STM JOURNALS

International Journal of
Advanced Control and
System Engineering

Volume 2, Issue 2, 2024
July–December
DOI (Journal): 10.37591/IJACSE

https://journals.stmjournals.com/ijacse

Review IJACSE

Development of Automobile Scaled Model from CAD (Blender) Using FDM 3D Printing

Aditi Ajit Patil[1,*], Shetty Shravan Venugopal[1], Ameya Nijasure[2]

Abstract

Additive manufacturing (AM), also known as 3D printing, has emerged as a disruptive technology with the potential to transform automotive manufacturing. This paper reviews the applications of AM across the automotive product development lifecycle. The paper examines case studies demonstrating the use of AM for developing computer-aided design (CAD) models from concept sketches. Overall, AM brings several benefits such as design flexibility, faster time-to-market, and distributed production. However, there are also limitations around part quality, materials, and costs. Blender is used as a CAD tool to explore various tool kits, freeform shape modeling techniques for an automobile prototype. Ultimaker fused deposition modeling (FDM) 3D printing is used to print prototypes of 1:10 scale. AM facilitates rapid prototyping and tooling, enabling faster design iteration and concept validation. This paper provides a holistic analysis of the role of AM in the automotive industry, including its capabilities, benefits, and challenges. The review will help automotive firms effectively leverage AM to enhance manufacturing agility, productivity, and innovation. In this article, the creation of a scaled car model that was created with Blender for 3D modeling and printed using FDM is examined. From CAD design in Blender to the actual model's realization through AM, the paper outlines the procedures involved. Important factors, including layer height, print optimization, and material selection are covered. FDM's effectiveness in quick prototyping and model manufacturing for the automobile industry is validated by the results, which show the scaled model's correctness and structural integrity. The ramifications for upcoming developments in 3D printing technology in vehicle prototyping are examined in the article's conclusion.

Keywords: 3D printing, Blender, modeling, automotive design, additive manufacturing, fused deposition modeling (FDM)

INTRODUCTION

Using digital simulation, innovative product visualization, and quick prototyping, 3D computer graphics have completely changed product design and manufacturing across industries. This report details an internship project in which the goal was to develop a digital prototype of the Tesla Model S electric car using the 3D modeling program Blender. This project aimed to introduce Blender fundamentals and provide practical experience with 3D modeling and animation methods. The aerodynamic exterior design and cutting-edge features of the Tesla Model S made it an obvious choice for the topic. It would be possible to thoroughly explore Blender's modeling, texturing, and rendering capabilities if a complex, real-world car was recreated. The modeling process involved gathering technical drawings and reference images of the Tesla Model S, then leveraging Blender's

***Author for Correspondence**
Aditi Ajit Patil
E-mail: aditiaj22ecs@student.mes.ac.in

[1]Student, Department of Electronics and Computer Science, Pillai College of Engineering, University of Mumbai, New Panvel, Raigad, Maharashtra, India
[2]Assistant Professor, Department of Electronics and Computer Science, Pillai College of Engineering, University of Mumbai, New Panvel, Raigad, Maharashtra, India

Received Date: August 20, 2024
Accepted Date: August 27, 2024
Published Date: September 05, 2024

Citation: Aditi Ajit Patil, Shetty Shravan Venugopal, Ameya Nijasure. Development of Automobile Scaled Model from CAD (Blender) Using FDM 3D Printing. International Journal of Advanced Control and System Engineering. 2024; 2(2): 1–9p.

mesh modeling tools to shape the vehicle's body, lights, windows, wheels, etc. Attention was given to accurately capturing the proportions, angles, and detailing of the original design. High-resolution texture maps were applied to replicate the paint finishes and interiors. Adjustments to the lighting and rendering parameters were made to achieve photorealistic results.

To highlight Blender's application in rapid prototyping, the 3D model was 3D printed using Cura slicer software and an Ultimaker printer. The digital model was strategically split into parts for optimized print preparation. Post-processing work like sanding and painting was performed to refine the final physical prototype.

