design of Delcam Crispin Engineer through the actual plate making operation. The experimental results show that, compared with the manual standard version, the DCE is slightly smaller than the standard version, the average difference between the parts is not obvious, the average size accuracy is 94.3%~98.7%, in addition to the individual version, Are in the footwear design error within the allowable range. In the application and research of many computer shoe-making software, the research on the accuracy of digital shoe design pattern has not been reported yet. To this end, this paper uses the leading shoe-like development technology Delcam Crisp in Engineer design software to the rocker on the representative of the bridge of the nose women's boots (4 inches) as the experimental object, through specific experimental operation and Coreldraw software version Dimensional measurement, compare DCE version and hand-made version of the size difference, analysis DCE software digital plate-making accuracy, to explore the shoe-like design CAD system in the shoe industry practicality.

Keywords: *Coordinate measuring machine; digital design; handmade plate; shoe design; precision*

1. Introduction

Edition design and production in the shoe-making process has a pivotal position, a direct impact on the comfort and aesthetics of the shoe [1]. Traditional shoe-like design is the use of manual "paste last method" plate, the US-profile paper paste on the outer surface of the shoe last, and then draw the patch to help line, will be drawn to help film lofting, the sample sent to department sample shoes, To verify compliance with the design requirements [2, 3]. Obviously, this plate-making method of a long cycle, high labor costs, the level of information is very low, it is difficult to adapt to today's "small quantities, and more varieties, faster update" market requirements seriously hindered the rapid development of China's footwear industry [4].

In recent years, the global shoe-making technology is to the computer technology-based information technology development, CAD/CAM (computer aided design/ manufacturing) technology is to shorten the shoe development cycle and enhance the competitiveness of key technologies [5]. Zhou Jiali and so on the use of gray-scale images based on weak feature detection method, the foot images obtained for different

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orientation detection, CAD system, foot reconstruction rate of up to 90% [6]. Xu from the rich use of the classic DFFD deformation method, designed based on the human foot dynamics of personalized shoes CAD software system [7]. At present, the common footwear design software is Shoepower, Delcam Crispin, Shoemaster, Miorodynamics and Dimension and so on. Among them, Delcam Crispin is widely used in the upper and sole design, technology, processing and footwear customization and comfort and other aspects of research [8, 9]. Qin Xujia proposed and realized the shoe-like design of the key technologies and methods, and this technology used in the development of Shoepower shoe CAD system, the effect is good [10].

In this paper, we select the typical female bridge of the nose bridge as the experimental object, and discuss the dimensional accuracy of the digital shoe design of Delcam Crispin Engineer through the actual plate making operation. The experimental results show that, compared with the manual standard version, the DCE is slightly smaller than the standard version, the average difference between the parts is not obvious, the average size accuracy is 94.28%~98.7%, in addition to the individual version, Are in the footwear design error within the allowable range. In the application and research of computer shoe-making software, the research on the accuracy of digital shoe design pattern has not been reported yet. To this end, this paper uses the leading shoe-like development technology Delcam Crisp in Engineer design software to the rocker on the representative of the bridge of the nose women's boots (4 inches) as the experimental object, through specific experimental operation and Coreldraw software version Dimensional measurement, compare DCE version and hand-made version of the size difference, analysis DCE software digital plate-making accuracy, to explore the shoe-like design CAD system in the shoe industry practicality.

2. Related mathematical theory and method

2.1 Parameter Representation of Curves and Surfaces

In analytic geometry, the coordinates of a point P on the spatial blue line can be expressed as a function of some parameter u: X = X (u), Y = (u), Z = Z (u). Putting together the three equations of the vector parameter u [11]:

$$p(u)=[x,y,z]=[x(u),y(u),z(u)] \tag{1}$$

This vector representation is equivalent to a Cartesian component representation:

$$p(u)=x(u)i+y(u)j+z(u)k \tag{2}$$

Where j, j, k are the unit vectors along the x-axis, y-axis, and z-axis, respectively. Usually this representation is often abbreviated as p = p (u).

