Ray Tracer
Implementation in C++

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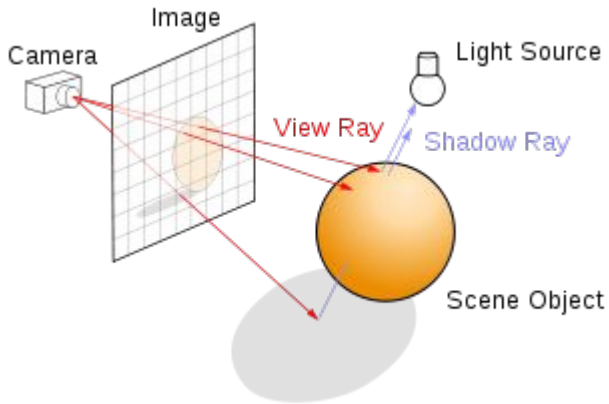
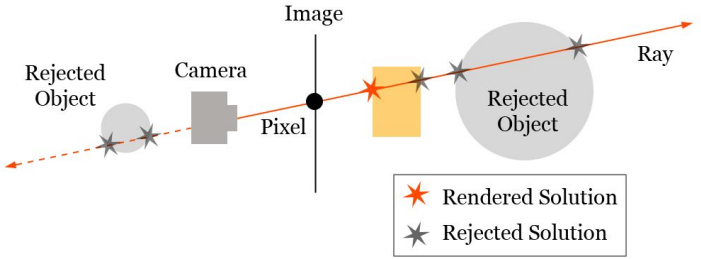
What is Ray Tracing?

- Simulating how light works in real life:
  light source -> primary object -> *physical* interactions -> eye

- *Physical interactions:* **shadows, reflection, refraction** based on object properties such as **specular or diffusion** coefficients

- For every pixel in the picture plane, check for primary and secondary ray-object intersections





Important Math : Object-Ray interactions

- **Plane Object and Ray (Line) intersections**
  - Plane Eq. -> $(p - p_0).n = 0$
  - Point on a line (ray)-> ray_origin + (ray_dir * t)
  - **Solve for t =** Substitute the eq. Of the line into the plane

- **Sphere Object and (Ray) Line intersections**
  - Sphere Eg. -> $x^2 + y^2 + z^2 = r^2$
  - Point on ray line -> ray_origin + (ray_dir * t)
  - **Solve for t =** Substitute the eq. of the line into the plane and

Our Implementation : An Overview

1. **Basic Scene**
   1. Vector, Color, Ray
   2. Camera, Light, Objects
   3. Ambient Light

2. **Object Properties**
   1. Ray-Object interactions
   2. Reflectivity, Transparency
   3. Specular, Diffusion

3. **Light Properties**
   1. Shadow
   2. Reflection
   3. Refraction

4. **Anti-Aliasing**
   1. Averaging RGB components of n pixels around current
   2. n = depth

Program Structure

Two Branches on Github

1. *master*: Reflection only
2. *refraction*: Reflection and Refraction

01 | **main.cpp** - create rays, render the scene via. anti-aliasing

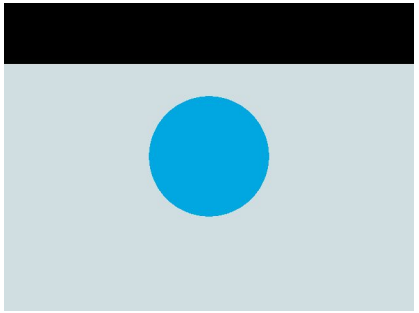
02 | **App.cpp -** getColorAt() is the main *ray tracing* function

03 | **getColorAt() -** shadows, ambient, diffuse, reflection, refraction

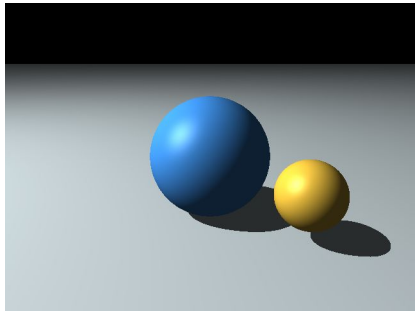
04 | **Other classes:** simulate vectors, camera, light, rays, objects


