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Photorealistic Computer Rendering

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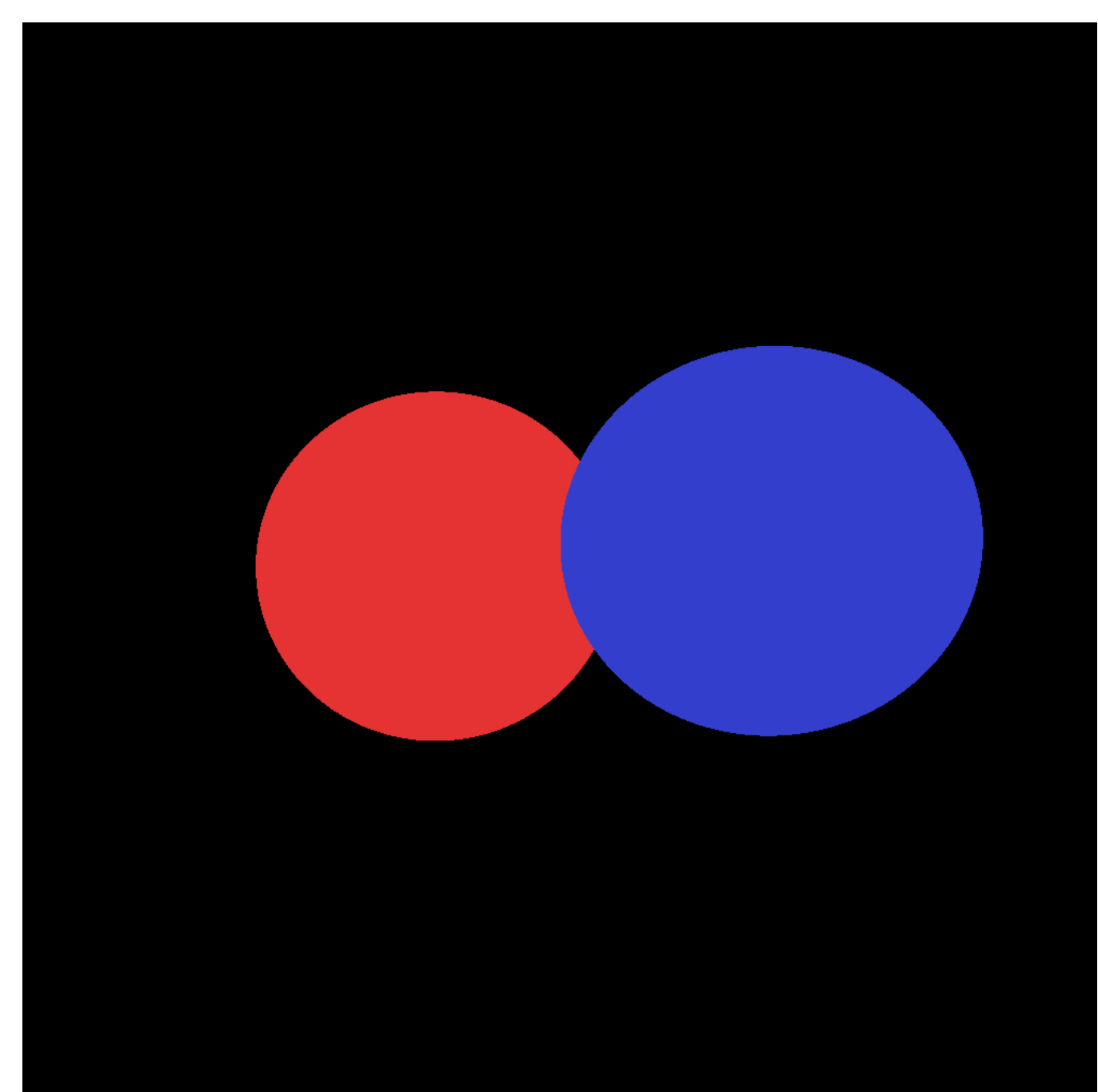
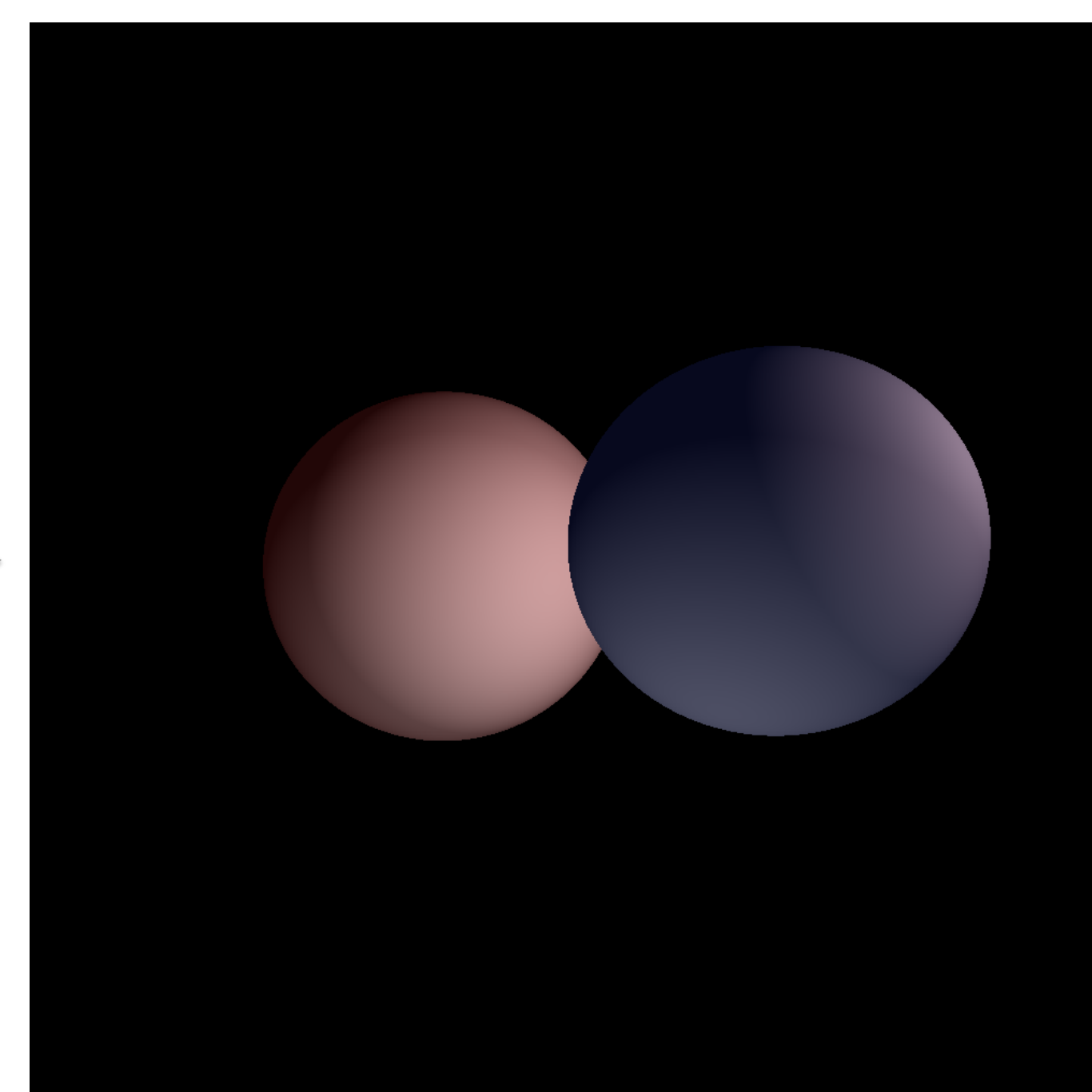