Overall, this project provided hands-on learning of automotive 3D modeling workflows using Blender. The skills gained have implications in facilitating design iteration, cost-effective prototyping, and visual marketing for the automotive industry. With Blender's expanding capabilities, it can empower future transportation design innovation.

LITERATURE REVIEW

Andrew Price’s [1] (also known as Blender Guru) Blender tutorial for beginners, the creator guides users through building a donut. They start by creating a new scene, deleting the default cube, and adding a torus with a recommended low polygon count. To enhance smoothness, "shade smooth" is applied. The tutorial introduces a subdivision surface modifier for increased smoothness and resolution by adding more faces to the mesh. Addressing the perfection issue, the creator demonstrates making the donut more realistic by introducing imperfections. This involves switching to edit mode, moving vertices around, and using proportional editing for ease. The video concludes with the creator noting that real donuts aren't perfectly round, flattening the bottom for added realism. Overall, the tutorial provides a concise, step-by-step guide to creating a basic donut model in Blender.

Cenglin Yao [2] discussed using 3D printing to construct digital models and prototypes of auto parts. It discusses utilizing 3D printing for rapid prototyping in the automotive industry. The process involves modeling the part digitally, slicing it into printable layers, and printing with materials like acrylonitrile butadiene styrene (ABS) plastic. The paper highlights benefit such as high efficiency and rapid turnaround. However, printed part quality and mechanical properties remain limitations. Overall, the paper explores 3D printing's capabilities to enable digital inventory and distributed manufacturing for the automotive sector.

Michal Fabian and František Kupec [3] did a case study on computer-aided design (CAD) model development for automotive components from hand-drawn concept sketches. It details a methodology in CATIA V5, involving importing and tracing sketches, analyzing curve quality, and generating class-A surfaces. Surface interrogation techniques, such as isophote plots, are employed to identify discontinuities. The paper showcases the rapid generation of model variants through parameter modifications, emphasizing the efficiency of this approach for swift automotive CAD model development in the early stages of product design.

R. Vignesh et al. [4] explore the integration of concept sketching and CAD modelling in automotive design, focusing on the rapid development of CAD models from hand-drawn sketches through parametric modelling. They detail the process of importing sketches, tracing curves, modifying for smoothness, and generating surfaces. Evaluation tools like reflection lines and isophotes assess aesthetics and continuity. The paper highlights the efficiency of this approach for swift automotive CAD model development, emphasizing the benefits of combining traditional sketching with CAD modeling in early design stages.

Sayan M [5] also known as Blue Inversion talks on how to model a car in Blender. The video is aimed at beginners and does not require any prior knowledge of Blender. The instructor guides you through the process of creating the base model of the car. He starts by setting up reference images and using them to establish the dimensions of the car. Then, he creates a plane and converts it into the car body using modifiers and extrusion. He refines the mesh by adding and adjusting edge loops. He creates a separate mesh for the car door using similar techniques. He briefly mentions how he would model the rest of the car, including the windows and the base.

3D Printer Academy Tutorials [6] was the YouTube channel which helped us to understand the basic concepts of Blender and how to be creative with the models. In the video, we clearly understand the extrusion technique by using it to make a mask.

In the work of N. Shahrubudin [7], 3D printing, also known as additive manufacturing, turns a geometric representation into a tangible thing by layering on materials. One rapidly developing technology is 3D printing. With the use of 3D printing technology, an object can be printed directly from a CAD model, layer by layer. The varieties of 3D printing methods, their applications, and the materials utilized for 3D printing in the industrial industry are all summarized in this paper.

Vinod G. Gokhare et al. [8] report on 3D printing, the numerous accoutrements used in it, and their rates, which have become a prominent content in technological aspects. Start with defining the terms" 3D printing" and "significant 3D printing." The history of 3D printing is also covered, along with information on the procedure and accoutrements demanded to produce 3D published products. The stylish accoutrements will next be chosen to work with our 3D printer. It also recognizes the benefits of 3D printing over cumulative manufacturing.