Parameter method has the following advantages: Geometric invariance: easy to specify the curve, surface range: easy to express spatial curve; easy to calculate the curve, the surface of electricity and other information; easy to handle multi-value problem, easy to handle infinite slope, and it can be used to segment and segment the curves and surfaces. It provides more possibility to control the shape and shape of curve and surface, and provides the possibility for the generalization of high dimension problem. Based on these advantages, the parametric method can better meet the requirements of shape mathematical description [12].

A k-th NURBS curve can be expressed as a piece of rational polynomial vector function:

$$p(u)=\frac{\sum_{i=0}^{n} w_i V_i N_{i,k}(u)}{\sum_{i=0}^{n} w_i N_{i,k}(u)} \quad (3)$$

It is defined in the node vector:

$$U=[u_0,u_1,u_2,\cdots,u_{n+k+1}] \quad (4)$$

It has the following recursive definition:

$$\begin{cases} N_{i,0}(u)=\begin{cases}1\cdots u\in[u_i,u_{i+1}] \\ 0\cdots u\in[u_i,u_{i+1}]\end{cases} \\ N_{i,k}(u)=\frac{u-u_1}{u_{i+k}-u_i}N_{i,k-1}(u)+\frac{u_{i+k+1}-u}{u_{i+k+1}-u_{i+1}}N_{i+1,k+1}(u)\end{cases} \quad (5)$$

2.2 Fertility level release

Toe wai is a closed space plane curve, calculate the toe circumference can be used chord length approximation method, the calculation method:

$$ds=\sqrt{(dx)^2+(dy)^2+(dz)^2} \quad (6)$$

Can be approximated:

$$\Delta s=\sqrt{(\Delta x)^2+(\Delta y)^2+(\Delta z)^2}=\sqrt{(x_{i-1}-x_i)^2+(y_{i-1}-y_i)^2+(z_{i-1}-z_i)^2} \quad (7)$$

Where, $\triangle x$- a rectangular coordinate system, the adjacent two points to the X coordinate component difference;

$\triangle y$- a rectangular coordinate system, the adjacent two points Y rN coordinate component difference:

$\triangle z$- a rectangular coordinate system, the adjacent two z-coordinate:

We can get the calculation of toe s:

$$S=\sum_{i=1}^{n-1}\sqrt{(x_{i-1}-x_i)^2+(y_{i-1}-y_i)^2+(z_{i-1}-z_i)^2} \quad (8)$$

In the fat level put the direction of the last part of the shoe to put the level of the toe as a benchmark, the Department of footwear other than the level of the toe ratio of toe-level put than kb, put the same level with the toe-class method. Therefore, the ratio of toe-to-toe-to-enlargement ratio is the ratio of the fertility grade Kn. The x, y of the last model data of the shoe last model are multiplied by the ratio kf of the fertility level, multiplied by the k- Ki will be able to achieve the shoe last fat level to put.

3. Materials and methods

3.1 Experimental materials and objects

Delcam Crispin Engineer version design software, two-dimensional graphic design, Coreldraw software, pointed high-heeled women's shoes last F609, knife, pencil, kraft paper, textured paper.

In this experiment, we choose representative 4-inch female bridge boots as the experimental object. Figure 1 showed the size of the female boots.

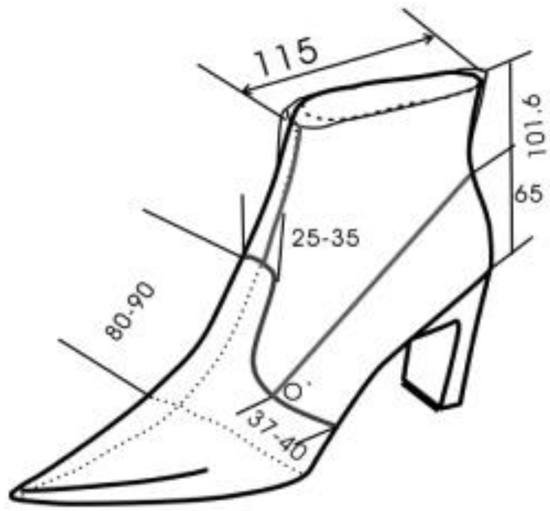

Figure 1. The size of the bridge diagram of women's boots

Relative to the foot, the instep and the heel side surface, the shape of the entire surface of the foot cover, called the shoe last surface. Relative to the soles of the bottom of the soles of the bottom surface, called the last shoe last. Shoes, sandalwood and the mouth of the mouth of the mouth intersecting, forming a closed nature of the space curve, called the mouth of the mouth along the line, the middle of the line with a rectangular, rounded front and rear ends.

