

Application of Data Processing Based on Point Cloud in Product Design

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Abstract:

Nowadays, more and more attention is paid to appearance design in product design, and the appearance design principle is especially its own characteristics and development trend under the constraint of relevant theories based on industrial modeling. Based on specific project practice and related industrial design technology research, this paper summarizes a product design integration and improvement optimization method based on appearance cloud point diagram. This method can be applied to optimize and discuss the generation of multi-transition three-dimensional surface models, and can play a certain role in promoting product appearance innovation. Finite element analysis method can be used in product design to make product design more convincing.

Keywords:

Appearance Design, 3D Point Cloud, Data Processing, Innovative Design

1. Introduction

The research of product design methodology has always been the main category of design research, and how to apply existing technical means to improve and innovate products has always been the research category of designers. This paper introduces the appearance of several models, draws the shape of vehicles in three dimensions, finds corresponding coordinate points in three dimensions, generalizes and integrates coordinate points with reasonable mathematical means, forms a new three-dimensional coordinate system of vehicle appearance, and then carries out surface design modeling to form a product innovation method that is more in line with scientific theories.

2. Key Points of 3D Appearance Cloud Point Feature Extraction

Extract the key points of the appearance design of the three models, and select the windward side of the three cars for three-dimensional drawing. The windward side mainly includes the front engine cover plate, vehicle roof plate, rear tailboard, etc. The key point extraction mainly includes transition surface and surface induction. In this paper, three types of vehicles are listed as Mi su7, Audi A4, Tesla, etc., to analyze

the shapes of the windward side. As shown in Figure 1 below, the part of the red dotted line is the part of the windward side extracted.

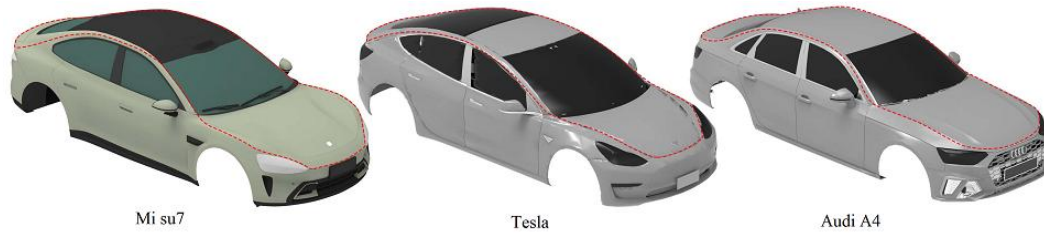


Figure 1. 3D model of product windward side.

2.1. 3D point cloud feature extraction

By importing the product 3D model into 3D software 3DMAX, the 3D coordinates of a specific point can be formed, and the coordinates of the midpoint of the vehicle wheel base are defined as the origin coordinates of the model, so that the three-dimensional models of three types of vehicles can be analyzed and extracted in the same coordinate system.

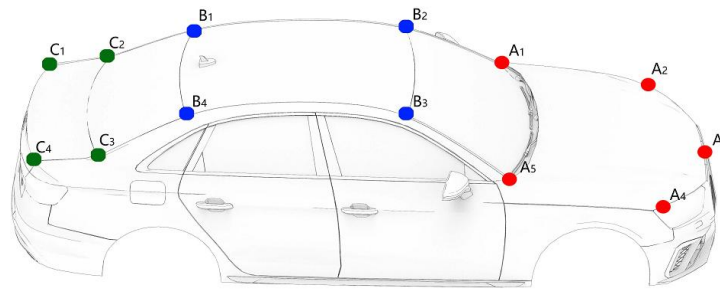


Figure 2. Cloud points of vehicle characteristics.

