CS 148 Final Project

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1. Results

Fig. 1-1 Rendered image.

Fig. 1-2 Variant A (different angle).

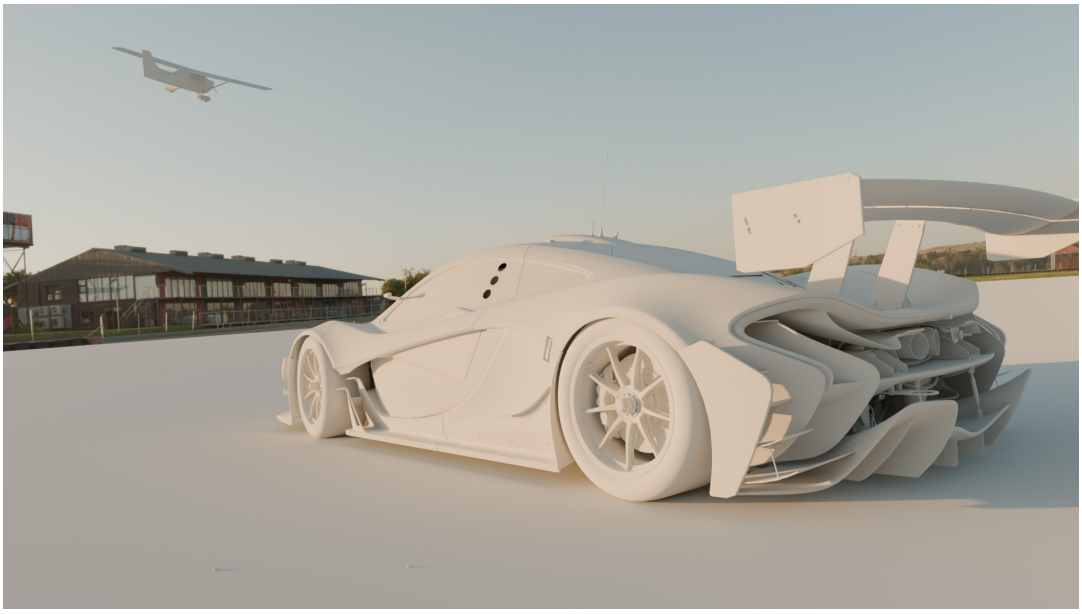

Fig. 1-3 Variant B (no texture).

2. Background

I am a motorsport enthusiast, and I was previously the principle aerodynamic engineer in a student formula racing team. In a student team, we had very limited budget, so fancy designs of bodywork and wings were difficult to come to life. But in a virtual world, creativity is not limited, so I designed and modeled a car named "McLaren P1 Omega" as a personal fun project.

The design is a heavily modified race version of the road-legal 2013 McLaren P1. I modeled this car mostly on Autodesk 3ds Max and Alias. Some assets (e.g., stock bodywork parts and some texture maps) were borrowed from the 2015 sim racing video game Project CARS, since this project was originally meant for exporting the car back to the game as a mod.

More information about this project can be found on my homepage and ArtStation.

3. Project Overview

For the CS148 final project, the car is exported from 3ds Max and imported to Blender for rendering. Since Blender's shader nodes are very different from 3ds Max, all materials are created from scratch in Blender to accommodate the Cycles renderer.

The project requirements are met as described below:

(1) **Ray tracing.** The rendered image leverages the power of the Cycles engine to achieve photorealism. The lighting uses natural environment light from the downloaded HDR panorama image, with additional emissive taillights of the car. Bodywork materials (e.g., carbon fiber, metallic paint) are carefully crafted using multiple layers of shaders, reflecting real-life layered materials.

(2) **Geometry modeling.** The geometry of the car is a mixture of unique parts designed/built from scratch (modeled in 3ds Max and Alias) and in-game assets (parts inherited from the original McLaren P1 design). More details are provided in 4.1.

(3) **UV mapping and texturing.** The bodywork employs 2 UV channels, with UV#1 for carbon fiber and UV#2 for paint design and stickers. All the bodywork UV maps were created from scratch in 3ds Max. The paint is also a unique design created from scratch in Photoshop. More details are provided in 4.2 and 4.3.

(4) **Cycles advanced feature.** The rendered image involves motion blur effects, volumetric rendering (a thin layer of mist that slightly lightens the distant background), and caustics effects. Some default render properties are modified to make caustics effects more prominent (light bouncing from the specular bodywork to the ground). More details are provided in 4.4.

(5) Zero post processing. No post processing is used to create the final image.