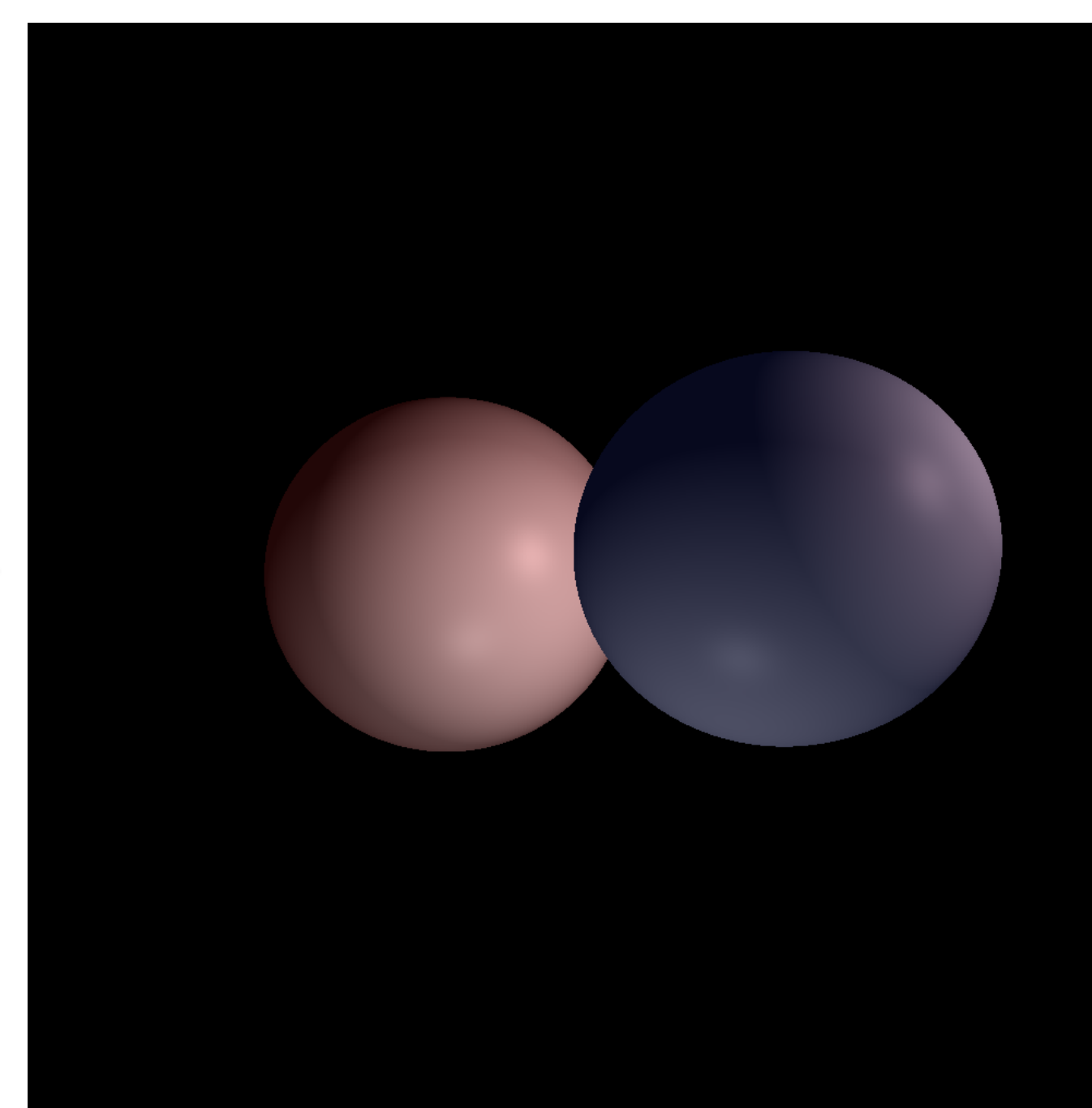
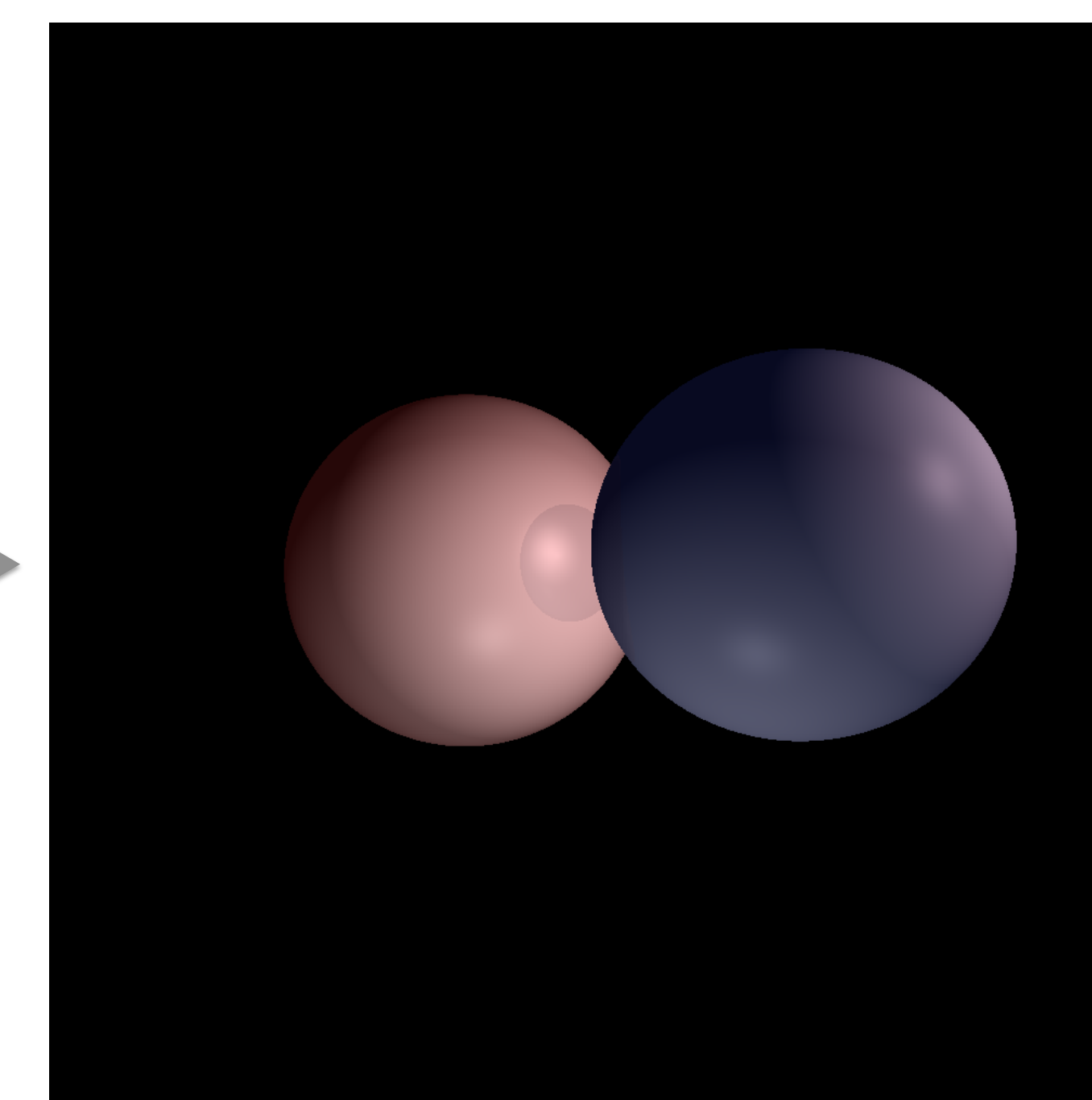