As shown in Figure 2 above, the feature points extracted are defined symbol A for the front engine cover plate, producing 5 points (A1,A2,A3,A4,A5), defining symbol B for the cockpit top plate, forming 4 points (B1,B2,B3,B4), and defining symbol C for the rear panel. The four points were formed into three types (C1,C2,C3,C4) to extract the coordinates of feature points. The characteristic coordinates of type 3 vehicles (Xiaomi su7 is symbol T, Audi A4 is symbol W, and Tesla is symbol Z) can be defined as:

$$\begin{aligned}
 A & \left\{ \begin{array}{l} A_W \\ A_Z \\ A_T \end{array} \right. \left\{ \begin{array}{l} A_1(715,-893,766) \\ A_2(766,-1809,591) \\ A_3(0,-2208,540) \\ A_4(-766,-1809,591) \\ A_5(-715,-893,761) \end{array} \right. \left\{ \begin{array}{l} A_Z \\ A_T \end{array} \right. \left\{ \begin{array}{l} A_1(750,-1115,740) \\ A_2(781,-1682,670) \\ A_3(0,-2252,450) \\ A_4(-781,-1682,672) \\ A_5(-750,-1115,740) \end{array} \right. \left\{ \begin{array}{l} A_T \\ A_W \end{array} \right. \left\{ \begin{array}{l} A_1(823,-954,968) \\ A_2(857,-1905,832) \\ A_3(0,-2415,615) \\ A_4(-857,-1905,832) \\ A_5(-857,-954,968) \end{array} \right. \\
 B & \left\{ \begin{array}{l} B_W \\ B_Z \\ B_T \end{array} \right. \left\{ \begin{array}{l} B_1(543,1162,1104) \\ B_2(543,-240,1135) \\ B_3(-530,-240,1135) \\ B_4(-530,1162,1104) \end{array} \right. \left\{ \begin{array}{l} B_Z \\ B_T \end{array} \right. \left\{ \begin{array}{l} B_1(543,1604,1076) \\ B_2(681,-177,1196) \\ B_3(-681,-177,1196) \\ B_4(-543,1604,1076) \end{array} \right. \left\{ \begin{array}{l} B_T \\ B_W \end{array} \right. \left\{ \begin{array}{l} B_1(596,1504,1344) \\ B_2(666,-222,1375) \\ B_3(-666,-222,1344) \\ B_4(-596,1504,1344) \end{array} \right. \\
 C & \left\{ \begin{array}{l} C_W \\ C_Z \\ C_T \end{array} \right. \left\{ \begin{array}{l} C_1(570,2122,821) \\ C_2(595,1740,875) \\ C_3(-595,1740,875) \\ C_4(-570,2122,821) \end{array} \right. \left\{ \begin{array}{l} C_Z \\ C_T \end{array} \right. \left\{ \begin{array}{l} C_1(709,2076,778) \\ C_2(608,1723,1043) \\ C_3(-608,1723,1043) \\ C_4(-709,2076,778) \end{array} \right. \left\{ \begin{array}{l} C_T \\ C_W \end{array} \right. \left\{ \begin{array}{l} C_1(600,2430,1028) \\ C_2(865,2110,1000) \\ C_3(-865,2110,1000) \\ C_4(-600,2430,1028) \end{array} \right.
 \end{aligned}$$

2.2. Three-dimensional feature point cloud matrix coordinate extraction

The coordinates of the three types of vehicles are summarized again, and the coordinates of each feature point can be obtained by forming 3 coordinate systems, and the coordinate position matrix of the same point is formed:

$$\begin{aligned}
 A & \left\{ \begin{aligned} & A_1 \begin{bmatrix} 715 & -893 & 766 \\ 750 & -1115 & 740 \\ 823 & -954 & 968 \end{bmatrix} & A_2 \begin{bmatrix} 766 & -1809 & 591 \\ 781 & -1682 & 670 \\ 857 & -1905 & 832 \end{bmatrix} & A_3 \begin{bmatrix} 0 & -2208 & 540 \\ 0 & -2252 & 450 \\ 0 & -2415 & 615 \end{bmatrix} & A_4 \begin{bmatrix} -766 & -1809 & 591 \\ -781 & -1682 & 670 \\ -857 & -1905 & 832 \end{bmatrix} \\ & A_5 \begin{bmatrix} -715 & -893 & 766 \\ -750 & -1115 & 740 \\ -857 & -954 & 968 \end{bmatrix} \end{aligned} \right\} \\
 B & \left\{ \begin{aligned} & B_1 \begin{bmatrix} 543 & 1162 & 1104 \\ 543 & 1604 & 1076 \\ 596 & 1504 & 1344 \end{bmatrix} & B_2 \begin{bmatrix} 543 & -240 & 1135 \\ 681 & -177 & 1196 \\ 666 & -222 & 1375 \end{bmatrix} & B_3 \begin{bmatrix} -530 & -240 & 1135 \\ -681 & -177 & 1196 \\ -666 & -222 & 1344 \end{bmatrix} & B_4 \begin{bmatrix} -530 & 1162 & 1104 \\ -534 & 1604 & 1076 \\ -596 & 1504 & 1344 \end{bmatrix} \end{aligned} \right\} \\
 C & \left\{ \begin{aligned} & C_1 \begin{bmatrix} 570 & 2122 & 821 \\ 709 & 2076 & 778 \\ 600 & 2430 & 1028 \end{bmatrix} & C_2 \begin{bmatrix} 595 & 1740 & 875 \\ 608 & 1723 & 1043 \\ 865 & 2110 & 1000 \end{bmatrix} & C_3 \begin{bmatrix} -595 & 1740 & 875 \\ -608 & 1723 & 1043 \\ -865 & 2110 & 1000 \end{bmatrix} & C_4 \begin{bmatrix} -570 & 2122 & 821 \\ -709 & 2076 & 778 \\ -600 & 2430 & 1028 \end{bmatrix} \end{aligned} \right\}
 \end{aligned}$$