Tsvetomir Gechev [9] reports than 3D printing is particularly used in the automotive industry to create prototype parts. However, because of its precision, repeatability, ability to work with a variety of materials, and range of printing options, it can also be used for medium-scale production in the building, automotive, aerospace, biotechnology, and other industries. The primary goal of this article is to provide a quick overview of the 3D printing techniques used in the automobile sector, emphasizing their benefits and drawbacks, outlining their precise uses, and providing instances and projects from the real world. The flow of work is shown in Figure 1a.

The study conducted by A.S. Elakkad [10] focuses on the subjects that follow an explanation of the problem statement, and preface and background of the study, and a literature analysis of publications that punctuate the significance of 3D technology in the machine sector. The results of this study will help the machine industry’s stakeholders understand how 3D printing technology may be used to produce high- quality vehicles at lower costs. Tesla Model S is shown in Figure 1b.

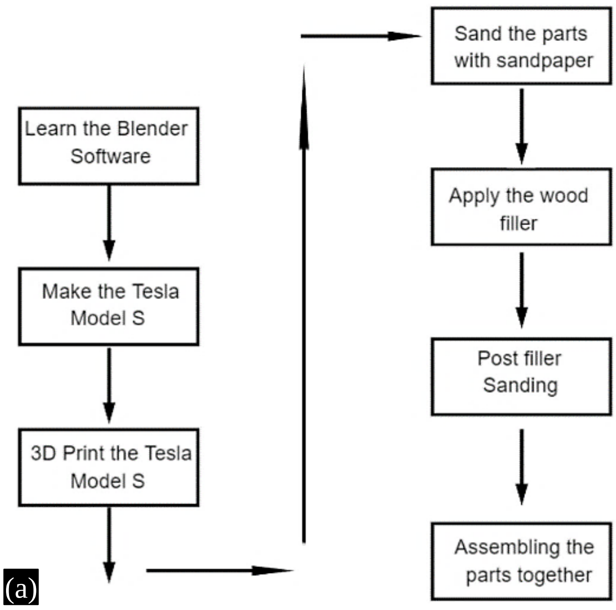

Figure 1. (a) Flow of work. (b) Tesla Model S.

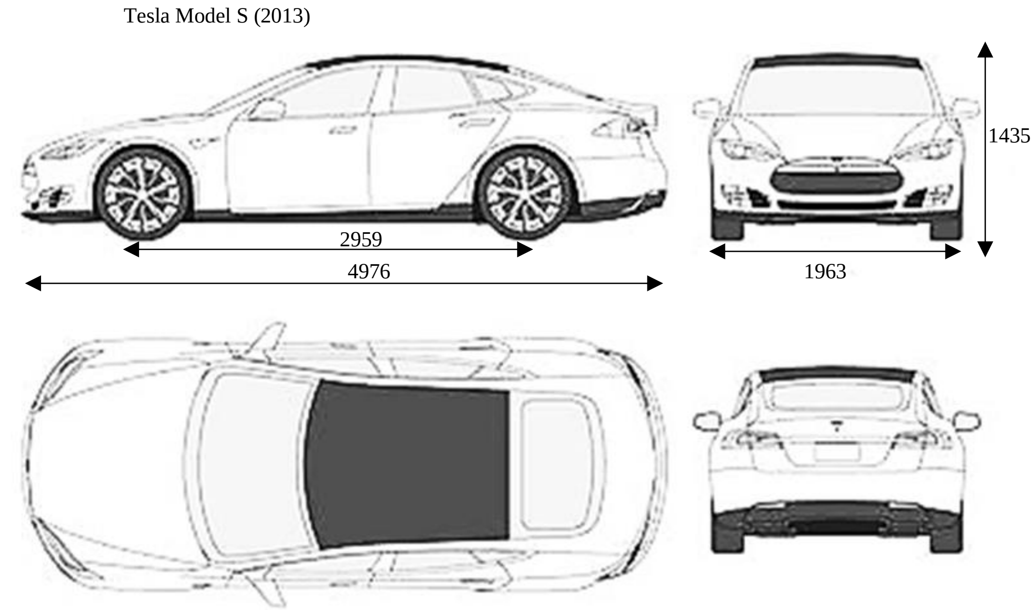

Figure 2. Reference images.

