Prof. Dr.-Ing. Ralf Steinmetz
Multimedia communications Lab

Dr. Florian Mehm
Dipl. Inf. Robert Konrad

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Solution 1

General Information

- The exercises may be solved by teams of up to three people. **Please form teams – if everyone turns in solutions individually, correction will take longer due to the large number of people**.
- The solutions have to be uploaded to the Git repositories assigned to the individual teams. To receive a group git repository, please write a mail to game-technology@kom.tu-darmstadt.de with your desired group name as well as the names and mail address of each member. **Send the mail until Wednesday, October 26, 23:59**
- **The submission date (for practical and theoretical tasks) is noted on top of each exercise sheet.**
- If you have questions about the exercises write a mail to game-technology@kom.tu-darmstadt.de or use the forum at https://www.fachschaft.informatik.tu-darmstadt.de/forum/viewforum.php?f=557

P1 Practical Tasks: Basic Setup (1 Point)

Create a Kore application which displays a simple geometric form by setting the colors of pixels. Simple examples are lines or circles. In the code, you will find a commented section into which you can draw your geometric form. Use the function setPixel(int x, int y, float red, float green, float blue) to set individual pixels.

Start out by cloning https://github.com/TUDGameTechnology/Exercise1.git recursively (git clone --recursive).

Make sure it actually works and push it to your team's Git repository. **Please push into the branch "exercise1".**

You can find introductions to Kore and Git at http://wiki.ktxsoftware.com

There is no solution code for this exercise. If you had problems with git, please contact us. If we noticed any problems, we have already contacted you.

T1 Theoretical Tasks: Light and Sound (5 Points)

T1.1 Light Waves (1 point)

List the basic wave parameters of electromagnetic waves in the visible spectrum (aka light). See slide 26 of lecture 1 for details.

Direction: transverse waves
Amplitude
Speed: c = ~ 299 792 458 m / s
Wavelength: 400 – 700 nm

T1.2 Sound Waves (1 point)

List the basic wave parameters of sound waves.

Direction: longitudinal waves
Amplitude

- *Amplitude of the air pressure in the wave*
- *dB -> logarithm of the amplitude squared*

Speed: ~ 340.29 m / s
Wavelength: 17 m - 17 mm

T1.3 Gamma Curves (2 points)

For this exercise, we are assuming a graphics program that adds together the pixels of two images. The two images are saved as bitmap files with gamma-corrected colors.

You sample the two following gamma-corrected color values from the bitmaps (in hexadecimal notation, 8 bits per color):

C1: #0066AA
C2: #AB1234

Add the two color values in linear color space and provide an output color that can be sent to a common monitor.

We usually use $\gamma \approx 2.2$*, since this is a common value for monitors. Note that during the inverse calculation, we use* $\frac{1}{\gamma} \approx 0.45$*. Please make sure you know when to use which value.*

If we denote the function for gamma-correction as $f_\gamma(x) = x^{\frac{1}{\gamma}}$, with the inverse $f_\gamma^{-1}(x) = x^\gamma$, the operation we want to carry out becomes:

$$C_{result} = f_\gamma(f_\gamma^{-1}(C_1) + f_\gamma^{-1}(C_2))$$

We first convert the hexadecimal to decimal values:

$$\begin{pmatrix} 00 \\ 66 \\ AA \end{pmatrix}_{16} = \begin{pmatrix} 0 \\ 102 \\ 170 \end{pmatrix}_{10}$$
$$\begin{pmatrix} AB \\ 12 \\ 34 \end{pmatrix}_{16} = \begin{pmatrix} 171 \\ 18 \\ 52 \end{pmatrix}_{10}$$

