Computer Graphics - Solution 01

Maximilian Richter

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1 Output Devices

a) The frequency is 60 Hz, so one picture is generated in 1/60 sec. So the time to generate one single pixel is:

$$\frac{\frac{1}{60}\left[\frac{s}{frame}\right]}{3840 \times 2160\left[\frac{pixel}{frame}\right]} = 0.000000002\,[s/pixel] = 2\,[ns/pixel] \tag{1}$$

b) A data load of 24 bit per pixel means that 2^{24} colors can be displayed (if one disregards the alpha channel). This is referred as True Color". Regarding the time to generate one pixel, we can estimate the bandwidth:

$$(3840 \times 2160)\left[\frac{pixel}{frame}\right] 60 \left[\frac{frame}{s}\right] 24 \left[\frac{Bit}{pixel}\right] \approx 11.94 \left[\frac{GBit}{s}\right] = 1.49 \left[\frac{GB}{s}\right] = 1.39 \left[\frac{GiB}{s}\right] \tag{2}$$

2 Perception

a) The human brain perceives color by combining the two spectra red-green and blue-yellow. Therefore, there is no way to achieve a reddish green color while reddish yellow is a valid combination of the two spectra.

b) The focusing point of the human eye is called Fovea. While having the most color sensing cells (cones), it has a comparatively low count of rods, the brightness sensing cells. Therefore, very dim stars can not be seen if one takes focus on them but become visible when looking right beside them since the count of rods is highest in the areas next to the Fovea.

c) A Metamerism is the matching perception of colors even though the actual light spectra differ in their wavelengths. These matching colors are called Metamers.

Additionally, the human eye is rather limited when it comes to perceiving differences in colors for example when it comes to nuances of blue. This can also lead to some kind of Metamers.

As a consequence, different spectra of light may cause the same response in the eye and are therefore perceived as the same color.

3 Radiometry

The radius of the Sun is small compared to the distance between Sun and Earth $r_S \ll d_{SE}$. So without loss of generality we can assume that the Sun is a point-like light source. Hence, we can approximate the part of total radiant power of the Sun Φ_S which reaches Earth by calculating the solid angle of the Earth as seen from the center of the Sun (see Fig.1).

We assume the surface A_E which the radiation can reach is equal to the spherical cap with a base radius

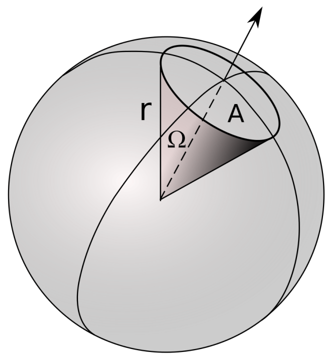

Figure 1: Illustration of the solid angle. The center of the sphere corresponds to the center of the sun, the surface of the sphere corresponds to the total radiant power and A is the part which reaches Earth.

equal to the radius of the Earth and $a = \sqrt{d_{Se}^2 + r_E^2}$, hence

$$A_E = 2\pi a \left(a - \sqrt{a^2 - r_E^2} \right) \approx \pi r_E^2 \tag{3}$$

The solid angle Ω of this surface A_E can be computed as follows

$$\Omega = \frac{A_E}{d_{SE}^2} \approx 5.71 \cdot 10^{-9} \text{ sr} \tag{4}$$

The ratio between the solid angle Ω and 4π is now equal to the ratio between the absolute radiant power of the Sun and the total radiant power reaching Earth

$$\frac{\Phi_E}{\Phi_S} = \frac{\Omega}{4\pi} \approx 4.54 \cdot 10^{-10} \tag{5}$$

This can finally be used to approximate the value for total radiant power reaching Earth

$$\Rightarrow \Phi_E = \Phi_S \cdot \frac{\Omega}{4\pi} \approx 1.75 \cdot 10^{17} \text{ Watts} \tag{6}$$

4 3D Visual Perception

Stereoscopy is the representation of images with the perception of depth. The main idea behind this is that 3d vision is a product of our brain, which combines two 2d images from each eye into a 3d image. Since our eyes are separated spatially, each eye sees a slightly different angle of the same scene. This information gets processed in the brain to sense and approximate distances to objects.

Stereoscopic images always need two images which are taken with a horizontal distance in the order of the distance of human eyes. If the left image is now displayed only to the left eye and the right image only to the right eye, the illusion of depth emerges.

- **Anaglyph 3D**: is a stereoscopic method which uses color filter goggles to separate a single 2d picture into two images for each eye. One glass (or foil) of the goggle only lets through red light and the other glass (or foil) only lets through cyan/blue light. The two images from different angles have to be laid on top of each other with some opacity, one is only the red channel and the other is only the cyan channel of the original images. This way, the observer with the googles on gets displayed only one image per eye and the brain combines them into a 3d vision.
- **Polarized light**: can be used to make stereoscopic images. If the two images taken at different angles are displayed by two different beams of light and the beams get polarized linearly (i.e. the electric field vector oscillates on a line while traveling through space), but with 90° difference (up/down and left/right polarized), then each image can be separated on each consecutive eye by using goggles with polarization filters, each aligned with 90° difference (up/down and left/right). This way, the full color range of the stereoscopic image can be used.