METHODOLOGY

The methodology from creating a 3D model with the Tesla Model S in Blender software to 3D printing it with Cura Slicing software is depicted in the flowchart (Figure 1a). Learning how to use Blender is the first step, after which comes designing and building the Tesla Model S 3D model in the software. 3D printing the designed model is the next stage. To remove any rough edges after printing, each component needs to be sanded using sandpaper. To get a smooth finish, a wood filler is then applied, followed by post-filler sanding. The 3D-printed duplicate of the Tesla Model S is then completed by assembling all of the polished and sanded elements.

MODELING OF TESLA MODEL S

The Tesla Model S, known for its sleek design and cutting-edge technology, serves as an ideal subject for a 3D modeling project [11]. The aim is to guide users through the intricate steps of replicating this electric vehicle within the Blender environment. Reference images are shown in Figure 2.

Reference Gathering

Accurate reference materials, including blueprints, photographs, and technical specifications of the Tesla Model S, are essential for achieving a faithful representation [12]. These references serve as a guide for precise measurements, proportions, and detailing.

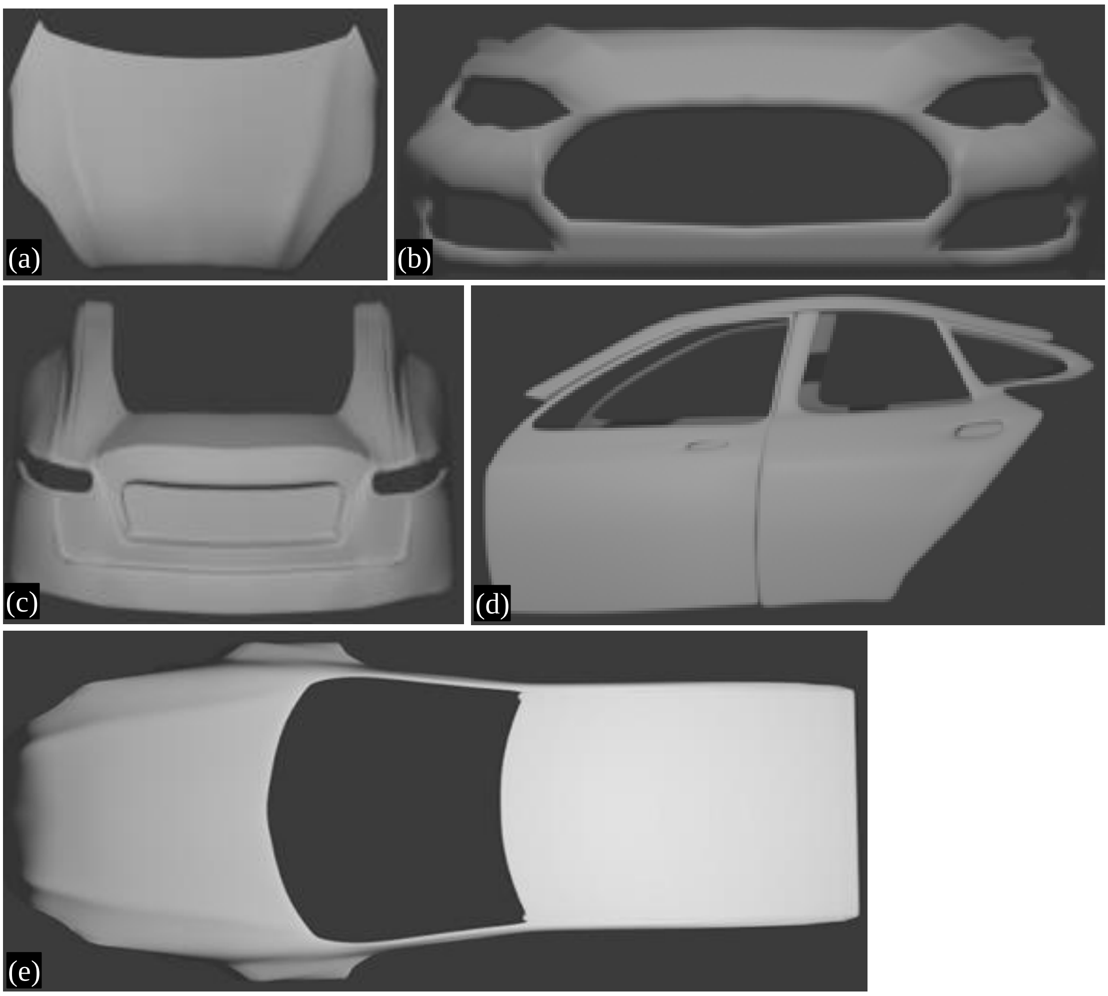

Figure 3. (a) Tesla bonnet. (b) Tesla front panel. (c) Tesla trunk. (d) Tesla doors. (e) Tesla top view.

3D Modeling

Utilizing Blender's powerful modeling tools, the initial phase involves creating the basic structure of the Tesla Model S. Tesla bonnet and Tesla front panel are shown in Figures 3a and 3b, respectively. This includes shaping the car's body, defining curves, and incorporating intricate details such as headlights, windows, and wheel arches. Tesla trunk and Tesla doors are shown in Figures 3c and 3d, respectively.

Texturing

High-resolution textures are applied to the 3D model, capturing the nuances of the car's paint finish, interior elements, and other distinctive features. Attention is given to replicating the subtle reflections and highlights that contribute to the vehicle's realism. Tesla top view is shown in Figure 3e.