3. Classification and Analysis of Three-Dimensional Feature Point Matrix Coordinates

Form the above space point coordinate matrix, according to the mean value theorem of space points:

$$\begin{aligned}
 X_M &= (X_1 + X_2 + X_3) / 3 \\
 Y_M &= (Y_1 + Y_2 + Y_3) / 3 \\
 Z_M &= (Z_1 + Z_2 + Z_3) / 3
 \end{aligned}$$

The coordinate positions of each point in the front cover plate, top plate and back plate can be obtained as follows:

$$\begin{aligned}
 A & \left\{ \begin{aligned} & A_1(763, -987, 825) \\ & A_2(801, -1799, 698) \\ & A_3(0, -2292, 535) \\ & A_4(-801, -1799, 698) \\ & A_5(-763, -987, 825) \end{aligned} \right. & B & \left\{ \begin{aligned} & B_1(561, 1423, 1175) \\ & B_2(630, -213, 1235) \\ & B_3(-630, -213, 1235) \\ & B_4(-561, 1423, 1175) \end{aligned} \right. & C & \left\{ \begin{aligned} & C_1(626, 2209, 876) \\ & C_2(689, 1856, 973) \\ & C_3(-689, 1856, 973) \\ & C_4(-626, 2209, 876) \end{aligned} \right.
 \end{aligned}$$

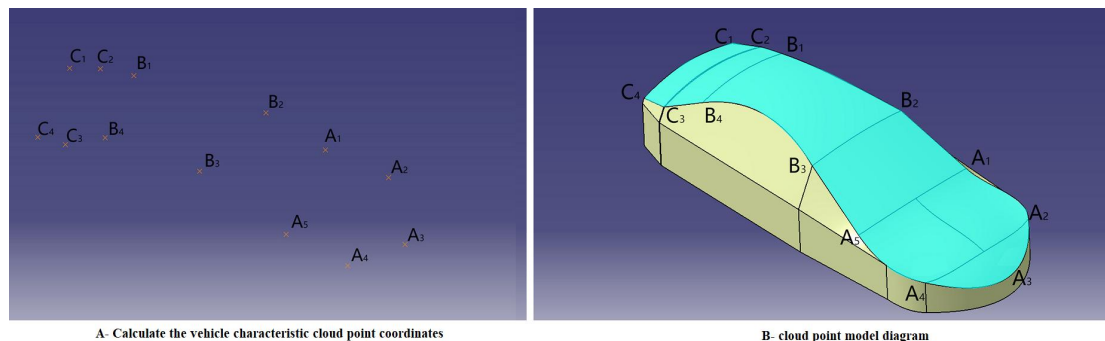


Figure 3. Calculate the vehicle characteristic cloud point coordinates and cloud point model diagram.

The point coordinates obtained from the matrix calculation are imported into the three-dimensional software catia to form the cloud point coordinate diagram as shown in Figure 3-A. The three-dimensional surface model is carried out according to the point coordinate system, and the new shape model can be obtained, which is different from the primary shape of the windward face of the previous three types of vehicles, as shown in Figure 3-B. The blue part is the windward face of the vehicle, which is obtained through the mean value calculation. The approximate drag coefficient of the vehicle can be calculated according to the new three-dimensional shape.

