School of Informatics

Computer Graphics Assignment 1

Reel or Real

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(a) Photograph (b) Composited Image

Figure 1: Augmented reality by rendering a virtual object into a real scene.

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1 Introduction

Reel or Real Studios, based in Edinburgh, is seeking talented interns to join their team for their next VFX blockbuster. In order to find the best student to fill that position, they set a hackathon environment to produce a prototype where student will required to evaluate their skills. Reel or Real Studios put a task that involves augmenting a real-life photograph with computer graphics imagery created by a photo-realistic renderer. Additionally, the company logo, which is a brush, must be included in the final image. The rendered image must exhibit lighting, reflections, and shadows that are physically accurate and blend seamlessly with the real-life elements in the photograph. The end result should be a photo-realistic image that convincingly overlays the brush and a 3D computer rendered objects onto the original photo [1]. We are participating in this competition, thus we create our own scene.

In this report, we will be illustrating and describing each of the steps of the following workflow:

1. Planning the scene
   (a) Organise an interesting scene.
   (b) Record the relative positions of interesting objects and the camera.
   (c) Take a photograph of the scene from the recorded camera position.
   (d) Take pictures of the interesting textures.
2. Modelling the scene
   (e) Roughly model the interesting objects (including textures) using a 3D modelling tool.
   (f) Place a virtual camera in the scene (using the recorded position).
   (g) Choose a virtual model (3D mesh) that you would like to insert in the scene.
   (h) Place the mesh in the modelled scene using the tool.
3. Rendering the scene
   (i) Export the scene in a format that can be rendered using PBRT (version 3).
   (j) Check the exported file to see that light sources and the camera are included.
   (k) Render the scene using PBRT.
4. Compositing the scene
   (l) Composite the rendered image of the mesh into the photograph taken in step 1c.

Note that the Introduction details were adopted by the Specification for Assignment 1 brief [1].

2 Workflow Steps

2.1 Planning the scene

We organized an interest scene by exhibiting interesting visual properties from items that could possibly give nice effects when blended with virtual items. The scene organization is a crucial step in creating an engaging and compelling visual experience. By considering the placement and arrangement of elements in a scene, we can give a more effective and convincing image to the viewers. The image was taken in a dark room, thus the black background (Figure 2). The objects selected were based on their structure (geometrical details), and their texture. The objects added include an interesting plant, a bottle liquid for cleaning shoes, a shoe, a camouflage bathroom bag, a pink storage box (used for laundry capsules), and a shoe brush. We planned to position the rendered objects in the middle of the image to maximize the effects with the real-world elements, thus we tried to place the real objects in an interesting positioning and take the photograph of the scene as seen in Figure 2. The light source in our picture was a phone flash based approximately 1 meter above the middle of the scene. From all these objects we focused on the objects that would create nice effects and interactions with our rendered items. Therefore, we selected the camo bag and the pink box due to their interesting textures, and the shoe laces that could create nice shadow effects on our augmented objects. The surfaces of the camouflage bag and the pink box were separately photographed to be added in the modelling using the same light source.

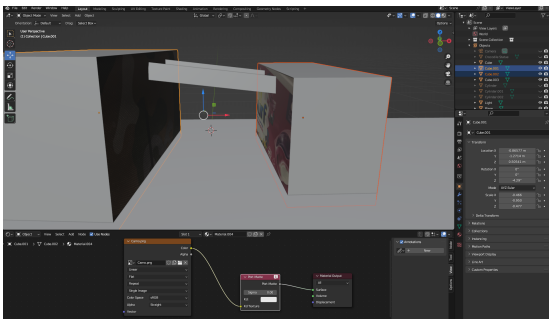
Figure 2: Real photograph of the scene.

Thereafter, we had to plan the virtual objects and their respective materials, ensuring that they possess captivating visual characteristics such as shadows and complex reflections. Our objective was to produce an image that would be both aesthetically pleasing and engaging to the viewer. To achieve this, we decided to place an upside-down like cup for mirroring textures, objects, and shadows. On top of that we placed a small stick that holds a crocodile statue. The crocodile statue was obtained from the online 3D model library (.ply) at `https://www.artec3d.com/3d-models/crocodile-statue` [2]. Furthermore, we added two monkeys on sticks gotten for blender software [3]. We used the sticks to hold the virtual objects higher in order to capture their complex shadows and reflections. The added virtual objects can be seen in Figure 5.

