Designing And Modeling Of De Havilland Canada Dash 8 Q300 Base on Simpleplanes

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Abstract. Mathematics development is aided by image-based 3D modeling. In certain ways, visual 3D modeling should be considered a branch and application of mathematical morphology. Airplanes are sometimes required in the scene due to storyline requirements. Due to the complexity and time-consuming characteristics of traditional modeling methods, this paper put forward a model making scheme using SimplePlanes software was proposed. After development and testing based on SimplePlanes software, the model is similar to the real aircraft, and using SimplePlanes will save a lot of time and meet the use requirements. In this paper, the method of modeling De Havilland Canada Dash 8 Q300 using SimplePlanes is explained in detail together with the basic modeling logic of this software. A user study is performed to demonstrates the overall good quality of the result and a significant improvement in terms of time efficiency.

Keywords: 3D modeling; De Havilland Canada Dash 8 Q300; simpleplanes.

1. Introduction

Image-based 3D modeling promotes the development of mathematics. In some sense, visual 3D modeling should belong to the branch and application of mathematical morphology. In the process of image processing, mathematical morphology uses mathematical methods to make the image processing more delicate and realistic [1]. For example, for the processing and analysis of the shadow part of the image, the composition of the shadow part and the size of the gray value can be analyzed through the resolution using mathematical methods [2-3]. This is a typical application of mathematical matrices. Therefore, image-based 3D technology requires higher mathematics [4].

In daily life, some entertainment activities, like games and movies, are ubiquitous. Sometimes, due to the needs of the plot, airplanes are needed in the scene. But buying a real airplane is too expensive and difficult to handle after shooting [5]. Therefore, in many cases, wooden airplane models are made or special software is used to make models instead. However, using traditional modeling methods is too complicated and takes too much time.

In order to solve the problem of aircraft acquisition, the following problems are summarized: ① the real aircraft is too expensive, and it is also expensive to hire a professional constructor; ② Wooden models are easily damaged; ③ Using traditional modeling methods will consume a lot of time.

So, we propose to use software to make models. Using SimplePlanes software has the following advantages: ① It is very convenient. Compared with traditional modeling methods, it saves about 5 hours; ② Because it is data, it is easy to save; ③ It is economical, and no specific modeler is required, because anyone can model; ④ High quality, the model is very similar to the real aircraft. Therefore, in order to meet the use needs of aircraft models in the scene, this study built the De Havilland Canada Dash 8 Q300 model based on SimplePlanes software.

2. The Design of De Havilland Canada Dash 8 Q300

This section is the central part of this paper, mainly explaining the intention of building this model, the characteristics of the software tools used, the classification of production steps, and describing the process and details of model production. This paper will describe in detail the process of using plane modeling-based software to build simulated 3D models [6].

De Havilland Canada Dash 8 Q300 model mainly explores the build process of simulated 3D scale models of civil aviation aircraft. The completed product of the model is also suitable for 3D scene objects such as video games, film and television works, and teaching videos. This paper will use SimplePlanes, a video game focusing on 3D modeling, to achieve the entire modeling work of the aircraft model [7]. This paper will use the blueprints based on the actual De Havilland Canada Dash 8 Q300 aircraft as a reference for modeling to achieve a higher degree of simulation (Figure 1).