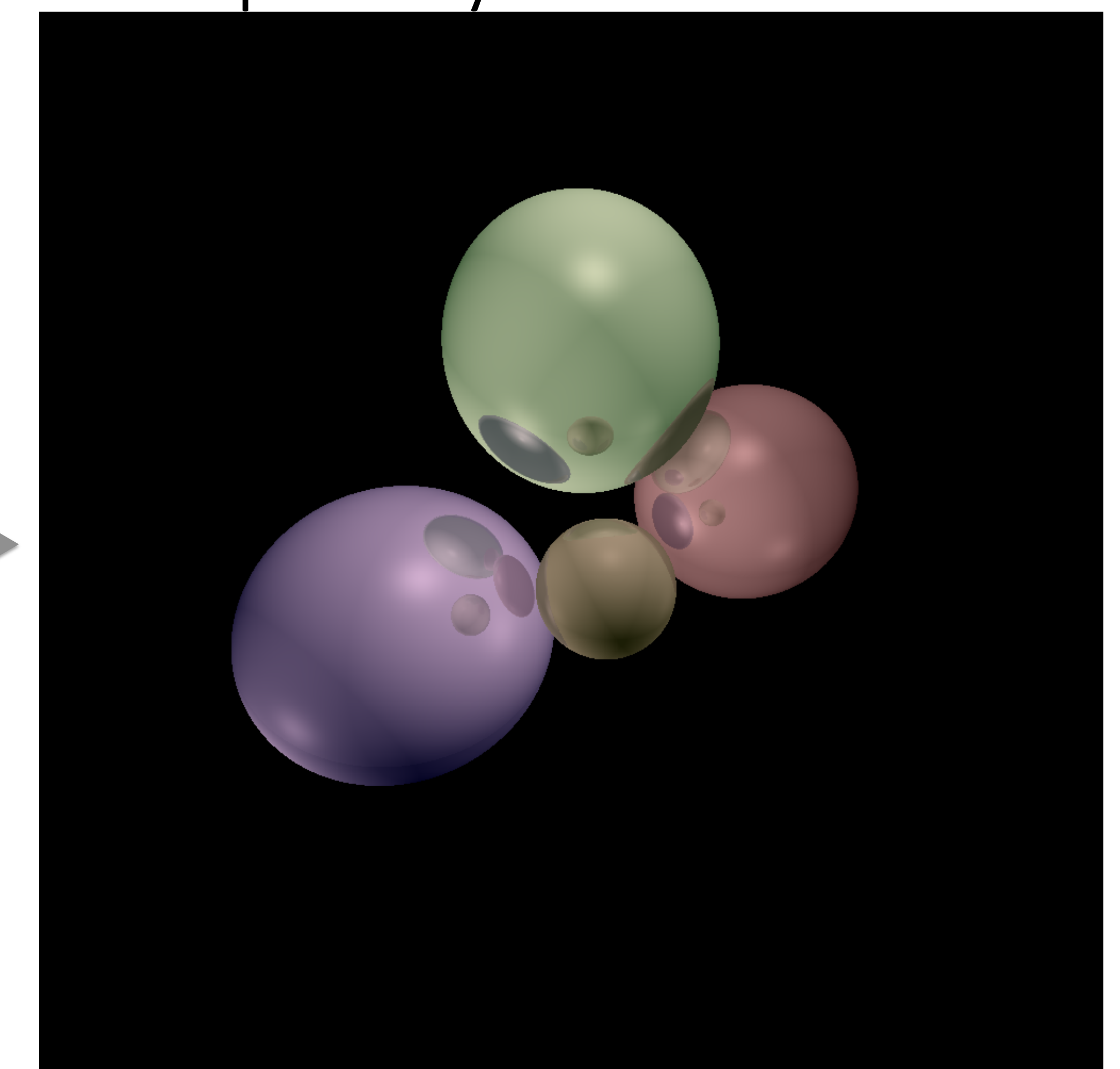
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Photorealistic Rendering

