

NPR rendering project for EDAN35

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Abstract

This project aims to create a non-photorealistic (NPR) shader, using a variation of the Ben-Day process. This is done by first rendering a scene as normal, then applying a post-processing effect that samples the color values of the pixels in order to create three rotatable, overlapping grids of red, green and blue. The grids contain circles, that vary in size depending on how much of the specific color was present at that position. A small museum featuring some art was also created in blender to showcase the effect more clearly than what can be seen in just the sponza scene.

1 Introduction

Almost immediately we discussed the idea of doing some sort of NPR shader. We were heavily inspired by the recent Spiderman movies, which feature a large variety of effects that we found interesting. We looked at the works from previous years, and were intrigued by the competition winner from 2021. At first, some kind of halftone shader combined with a toon shader seemed like it would become our chosen project. But we also didn't just want to replicate something that's already been done, thus we came up with the idea of using Ben-Day dots after some research. The topic of adding some silhouettes using some sort of edge-detection was discussed as well, but we ultimately ended up scrapping that idea due to time constraints.

1.1 The Ben-Day process

The Ben-Day process is a technique for printing by using colored dots to create the illusion of full color. Roy Lichtenstein is perhaps the most noted user of the technique, using it to create comic book effects in his art from the 1960's. [Mugrabi 2019]. Usually the effect is used on a white sheet of paper utilizing cyan, yellow and magenta as a subtractive model. We used an additive model instead with a black background and the combination of red, green and blue.

2 Application

We decided that it would be easiest to build upon the deferred shading program we wrote in assignment 2 to achieve our goal. The general setup is the same as in the assignment, but we load our own model and modify the lighting to mimic a sort of point light in the center of the room. This is done by creating a lot of lights in the center pointing outward, and setting them all to be a pure white color. We also had to slightly modify the near and far planes of the lighting-cones, otherwise the size of our museum would cut off some of the cones and create very odd shadows.

2.1 The algorithm

This effect utilizes a post-processing shader, operating independently on each color channel (red, green, and blue). It begins by using the color's angle variable and constructing a 2D rotation matrix. The pixel's coordinates are then transformed with this matrix, and a scaling matrix which provides us with the new position and its corresponding 1 by 1 grid square.

Next, the shader samples the colors within this area, calculates their average, and uses it to determine the dot's radius. The pixel's position is checked against a step function, allowing for variable control over the dot size. This process is repeated for all color channels, and the results are summed to produce the final output.

2.2 Buffers

To achieve this desired effect with the assignment code, we found it necessary to incorporate a separate post-processing buffer. This turned out to be more challenging than initially anticipated; however, through persistent effort we successfully managed to make it work.

2.3 Museum

To try to showcase the effect in a clearer way we created a museum in blender. We wanted some more vibrant and flatter colors to make it all easier to see compared to just the sponza scene we used in assignment 2. The room itself was constructed with the blender add-on "archimesh", which made it easy to create a room that wasn't just a cube or a rectangle. Some custom textures were also added for the color of the room. We added some random art we deemed appropriate and used the add-on "import images as planes" to speed up the process. (Note for anyone doing this themselves: We had to disconnect the alpha channel that automatically gets connected to the BSDF shader node in blender, otherwise the generated .mtl file wouldn't contain a valid alpha-value which would make any texture/mesh invisible.) A few models from Polyhaven were added, as well as placing the entirety of the sponza-scene to be one of the exhibits. Finally, some museum labels were added next to all the art.

The whole scene was then exported into a single .obj file with an accompanying .mtl file that describes all the file paths for the textures.

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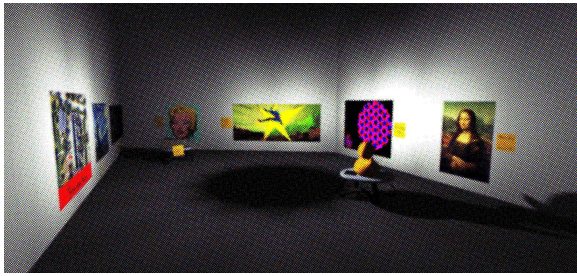


Figure 1: The finished museum, with the effect active.