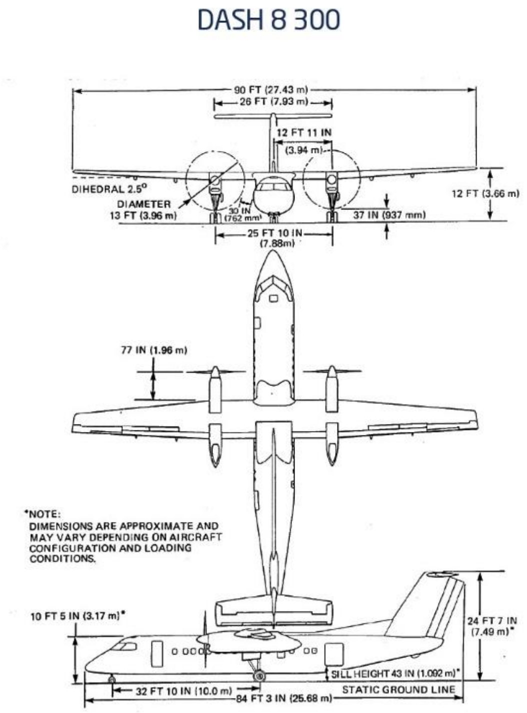


Fig. 1 The scale blueprints used for reference

The model of SimplePlanes is composed of many cylinders with different heights, base shapes, and cross-sections. Each part can modify its respective x, y, and z-axis location. The base surface shape can be modified by modifying the length of its x-axis and y-axis and the radians of the four corners. Each cylinder has seven connection points expressed as a blue pyramid, referring to two of each x, y, and z-axis and one central point *(Figure 2)*.

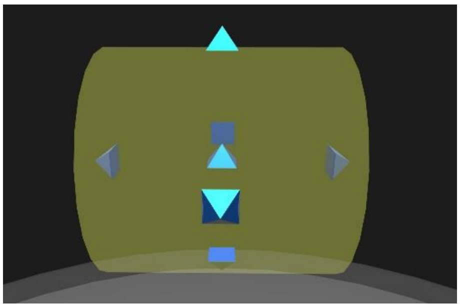


Fig. 2 The connection points of a cylinder

When two or more parts are connected at a specific connection point, the model composed of multiple parts will be recognized as a whole model rather than separate parts.

The modeling work is divided into the following four categories: Cockpit, Fuselage and T-tail, rectangular wing, Turboprop engines and landing gears.

2.1. Cockpit

The cockpit is the complicated part of the overall model because its appearance is difficult to reach the level of simulation, and it is also the part with the highest priority. First, drag out the "Hollow Fuselage" part from the Structural column, set the Width value of the two bottom surfaces of the cylinder to 5.25, the Height value to 5.00, the Corners to Circular. This slightly flattened elliptical hollow cylinder will be the critical part of the overall model, determining the size and proportion of the overall fuselage (Figure 3).

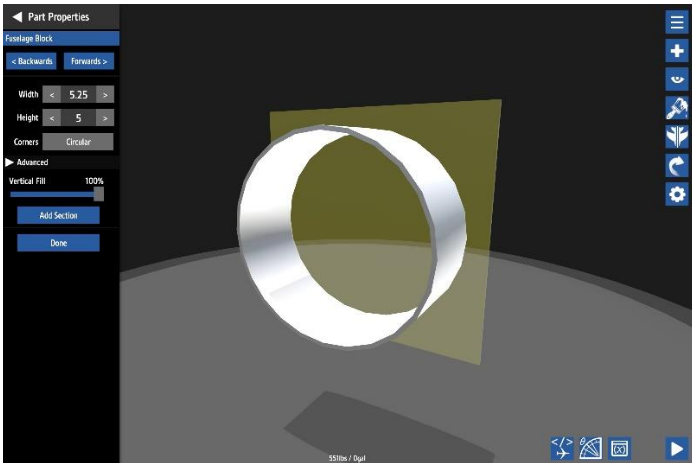


Fig. 3 The critical part and its variables

Use the "Blueprint" tool to open the scale blueprint as a background scene, adjust its size to W: 34.33 and H: 20.60, drag it to the critical part, and let the upper and lower sides of the part perfectly fit in the reference drawings. Use the "Paint" tool to set the color of the part to red (HEX code: FF0F0F) to build a high contrast to the blueprint, which makes it easier to distinguish the part and reference drawings (Figure 4).

