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CAD FOR STYLING DESIGN

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ABSTRACT

The measuring point data of clay model are widely used to design parts whose external features are important design factor such as automobiles and general die products. This paper presents a method for improving the process to generate smooth surfaces from the measuring point data using turnkey CAD/CAM system.

The process of smooth-surface generation involves several steps: styline finding, curve fairing, surface generation and filleting. The process is improved by automatic curve fairing, local correction of surface and multi-boundary surface treatment. An automobile bumper and a telephone receiver are measured and modeled to test the new method. Significant time saving is resulted by changing interactive mode to automatic mode and eliminating inefficient loop of surface generation process.

1. INTRODUCTION

The method of designing automobile body and general die products using measuring point data of clay model has been used for a long time. As the CAD/CAM system generalized, most of the automobile companies and die makers employed CAD system for the purpose of styling design. It is true that the employment of CAD system improved the efficiency and accuracy of surface generation from measuring data. But, the general-purpose turn-key CAD/CAM systems have limitations for this kind of job.

Since the measuring data has errors due to the errors in model itself and measuring errors, a process called 'fairing' is required to get smooth surfaces from the measuring point data. The method used to generate smooth surfaces from the measuring point data using turnkey CAD/CAM system is illustrated in figure 1. The first step of the fairing process is 'styline finding'. Since most of surfaces are bounded by rounding surfaces, it is nesessary to find the intersection curve between two bounding surfaces which is not appearing in the clay model. These curves are called stylines, and determines the shape of the product. The second step is 'curve fairing'; the process to generate smooth curves from rows of point data. This step is very important, because the smoothness of the surface is directly related to the smoothness of the curves from which the surface is made. Using the curves generated by the curve fairing step, the surfaces are generated. Since the surfaces are constructed with curves faired in one direction, they have local unsmoothness in the other direction. So the fairing process in this direction is required. Since most of the turn-key systems do not support the surface local correction funtion, the loop shown in figure 1 is required which is very time consuming. The last step of fairing process is filletting or belending of surfaces.

The each step of fairing process with turn-key CAD/CAM system is interactive or limitedly automated, so it is very time consuming process. This paper presents new functions developed to improve fairing process using turn-key CAD/CAM system.

2. THE NEW FUNCTIONS FOR IMPROVING SURFACE-GENERATION PROCEDURE

Four new funtions to speed up the fairing process are developed. The new functions are named 'styline', 'autofairing', 'local correction' and 'multi-boundary surface'.

To determine the styline, extrapolation of curves are required. The extrapolation must be controlled to follow the property of whole curve or a part of the curve. The least square method is used to extrapolate the curve; in this case the user can be select the range of the extrapolation and the degree of the least square function. The Newton-Raphson method is used to calculate the intersecting point between the extrapolated curves. The styline is determined by fairing the curve constructed with the intersecting points.

The "autofairing" function is developed to speed up and increase accuracy of curve fairing process. There are lots of methods developed for curve fairing such as direct-shift method, divided-difference method(15), elimination of external shear method(13), least square method(16) and backshift method(17). But these method have some problems in common such that the methods are time consuming and the resulting curves are nonunique and exceed the maximum allowable deviation. Several automatic fairing methods are developed, among which two method are most useful. The most useful method is named 'cuvcon'. The method uses the fact that the curvature of a curve is the square of second differential if the value of first differential is negligible. The curve can be faired by changing the shape of second divided difference which has similiar shape with the curvature, and integrate the second divided difference. The second autofairing method is "autofair". The 'autofair' uses least square method locally i.e. moves the points in the direction of least square curve generated by 5 points locally. By controlling the weighting factors the method can generate a convex spline curve which satisfies the maximum allowable deviation.

As mentioned in chapter 2 the local correction is required for the surfaces generated by curves faired in one direction. Since most of turnkey CAD/CAM systems do not provide local correction function, a new function to do the local correction is developed. The function correct the local unfairness of surface by approximating the surface to the unform cubic B-spline surface and moving the control points of the approximated B-spline surface. In this method the direction of correction is given by the program in the direction of average surface normal and the amount of correction is determined by the user by giving the weighting factor to the distance between the original contol point and the new control point which is 1 mm apart from the original in the direction of correction. The control point can be moved either one by one or by a row.