4. Project Details

4. 1. Geometry design and modeling

Since the car is intended to be a racing modification of an existing design, and the mesh was originally created for the video game Project CARS, in-game assets of the base McLaren P1 are used as a reference, which partially contribute to the final mesh of the McLaren P1 Omega.

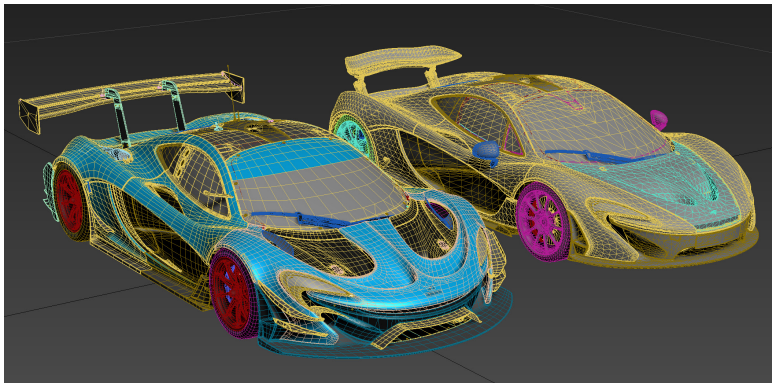

Fig. 4-1 Comparison between the McLaren P1 Omega (left) and the original McLaren P1 (right). Most of the front is redesigned and modeled from scratch, except that the windscreen, wipers, and front lights are borrowed from the original model.

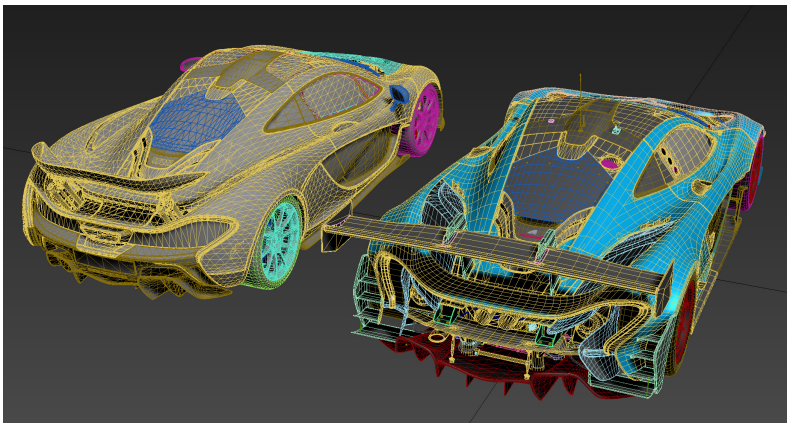

Fig. 4-2 Comparison between the McLaren P1 Omega (right) and the original McLaren P1 (left). The rear is also heavily modified with unique parts built from scratch.

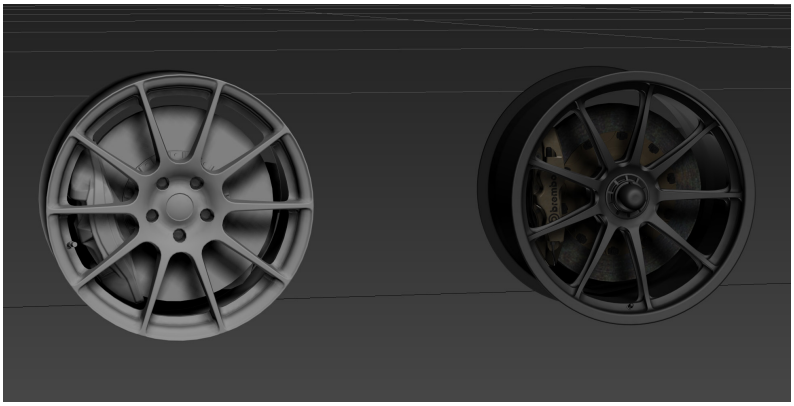

Fig. 4-3 Comparison between the McLaren P1 Omega (right) and the original McLaren P1 (left). The rim and brake disc are fully redesigned and modeled from scratch.

