SCHOOL of ELECTRICAL ENGINEERING & COMPUTING
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The UNIVERSITY of NEWCASTLE

Comp3320/6370 Computer Graphics

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Exercises IV

This paper provides practice exercises for the lectures. These questions (some of them with hints or partial solutions) should help for exam preparation. It is recommended to look at the solutions only after you have first tried to solve the exercises yourself. If you detect errors or have any suggestions for improvement please let us know.

Exercise 22 (Effects)

Question: What are lens effects and why are they used in computer graphics?

Answer: See lecture slides and associated bookchapters.

Exercise 23 (RGB and HSI)

Question:

a) Describe the RGB cube and where the different colours are located.

b) What is the geometric relation between the RGB cube and the HSI hexcone ?

Answer: See lecture slides and associated bookchapters.

Exercise 24 (CIE Chromaticity Diagram)

Question: Explain what is the CIE Chromaticity Diagram.

Answer: See lecture slides and the associated book chapters.

Exercise 25 (Chromatic Light)

Question: Let a surface be coated with cyan and yellow colours and illuminate it with white light.

a) Which colours are reflected?

b) Which colours are absorbed?

Answer: The surface will absorb red and blue. I.e only green is reflected from illuminating white light. We can use the following equation to sort this out:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix}$$

Let's set $C = 1, Y = 1$ and $M = 0$. Then we obtain

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

Another example: White light is the sum of red, green and blue. If the surface is coated with cyan ink, no red light will be reflected from the surface. This is because cyan subtracts red from the reflected white light. Details about this question can be found in chapter 11.3.2 on the CMY colour model in [?], chapter 21 in [?] or chapter 11 of [?].

Exercise 26 (Virtual Reality)

a) Calculate the average horizontal angular pixel density of the following display systems:

   i) A 36x20cm screen with resolution of 1920x1080 viewed at a distance of 50cm.

   ii) A projector of resolution 2000x2000 uniformly spherically reflected onto a hemispherical dome.

   iii) A head-tracked, stereoscopic HMD with a horizontal field of view of 110°. Two screens are used, one for each eye, of resolution 1920x1080.

b) Which of the above displays has the highest perceived resolution. Discuss the tradeoffs between field of view and angular resolution.

c) Which of the above displays has the highest field of view (FOV)? Which has the highest field of regard (FOR)? Discuss the relative advantages of high field of view and high field of regard in immersive displays.

d) Which display(s) would be best for displaying the following applications (write a sentence or two explaining your choice):

   i) word processing

   ii) a 360 photo viewer

   iii) a driving simulator

   iv) a game where enemies can approach the player from any direction

e) When wearing a HMD with head tracking as above, the user is fixated on objects which are fixed relative to the real world. In order to achieve this, the image displayed in the headset moves counter to the user's head movement. What effect does this movement have on the perceived resolution of the screen?

Answer:

a) (See slide 29 of VR Lecture for equations)

   i) 48.5 px/deg or 0.02 deg/px

ii) 11.1 px/deg or 0.09 deg/px

iii) 17.5 px/deg or 0.057 deg/px

b) The screen (i) has the highest perceived resolution. Field of view is immersive but comes at the cost of lower perceived resolution for a given screen resolution.

c) The dome (ii) has the highest FOV (180°). The HMD (iii) has the highest FOR because you can look in any direction and remain immersed. High FOV displays are bigger and bulkier, making it more difficult and expensive to mount them to a HMD and give them high FOR.

d) i) screen, ii) dome, iii) dome or HMD, iv) HMD

e) During screen space object movement, pixels will sample details of the object which are smaller than the spacing between pixels, giving a perceived higher resolution. This is called temporal super-resolution. (see lecture slide 30 in VR lecture)

Final note: No guarantee that the solutions are correct yet. Please email any errors that you detect. Check blackboard for updates.