The "multi-boundary surface" function is developed to treat the surfaces which have boundary curves more than four. This type of surfaces is made around the merging positions of more than two surfaces such as 'corners' or the surface which has shape of multiboundary such as a 'fender'. The multi-boundary surfaces can be divided into several four-boundary surfaces by defining internal bounding curves. The internal bounding curves are very important because they determine the final shape of the surfaces. The separated surfaces can be modified by changing the internal curves while maintaining the properties of the external bounding curves. The visual continuity is satisfied between neibouring surfaces.

3. ILLUSTRATIVE EXAMPLES

To illustrate the developed method a bumper is measured as shown in figure 2. Figure 3 shows a example of intersecting point finding. By using the intersecting points of the curves generated by using the measuring point data the stylines are determined as shown in the figule 4. The figures 5 and 6 shows the autofairing process by 'cuvcon' and 'autofair' respectively. Figure 5(a) is the original curve with curvature; 5(b) the second divided difference of the original curve; 5(c) the modified second divided difference; 5(d) curve generated by integrating 5(c). The curve numbered 1 in figure 6 is the display of the curvature of the original curve, and the curves numbered 2, 3, 4 and 5 are the display of the curvature after each additional itteration of 'autofair' process. This figure shows that the 'autofair' process averages the curvature locally. Figure 7 shows all the curves faired. Using these curves the surfaces are generated. But the surfaces have local unsmoothness to be corrected. Figure 8 shows the local correction procedure. Figure 8(a) is the display of the approximated B-spline surface with u-curvature arrows on it. Figure 8(b) shows the process of local correction: contorl point display on the u, v-isolines and the new points 1 mm apart to the direction of correction. The final surface corrected is shown in figure 8(c). Figure 9 is the display of the final bumper surfaces. In figure 10 another example, i. e. telephone receiver, is shown. In this case the multi-boundary surface is shown in (a). The figures 10(b) and 10(c) are generated by sending data to another program MOVIE-BYU and PRIMAT respectively; they show the whole receiver generated using symmetry function in MOVIE-BYU and NC tool path generated by PRIMAT.

4. CONCLUSION

New computer programs to improve the process of surface generation from measuring point data using CAD/CAM system are developed. The program improves the 'fairing' process by changing interactive mode to automatic mode, and by developing new functions: i.e. styline finding, automatic curve fairing, surface local correction and multi-boundary surface generation.

The programs can be implemented into turnkey CAD/CAM systems by using user interface utilities of the turnkey system, or can be packaged into a special purpose system by adding functions such as filleting, blending and by improving system funtions to be more user friendly.

Further research works are recommended to make the program more efficient. They are using new surfaces such as the non-uniform B-spline surface and Gordan surface, developing new approximating schemes, developing more efficient surface smoothness display methods, developing database management system which can access the data more efficiently, etc.

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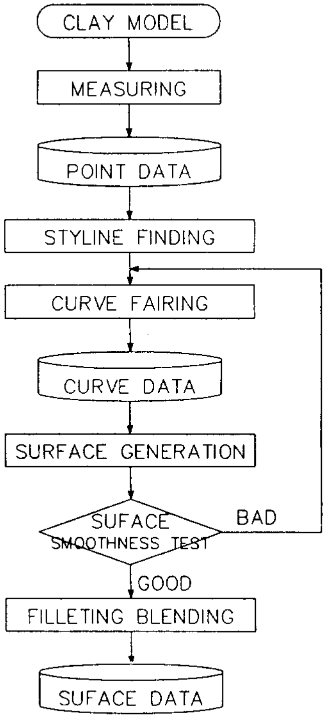


Fig. 1. The process for generating smooth surface from measuring point data using turnkey CAD/CAM system