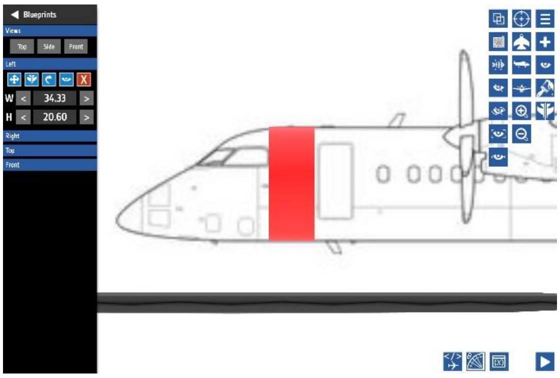


Fig. 4 The Blueprint tool and colored part

Select the left base face of the part and click the Add Sections option to create a new cylinder identical to it in front of it, modifying its cross-section to fit the scale blueprint. The front-end modeling work of the cockpit will go back and forth this way by modifying the Rise, Height, and Length value and cross-section to achieve a perfect fit with the reference blueprint (Figure 5) . When the side view conforms to the reference shape, switch to the top view, change to the blueprint's top view, and modify its Width value until the edge of the model follows the outline of the drawing.

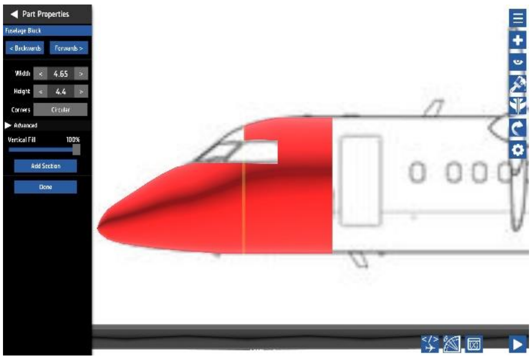
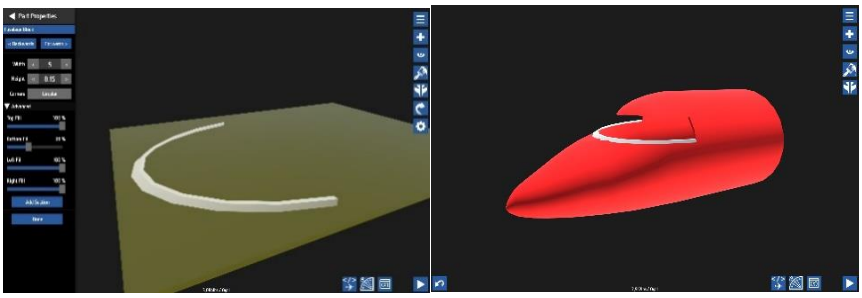


Fig. 5 modeling strictly following contours

Create a new hollow cylinder, modify the Width value to 5.00, the Height value to 8.15, the Length value to 0.1, rotate the x-axis by 90 degrees, and modify its Bottom Fill value of both bases to 38%. Attach this horseshoe-shaped piece to the bottom of the porthole section so that it looks like the metal edging of the porthole (Figure 6).



(a) (b)

Fig. 6 (a) Metal edge banding (b) Porthole with lower metal edging installed

Create another identical part in front of the fuselage, adjust its Length to 0.1, and modify its Top Fill and Bottom Fill values to make the edge banding effect at the end of the porthole (Figure 7).

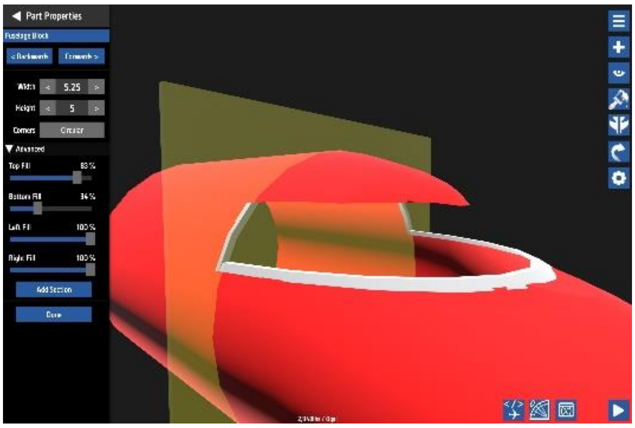


Fig. 7 Porthole rear edge banding

The method of making the edge banding effect of the upper part of the porthole is similar to that of the lower part, and the interval between each porthole can be achieved by using an inclined cuboid whose bottom side length is 0.1. Switch the red part to white (HEX code: FFFFFF), and the cockpit part is complete (Figure 8).