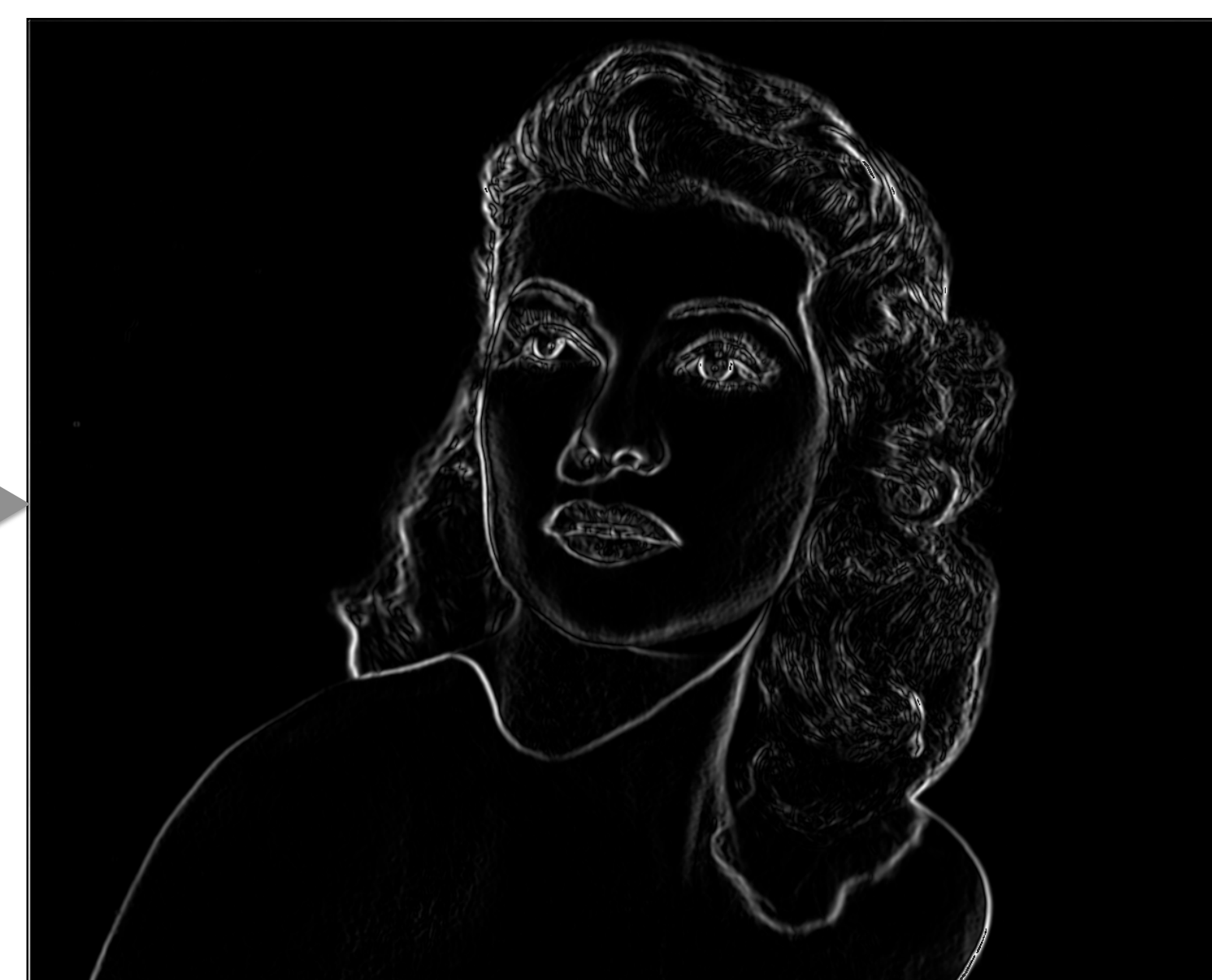
Ray tracing is the process of simulating the propagation of light rays through a scene, including subsequent reflections and transmissions, in order to achieve a realistic computer rendering. The ray tracer works by shooting a ray from the Center of Projection (COP, or camera, or "eye") through each pixel of the desired image and determining if the light ray intersects any objects within the scene. If it does not, the background color is used. If it does, more rays are created to calculate diffuse lighting and specular shading, as well as reflections between objects. Direction, intensity, and color of subsequent rays are determined by the surface normal(s) and color(s) of the object being intersected.