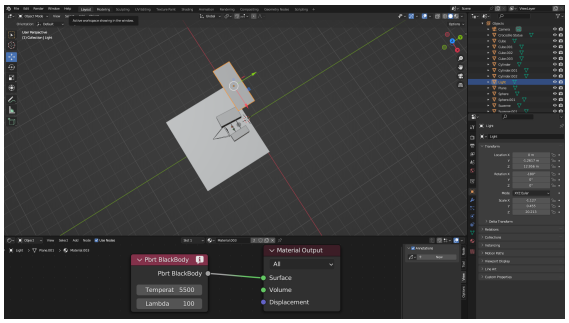
2.2 Modelling the scene

For modelling the scene we used a library that is based on the book: Physically Based Rendering: From Theory to Implementation (PBRT) [4, 5]. Additionally, Blender, a 3D modelling software that interfaces with PBRT was used alongside its respective PBRT exported to capture the scene [3, 6].

Firstly, we modelled the real scene in Blender (Figure 3) in order to get the actual objects that will interact with the virtual added objects. A matte white plane was applied to match the table of the real scene, where the real and virtual object are being placed. Additionally, we created two cubes to represent the camo bag and the pink box respectfully with matte PBRT materials as we were only interested on capturing their textures. Then, we matched the materials of the two objects with their image texture we captured during the phase of planning the scene. Later, we create two new cubes as showed in Figure 3a, to represent the two shoe laces. We scaled the material down to match approximately the size of the shoe laces in order to get a nice shadow close to the real image. Material matte was used again for this. Finally, we set a lighting source that uses PBRT black body material. The light source parameters were set to 5500 temperature and lambda to 100. The light was placed approximately in the middle of the scene so we could mirror the actual flash from the phone (Figure 3b). We tried to make sure that the materials were appropriately defined, and the desirable textures were mapped correctly. Finally, the last thing we did to model the real scene, was to define the camera's position to match the real camera's view used in the real image (Figure 4).



(a) Modelling real objects, shadows, textures



(b) Modelling the light source

Figure 3: Modelling the real scene in Blender.

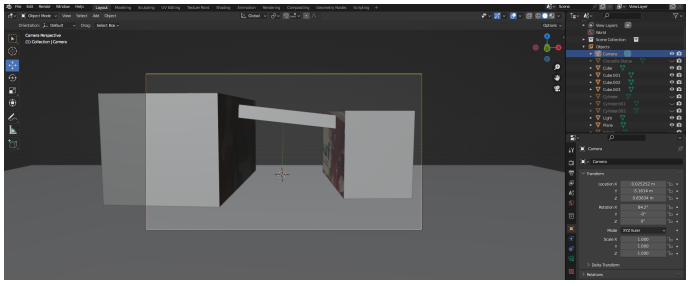
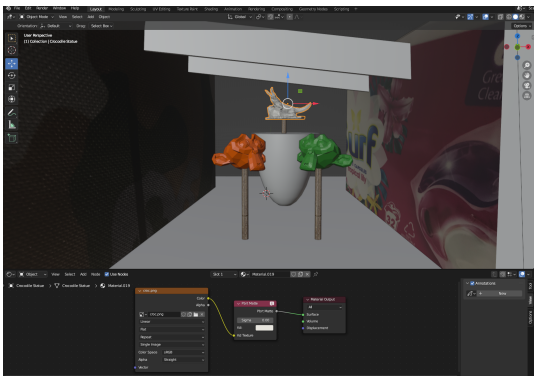


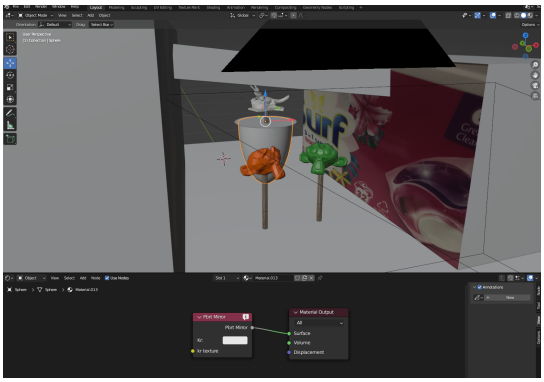
Figure 4: Camera view of the modelling scene.

