CPSC 314
Computer Graphics

Dinesh K. Pai

Projection

1

Today

- Exam preparation tips
- Wrap up transformations: lookAt, object rotations
- Cameras and projections (Chapter 10 of text)
  - Pinhole camera model
  - Projection in homogeneous coordinates
  - Distinguish between
    - Eye coordinates
    - Clip coordinates
    - Normalized device coordinates (ndc)

2

Exam Format

- The exam is closed book, closed electronic device (laptops, phones, etc. should be out of sight).
- 50 marks (in 50 minutes. Please be on time!)
- Three types of questions
  - small questions (fill in the blank, many choices given)
    "Can you recognize the concepts?"
  - direct questions (write down short answer)
    "Do you understand the concepts?"
  - problem solving questions
    "Can you use your knowledge in a new situation?"

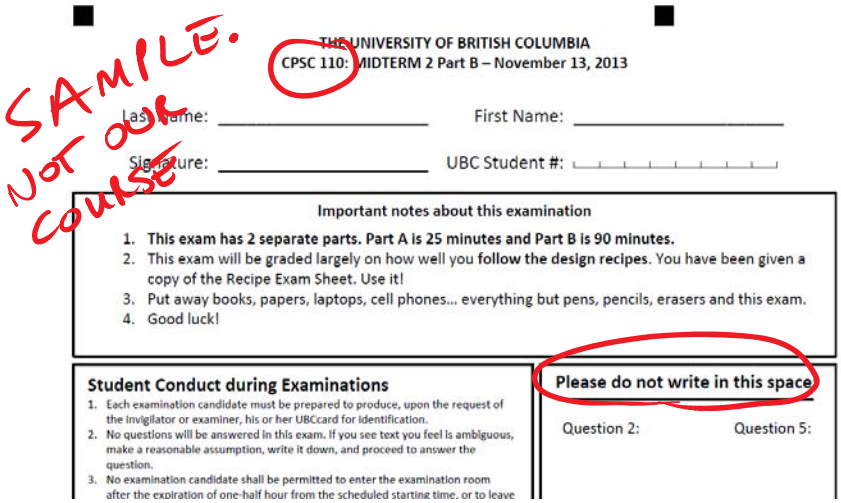
3

Exam Format

- The first two question types are meant to be easy. Try to go through them quickly, so that you have time to think about the problem solving questions at the end.
- Some questions may have multiple parts that build on one another. Answer for part (a) is used in part (b), etc. Even if the answer for (a) is incorrect, you can get credit for later parts if you show your steps (i.e., later parts will be graded on the subsequent logic).

4

Exams will be scanned and returned electronically



SAMPLE. NOT OUR COURSE

THE UNIVERSITY OF BRITISH COLUMBIA
CPSC 110: MIDTERM 2 Part B – November 13, 2013

Last Name: _____ First Name: _____

Signature: _____ UBC Student #: _____

Important notes about this examination

1. **This exam has 2 separate parts. Part A is 25 minutes and Part B is 90 minutes.**
2. This exam will be graded largely on how well you **follow the design recipes**. You have been given a copy of the Recipe Exam Sheet. Use it!
3. Put away books, papers, laptops, cell phones... everything but pens, pencils, erasers and this exam.
4. Good luck!

Student Conduct during Examinations

1. Each examination candidate must be prepared to produce, upon the request of the invigilator or examiner, his or her UBCcard for identification.
2. No questions will be answered in this exam. If you see text you feel is ambiguous, make a reasonable assumption, write it down, and proceed to answer the question.
3. No examination candidate shall be permitted to enter the examination room after the expiration of one-half hour from the scheduled starting time, or to leave

Please do not write in this space

Question 2: Question 5:

5

Tips for manipulating matrices

- Rotations

$$R^{-1} = R^T$$

- Rigid Motions

$$\text{if } M = \left[\begin{array}{c|c} R & t \\ \hline 0\,0\,0 & 1 \end{array}\right]$$

$$M^{-1} = \left[\begin{array}{c|c} R^T & -R^T t \\ \hline 0\,0\,0 & 1 \end{array}\right]$$

6

C³ Survey

- How far along are you with Assignment 2
  a) Not started
  b) Can run template code
  c) Finished at least one part
  d) Finished all specified parts (1,2,3)
  e) Finished everything

7

C³ Homework: Viewing

- Find the view transform from world coordinates to eye coordinates, corresponding to an eye located at (2,5,0), looking straight at (10,5,0), both in world coordinates. Assuming y is the up direction.
- What are the world coordinates of a point whose eye coordinates are (5,3,-4)?
- What are the eye coordinates of a point whose world coordinates are (5,3,-4)?