Milestones

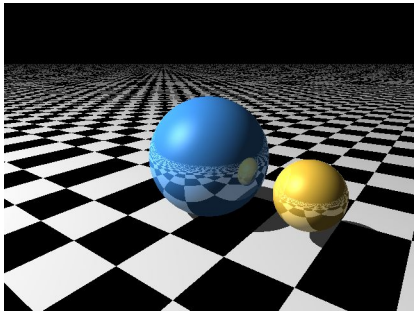
Rendered first scene with objects



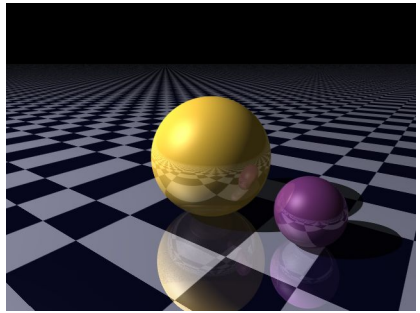
Shadow (without anti-aliasing)

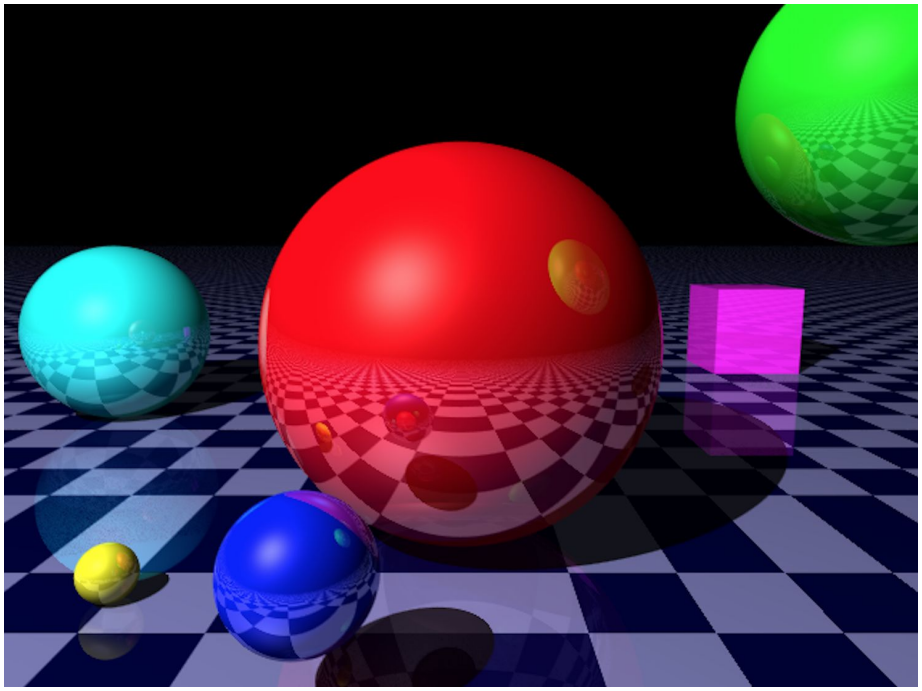


Reflection (without anti-aliasing)