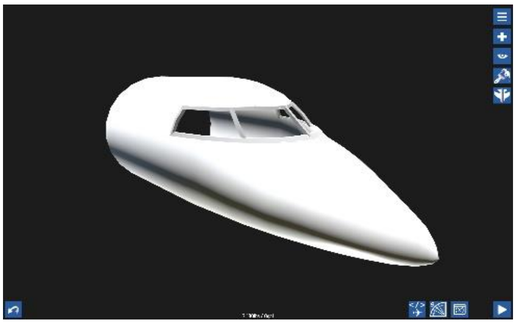


Fig. 8 Cockpit finished product display

2.2. Fuselage and T-tail

The fuselage part is the most straightforward of the overall model, thanks to the Sub-Assemblies function [8]. The Sub-Assemblies tool can customize and save a model composed of multiple parts so that a formed model can be used directly like a separate part as a single cylinder, thereby eliminating many repetitive parts of editing work and providing convenience for repeated work. The fuselage porthole section is the same model stacked several times.

A cabin porthole can be divided into upper and lower parts, composed of six hollow cylinders with different cross-sections. The structure is shown in the Fig.9.

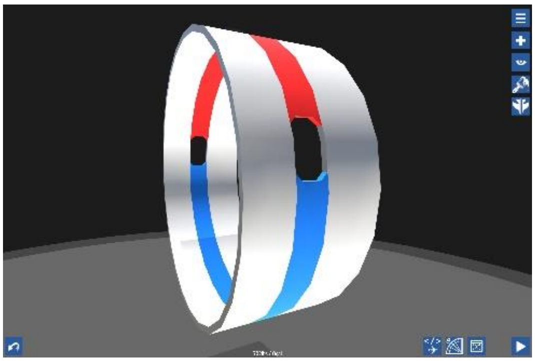


Fig. 9 Bin portholes divided into upper and lower parts

Save the above structural model as a Sub-Assembly and then drag it to the cockpit rear side, repeating several times according to the number and interval of portholes on the scale blueprint. Then the cabin part can be completed (Figure 10). The production steps of the fuselage rear part are similar to those of the front part of the cockpit. Adjust the Width, Height, Rise, Run, and Length values according to the outline of the blueprint. At this point, the work of the fuselage and its T-tail part is completed (Figure 11).