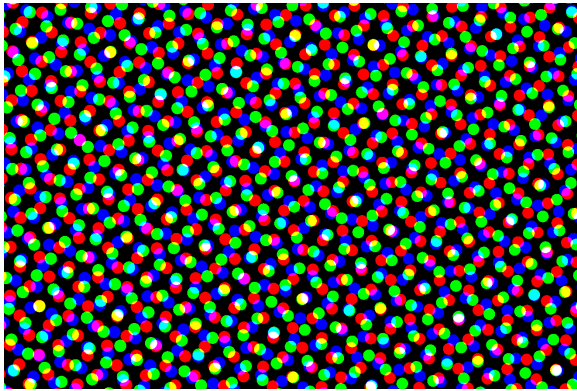


Figure 2: Effect on a grey wall, using a large grid size.

3 Result

Here are some screenshots of the completed project, which turned out quite well. We also have a few sliders for adjusting the grid rotations and sizes which aren't shown here, but are visible in the youtube video for the project.

3.1 Performance

This effect can be both very fast, but also incredibly heavy depending on the settings. When the grid size is small, it is not much more heavy than just rendering the scene normally as we did in assignment 2. But when the grid size creates very large circles, it is very difficult to run. When running the scene at the default resolution of 1600x900 but with max grid size, even an Nvidia RTX 3070 was not enough to keep it at a stable 60fps. The frame times dropped to somewhere around 20-30ms, which equates to around 35fps. The reason for this is what we described in the algorithm section, its due to the way we sample the pixels. At max size, for every pixel, we would sample a 50x50 area, which means we have 2500 pixels to be averaged out. We do this once for every color, so it would actually mean 7500 pixels will be sampled and averaged, per pixel rendered. Is it fast? No. Does it work? Yes.

4 Discussion

Overall, we were quite pleased with the result. The museum tied it all together, and we feel it gave the project a natural goal/ending. We really wanted to make something that you could visibly appreciate and understand, instead of something super technical and low level. The sliders for rotating the grids can also generate some very strange/interesting visual artifacts depending on how the grids happen to align. If the grids are all at the same angle, we've essentially created a very low resolution monitor that displays circles instead of pixels. Also when the grid size is medium to large, setting the circle size to be larger than the grid cell that it is in will create an interesting effect: If a specific area is very bright, the circle that en-

compasses it will be very large and almost mimic a kind of bloom effect as it "bleeds" over to the pixels that are near it.

4.1 Future improvements

To enhance the efficiency of the current effect, a potential avenue for improvement involves implementing a two-pass rendering approach for the post processing. In the first pass, the shader can focus solely on color sampling, extracting relevant information for subsequent processing. The second pass would then handle the dot boundary tests, leveraging the precomputed data from the initial pass. This separation of tasks allows for a more streamlined and optimized execution, reducing redundant computations and considerably improving overall performance.

A captivating stylistic addition to the current effect involves integrating edge detection techniques. By implementing algorithms to identify object borders within the scene (like using a Sobel operator on the depth map), the effect can be enhanced to highlight these boundaries on top of the existing visual transformation. This stylistic embellishment not only adds an aesthetically pleasing aspect but also contributes to a more visually comprehensive representation of the scene. Making it "pop" a little more. It would maybe appear a little cluttered, but we never got around to trying it out.

Another avenue for future improvements is the introduction of different dot sizes based on individual color channels. Currently, the effect employs a uniform dot size across all channels. However, by allowing for variability in dot sizes depending on the color being processed, the visual outcome can be further diversified.

5 Conclusion

All in all, we were happy with our result. (We guess the judges were too, we won the competition!) It wasn't too much work or too little either.

Maybe the most interesting aspect of this project is in its future use, e.g. if it could be integrated into something else. During the initial phase of the project when we were researching different types of NPR's, a few halftone shaders were created in blender that have already been put to good use for other personal projects. Maybe this effect could be used for something different as well? Combine it with some glare, bloom and motion blur to create some kind of interesting music video effect maybe?

References

MUGRABI, C., 2019. Ben-day dots.