After creating the virtual representation of the actual scene, we started adding the virtual objects (3D meshes) to be blended with the actual scene. We added eight more objects. The first one is a crocodile statue .ply object [2]. We gave it a matte material and added an image

texture to it (Figure 5a) [7]. The second and third objects are two matte monkeys with two different colours (orange and green). These three objects were placed on the top of three matte cylinder objects to show the shadows (sticks). The sticks were given a Parthenon ancient building texture [8]. Furthermore, we added a half-sphere object as a mirror material to show the reflections of the shadows, the textures, and the objects (Figure 5b). Due to the noise the light source was generating by reflecting to the mirror, we decided to cover the top of the sphere with a new flat matte plane as an "umbrella" of the light. The crocodile as seen in the Figure 5 was placed above the sphere mirror. We tried to place the items in positions where we can get the best interactions. The two monkeys were place below the one shoe lace, and the mirror sphere with the crocodile under the second one to get their shadows on the augmented items. With this setup we managed to record shoe laces shadows, reflections of lace shadow, textures of the camouflage bag and pink box, and the monkeys and their sticks to the mirror.



(a) Modelling crocodile statue .ply object



(b) Modelling the mirror

Figure 5: Modelling the virtual objects in Blender.

2.3 Rendering the scene

After having our setup of modelling ready for rendering, we change the camera view to a new position that zooms in to the new augmented objects in order to capture their details (textures, shadows, colours) more accurately. Figure 6 shows the final view of the modelling scene before exporting to PBRT file format.

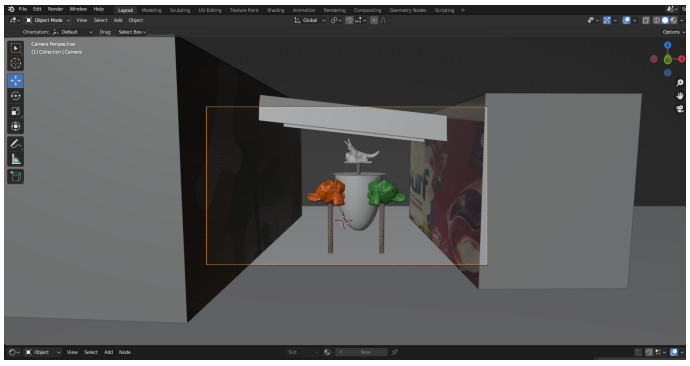


Figure 6: Camera view of the final modelling scene.

The PBRT settings were set to default with path tracing integrator, and 9999 number of samples per pixel. We used 9999 samples, which is the max number of samples after wanting the best

convincing effects in the image. Thereafter, we exported the settings to a PBRT format file. Finally, we rendered the image with PBRT version 3. Figure 7 displays the rendered image.

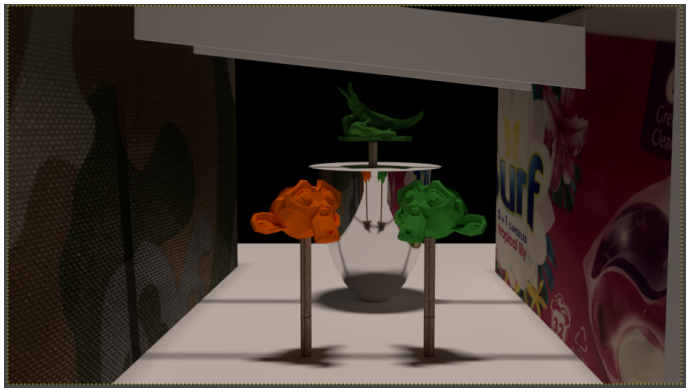


Figure 7: Rendered scene.

2.4 Compositing the scene

We used Gimp image editing software to composite the virtual objects with the real-world photograph [9]. Firstly, we used the free selection tool to carefully select the important virtual objects in the image and their shadows. After selecting the points of interest, we delete everything else by making them transparent (Figure 8a). We were left with an image that contains only the important virtual objects. Then, we added that on top of the real image (Figure 8b)

(a) Transparent image with only the important objects

(b) Transparent image on top of the real image

Figure 8: Compositing the scene with the rendered image.

Moreover, we adjusted the colour histogram and intensity of the produced composite image with Gimp colour image tools. Finally, we adjusted colour values and the shadow values where necessary to produce a photo-realistic results as shown in Figure 9.