4. 3D Surface Design Air Flow Simulation

Based on the generalization and arrangement of three-dimensional point coordinates, three-dimensional modeling software catia was used to model the surface of the formed three-dimensional cloud point coordinates and form a new three-dimensional appearance. The new model was converted into step format and imported into ANSYS software for mechanical calculation, and aerodynamic simulation experiment was conducted on the model. It can produce pneumatic analysis diagram of products in new form, and view relevant standard documents to test the rationality of product appearance design.

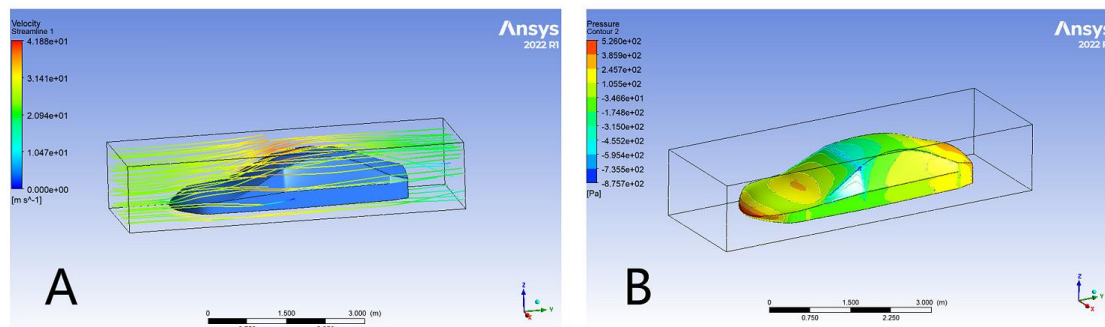


Figure 4. Calculate the vehicle wind resistance coefficient and the vehicle profile pressure cloud map.

The Figure 4 above is the wind resistance coefficient and pressure cloud diagram of the vehicle's outer profile measured by FLUENT. As shown in Figure (4-A), when the air flow rate is set to 25m/s in the outer fluid domain, the wind resistance coefficient on the top of the vehicle body is the largest, about 12ms^{-1} , about the wind resistance coefficient ($c_d=0.08$). It can be seen from the figure that steady flow can be achieved in the basin outside the vehicle. As shown in FIG. (4-B), it can be seen that when the drainage basin of the exterior of the vehicle is 25m/s, the air pressure on the front baffle of the vehicle body is the largest, about 16pa, and there is a slight pressure difference between the bottom of the front windshield and the top of the rear cover plate, and the pressure is about 10pa.

Through data collection and search, the appearance of three types of vehicles was collected in the early stage of this paper, and the following values of vehicle wind resistance coefficient were collected:

vehicle model	Mi SU7	Audi A4	Tesla
Wind resistance coefficient (CD)	0.195	0.23	0.23~0.3

According to the above table, it can be seen that the wind resistance coefficient of Xiaomi SU7 is 0.195, that of Audi A4 is 0.23, and that of Tesla is 0.23~0.3. According to the calculation in the previous chapter, the wind resistance coefficient of the new model is 0.08, which is much lower than that of Xiaomi SU7, Audi A4 and

Tesla. However, the new model is mainly the calculated value of the wind resistance of the product upwind side, which has removed the interference of vehicle tires and external parts, but its coefficient is also smaller than the wind resistance coefficient of the three vehicles, so it is considered that the new model has certain reference value.

5. Conclusions

Based on the specific three-dimensional form, this paper simulates the three-dimensional model of three vehicles already on the market. On the basis of the simulation, relevant coordinate points are extracted and the matrix of relevant feature points is analyzed. The new coordinate values of innovative relevant points can be solved by using the mean value theorem of coordinate points, and the appearance model of new products can be drawn by using the coordinate values. Then, the finite element analysis software is used to conduct the aerodynamic simulation of the new vehicle appearance model in the outer basin, and the wind resistance coefficient of the relevant listed vehicles is compared, so that the finite element analysis of the product is relatively more convincing. This paper puts forward a new method of product appearance innovation, which can be analyzed and analyzed effectively.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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