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A Smart Pad Assisted Hybrid Sketch System

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Abstract. A sketching system using a tablet PC and a large display connected to a server is proposed for the conceptual modeling stage of vehicles. In the stage of setting the volume and proportion of a vehicle in conceptual design, the plane and spatial sketch interfaces can be used conveniently and efficiently in the stage of 3D model modification. A tablet PC can be used to implement plane input and the large display connected to the server, shows the complicated 3D models, traces, and spatial movement using sensors embedded in the tablet PC.

Keywords: Conceptual modeling, pad interface, sketch-based modification.

1 Introduction

When designing a vehicle, a designer sketches using a tablet, after which modeling engineers recreate the sketch as 3D model data. Considerable savings in terms of time and money could be achieved in designing vehicles if designers could create the 3D model data themselves. For this reason, there have been studies to naturally connect the designers' sketching process to 3D modeling using modelling systems that automatically create 3D model data through plane sketches [1], or by using an applied interface similar to the plane sketch in three dimensional space [2]. Despite the development of various sensor technologies as well as continuous research, the vehicle design process has not yet changed in this regard. The initial vehicle design process can be divided into the volume creation stage and the model modification stage. In the volume creation stage, the designer's view is limited to the side-view.

2 Hybrid Sketch System

The first stage in the process of vehicle modeling is to setting the volume of the vehicle, drawing the sides of the vehicle in a fixed side-view, and designing the overall balance and style. The second stage is to review the shape of the vehicle in various views using 3D spatial data, and modifying them to create an intended 3D vehicle model. The proposed sketching system is made up of a PC with a large screen, and a tablet PC, as shown in Fig. 1. The large screen displays the 3D model of a vehicle, and the tablet display shows the side-view image in the sketching stage in

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which the curves of the cross plane are modified to change the overall 3D vehicle model. The data of the tablet's position, orientation and sketch data drawn on the touch screen are delivered to the server using Wi-Fi as shown in system architecture. The orientation data are obtained using a sensor API [3], and the position data is obtained using the 3D pose estimation algorithm. The rear camera in tablet PC is used for movement of the pad interface.

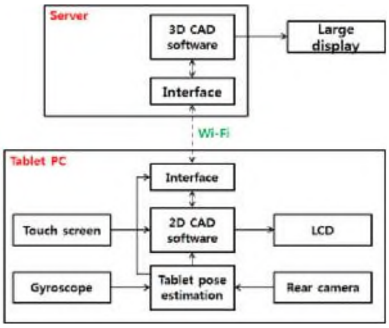

Fig. 1. System architecture.

3 Curve-based Sketch

Parametric curve and polynomial patches had been used to represent industrial design objects like car, because cubic and higher order polynomials allow surfaces to be controlled with C^2 continuity [4]. The cubic Hermite curve was set as the default curve of the sketch to design the character line and the exterior surface of the car. The oversketch algorithm that uses Hermite curves can obtain the position (P_{RS}, P_{RE}) and tangent vector (T_{RS}, T_{RE}) of a new curve R using the position (P_S, P_E) and displacement vector (T_{DS}, T_{DE}) of the starting and end points of the curve C, and the position (O_S, O_E) and tangent vector (T_{OS}, T_{OE}) of two points of the curve O, (Fig. 2(c).) The displacement vector of two curves can be obtained according to equation (1). The position and vector of two points are calculated by equations (2) and (3), and W_{PS}, W_{PE}, W_{TS} and W_{TE} are set differently depending on the type of the oversketch.

$$T_{Dx} = P_{Ox} - O_x \text{ ; where, } x = \{S, E\} \quad (1)$$

$$P_{Rx} = (P_x \times W_{Px}) + (P_x \times (1.0 - W_{Px})) \text{ ; where, } x = \{S, E\} \quad (2)$$

$$T_{Rx} = (T_{Dx} \times W_{Tx}) + (T_{Ox} \times (1.0 - W_{Tx})) \text{ ; where, } x = \{S, E\} \quad (3)$$

Type 1 is the case that an oversketch curve is drawn in front of or behind an existing curve, and the length of the resulting curve is extended. (Fig. 2(a)). Type 2 is the case that an oversketch curve is drawn up or down the existing curve, and the resulting curve is deformed. In the case of Fig. 2(c) Type 3 is the oversketch method if two curves intersect. Two curves can be separated into the curve sharing only the position and also maintaining C_1 continuity, as shown in Fig. 2(e),(f) and (g).