Along the longitudinal direction with the longitudinal profile of the last surface is divided into internal and external pregnant two sub-surface film, together with the last bottom surface film, cornelian shoe last body surface is divided into three sub-surface film was shown in Figure 2:

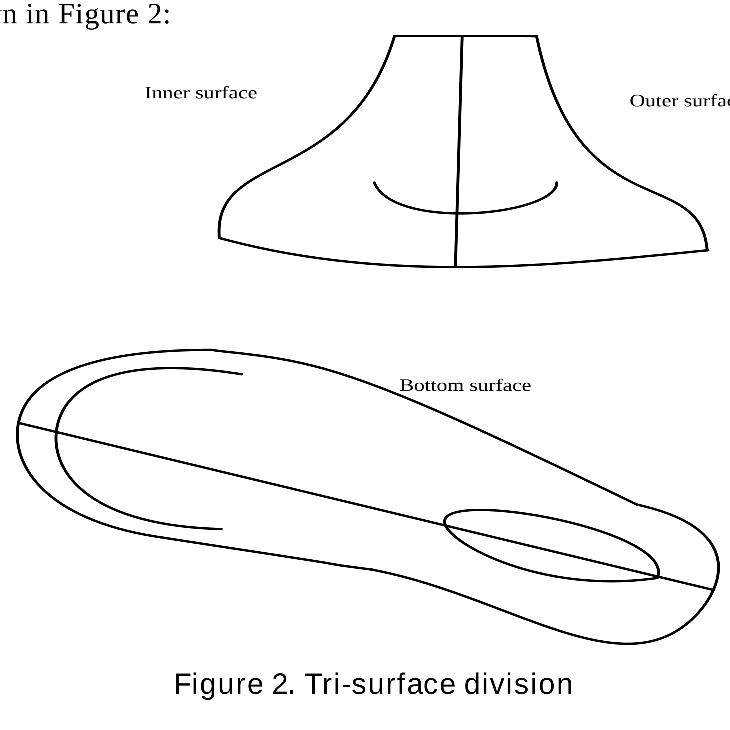

Figure 2. Tri-surface division

Copy the parent sample, copy the sample processing-like version of the sample, take the kind of work sample plate line as the mouth of the following 25mm-like skin care version, and the remaining part of the sample to help. Take the inside in front of the zipper-like pattern, the girth and dorsal midline of the intersection of the alignment of the origami, before the tip to take a rocker, symmetrical front tip of the pregnant version of the sample, get help before the version of help; Half, symmetrical to get the former to help within the bosom; copy the work version of the heel with the site, you can get heel sample. In order to ensure the accuracy of manual open version, the experiment with the above version produced a kind of shoes, the results found that stretched last effect is very good, that sets the standard version of the standard.

3.2 Measurement methods and data processing

Shoe last digital processing is based on three-dimensional measurement of the last shoe. We know that the last surface is a complex surface, but no matter how complex the surface, the decision of its only four elements of the graph, the coordinate system, point, line, surface, these elements can be essentially from the coordinate system And the point of two factors. Because any point on the space can be used x, Y, z three coordinate values that point in the air to do a regular movement to generate the line, the line by the rules of movement can be surface. By using CMM, it can quickly and accurately map the complex surface of shoe last model and digitize it. Then, the surface model can be built according to the data.

At present, there are many ways to measure the shoe last with the measuring machine to obtain the original model shape data, which was shown in Figure 3. These methods can be roughly divided into non-contact and contact measurement. The non-contact can be divided into optical, acoustic and magnetic field, in the contact measurement, according to the machine structure can be divided into mechanical arm and coordinate measuring machine type.

