KAIST

CS 380

Introduction to Computer Graphics

LAB (3)

2015.03.18

VISUAL COMPUTING Lab

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- Note that we will not teach the answer of this homework, as the homework must be done by yourself.
- Instead, we will explain the necessary background which is required to finish this HW.
- Some part of this slides are from lecture notes of this course.

VISUAL COMPUTING Lab

Goals

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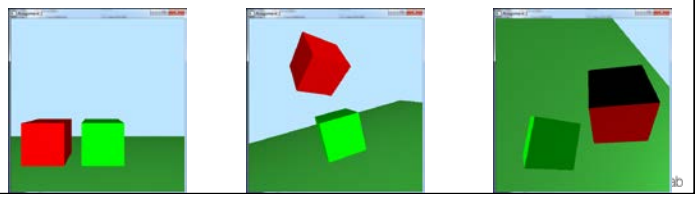
1. Draw two cubes
2. Create different viewpoints
3. Move the objects freely w.r.t. the current viewpoint frame

- We have four tasks to complete in this hw2.



Affine Transformation

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Full affine transformation = Translation × Rotation

$$\begin{bmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & l \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & d \\ 0 & 1 & 0 & h \\ 0 & 0 & 1 & l \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} a & b & c & 0 \\ e & f & g & 0 \\ i & j & k & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

$$\begin{bmatrix} l & t \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} i & t \\ 0 & 1 \end{bmatrix} \begin{bmatrix} l & 0 \\ 0 & 1 \end{bmatrix} \qquad A = TL$$

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Transformation Respect

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- We are transforming a point $\tilde{p}$ in a frame $\vec{\mathbf{f}}^t$

$$\tilde{p} = \vec{\mathbf{f}}^t \mathbf{c}$$

- With a matrix

$$\mathbf{S} = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

the stretches by factor of two in first axis of $\vec{\mathbf{f}}^t$

- Performing a transform: $\vec{\mathbf{f}}^t \mathbf{c} \Rightarrow \vec{\mathbf{f}}^t S\mathbf{c}$
- Suppose another frame: $\vec{\mathbf{a}}^t = \vec{\mathbf{f}}^t A$

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Transformation Respect

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- We could express the point with a new coordinate vector

$$\tilde{p} = \vec{\mathbf{f}}^t \mathbf{c} = \vec{\mathbf{a}}^t \mathbf{d} \qquad \vec{\mathbf{a}}^t = \vec{\mathbf{f}}^t A$$
$$\vec{\mathbf{f}}^t \mathbf{c} = \vec{\mathbf{f}}^t A\mathbf{d} \qquad \vec{\mathbf{f}}^t = \vec{\mathbf{a}}^t A^{-1}$$
$$\mathbf{d} = A^{-1}\mathbf{c}$$

- Now S transforms the point $\tilde{p}$ with respect to $\vec{\mathbf{a}}^t$

$$\vec{\mathbf{a}}^t \mathbf{d} \Rightarrow \vec{\mathbf{a}}^t S\mathbf{d}$$

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Transformation Respect

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- Point is transformed with respect to the the frame that appears immediately to the left of the transformation matrix in the expression.
- We read

$$\vec{\mathbf{f}}^t \Rightarrow \vec{\mathbf{f}}^t S$$

$\vec{\mathbf{f}}^t$ is transformed by S with respect to $\vec{\mathbf{f}}^t$

- We read

$$\vec{\mathbf{f}}^t = \vec{\mathbf{a}}^t A^{-1} \Rightarrow \vec{\mathbf{a}}^t S A^{-1}$$

$\vec{\mathbf{f}}^t$ is transformed by S with respect to $\vec{\mathbf{a}}^t$

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Eye Coordinate

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- we explicitly store the matrix E $\qquad \vec{\mathbf{e}}^t = \vec{\mathbf{w}}^t E$

$$\tilde{p} = \vec{\mathbf{o}}^t \mathbf{c} = \vec{\mathbf{w}}^t O\mathbf{c} = \vec{\mathbf{e}}^t E^{-1} O\mathbf{c}$$

  - Object coordinates: $\mathbf{c}$
  - World coordinates: $O\mathbf{c}$
  - Eye coordinates: $E^{-1}O\mathbf{c}$
  - Calculating the eye coordinates of every vertexes:

$$\begin{bmatrix} x_e \\ y_e \\ z_e \\ 1 \end{bmatrix} = E^{-1}O \begin{bmatrix} x_o \\ y_o \\ z_o \\ 1 \end{bmatrix}$$

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Task1. Draw Two Cubes

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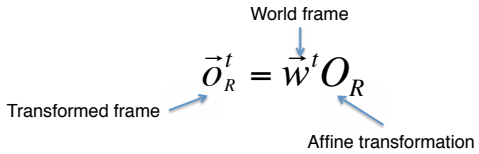
- A frame needs to be defined to the each object.
- A frame of a red cube



- A frame of a green cube

$$\vec{o}_L^t = \vec{w}^t O_L$$

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Task2. Matrix Operations

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- linFact
  - Rotation matrix: 4 x 4
- transFact
  - Translation matrix: 4 x 4
- By using these two function, you can obtain the full affine transformation matrix

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Task3. Change Viewpoint

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- Now, we have a pre-defined view point, which is called eye-view.
- The rendered image is generated in the frame of the eye-view.
- Our job is to change the eye-view according to the input of the user **by modifying the eye-view matrix**.

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Task4. Move Objects

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- In this task, we have to add manipulation features for the objects and the views.
- In order to complete task4, you should utilize a transformation w.r.t. a frame.

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