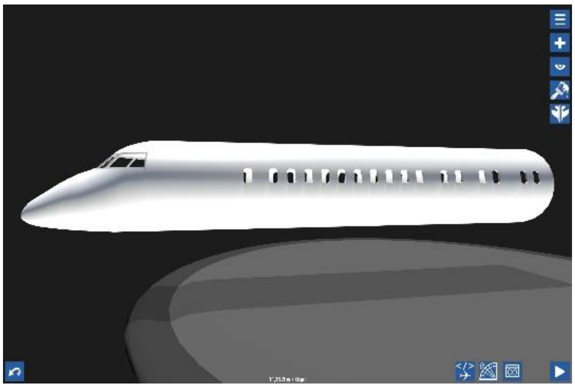


Fig. 10 The completed cabin porthole part

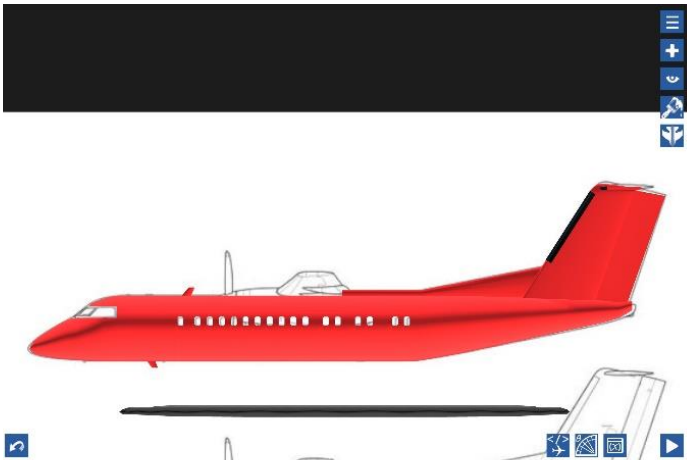


Fig. 11 The completed fuselage and tail

2.3. Rectangular wing

A scale blueprint of the top view will be used to make the rectangular wing section. First, make the junction of the wings connect to the fuselage. Create a new hollow cylinder with Width set to 4.5 and Height set to 1.95. In order to make the bottom fit the fuselage, the four-corner radian of the bottom surface needs to be trimmed [9]. The radian values of the lower two corners are both set to Hard, forming a right angle without radians. The right-angled side is perpendicular to the fuselage to fit the fuselage. The radians of the upper two corners are set to Smooth. Repeat the above steps to make the tail and head, and the junction is completed (Figure 12).

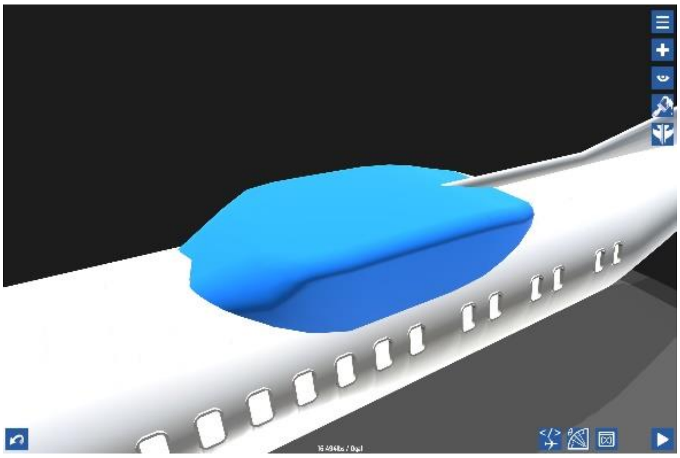


Fig. 12 The completed junction part

The wings are made of flattened cylinders. Set its front two corners to Smooth and the rear two corners to Circular to achieve the streamlined section of the wing. Center the wing at the junction and move the y-position, so it blends into the junction. Adjust the viewing angle to top view, open the drawing, and create new parts at both ends. Leave a part the same width as the engine at the turboprop engine and add different colors to indicate the position of the engine for subsequent work.

After the wing structure is completed, some details need to be added to it: the navigation light, the flap rail fairing, et cetera. At this point, the rectangular wing is completed (Figure13).

Fig. 13 The completed wing

2.4. Turboprop Engines and Landing Gears

The turboprop and landing gear are the final pieces of the model. Still use the above modeling method to complete. The main body of the engine is composed of smooth parts at all four corners. The position of the front blade is Circular, and a large number of parts with a Length of 0.2 are needed to trim its smoothness [10]. The blade is made of two ultra-thin parts with a Width value of 0.05, and the inclination of the engine blade is achieved by modifying its z-axis rotation (Figure 14).

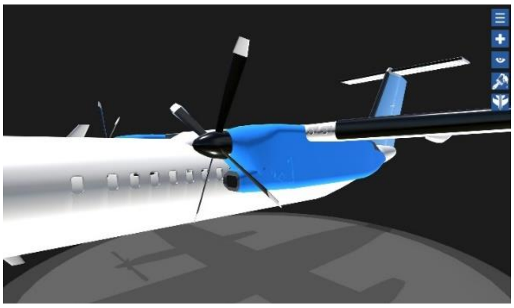


Fig. 14 The completed engine

The main landing gear is located under the engine. It is mainly composed of an inclined cylinder. The two cylinders with the y-axis rotated 90 degrees below act as wheels. The front is equipped with two thin cylinders in the shape of the letter V as the bracket (Figure 15 (a)). The nose landing gear is made of a short, inclined cylinder as a bracket, and two cylinders are used as wheels (Figure 15 (b)).

