Foundations of Computer Graphics

Chapter Summary Notes

Stephen Chen

Part IB Natural Sciences
King's College,
University of Cambridge

Contents

1 Raster Images

1.1 Introduction

- Images can be presented on **raster displays** which show images as arrays of **pixels**. For example, computer screens and TV's.
- A raster image is a 2D array which stores the **pixel value** for each pixel
- A raster image is **device-independent**
- A vector image is described without any reference to any particular pixel grid
- Vector images are **resolution independent** but must be **rasterised**

1.2 Pixels

- We can abstract an image as a function:

  $$I(x, y) : R \to V$$

  where $R \subset \mathbb{R}^2$ and V is the set of possible pixel values.
- For example, a RGB colour image has $V = (\mathbb{R}^+)^3$
- In these notes, the bottom-left pixel is $(0, 0)$ and the top-right pixel is $(n_x - 1, n_y - 1)$ given n_x columns and n_y rows.
- The rectangular domain of a $n_x \times n_y$ image is

  $$R = [-0.5, n_x - 0.5] \times [-0.5, n_y - 0.5]$$

- Example pixel formats:
  - 8-bit RGB fixed-colour range: photographs and web/email applications
  - 16-bit fixed-range grayscale: medical imaging
  - 16-bit fixed-range RGB: professional photography and printing

1.3 Intensity

- ⋆ Assume a numerical descrition of pixel colour from 0 to 1
- ⋆ Monitors are non-linear with respect to input and therefore characterised by a γ value:

$$I = I_{max}(a)^{\gamma}$$

  where $0 \leq a \leq 1$.

- ⋆ We can find γ by finding the value of a that gives an intensity halfway between black and white so $a^{\gamma} = 0.5$
- ⋆ Usually:

$$a = \left\{ 0\ ,\ \frac{1}{255}\ ,\ \ldots\ ,\ \frac{254}{255}\ ,\ 1 \right\}$$

$$\implies I = \left\{ 0\ ,\ I_{max}\left(\frac{1}{255}\right)^{\gamma}\ ,\ \ldots\ ,\ I_{max}\left(\frac{254}{255}\right)^{\gamma}\ ,\ I_{max} \right\}$$

1.4 RGB

- ⋆ RGB colour can be represented as a RGB colour cube. Coordinates of colours are:
  - black = (0, 0, 0)
  - red = (1, 0, 0)
  - green = (0, 1, 0)
  - blue = (0, 0, 1)
  - yellow = (1, 1, 0)
  - magenta = (1, 0, 1)
  - cyan = (0, 1, 1)
  - white = (1, 1, 1)
- ⋆ Gamma correction issues apply to each RGB component separately

1.5 Compositing

- The **pixel coverage** (denoted α) is the fraction of the pixel covered by the foreground layer.

- For a composite with foreground colour $\mathbf{c}_f$ over a blackground colour $\mathbf{c}_b$:

$$\mathbf{c} = \alpha\mathbf{c}_f + (1 - \alpha)\mathbf{c}_{background}$$

- The α values can be stored in a separate greyscale image known as a **alpha mask** or **transparency mask**

2 Ray Tracing

2.1 Introduction

- ⋆ Rendering takes an input of a set of objects and outputs an array of pixels
- ⋆ In **object-order rendering**, each object is considered in turn (for each object). In **image-order rendering**, each pixel is considered in turn (for each pixel).
- ⋆ Image-order rendering is simpler to get working and more flexibile but takes longer to produce a comparable image

2.2 Basic Ray-Tracing Algorithm