Lighting and Rendering

Blender's advanced rendering engine is employed to set up realistic lighting scenarios. Consideration is given to environmental lighting, reflections, and shadows to enhance the lifelike appearance of the Tesla Model S. Iterative rendering and fine-tuning are conducted to achieve optimal visual results. Final Tesla Model S in Blender is shown in Figure 4.

3D Printing Process

The objective is to use 3D printing fusion deposition modeling (FDM) technology to create a detailed scaled model of the Tesla Model S. The process involves converting the CAD model into an STL file and then printable G-code through the Cura slicing software and subsequently using an Ultimaker 3D printer for the physical model. To optimize the printing process and reduce overall print time, a crucial step involves dissecting the model into manageable parts directly within Blender. Optimize Print Format Division is shown in Figure 5. Here the idea is to divide parts into smaller sections so that it can be printed faster with a smaller number of supports in different orientations. This segmentation not only facilitates efficient printing but also allows for easier assembly of the final 3D printed Tesla Model S. This strategic approach in digital model preparation sets the stage for a streamlined and time-efficient 3D printing workflow. Polylactic acid (PLA) is used as printing material in spool form. PLA has a melting temperature of around 200ºC and requires a bed temperature of around 55ºC. Ultimaker Extended 2 is used as a FDM printer to print half models of scale 1:10. For printing half model is selected to save material and time of printing. Same model can be used to showcase a physical prototype as output of this project.

Slicing with Cura

Cura, a widely used slicing software, is employed to convert the 3D model into layers (slices) suitable for 3D printing. Cura slicing is shown in Figure 6. Key considerations include layer height, infill density, support structures, and print speed. Optimization settings are adjusted to strike a balance between print quality and time.

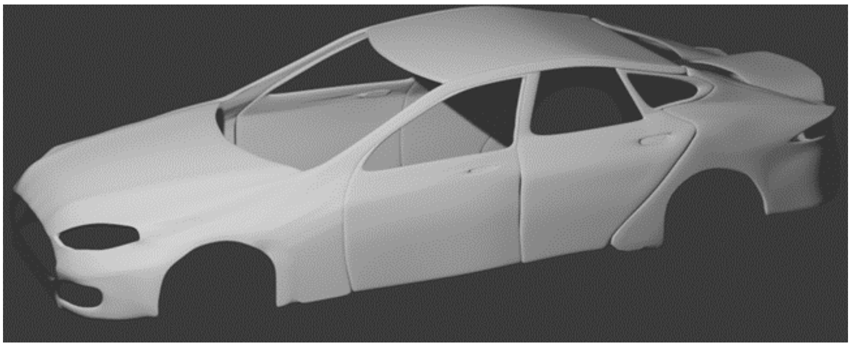

Figure 4. Final Tesla model S in Blender.