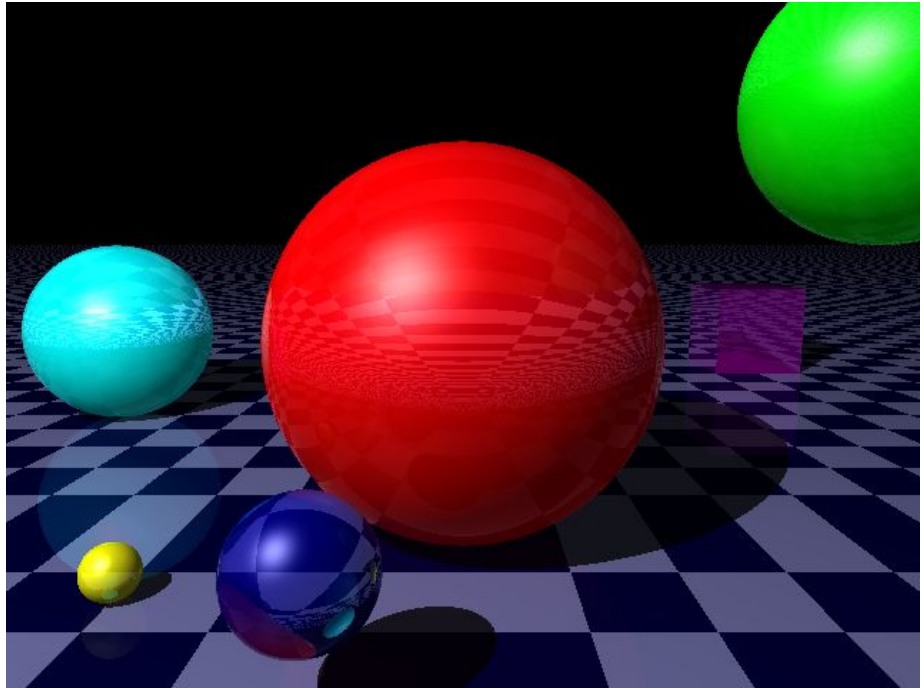


Anti-aliasing



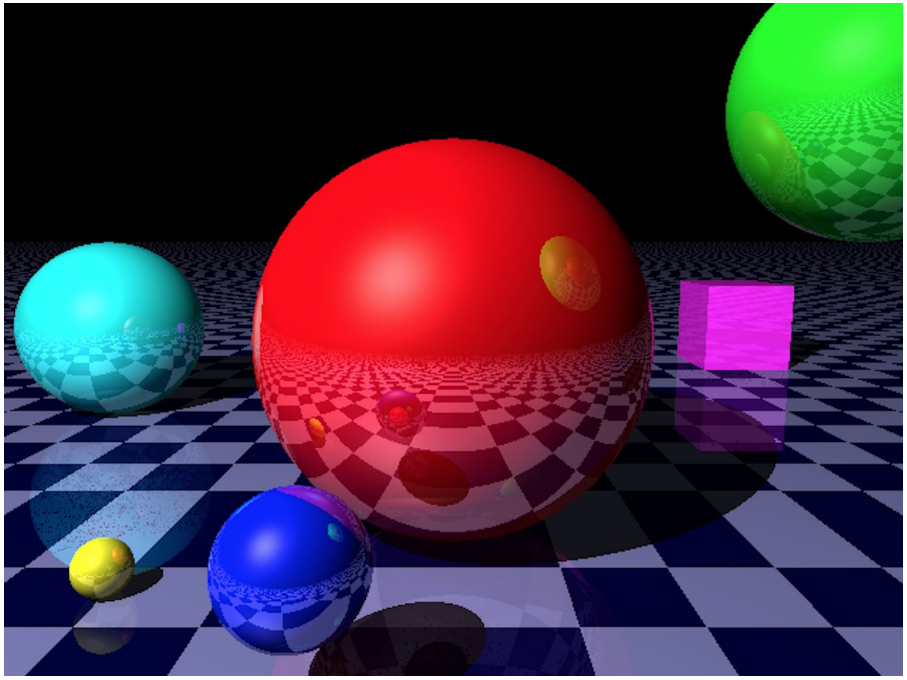


Reflection + Shadows

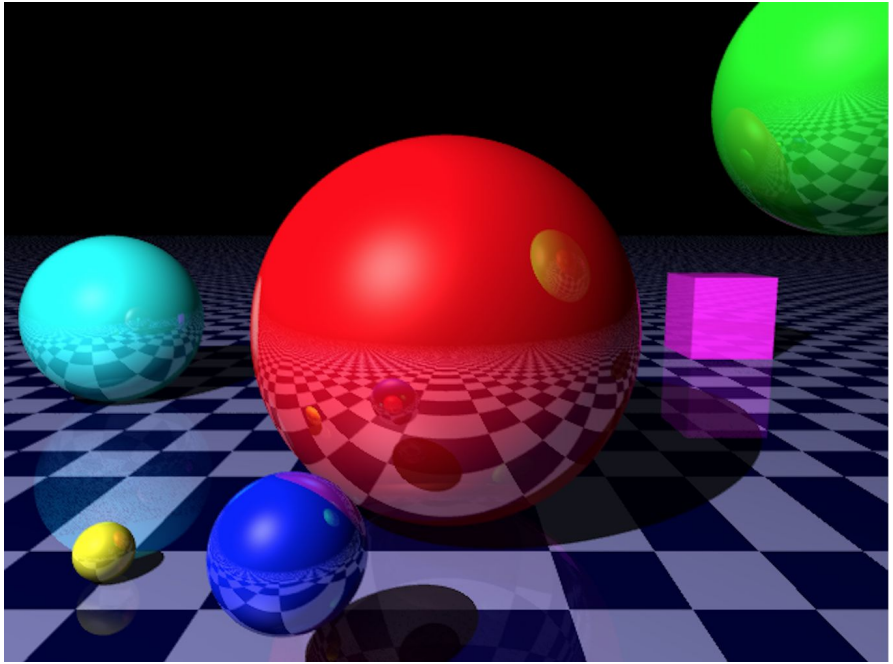


Reflection + Refraction + Shadows

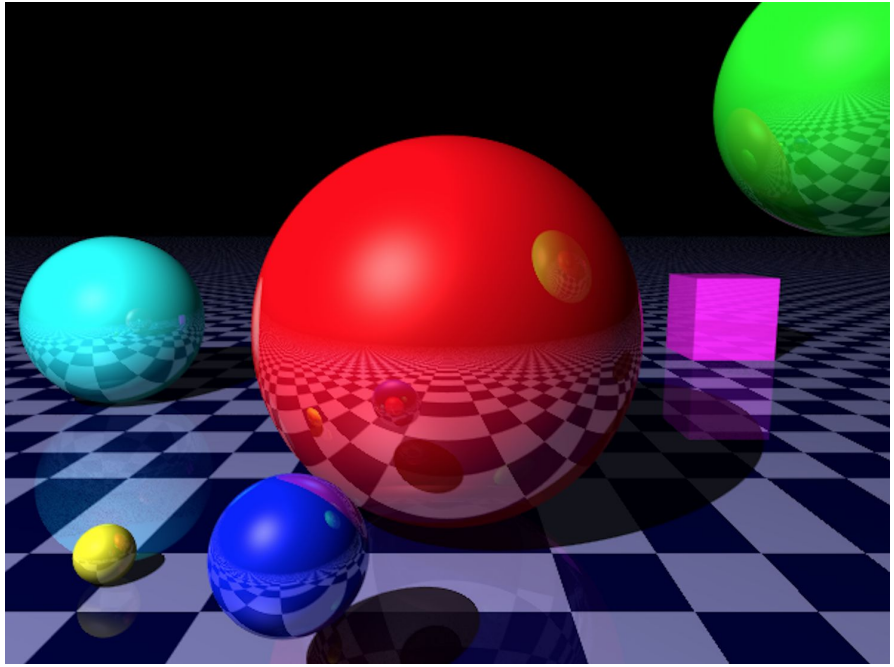

Anti-Aliasing



No Anti-Aliasing