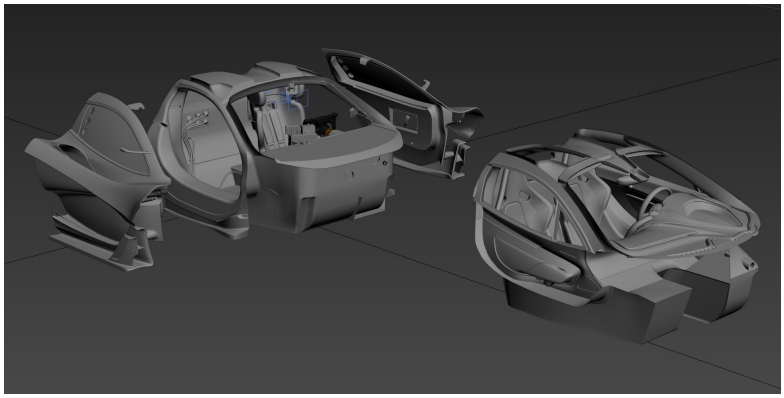

Fig. 4-4 Comparison between the McLaren P1 Omega (left) and the original McLaren P1 (right). The new cockpit does not have much in common with the original version, so most of it is built from scratch. More details (e.g., door frame) are added as well.

Fig. 4-5 Comparison between the McLaren P1 Omega (left) and the original McLaren P1 (right). The redesigned interior adopts flat racing aesthetics, which is very different from the original version.

4. 2. Paint design

The paint design is inspired by the reflection lines that automotive designers often use to evaluate surface smoothness. To create the texture for this design, the entire bodywork is unwrapped into the UV space, as shown below.

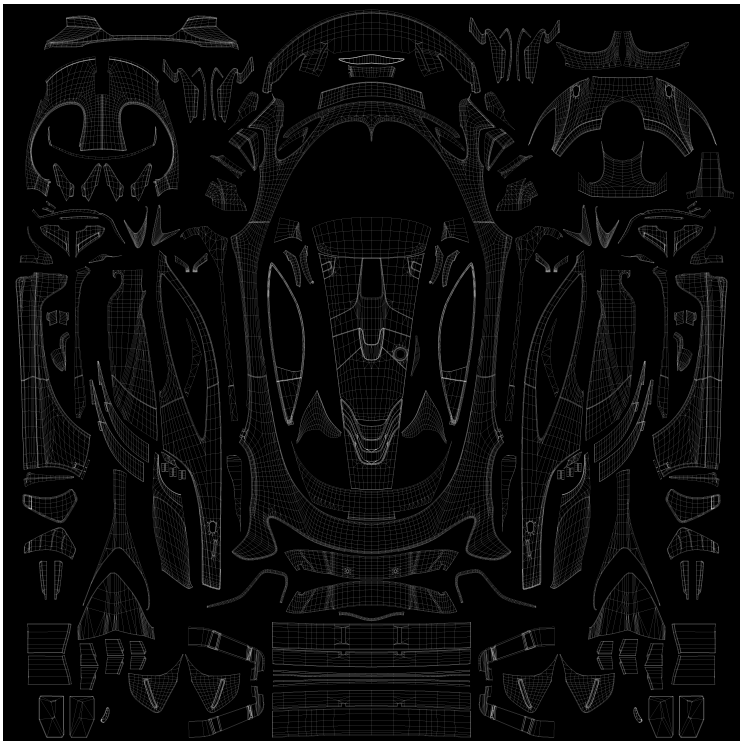

Fig. 4-6 UV map of the bodywork for paint design.

Then, iso-angle lines are baked to an initial texture map as a reference. The final texture map is completed in 8K resolution using Photoshop.

4. 3. Carbon fiber material

Carbon-fiber reinforced polymer is a frequently used composite material in race cars. In Blender, the visuals of this material are created by overlaying a smooth clear coat shading layer on top of an anisotropic carbon fiber fabric layer. The normal texture for the fabric layer is baked by projecting the surface normals of a fabric mesh to a plane, as shown below.

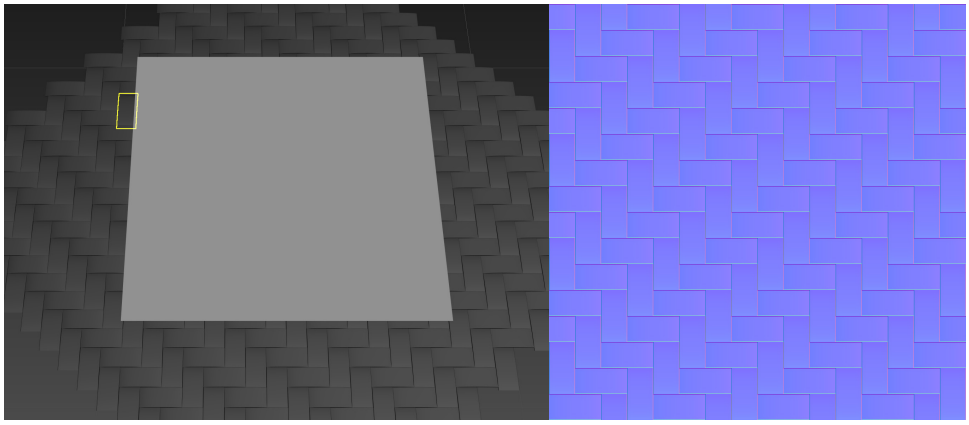

Fig. 4-7 Baking the normal texture of carbon fiber fabric.