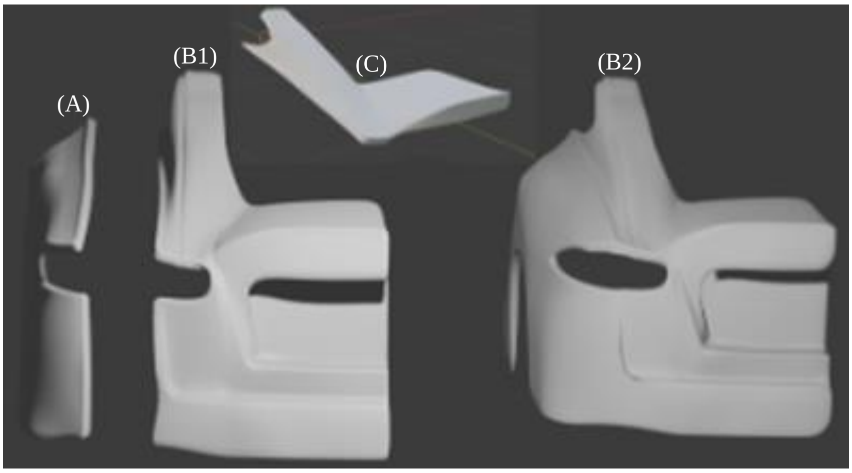

Figure 5. Optimize print format division.

3D Printing

Table 1 shows the material and time taken in Cura software to print this model with fixed settings of the following parameters. 3D printing of the parts of Tesla Model S is shown in Figure 7. The orientation of each part is adjusted such that it will take less time and a better smooth surface on the outside surface of a model.

- *Nozzle:* 0.0004 m (0.4 mm)
- *Material:* Polylactic acid (PLA)

- *Infill density:* 15%
- *Print speed:* 60 m/s
- *Supports:* Everywhere

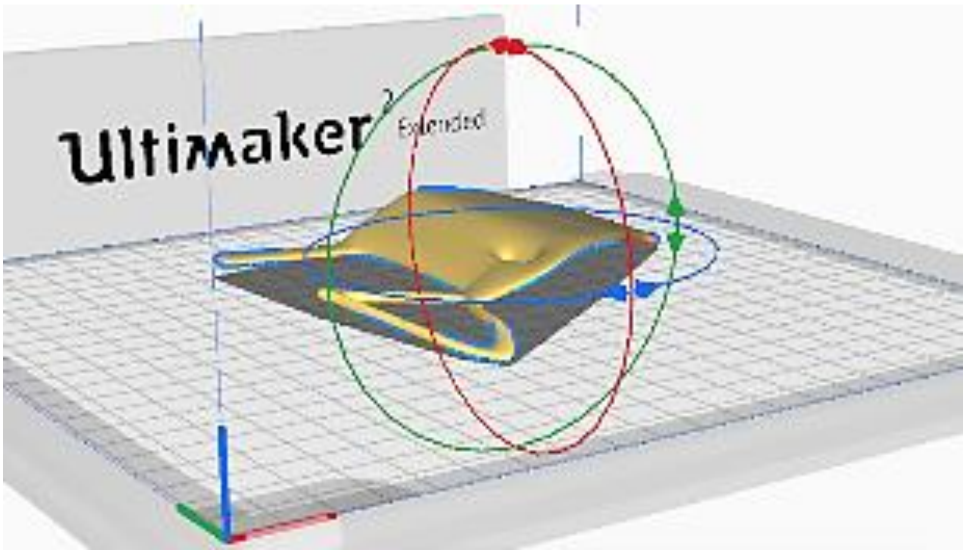

Figure 6. Cura slicing.