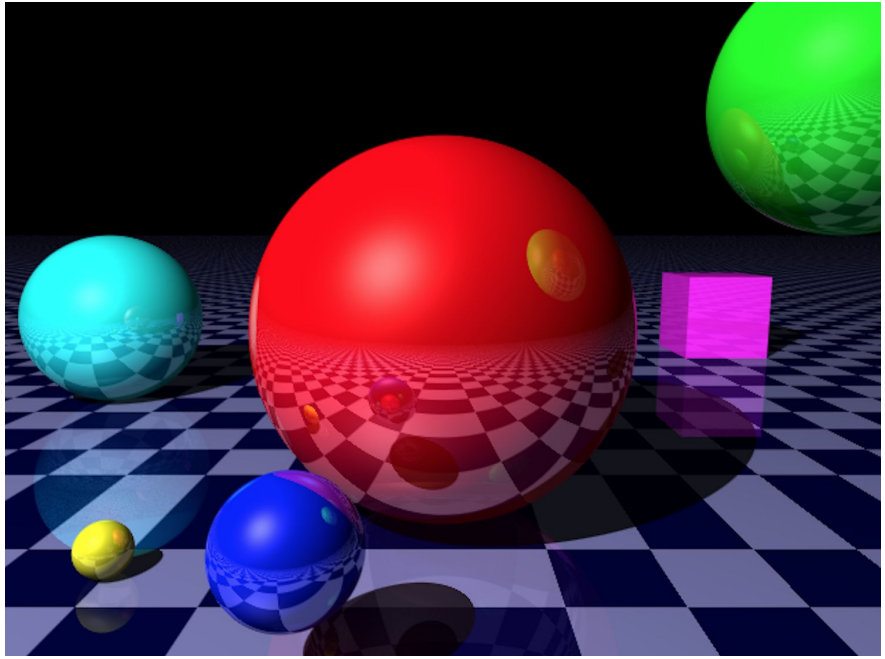


Anti-Aliasing Depth = 5



Anti-Aliasing Depth = 10

Anti-Aliasing Depth = 20



Technical Challenges

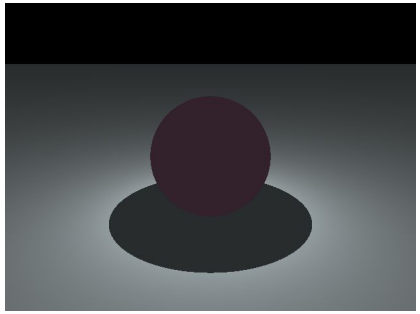
01 | Ray-Object Intersection

02 | Shadow Implementation

03 | Shadow Acne

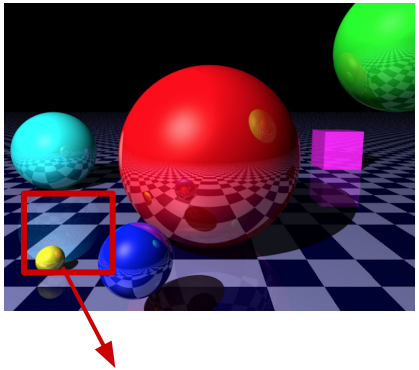
04 | Refraction

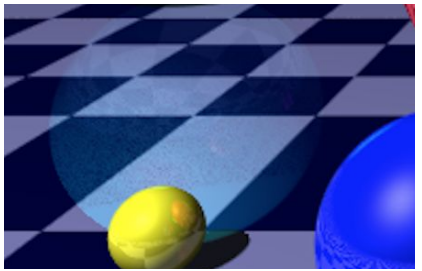
02



Buggy Shadow Implementation

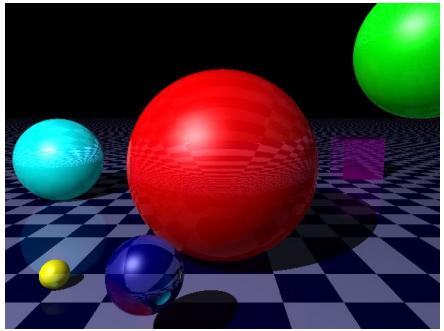
03





Shadow Acne

04



Unrealistic Refraction

Future Work

01 | Removing Shadow Acnes

02 | Implement transparency

03 | Add an Interactive component

Thank you.