To map the texture onto the surface of the car, another UV channel is created exclusively for the fabric texture, which is independent from the previous UV channel for paint design.

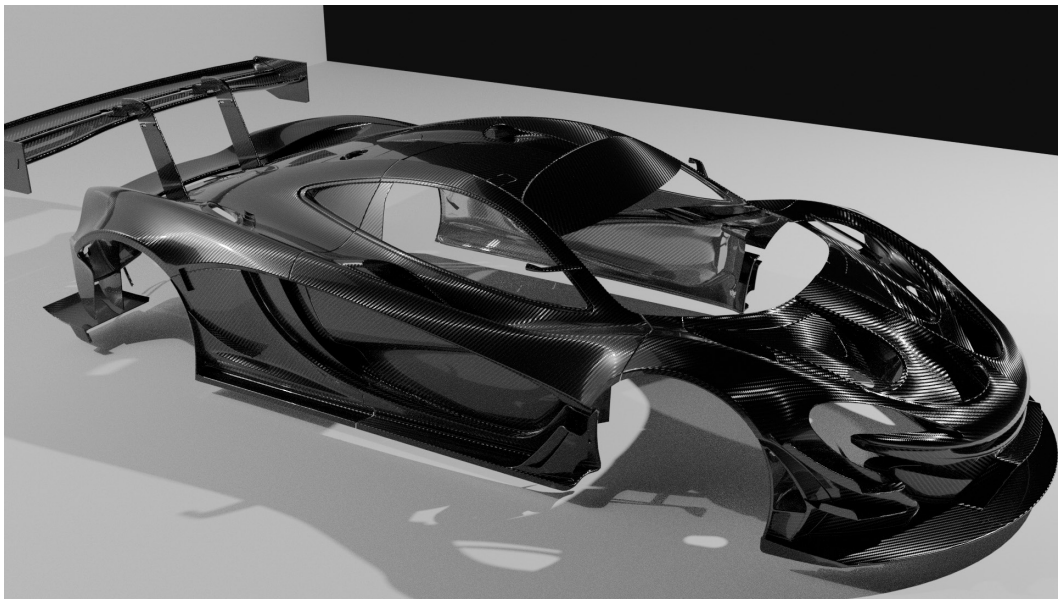

Fig. 4-8 Carbon fiber material rendered using Cycles.

4. 4. Caustics effects

Blender Cycles does not natively support forward ray tracing and photon maps for efficient caustics effects. Therefore, brute force backward ray tracing is used in this project. By default, Blender softens the caustics to reduce noise. To recover sharp caustics, light path settings in the Cycles renderer are changed from the defaults, as shown below.

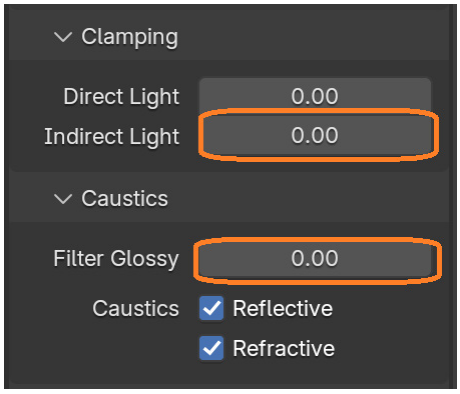

Fig. 4-9 *Indirect Light* clamping and *Filter Glossy* are disabled to produce sharp caustics.

These modifications improve the sharpness of caustics effects, at the cost of introducing lots of noise. To reduce noise, two RTX 3090 GPUs are used to render the final image with over 2 million samples.

5. Resources

(1) Base McLaren P1 model and miscellaneous texture (tire, radiator, fuel tank cap, fire extinguisher, exhaust pipes, seat belt, Alcantara): Project CARS

(2) Environment HDRI: https://polyhaven.com/a/zwartkops_curve_sunset

(3) *Flatten Ground* node group: modified from https://hdrmaps.com/blog/hdri-dome-projection-in-blender-using-shader-nodes-only/

(4) Ground plane tutorial: https://www.youtube.com/watch?v=dj6QJtibF4o

(5) Asphalt normal and displacement texture: https://polyhaven.com/a/asphalt_track

(6) Aircraft model: https://www.blenderkit.com/get-blenderkit/bf57181d-36c4-4da6-bad4-50384eff0f25/