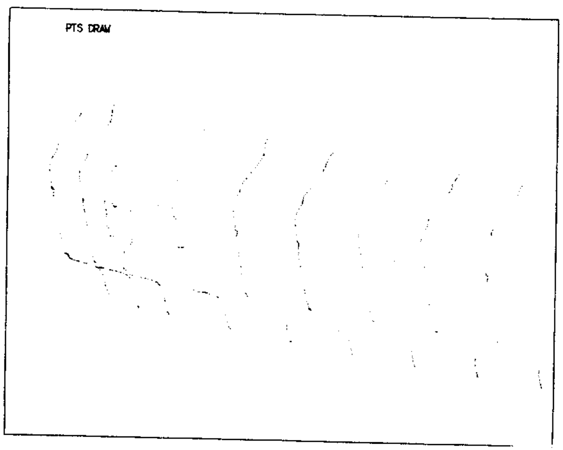


Fig. 2. The measuring point data of a automobile bumper

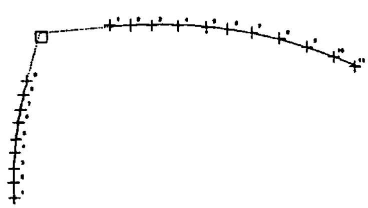


Fig. 3. An example of intersecting point calculation for sytline finding

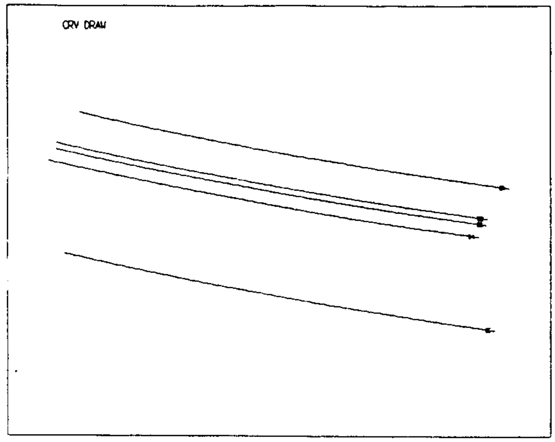


Fig. 4. The stylines of the bumper

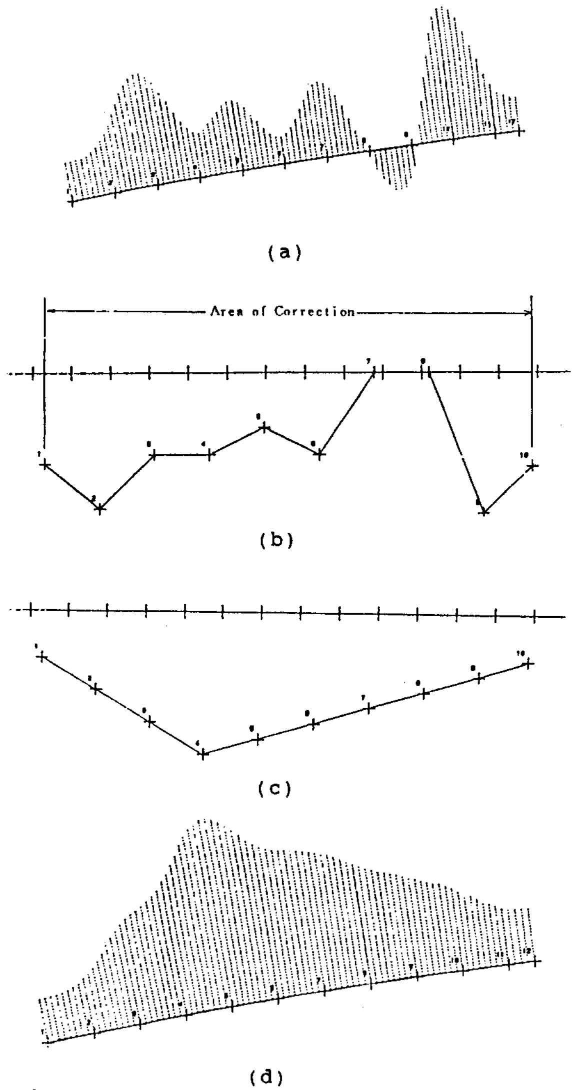


Fig. 5. Automatic curve fairing using 'cuvcon' function

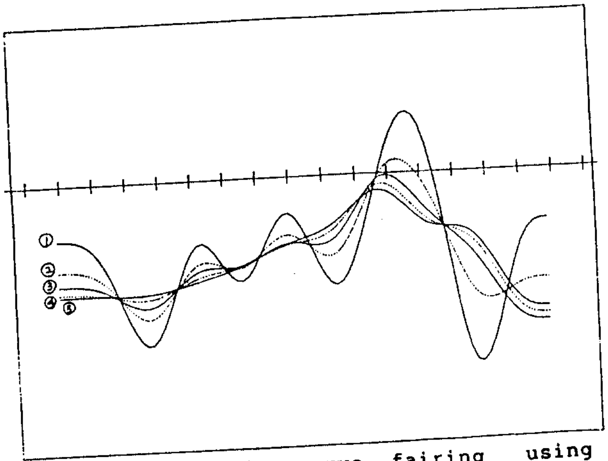


Fig. 6. Automatic curve fairing using 'autofair' function

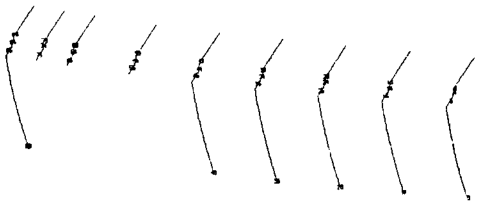
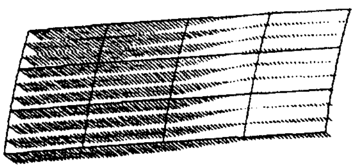