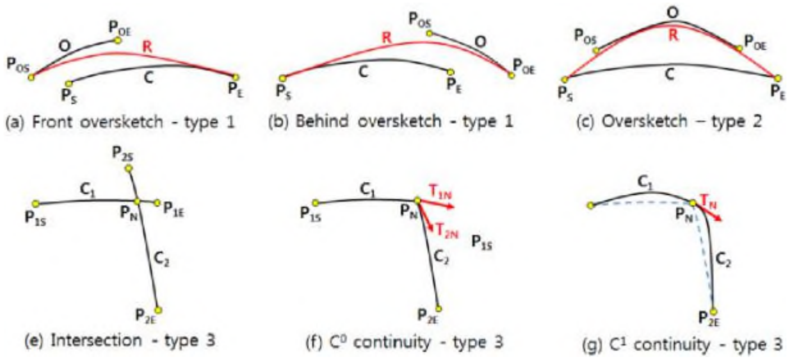

Fig. 2. Oversketch algorithm (type 1, 2 and 3).

4 Smart Pad Oversketch

In order to calculate the curves on cross-plane, the intersection of the surface patches in the 3D template with the cross-plane is calculated. The point of intersection on the curves with cross-plane is computed by using line-plane intersection algorithm. The intersected curves in the surface patch are divided at a point of intersection with interval *dT*, where dT_1 and dT_2, from the intersected curves in the surface patch are considered as shown in Fig. 3(a) and they are set as a start and end point (P_{IS}, P_{IE}) for the new cross-sectional curve and for the tangent vectors (T_{SP}, T_{EP}) at the start and end point, the intersection vertices are calculated between the surface and the cross-plane. A new Hermite curve C_{NEW} uses the position (P_{IS}, P_{IE}) and tangent vectors (T_{SP}, T_{EP}) as shown in Fig. 3(b), which shows a surface cross-section curve intersected on the plane.

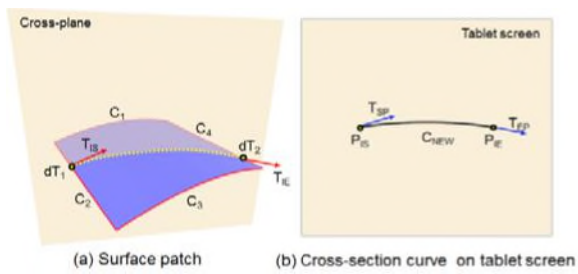

Fig. 3. Creating a cross-sectional curve.

5 3D Car Template

A sedan style car is defined as a left-side template that consists of 14 surface patches and a surface patch consists of four Hermite curves (Fig. 4(a)). Because the edge of surface patch and the character line are defined as a Hermite curve, the character line is assigned by subdivision to the edge of the surface patch [5]. As shown in Fig. 4(c), character line C1 is used to create the edges of surface S1 of the template. Curve C1 is separated into two Hermite curves, and the first curve (C1-D1) is reversed and then applied to edge H2 of Surface S1(S1-H2), and second curve(C1-D2) is applied to edge H1 of Surface S1(S1-H1). The remainder vertical edges are obtained by interpolation as the calculated vertical edges of surfaces. The surface patch of right side-view is created to extend a 2D template to a 3D template. The tangent vectors of horizontal edges of the left surface patch are reversed, and the vertical edges can generate the right side-view template by changing the depth value. The surface patches of center of a car are created using the edge information of the left and right templates and the 3D template consisting of surface patches is completed (Fig. 4(d)).

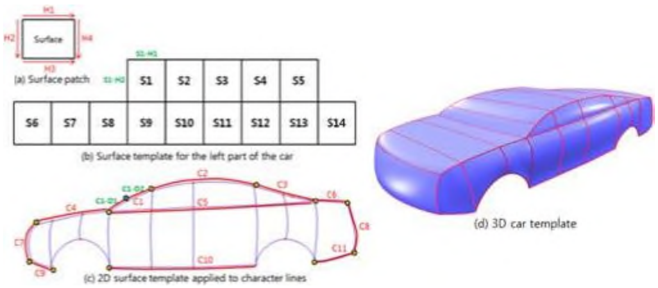

Fig. 4. 3D template conversion.

6 Conclusions

A new sketching interface in the stage of vehicle conceptual modeling has been proposed. Plane sketch is a method to precisely sketch a model in single viewpoint through a tablet with repulsive force. For the user's oversketch input, an oversketch algorithm was defined based on the Hermite curve. In the future research, a study expressing additional character lines and vehicle curves will be conducted.

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