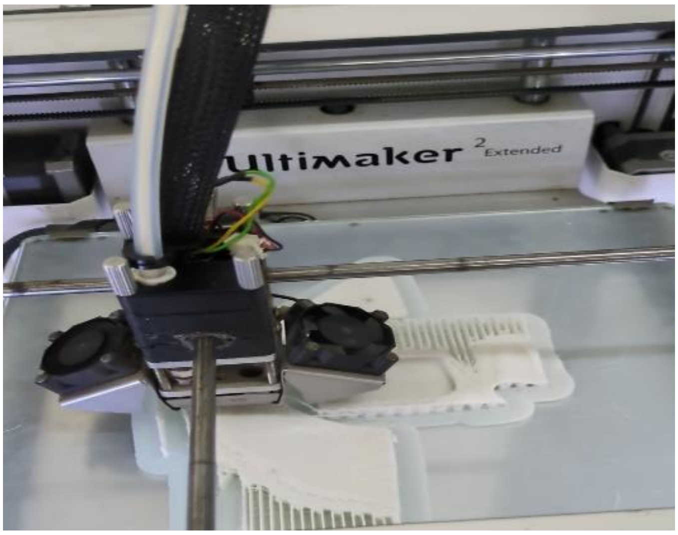

Figure 7. 3D printing of the parts of Tesla Model S.

Table 1. Printing parameters for a half model.

S.N.	Part Name	Material	Time
1	Trunk (Figure 5(c))	0.66 m	1740 s
2	Trunk (Figure 5(a))	4.79 m	10980 s
3	Trunk (Figure 5(B(B1)))	2.61 m	6660 s
4	Trunk (Figure 5(B(B2)))	2.04 m	5580 s
5	Side panel	2.07 m	5220 s
6	Front panel upper part	1.05 m	2880 s
7	Door (front)	4.03 m	9900 s
8	Door (back)	3.88 m	9840 s
9	Roof	5.48 m	13020 s
10	Bonnet	5.24 m	11880 s
Total		31.85 m	79080 s

Figure 8. (a) Sanding parts with sandpapers. (b) Applying wood filler and finishing parts.

Figure 9. Final model.

Post-processing

Once the 3D printing is complete, post-processing steps are undertaken. This involves removing support structures, sanding to achieve a smoother finish, and applying finishing touches to capture the desired level of detail. Post-processing is required to remove burrs and excess material in layers. Sandpapers of different grades (80, 100, and 120) are used starting from lower grades to higher to make the final model smooth. Once this is done, wood filler is used to fill gaps within layers of 3D printing. After the wood filler is dried, final sanding is done with finish paper. Sanding parts with sandpapers and applying wood filler and finishing parts are shown in Figures 8a and 8b, respectively.

Assembling

After efficiently preparing, slicing, and 3D printing with Cura and Ultimaker, the exciting part begins putting it all together. The segmented parts make assembly a breeze, emphasizing how 3D printing brings our digital visions to life, piece by piece. The final model is shown in Figure 9.

CONCLUSION

In conclusion, Blender shows up as a useful tool in the ever-changing automobile industry, providing a platform for designers to realize their ideas and expedite the design process. Cura and Ultimaker seamlessly convert digital models into precise 3D prints. Efficient preparation, slicing, and printer setup lead to detailed objects. Post-processing ensures a refined final product. This cohesive process underscores 3D printing's transformative capacity for turning virtual designs into physical reality.

A few of the challenges and modifications suggested for future models are in bender design; one can add extrusions in two assembly parts like press fit to get better reference while assembling multiple parts together. For 3D printing multiple parameters like print resolution, speed of print, infill density, infill pattern can be varied to get better results in terms of quality and time/material required for printing. For finishing a product, spray painting will be recommended over manual painting so that even paint coats can be added on the model.

Acknowledgments

We wish to extend our sincere gratitude to Dr. Amey Marathe for his invaluable expertise, guidance, and encouragement throughout the duration of this project. His dedication, time, and motivation were instrumental in its successful completion. We are deeply indebted to Pillai College of Engineering for the provision of excellent facilities, which greatly facilitated the execution of this report. Special thanks are also due to the Maker's Studio for their assistance in 3D printing the Tesla Model S, a pivotal element of our project.

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