*Object intersection**Diffuse lighting**Specular highlights**Reflection**Sample final image*

The above four images demonstrate the additions of various forms of ray propagation; each subsequent image is cumulative.

Non-Photorealistic Rendering (NPR) and Rita Hayworth

The following images demonstrate image processing techniques such as edge detection and image segmentation to render a non-photorealistic image. Specifically, I implemented the Canny Edge Detection algorithm and a version of the Mean Shift algorithm. I also implemented a noise removal function, an important component of proper edge detection.

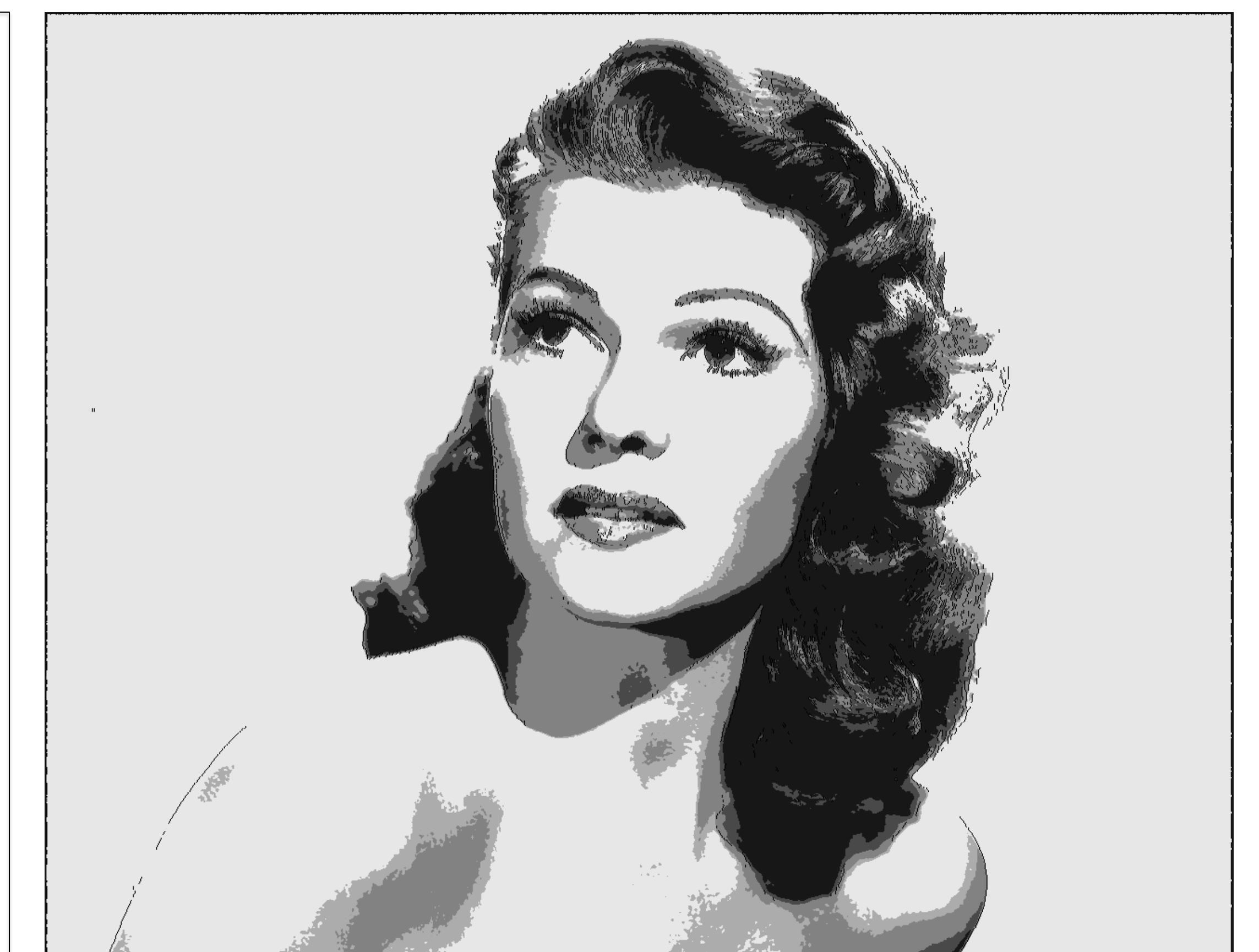
*(a) Original image**(b) Noise removal**(c) Edge strength and direction*