(a) (b)

Fig. 15 (a)Main landing gear installed (b) The nose gear

After finishing the nose landing gear, all the work on this model is done.

3. Result

3.1. Results Display

After the modeling process is done, SimplePlanes supports models to be exported as .obj file for further utility. A simple online 3d viewer, Creator3D, is used to demonstrate the result as shown in Figure 16-18.

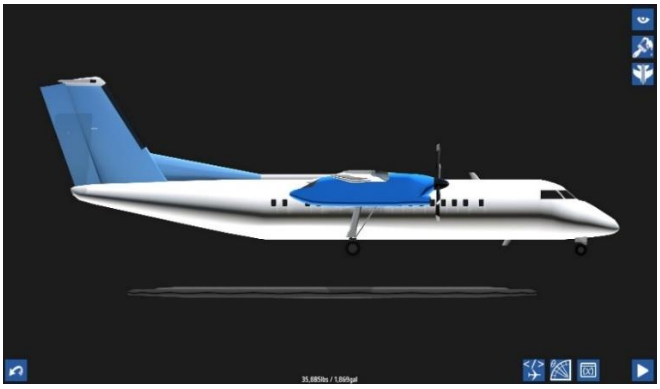


Fig. 16 The side view of the SimplePlanes

Fig. 17 The front view of the SimplePlanes

Fig. 18 The demonstration of the SimplePlanes

Comparing the result to the blueprint, above methods ensure the model is visually matching the blueprint of De Havilland Canada Dash 8 Q300 (Figure 18).

Importing a scaled blueprint in SimplePlanes as a reference makes accurate ratios between each part and positions of intersections accessible. It saves approximately 5 hours of work compared to tradition modelling methods, which requires measuring the data manually from the blueprint. (Figure 19).

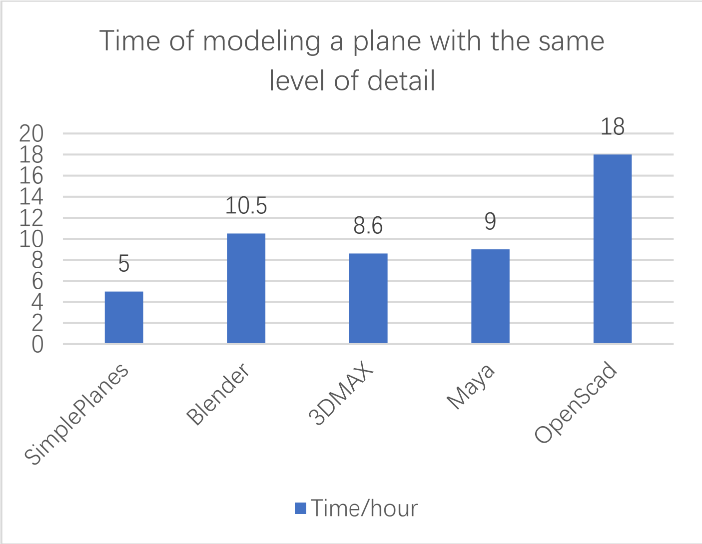


Fig. 19 Time of modeling a plane with the same level of detail

The result is set to be as realistic as possible, components obtained from the model are expected to be able to support the functionality of an airplane. Hence, extra cautions are paid in modeling wings. Figure 20 shows that, the exported model remains details of flap, slats, spoilers, air brakes and aileron.

