Final Project Report

CSS 552
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Ray Tracing with Dispersion

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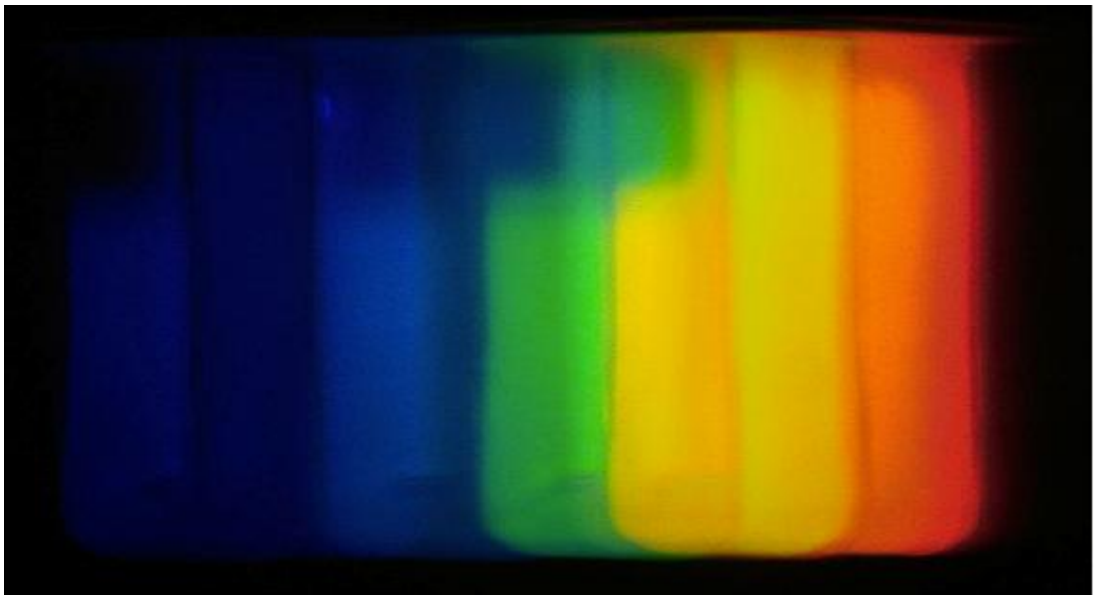
Problem Statement

When a beam of white light enters a transparent object from air, its components of various wavelengths are refracted into different directions. The transmitted lights form a colored strip. This phenomenon is called *light dispersion*.

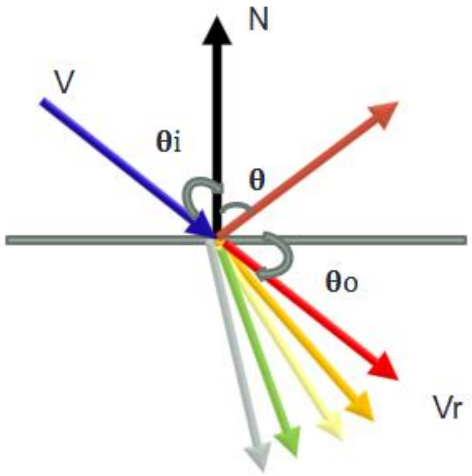


Picture1: A compact fluorescent lamp seen through an Amici prism

Our objective is to render dispersion of a white light when passed through a transparent material; it should closely match the photographs of their real-world counterparts.

Simulation/Our Solution

1. Light Ray-tracing
    1. Photon Map Buffer
        - For each object, aggregating color from all the light source
2. Regular Ray-tracing without Phong illumination
    1. The color will be obtained by the Photon map buffer



Picture 2: Calculating the direction of monochromatic ray using Snell's law

From Snell's law, the refract vector Vr is

$$Vr = \frac{n1}{n2} * (-V) + \{(\frac{n1}{n2}) \cos(\theta i) - cos(\theta o)\} * N$$

Where
n1: refraction index of material 1 (origin) – constant (air)
n2: refraction index of material 2 (target) – transparent
θi: insert angle (angle of incidence)
θo: refract angle
V: View vector (Ray direction * -1)
N: Normal vector at view point
In this case
Refractive index:

$$n = \frac{n2}{n1} = \frac{\sin(\theta i)}{\sin(\theta o)}$$

$$\sin(\theta o) = \frac{1}{n} * \sin(\theta i)$$

$$\cos(\theta i) = V \text{ dot } N$$

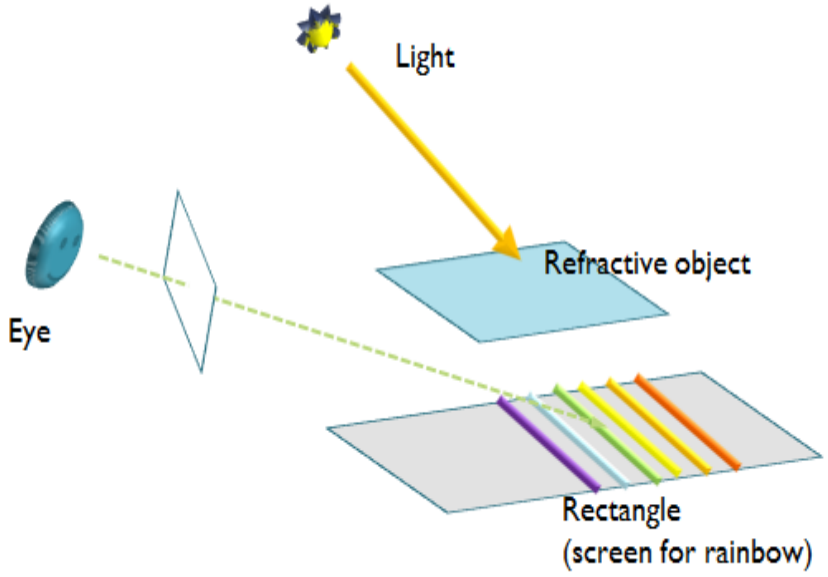
$$cos(\theta o) + \sqrt{1 - Sin^2(\theta o)} =$$

$$\sqrt{(1 - n\text{^} - 2(1 - cos\text{^}2(\theta i)))} = \sqrt{(1 - n\text{^} - 2(1 - (V\ dot\ N)\text{^}2))}$$

Therefore

$$Vr = \frac{1}{n} * (-V) + \{\frac{1}{n} * V\ dot\ N - \sqrt{(1 - n\text{^} - 2(1 - (V\ dot\ N)\text{^}2))}\}$$

Steps for Ray Tracing with Dispersion

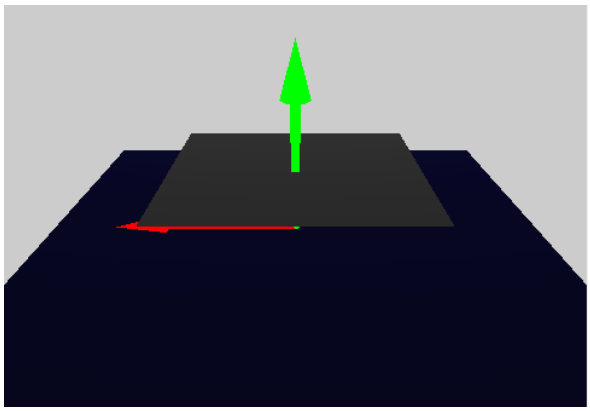


Picture 3: Scene

1. Photon map initialization:
   - Light-ray intersection with objects
   - Accumulate into buffer 2-D array
   - The color will be calculated from all the light sources
   - The final image will be created on the view plane
2. Dispersion on transparent object with refractivity property using Snell's law and calculating the direction of monochromatic ray from refractive lights.
3. Illuminate view image plane by calculating the color from photon map by the intersection of light rays from camera position and refractive.

Sample Output

Image before Dispersion

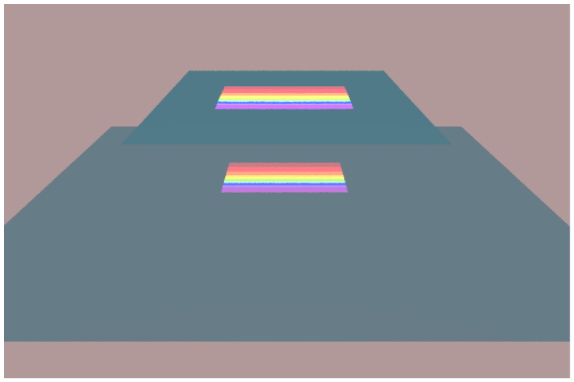


Picture 4: Image before Dispersion

Output with no dispersion

Picture 6: Image with no Dispersion effect

Output with dispersion effect (Rainbow color strip)



Picture 5: Image after Dispersion

Problems

Here are some of the problems we encountered as a group in our implementation

- Building the photon map
- Filtering the color values from the Photon map
- Manipulating the refracted ray direction and viewing the color spectrum on the viewing screen.

References

[1] Rendering Light Dispersion with composite spectral model - http://www.cs.sfu.ca/~mark/ftp/Cgip00/dispersion_CGIP00.pdf

[2] New Techniques for Ray Tracing procedurally defined objects http://delivery.acm.org.offcampus.lib.washington.edu/10.1145/810000/801137/p91-kajiya.pdf?key1=801137&key2=5926866921&coll=DL&dl=ACM&CFID=8580776&CFTOKEN=21577878

[3] Dispersion effects on the ray tracing and reflectivity in a hybrid nematic cell under an electric field http://rmf.fciencias.unam.mx/pdf/rmf-s/52/5/52_5_041.pdf

[4] An Experiment in Simulating Dispersive Refraction in Computer Graphics http://www.mentis.ca/design/graphics/dispersion/

[5] Diamond Appearance: The Components of a Computer Model - http://www.gia.edu/research-resources/cut-microsite-pdfs/diamond-appearance-computer-model.pdf

[6] Diamond Design - http://www.folds.net/diamond_design/