Next, we convert the values into linear space:

$$f_\gamma^{-1}\left(\begin{pmatrix} 0 \\ 102 \\ 170 \end{pmatrix}_{10}\right) = \begin{pmatrix} 0^{2.2} \\ 102^{2.2} \\ 170^{2.2} \end{pmatrix}_{10} \approx \begin{pmatrix} 0 \\ 26237 \\ 80721 \end{pmatrix}_{10}$$
$$f_\gamma^{-1}\left(\begin{pmatrix} 171 \\ 18 \\ 52 \end{pmatrix}_{10}\right) = \begin{pmatrix} 171^{2.2} \\ 18^{2.2} \\ 52^{2.2} \end{pmatrix}_{10} \approx \begin{pmatrix} 81770 \\ 578 \\ 5959 \end{pmatrix}_{10}$$

The addition is carried out component-wise:

$$\begin{pmatrix} 0 \\ 26237 \\ 80721 \end{pmatrix}_{10} + \begin{pmatrix} 81770 \\ 578 \\ 5959 \end{pmatrix}_{10} = \begin{pmatrix} 81770 \\ 26815 \\ 86681 \end{pmatrix}_{10}$$

The end-result is gamma-corrected:

$$f_\gamma\left(\begin{pmatrix} 81770 \\ 26815 \\ 86681 \end{pmatrix}_{10}\right) = \begin{pmatrix} 81770^{\frac{1}{2.2}} \\ 26815^{\frac{1}{2.2}} \\ 86681^{\frac{1}{2.2}} \end{pmatrix}_{10} \approx \begin{pmatrix} 171 \\ 103 \\ 176 \end{pmatrix}_{10}$$

Finally, we revert back to hexadecimal:

$$\begin{pmatrix} 171 \\ 103 \\ 176 \end{pmatrix}_{10} = \begin{pmatrix} AB \\ 67 \\ B0 \end{pmatrix}_{16} = \#AB67B0$$

The equivalent calculation using floating point values is:

	Color 1			Color 2		
Hex	0	66	AA	AB	12	34
Dec	0	102	170	171	18	52
0..1	0	0,4	0,66666667	0,670588	0,070588	0,203922
Gamma	0	0,1332085	0,40982574	0,415148	0,002932	0,030257
Addition	0,415148	0,1361408	0,44008226			
Gamma	0,670588	0,4039786	0,68860463			
Dec	171	103	176			
Hex	AB	67	B0			

T1.4 Monocular cues (1 point)

On slide 39, you can find an overview of monocular cues. Choose one of the monocular cues not presented in the lecture, research it and explain it in your own words.

From Wikipedia (https://en.wikipedia.org/wiki/Depth_perception#Monocular_cues)

Motion parallax
When an observer moves, the apparent relative motion of several stationary objects against a background gives hints about their relative distance. If information about the direction and velocity of movement is known, motion parallax can provide absolute depth information. This effect can be seen clearly when driving in a car. Nearby things pass quickly, while far off objects appear stationary. Some animals that lack binocular vision due to their eyes having little common field-of-view employ motion parallax more explicitly than humans for depth cueing (e.g., some types of birds, which bob their heads to achieve motion parallax, and squirrels, which move in lines orthogonal to an object of interest to do the same).

Depth from motion
*When an object moves toward the observer, the retinal projection of an object expands over a period of time, which leads to the perception of movement in a line toward the observer. Another name for this phenomenon is **depth from optical expansion**. The dynamic stimulus change enables the observer not only to see the object as moving, but to perceive the distance of the moving object. Thus, in this context, the changing size serves as a distance cue. A related phenomenon is the visual system's capacity to calculate time-to-contact (TTC) of an approaching object from the rate of optical expansion – an ability that is useful in contexts ranging from driving a car to playing baseball. However, calculation of TTC is, strictly speaking, perception of velocity rather than depth.*

Kinetic depth effect
If a stationary rigid figure (for example, a wire cube) is placed in front of a point source of light so that its shadow falls on a translucent screen, an observer on the other side of the screen will see a two-dimensional pattern of lines. But if the cube rotates, the visual system will extract the necessary information for perception of the third dimension from the movements of the lines, and a cube is seen. This is an example of the kinetic depth effect. The effect also occurs when the rotating object is solid (rather than an outline figure), provided that the projected shadow consists of lines which have definite corners or end points, and that these lines change in both length and orientation during the rotation.