The *Sobel operator* is used to determine 2D spatial gradient measurements, using the following matrices:

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$$

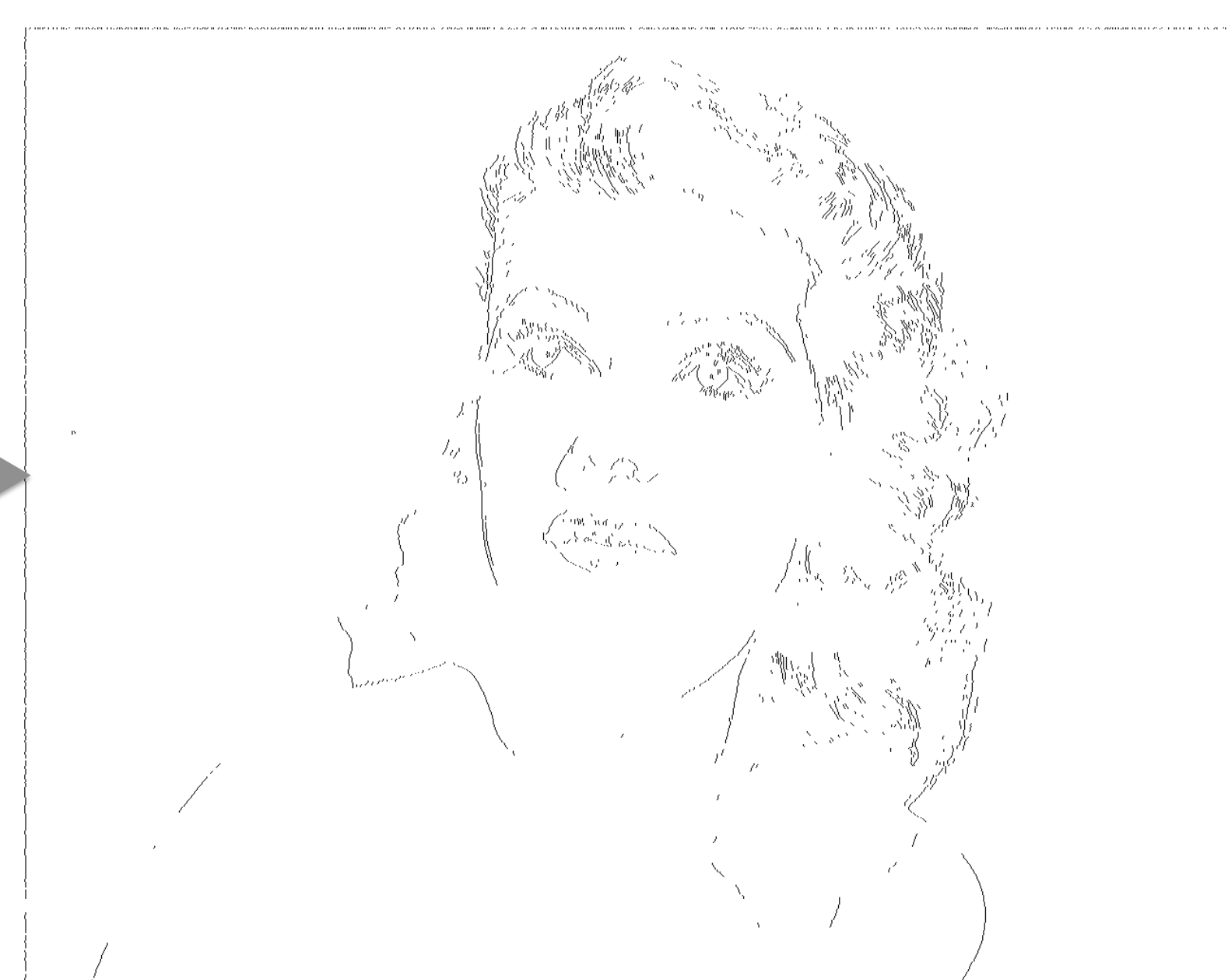
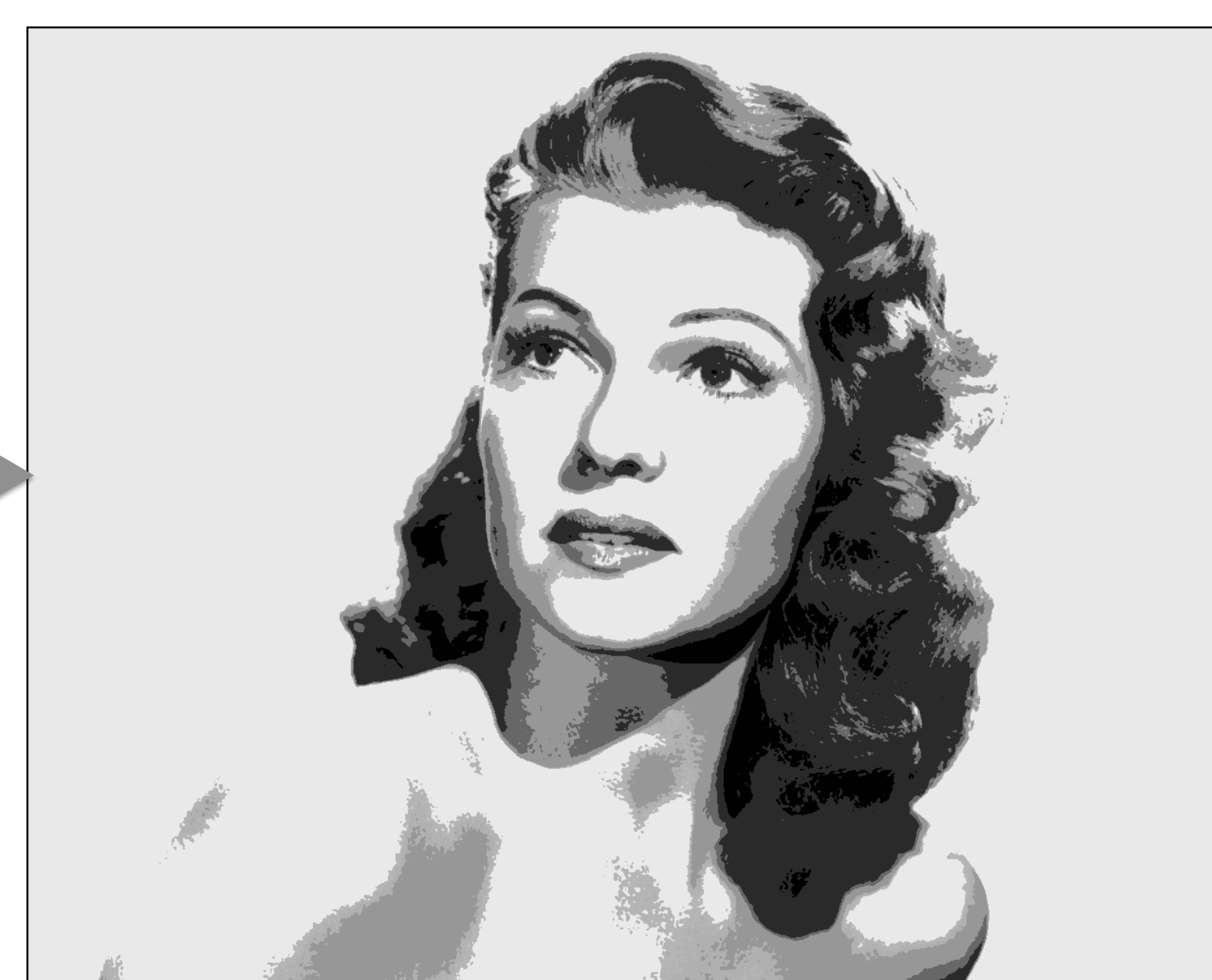
$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$$

$$|G| = |G_x| + |G_y|$$

*Final image*

Edge direction is determined by: $\theta = \tan^{-1} \left(\frac{G_y}{G_x} \right)$

Non-maximum suppression is an edge-thinning technique that uses pixel intensity to mark edges as "strong" or "weak".

*(d) Non-maximum suppression**(e) Hysteresis**(f) Color segmentation (Mean Shift)*