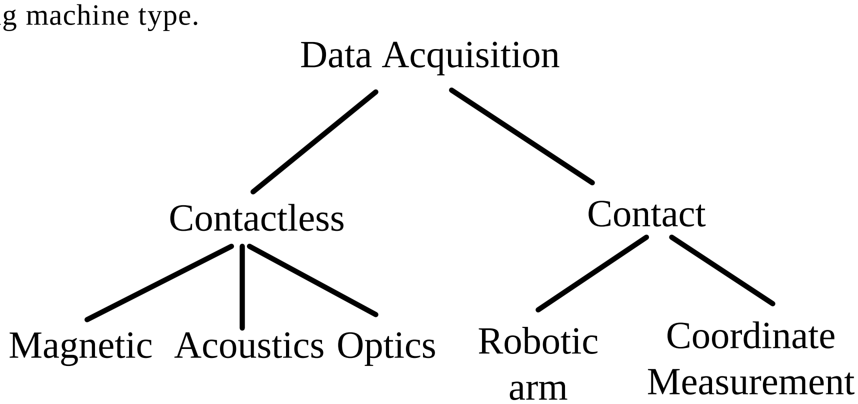

Figure 3. Data measurement method

4. Experiment and results

4.1 Analysis of version

Using the two version of the production method to get the nose version of the bridge, the bridge like the nose of the measurement results in Table 1. Table 1 showed manual nose version of the size and size of the DCE version of the difference is not obvious, the average difference of 2.11mm, the average percentage difference of 1.85%, the version accuracy of 98.15%, DCE design version of the simulation is very high.

Table 1. The measurement results of the bridge of the nose

Segment	Handwork(mm)	DCE(mm)	Deviation(mm)	Deviation (%)
AD	195.22	197.56	2.34	1.20
BC	65.40	65.62	0.22	0.34
AB	179.25	182.26	3.01	1.68
BD	99.00	99.51	0.51	0.52
DG	97.24	97.75	0.51	0.52
FG	62.78	64.88	2.10	3.34

4.2 Simulation analysis

Table 2 and Table 3 showed the results of the measurement of the inner edge of the bridge. The average difference between the back-side and the back-side of DCE's design is 1.48mm and the average difference is 2.31%. Among them, the individual size of the difference is 3.65mm, but its accuracy can still reach 97.79%, in the version design error control range.

Table 2. The measurement results of back edge

Segment	Handwork(mm)	DCE(mm)	Deviation(mm)	Deviation (%)
HI	165.55	169.11	3.56	2.15
HJ	59.77	60.92	1.15	1.93
JK	62.40	63.49	1.09	1.75
I	99.25	99.53	0.28	0.28
MN	53.44	53.74	0.30	0.56
NO	114.24	114.76	0.52	0.45
MP	162.58	164.26	1.68	1.03

Table 3. The measurement results of back edge

Segment	Handwork(mm)	DCE(mm)	Deviation(mm)	Deviation (%)
RS	122.51	123.53	1.02	0.83
ST	57.77	59.40	1.63	2.82
TV	115.93	115.44	-0.49	0.42
UV	113.28	115.14	1.86	1.64
RU	114.79	114.44	-0.35	0.31
RV	179.24	179.44	0.20	0.11
RT	138.88	139.38	0.50	0.36

Before the help version of each part of the plate size than the DCE version of hand-size slightly larger, individual parts of the small. The average difference of the size is 4.15 mm, the average percentage difference is 3.49%. The main reason for the deviation is the error of the inner wing point in DCE design process. However, with the exception of individual deviations, the average accuracy of the DCE design can still reach 96.51%.

5. Conclusions

The experimental results show that, compared with the manual plate, the DCE method is slightly smaller than that of the DCE method, and the difference between the parts is not obvious. The average size accuracy is over 97.5%. Among them, the accuracy of vertebrae and vestibule pattern of the bridge was 98.15% and 98.75%. The error was within the allowable range of 0.5% ~ 3.5%. The application of computer technology in sample design is the technical optimization of shoe - like structure design. Using the Delcam Crispin Engineer-assisted design version automatically expand, transform or edit the modified graphics, changing the traditional manual plate method, the user interface is simple, saving the design phase of the sample supplies. At the same time, the results of this experiment further show that digital design of shoe-making has gradually become more perfect, computer-aided design to replace the traditional hand-made version of the era is coming.

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