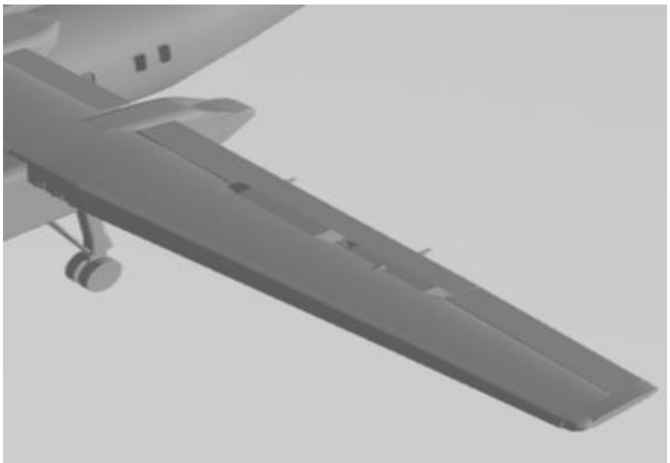


Fig. 20 Details of the wing

3.2. Evaluation

A study is performed to evaluate the overall quality of the model compared to a realistic airplane in terms of appearance, details, and time efficiency. To ensure the study reflects a realistic result, 10 out of 30 subjects have used SimplePlanes, 10 subjects have experience in modeling with other software while the remaining 10 subjects have 0 knowledge in modeling. Subjects are presented with the blueprint, the model, a real-life picture of De Havilland Canada Dash 8 Q300 and the time it takes to model this plane. Then they are asked to give each of three aspects a score out of 5, where a higher score means a higher satisfaction.

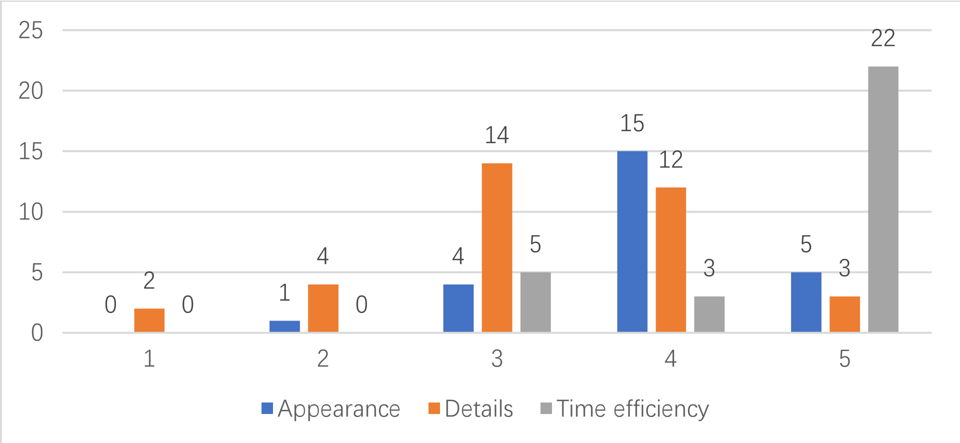


Fig. 21 User study

As shown in Figure 21, overall scores fall in the high range (3 to 5), that implies a decent quality of this model. Time efficiency, as expected, receives the highest comment, as 22 out of 30 subjects vote full marks. As in appearance and details, subjects tend to recognize this model has good appearance but not impressing in detail.

3.3. Limitations

From the user study, the model receives overall good comments, however, some problems are pointed out. The initial goal of this model is to be utilized in simulations or games that focus on interacting with various airplanes with a realistic background. In this case, it is crucial to be able to identify the type of certain airplane and to ensure a model with realistic details. Methods used in this paper can achieve the goal with significantly better time efficiency. However, the model is only able to deliver the outside detail of the plane, the inside remains empty. Meanwhile, windows are simply frames with no separate components, it is relatively easy to be seen through and notice the body of the plane is empty and the wall has no thickness. An additional question is asked to the 20 subjects that had experience in modeling at the end of the use study, how willingly do you like to use this modeling method in your future work. The result suggest only half of subjects are convinced to use this method over other methods. The main reason is, in the work of modeling, level of freedom is well concerned. Though this new method can reduce the work time significantly, other methods hold advantage in satisfying a wider range of demands. Therefore, a future improvement in the versatility of this method may solve more problems.

4. Conclusion

In this paper, the method of modeling De Havilland Canada Dash 8 Q300 using SimplePlanes is explained in detail together with the basic modeling logic of this software. A user study is performed to demonstrates the overall good quality of the result and a significant improvement in terms of time efficiency. However, this improvement in efficiency causes certain limitations due to this modeling software specializes in modeling planes. In the future, it is possible to developing from this paper and innovates new methods that can increase the detail of model as well as maintain the high time efficiency.

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