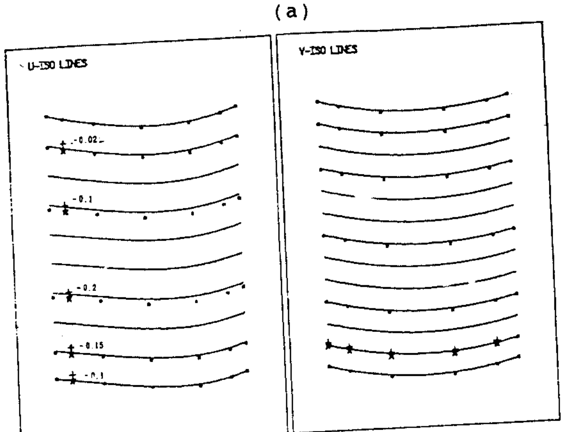


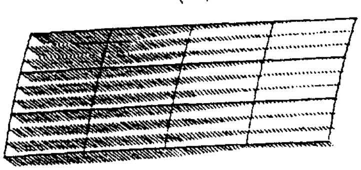
Fig. 7. The curves of the bumper faired using autofairing functions



(a)



(b)



(c)

Fig. 8. Local correction of a surface

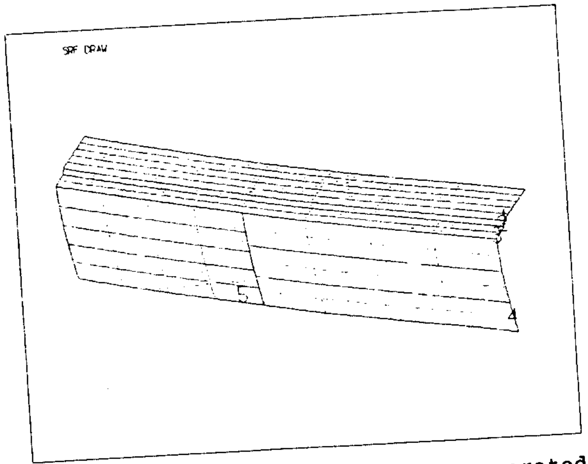
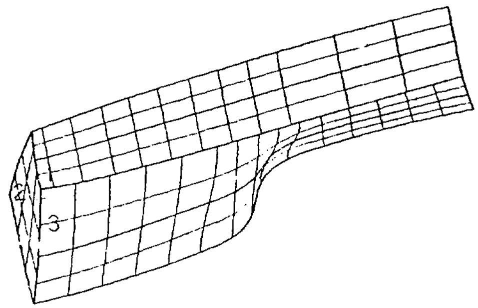
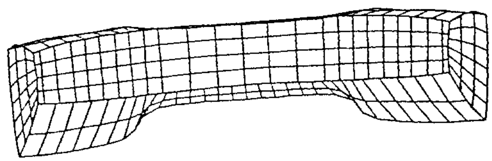


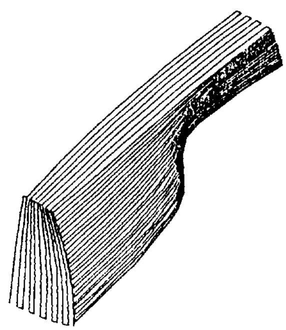
Fig. 9. The final surfaces generated using new fairing functions



(a)



(b)



(c)

Fig. 10. Surfaces of a telephone receiver generated using new fairing functions