Perspective
The property of parallel lines converging in the distance, at infinity, allows us to reconstruct the relative distance of two parts of an object, or of landscape features. An example would be standing on a straight road, looking down the road, and noticing the road narrows as it goes off in the distance.

Relative size
If two objects are known to be the same size (e.g., two trees) but their absolute size is unknown, relative size cues can provide information about the relative depth of the two objects. If one subtends a larger visual angle on the retina than the other, the object which subtends the larger visual angle appears closer.

Familiar size
Since the visual angle of an object projected onto the retina decreases with distance, this information can be combined with previous knowledge of the object's size to determine the absolute depth of the object. For example, people are generally familiar with the size of an average automobile. This prior knowledge can be combined with information about the angle it subtends on the retina to determine the absolute depth of an automobile in a scene.

Absolute size
Even if the actual size of the object is unknown and there is only one object visible, a smaller object seems further away than a large object that is presented at the same location

Aerial perspective
Due to light scattering by the atmosphere, objects that are a great distance away have lower luminance contrast and lower color saturation. Due to this, images seem hazy the farther they are away from a person's point of view. In computer graphics, this is often called "distance fog." The foreground has high contrast; the background has low contrast. Objects differing only in their contrast with a background appear to be at different depths. The color of distant objects are also shifted toward the blue end of thespectrum (e.g., distant mountains). Some painters, notably Cézanne, employ "warm" pigments (red, yellow and orange) to bring features forward towards the viewer, and "cool" ones (blue, violet, and blue-green) to indicate the part of a form that curves away from the picture plane.

Accommodation
This is an oculomotor cue for depth perception. When we try to focus on far away objects, the ciliary muscles stretch the eye lens, making it thinner, and hence changing the focal length. The kinesthetic sensations of the contracting and relaxing ciliary muscles (intraocular muscles) is sent to the visual cortex where it is used for interpreting distance/depth. Accommodation is only effective for distances less than 2 meters.

Occlusion

*Occlusion (also referred to as **interposition**) happens when near surfaces overlap far surfaces. If one object partially blocks the view of another object, humans perceive it as closer. However, this information only allows the observer to create a "ranking" of relative nearness. The presence of monocular occlusions consist of the object's texture and geometry. Monocular occlusions are able to reduce the depth perception latency both in natural and artificial stimuli.*

Curvilinear perspective

At the outer extremes of the visual field, parallel lines become curved, as in a photo taken through a fisheye lens. This effect, although it is usually eliminated from both art and photos by the cropping or framing of a picture, greatly enhances the viewer's sense of being positioned within a real, three-dimensional space. (Classical perspective has no use for this so-called "distortion," although in fact the "distortions" strictly obey optical laws and provide perfectly valid visual information, just as classical perspective does for the part of the field of vision that falls within its frame.)

Texture gradient

Fine details on nearby objects can be seen clearly, whereas such details are not visible on faraway objects. Texture gradients are grains of an item. For example, on a long gravel road, the gravel near the observer can be clearly seen of shape, size and colour. In the distance, the road's texture cannot be clearly differentiated.

Lighting and shading

The way that light falls on an object and reflects off its surfaces, and the shadows that are cast by objects provide an effective cue for the brain to determine the shape of objects and their position in space.

Defocus blur

Selective image blurring is very commonly used in photographic and video for establishing the impression of depth. This can act as a monocular cue even when all other cues are removed. It may contribute to the depth perception in natural retinal images, because the depth of focus of the human eye is limited. In addition, there are several depth estimation algorithms based on defocus and blurring. Some jumping spiders are known to use image defocus to judge depth.

Elevation

When an object is visible relative to the horizon, we tend to perceive objects which are closer to the horizon as being farther away from us, and objects which are farther from the horizon as being closer to us. In addition, if an object moves from a position close the horizon to a position higher or lower than the horizon, it will appear to move closer to the viewer.