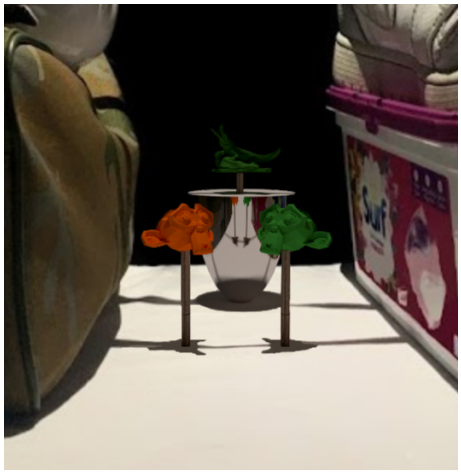
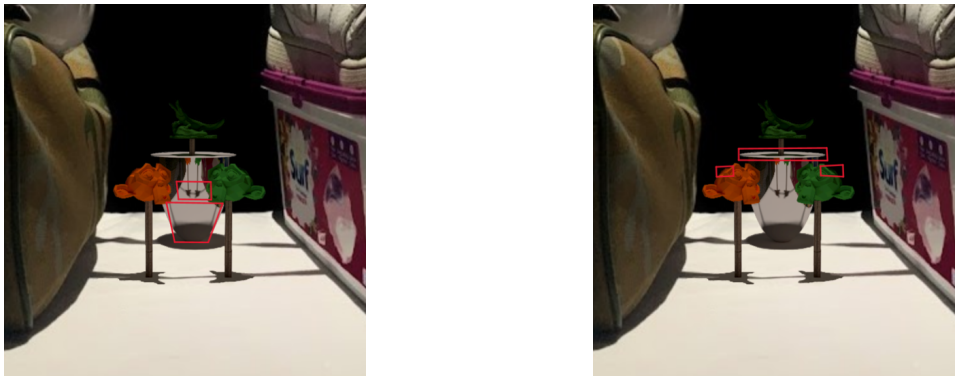


Figure 9: Zoomed area of final composited image (Figure 1b).

3 Results and Discussions

Based on the above workflow, we ended up with our final composited image. Figure 10 allows a closer look in the interesting visual features that we can get from the real-world and augmented objects interaction.

(a) Virtual objects' reflections (b) Real objects' reflections (c) Virtual objects' shadows



(d) Reflections of virtual objects' shadows (e) Shadows of real objects on virtual objects

Figure 10: Collection of interesting photo-realistic effects of the interaction of synthetic and virtual objects

We observe that the reflections of the virtual objects are visible on the reflective surfaces of the rendered objects (Figure 10a). Furthermore, we can see the real objects' reflections on the rendered mirror (Figure 10b), something that can give an accurate illusion that is believable and consistent. Additionally, synthetic objects' shadows coexist in a photo-realistic way given a high level of detail in the image. The virtual objects shadows were produced and blended realistically in the real-world scene (10c). Moreover, the reflections of virtual objects' shadows can be seen in Figure 10d. The complex shadows of the monkeys are visible on the cup-like mirror making everything more believable. Finally, shadows of the real objects (shoe laces) are seen to be cast onto the augmented objects (Figure 10e), giving an appropriate and consistent realism of the scene.

Further direction for improving our world even more could include: choosing a real-time rendering engine that would enable faster interactive explorations and previewing of the scenes. Furthermore, global illumination algorithms can be used to improve accuracy and efficiency of the lighting (indirect reflections). Finally, we could consider more materials for variety that would lead to a more photo-realistic rendering results.

References

[1] Amir Vaxman Chris Lochhead. Specification for assignment 1, 2023.

[2] Artec3d online .ply library.

[3] Blender Online Community. *Blender - a 3D modelling and rendering package*. Blender Foundation, Stichting Blender Foundation, Amsterdam, 2018.

[4] Wenzel Jakob Matt Pharr and Greg Humphreys. *Physically Based Rendering:From Theory To Implementation*. 2004-2018, `https://www.pbr-book.org/`, 2018.

[5] Wenzel Jakob Matt Pharr and Greg Humphreys. *pbrt, Version 3*.

[6] *Blender exporter for PBRT Blender add-on io_scene_pbrt*.

[7] Crocodile texture `https://www.shutterstock.com/image-photo/closeup-nature-view-green-monstera-260nw-1715602294.jpg`.

[8] Sticks statue texture `https://c8.alamy.com/comp/B49BF0/ancient-pillars-closeup-detail-from-parthenon-thens-greece-B49BF0.jpg`.

[9] The GIMP Development Team. Gimp.