C³ Homework: Viewing

- Find the view transform from world coordinates to eye coordinates, corresponding to an eye located at (2,5,0), looking straight at (10,5,0), both in world coordinates. Assuming y is the up direction.
- What are the world coordinates of a point whose eye coordinates are (5,3,-4)?

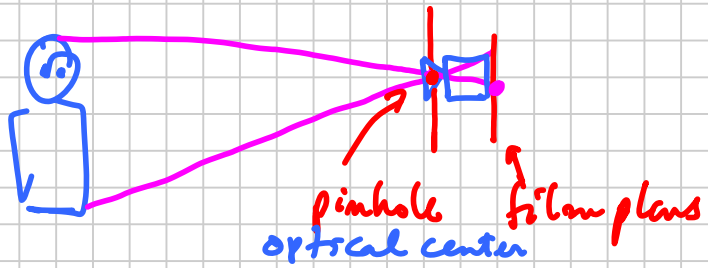
a) (2, -2, 5)
b) (6, 8, 5)
c) (4, 8, 7)
d) (-4, 8, -7)
e) None of the above

C³ Homework: Viewing

- $\underline{\tilde{e}} = \underline{\tilde{w}} \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 5 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
- $\underline{\tilde{e}} \begin{bmatrix} 5 \\ 3 \\ -4 \\ 1 \end{bmatrix} = \underline{\tilde{w}} \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 5 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 5 \\ 3 \\ -4 \\ 1 \end{bmatrix} = \underline{\tilde{w}} \begin{bmatrix} 6 \\ 8 \\ 5 \\ 1 \end{bmatrix}$

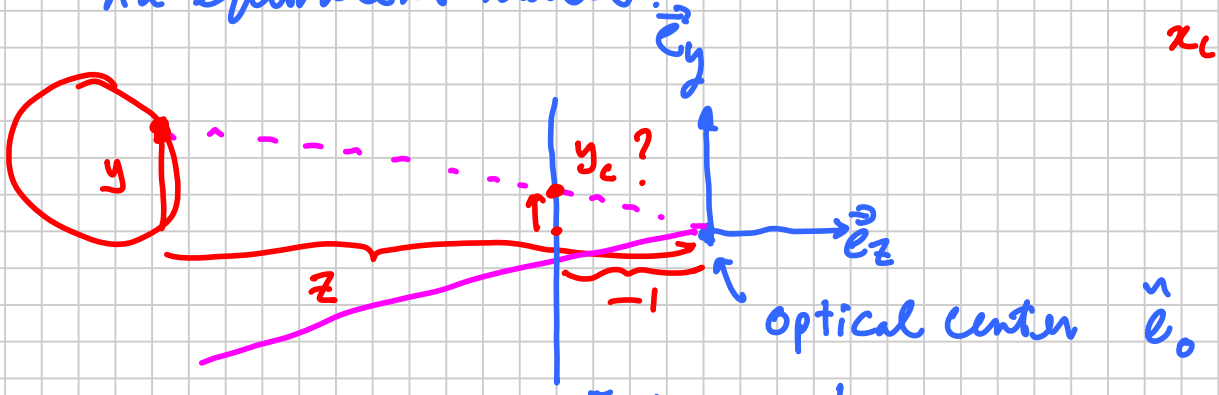
Cameras & Projection

Note Title 2014-02-03



Simplest Model: Pinhole Camera

An equivalent model:



x_c is similar

From similar triangles

$$\frac{y}{z} = \frac{y_c}{-1}$$

So $\begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$ Project $\Longrightarrow$ $\begin{pmatrix} -x/z \\ -y/z \\ -z/z \\ 1 \end{pmatrix}$

Using cool fact from last class

$$= \begin{pmatrix} x \\ y \\ z \\ -z \end{pmatrix}$$

Representing Projection as a matrix.

$$\begin{pmatrix} x_c \\ y_c \\ z_c \\ -z_e \end{pmatrix} = \begin{bmatrix} 1 & & & 0 \\ & 1 & & 0 \\ & & 1 & 0 \\ 0 & 0 & -1 & 0 \end{bmatrix} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$

Clip coordinates

The basic Projection Matrix (★) $\underline{P}$

Eye coordinates of a point

Eg. gl_position in Vertex Shader

In a typical OpenGL application

Model-View-Projection matrix

C E^{-1} P

gl_position = Proj * View * Model * c

$= P E^{-1} C c$